

# A fuelscape for all land ownerships in the state of California

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# 1 Executive Summary

The Pacific Southwest Region of the USDA Forest Service contracted Pyrologix to complete an assessment of wildfire hazard across all land ownerships in the state of California. The foundation of any wildfire hazard assessment is a current-condition fuelscape, updated for recent disturbances and calibrated to reflect the fire behavior potential realized in recent historical wildfire events. We leveraged LANDFIRE 2016 Remap 2.0.0 (LF Remap) data to generate a calibrated fuelscape for use in this statewide assessment.

LF Remap was released in the spring of 2019 with significant improvements from previous versions of LANDFIRE, including the use of new satellite imagery and continuous vegetation cover and height classifications<sup>1</sup>. LF Remap data represents ground conditions circa 2016, based on 2013-2017 Landsat 8 satellite imagery with priority given to 2016 imagery<sup>2</sup>. Starting from LF Remap as the most up-to-date fuel and vegetation available for CA, we aimed to calibrate the fuel mapping to observed fire behavior, make use of the new LF Remap data and features to the fullest extent, update the fuelscape to reflect recent disturbances, and produce a landscape absent of seamlines due to LANDFIRE map zone boundaries.

Our fuelscape production method differs from LF Remap in three primary ways. First, our process integrates fuel mapping rules for a given vegetation type across the entire fuelscape, rather than by mapping zone. This serves to eliminate seamlines artificially introduced where fuel rules, and often resulting fire behavior, differ for the same vegetation type across arbitrary boundaries. These distinctions are rarely present in the imagery and do not represent on-the-ground vegetation differences. Second, we use a different process in the mapping of pre-disturbance vegetation products in disturbed areas. Because the foundational imagery was 'remapped', the needed information about pre-disturbance conditions was unknown. The LANDFIRE process for obtaining pre-disturbance information was to acquire the needed vegetation inputs from vintage LANDFIRE products. We wished to leverage the new imagery wherever possible and devised a method to backwards calculate pre-disturbance conditions using post-disturbance information and disturbance severity to calculate the degree of change from pre-disturbance conditions. The final difference in the Pyrologix methodology is in the use of continuous values of vegetation cover (1 percent) and height (1 meter) rather than pre-defined bins (e.g. 10% cover classes) to calculate canopy fuel layers. This allows for more precision on values of canopy cover, canopy height, canopy bulk density, and canopy base height.

After developing tools to implement the customizations discussed above, Pyrologix conducted calibration workshops to modify fuel mapping rules by vegetation type and produce locally accurate fire behavior results. Calibration was completed through two, two-day workshops held in 2020 on March 2-3 in McClellan Park, CA and March 5-6 in Riverside, CA. At these workshops we received feedback from a group of interagency fire and fuels personnel. The list of invited agencies included the U.S. Forest Service, CALFIRE, U.S. Fish and Wildlife Service, The Nature Conservancy, Bureau of Land Management,

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<sup>1</sup> Additional information can be found at <http://www.landfire.gov/>.

<sup>2</sup> <https://www.landfire.gov/faqprint.php>

National Park Service, Bureau of Indian Affairs, as well as Kern, Orange, Los Angeles, Santa Barbara, and Ventura Counties.

The final step in producing a current-condition fuelscape is to update for recent fuel disturbances occurring after the LANDFIRE data release. We gathered available spatial data on fuel disturbances including prescribed fire, wildfire, mechanical treatments, wind events, insect mortality, and disease mortality from 2010 through 2016; wildfires from 2017 through 2019; and fuel treatments from 2017 through early 2020. The addition of recent disturbances and adjustment to time since disturbance for past disturbances render the fuelscape suitable for use in the 2020 fire season.

The following sections of this report detail the process used to develop this custom California fuelscape. A full wildfire hazard assessment report will accompany the final results. However, this document contains further details regarding the fuelscape development process used by Pyrologix, and highlights differences and similarities to the fuelscape development approaches employed by LANDFIRE. The final fuelscape for use in the 2020 fire season is available via ftp [link](#).

## 2 Pyrologix Fuelscape Methods

A fuelscape is a quantitative raster representation of the fuel, vegetation, and topography across a landscape. The fuelscape consists of geospatial datasets representing surface fuel model (FM40), canopy cover (CC), canopy height (CH), canopy bulk density (CBD), canopy base height (CBH), and topography characteristics (slope, aspect, elevation). These datasets can be combined into a single landscape (LCP) file and used as a fuelscape input in fire modeling programs.

In the spring of 2020, the USFS Pacific Southwest Region (R5) and Pyrologix generated an updated, calibrated fuelscape as part of the California All-Lands (CAL) Wildfire Hazard Assessment. This fuelscape covers all lands in the state of California (Figure 1) and can be used in the 2020 fire season to support fire operations in response to wildfire incidents. Pyrologix will also use the CAL fuelscape to complete the wildfire hazard assessment, the results of which can be used to aid in the planning, prioritization, and implementation of prevention and mitigation activities.

In the following sections we discuss the Pyrologix process of generating a fuelscape. The process outlined in sections 2.1 - 2.4 was utilized within the United States portion of the landscape. Our methods for generating a fuelscape within Mexico is subsequently discussed below in section 2.5.2.

**Figure 1. Overview of fuelscape extent for CAL wildfire hazard assessment.**



## 2.1 Fuelscape Inputs Overview

The vegetation and disturbance inputs for the United States portion of CAL were derived from the newly released LF Remap 30-m raster data. This new release had significant changes from previous versions of LANDFIRE, including the use of new imagery and continuous vegetation cover and height classifications<sup>1</sup>. Capitalizing on the new features of the LF Remap data, Pyrologix developed a custom fuelscape-generation method. In this approach, the generation of the surface fuels portion of the fuelscape (FM40) was handled differently than the generation of the canopy fuels (CC, CH, CBD, CBH). The two approaches are discussed in the following sections.

### 2.1.1 Surface Fuels

Pyrologix generated the surface fuels portion of the fuelscape (FM40) through the use of the LANDFIRE Total Fuel Change Tool (LTFCT, Smail *et al.* (2011)). LTFCT requires *pre-disturbance* vegetation characteristics to assign a surface fuel model. Some of these pre-disturbance characteristics are represented as datasets known as the *fuel* vegetation datasets, and include fuel vegetation type (FVT), cover (FVC) and height (FVH). The fuel vegetation datasets are used in conjunction with the biophysical settings (BpS) dataset and the fuel disturbance (FDIST) dataset as inputs to LTFCT. Using these inputs, LTFCT then queries a database of “fuel rules” to generate the surface fuel model (FM40) dataset, as well as a canopy guide (CG) dataset.

In general, LANDFIRE derives the fuel vegetation datasets above from the LANDFIRE *existing* vegetation datasets: existing vegetation type (EVT), cover (EVC), and height (EVH). In a similar fashion, Pyrologix derived the CAL fuel vegetation datasets from the LF Remap EVT/EVC/EVH, however we used a slightly modified approach.

LF Remap is based on recent imagery that includes disturbances through 2016. If an area did *not* experience a disturbance during that time period, then the existing vegetation datasets were considered to be the same as the fuel vegetation datasets and therefore were considered pre-disturbance vegetation characteristics. However, if an area *did* experience a disturbance during that time period then the imagery-based existing vegetation datasets reflect a *post-disturbance* condition and the needed pre-disturbance vegetation information is unknown.

For unknown pre-disturbance information in LF Remap, LANDFIRE relied on previous vintages of LANDFIRE data to determine the needed LTFCT inputs. In the Pyrologix method, we wished to retain as much information from the new imagery – to the extent possible – and to avoid relying on vintage LANDFIRE data for the unknown inputs. Pyrologix therefore derived FVT directly from LF Remap EVT, and derived FVC and FVH for disturbed areas by starting with the post-disturbance information on vegetation cover and height (EVC and EVH, in this instance) and using the disturbance severity to ‘add back’ the cover and height to a presumed pre-disturbance condition. For cover modifications, we used the inverse of standard severity reductions<sup>3</sup> to add back cover for disturbed tree and shrub FVTs. Maximum values of tree and shrub cover were calculated in the CAL project area for each FVT to ensure values did not exceed observed covers in the project area. Herbaceous covers were not adjusted as the cover recovery time for herbaceous FVTs is relatively short. Height modifications were only made to tree

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<sup>3</sup> Standard cover reductions include 20 percent for low severity, 50 percent for moderate severity, and 80 percent for high severity. The exception to these standard values is for insect and disease disturbances where 10 percent is used for low severity, 40 percent for moderate, and 80 percent for high severity.

FVTs that experienced a high severity disturbance, which most likely affected the overall height of the stand. To determine the pre-disturbance height for these areas, for each tree FVT we calculated the overall maximum height and also the mean non-disturbed height in the CAL project area. If the post-disturbance height was less than the mean, the pre-disturbance height was set to the mean non-disturbance height. Otherwise, the pre-disturbance height was set to the overall maximum height.

Using the methods above, Pyrologix was able to derive fuel vegetation datasets from the recent imagery that represented pre-disturbance conditions for both disturbed and non-disturbed areas. It should be noted that while EVC and EVH are continuous data, LFTFCT requires inputs to be binned into standardized bins so the FVC and FVH derived by Pyrologix for surface fuels were not continuous.

## 2.1.2 *Canopy Fuels*

For LF Remap, canopy fuels datasets (CC, CH, CBH and CBD) were created in conjunction with surface fuels through LFTFCT. In contrast, Pyrologix developed an independent process for generating canopy fuels. Although we developed the canopy fuels outside of LFTFCT, we generally mimicked the LFTFCT process and calculations, adjusting canopy fuels based on disturbance scenario and time since disturbance. A few differences in approach warrant highlighting below in sections 2.1.2.1 - 2.1.2.3. It should be noted that in both approaches canopy characteristics are only calculated for pixels with a CG<sup>4</sup> other than zero. The inputs used to generate canopy datasets include FVT, EVC, EVH, CG, and LANDFIRE coefficients for each vegetation type/disturbance combination. The coefficients come from linear equations derived from Forest Vegetation Simulator (FVS) scenario outputs<sup>1</sup>.

### 2.1.2.1 Canopy Cover (CC) and Canopy Height (CH)

The LF Remap process groups the continuous values of pre-disturbance vegetation cover and height into classes when generating their FVC and FVH. Using the midpoint values of those classes, along with the coefficients mentioned above, LFTFCT calculates post-disturbance CC and CH and then groups the results into the same classes as the inputs. Final LF Remap CC and CH datasets only contain midpoint values. In the Pyrologix method we again wished to retain as much of the new information as possible, and by generating canopy grids outside of LFTFCT we were able to generate CC and CH using the continuous inputs for cover and height, and kept the additional resolution of the continuous outputs in our final CC and CH.

In disturbances occurring in 2010-2016, we used the continuous values for existing vegetation cover (EVC) and height (EVH) as our CC, to reflect post-disturbance conditions. For post-2016 disturbances we started from the continuous LF Remap cover (EVC, which was considered pre-disturbance cover in this case) and we adjusted CC using the LANDFIRE coefficients, setting a minimum cover limit of 5 percent. No additional adjustments were made to CH for post-2016 disturbances. CC and CH were set to zero for pixels where either CG was zero or CC or CH were zero.

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<sup>4</sup> Canopy Guide is a code used by LANDFIRE to flag whether tree canopy is available for crown fire activity. 0 = no tree canopy, 1 = CBH and CBD available for crown fire, 2 = tree canopy is present and will reduce windspeed accordingly but CBH and CBD set to prevent crown fire activity, 3 = artificial reduction in CBD to prevent active and conditional crown fire.

### 2.1.2.2 Canopy Bulk Density (CBD)

We calculated CBD using a generalized linear model (Reeves *et al.* 2009) employed by LANDFIRE but used our continuous CC for an input rather than the binned midpoints used in the default process. Consistencies with the LANDFIRE process include the maximum CBD value of 0.45 kg/m<sup>3</sup> and the default value of 0.01 kg/m<sup>3</sup> for CG 2. We changed the default for CG 3 from 0.05 kg/m<sup>3</sup> to 0.02 kg/m<sup>3</sup> to further reduce potential for crown fire and only allow for ember lofting rather than possible low- to mid-grade passive crown fire.

### 2.1.2.3 Canopy Base Height (CBH)

Our method for CBH calculation was consistent with that used by LANDFIRE, however, we added a post-calculation check to make sure that the disturbed CBH was never lower than corresponding non-disturbed CBH. This check did not include insect and disease disturbances, given that we developed a process for calculating CBH in areas with insect and disease detailed below.

Previous reviews of LF Remap fuelscapes highlighted the need for adjustments to the LF Remap CBH calculations in areas disturbed by insect and disease. Adjustments were made for the CBH calculation to both the CBH coefficients and the input cover value to better align these areas with the expected increase in fire behavior and surface winds due to a reduction in canopy cover from insect mortality, and to maintain fuelscape characteristics similar to the non-disturbed scenario. This change ensured the fuelscape would produce more active fire behavior in moderate conditions and no worse than the non-disturbed fuel in the more extreme conditions.

Finally, while we retained the same minimum CBH value of 0.3 m and maximum CBH value of 10 m as LANDFIRE, we altered our handling of pixels in the case where the calculated CBH resulted in a value greater than the final CH. When that occurs, the standard LANDFIRE adjustment is to set CBH to be two-thirds of the CH. Instead we chose to set the CBH to 90 percent of the CH, but no greater than 10 m to be consistent with the maximum CBH value noted above. This adjustment was made to prevent crown fire in shorter stands where, with more volatile fuel models, a CBH of two-thirds the CH would still allow for some crown fire. These situations primarily occur with CG 2 or where the CBH value is raised after a disturbance to turn crown fire off. We also adjusted the default CBH for CG 2 to be 9.9 m rather than 10 m, simply to more easily identify pixels with CG 2.

### 2.1.2.4 Canopy Overrides

During a fuelscape calibration, specialists may choose to override the calculated values of CC, CH, CBD, or CBH if these values do not characterize appropriate fire behavior for a given vegetation/disturbance combination. The canopy fuels process incorporates these overrides into the final datasets as the last part of the process.

## 2.2 CAL Fuelscape Calibration

A fuelscape calibration reviews the derivation of fuels datasets and further calibrates the fuelscape to more accurately reflect expected fire behavior conditions in a given vegetation type. In most cases the fuels datasets are derived from remotely sensed vegetation, using fuel rules that translate the vegetation data into fuels data. Fuelscape calibration typically involves reviewing the fuel rules used and adjusting them to incorporate feedback from local fire and fuels staff, as well as updating the fuelscape for recent disturbances.

LANDFIRE is the national, readily available source of fuelscape data and is sometimes used without modifications. Pyrologix fuel calibrations utilize many components of the secondary LANDFIRE calibration process to provide an improved, updated fuelscape. Additional general information on customizing fuelscapes can be found in the LANDFIRE data modification guide (Helmbrecht and Blankenship, 2016).

### ***2.2.1 Consolidating Fuel Rules***

The LANDFIRE fuel mapping process assigns fuel model and canopy characteristics using two primary input layers: Existing Vegetation Type<sup>5</sup> (EVT) and LANDFIRE map zone. Using these inputs (and information about the fuel disturbance(s), vegetation height and cover, and biophysical setting), a rule is queried from the LANDFIRE ruleset database to assign surface fuel model and, if applicable, canopy characteristics for the given EVT and map zone. When working with a large project extent, such as CAL, many map zones are present. The challenge in fuelscape calibration is to produce a set of output fuel rasters without artificial and often arbitrary seamlines across map zones. To do so, the rules from multiple zones must be reconciled and filtered to one ruleset per EVT. As an unbiased way to reconcile rules from multiple map zones, we determined which zone holds the greatest share of each EVT on the landscape and applied those rules across the entire fuelscape. After unifying rulesets to produce a preliminary fuelscape, we conduct fuelscape calibration workshops to further customize and calibrate rulesets to the project area of interest.

### ***2.2.2 Fire Behavior Summary***

Prior to the fuel calibration workshops, we produced an initial set of fire behavior results with gNexus<sup>6</sup> and FlamMap using the preliminary fuelscape. The fire behavior results include maps of Rate of Spread (ROS), Heat Per Unit Area (HPUA), Flame Length (FL), Fireline Intensity (FIL), Crown Fraction Burned (CFRB), Torching Index (TI), and Crowning Index (CI). These maps were then summarized by each rule in the LFTFCT database for landscape critique and evaluation by workshop participants.

### ***2.2.3 Workshops***

A prioritized list of EVTs was determined to focus calibration efforts. The set of EVTs reviewed in fuel calibration were identified as being among the most abundant EVTs, EVTs that had recently burned, and EVTs with inconsistencies in fire behavior across the range of vegetation cover and height values (i.e. passive crown fire is possible at all windspeeds for part of the rule while the remainder of the rule could only ever experience surface fire under all observable windspeeds).

Two CAL fuel calibration workshops were held; the first workshop was held March 2-3, 2020 in Sacramento, CA and the second was held March 5-6, 2020 in Riverside, CA. At the workshops we solicited feedback from local fire and fuels staff from R5 as well as interagency partners across the state. The intent of the workshops was to review the preliminary fire modeling results and refine the rulesets to produce fire behavior results consistent with the experience of workshop participants for the

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<sup>5</sup> For simplicity, we use existing vegetation type (EVT) and fuel vegetation type (FVT) synonymously in this section. The reader is reminded that FVT is the input needed by LFTFCT and is derived from EVT, which in the LANDFIRE approach may be a vintage EVT. Pyrologix uses solely LF Remap EVTs to derive FVT.

<sup>6</sup> gNexus is a custom spatial implementation of the fire behavior calculator software, NEXUS 2.1 (available at <http://pyrologix.com/downloads>)

dominant EVT that experience fire. The EVTs reviewed covered the majority of the burnable portion of the state of California.

The complete set of calibrated EVTs are listed in the final 'Fuel Boxes' spreadsheet that will be provided with the final project deliverables<sup>7</sup>. Two shrub EVTs, California Montane Woodland and Chaparral (2098) and Recently Burned-Shrub Cover (2190), had separate rules for northern and southern portions of the CAL fuelscape so a wildcard was created to allow for correct spatial implementation of these rules. All other calibrated EVTs had a single set of rules for the entire fuelscape. See the 'Fuel Boxes' spreadsheet above for additional details.

## 2.3 Post-Workshop Fuelscape Modifications

### 2.3.1 *USFWS Requested Edits*

Following the workshops, we received additional feedback regarding the portions of select USFWS refuges mapped as non-burnable. These areas were over-characterized as standing water due to 2016, the year of image collection, being a wetter year. USFWS provided us with polygons indicating the affected refuges and requested adjustments to the mapping therein. The misclassifications came in three forms: a burnable EVT misclassified as water, a burnable EVT misclassified as a non-burnable EVT other than water, or a burnable EVT with a non-burnable fuel rule. For the first form of misclassification we replaced the Water (11) EVT within the appropriate refuge polygons with the Temperate Pacific Freshwater Emergent Marsh (2662) EVT, with an herbaceous cover of 30-40% (123) and height of 0-0.05 m (425). For the second case, we replaced both the Row Crop (2964) and Close Grown Crop (2965) EVTs with the Pasture and Hayland (2967) EVT in the appropriate refuge polygons. For the third case, we altered the rule sets to include burnable fuel models for two different EVTs in different refuge polygons: Temperate Pacific Tidal Salt and Brackish Marsh (2668) and North American Arid West Emergent Marsh (2225). See the 'Fuel Boxes' spreadsheet above for additional details.

### 2.3.2 *Recent Disturbances*

In addition to calibrating fuel rulesets, both the surface and canopy inputs were updated to reflect recent fuel disturbances. LF Remap accounts for disturbances up to and including 2016. To update the CAL fuelscape for use in the 2020 fire season we added disturbances occurring between 2017 and 2019, inclusively, as well as treatments in early 2020. Pyrologix gathered fuel disturbances across the state and assigned appropriate disturbance codes using the same queries and logic developed by LANDFIRE. Fuel disturbances included events such as mechanical treatments, prescribed fire, wind events, insect mortality, and wildfires. Datasets were collected from a variety of sources but included sources such as the USFS Forest Service Activity Tracking System (FACTS), Department of Interior National Fire Plan Operations & Reporting System (NFPORS) and the data from CALFIRE's CalMAPPER database.

Pyrologix incorporated recent wildfire disturbances using three difference sources: Monitoring Trends in Burn Severity (MTBS) data, Rapid Assessment of Vegetation Condition after Wildfire (RAVG) data, and Geospatial Multi-Agency Coordination (GeoMAC) perimeter data. We gathered severity data as available from MTBS, then RAVG, and where severity data was unavailable, we relied on final perimeters from GeoMAC. We cross walked MTBS and RAVG severity to the appropriate disturbance code (112, 122, or

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<sup>7</sup> CAL\_FuelBoxes\_Final.xlsx

132) corresponding with fire disturbances of low, moderate, or high severity, occurring in the past one to five years. GeoMAC perimeters were assigned a severity disturbance code of 122.

## 2.4 Final Fuelscape

After all workshop edits and recent disturbances were incorporated into the final calibrated fuelscape, we generated the CAL United States fuel raster shown by fuel model group in Figure 2. CC, CH, CBD, and CBH are shown in Figure 3 through Figure 6.

Figure 2. Map of fuel model groups across the CAL LCP extent.



Figure 3. Map of canopy cover (CC) across the CAL LCP extent. CC is continuous but is displayed in the standard LANDFIRE 10% classes below for ease of viewing.

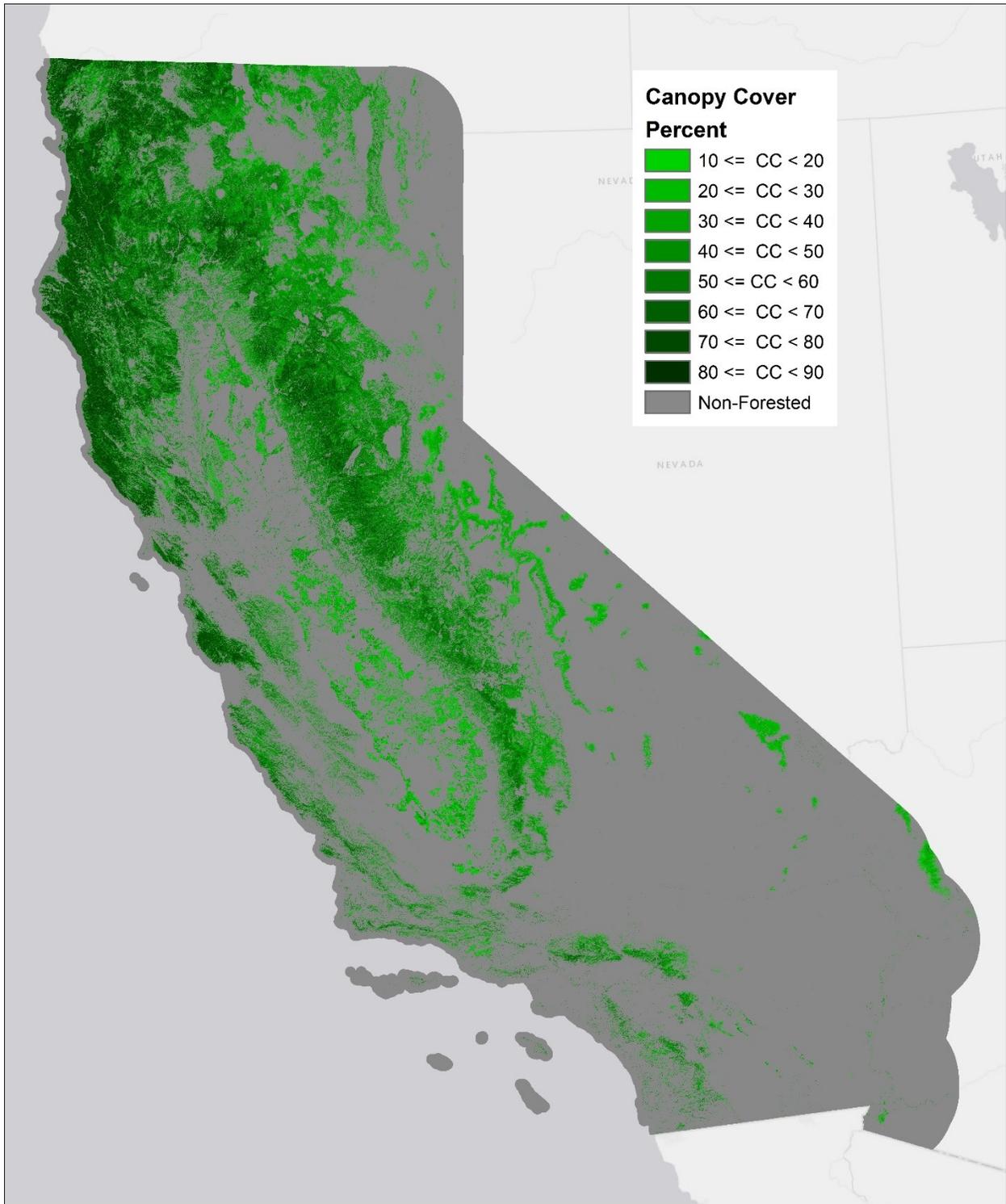


Figure 4. Map of canopy height (CH) across the CAL LCP extent. CH is continuous but is displayed in the standard LANDFIRE height classes below for ease of viewing.

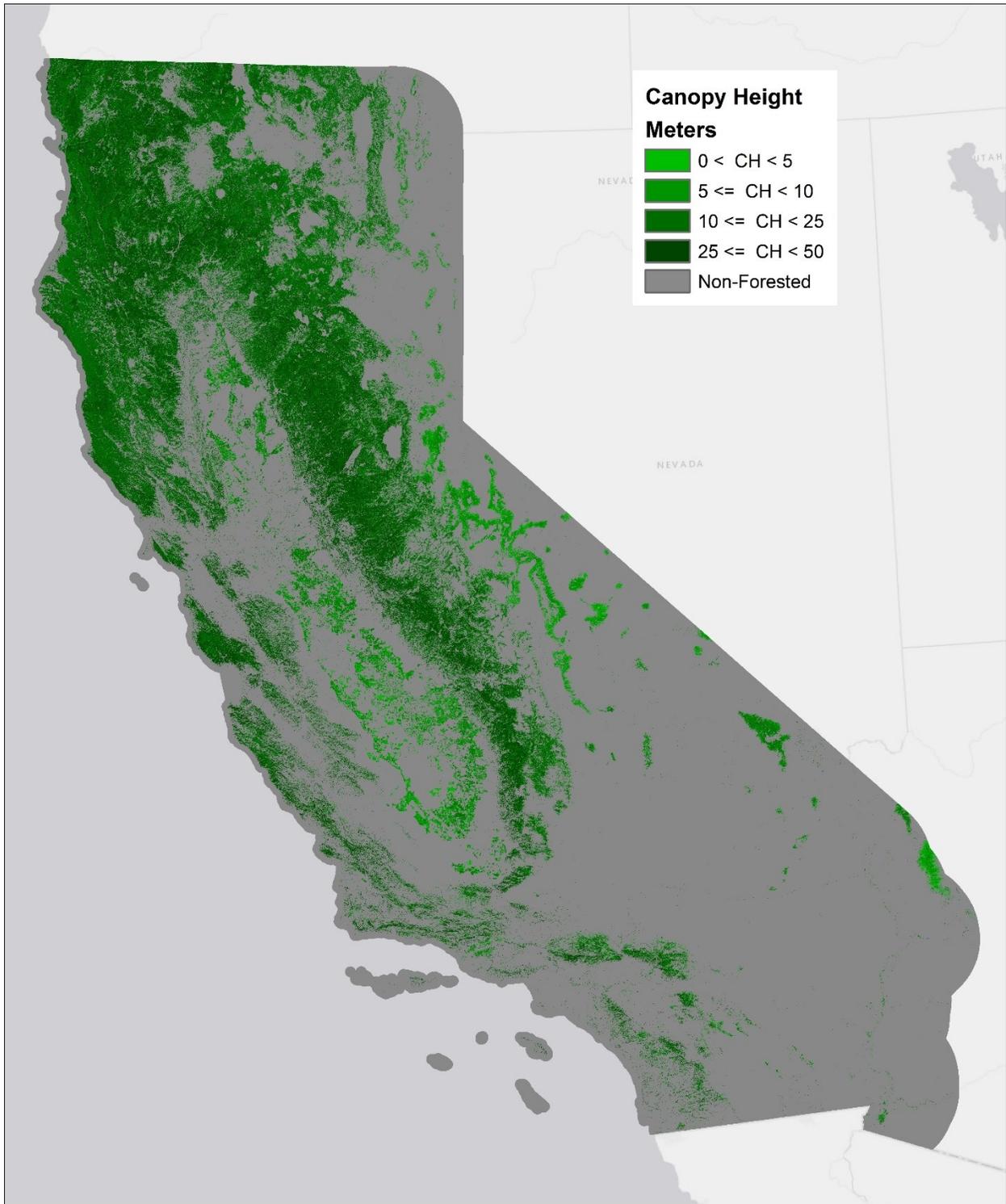


Figure 5. Map of canopy bulk density (CBD) across the CAL LCP extent.

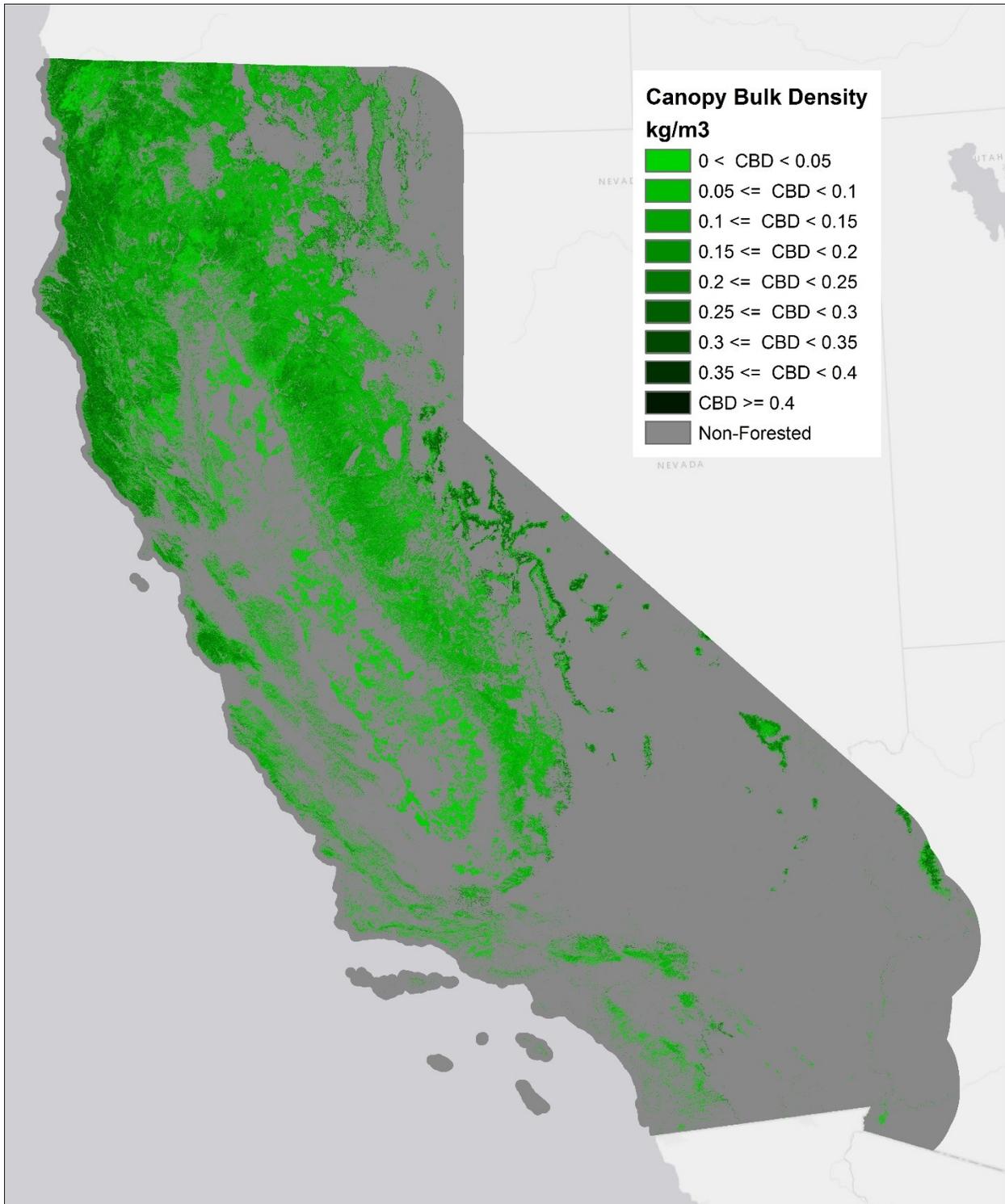
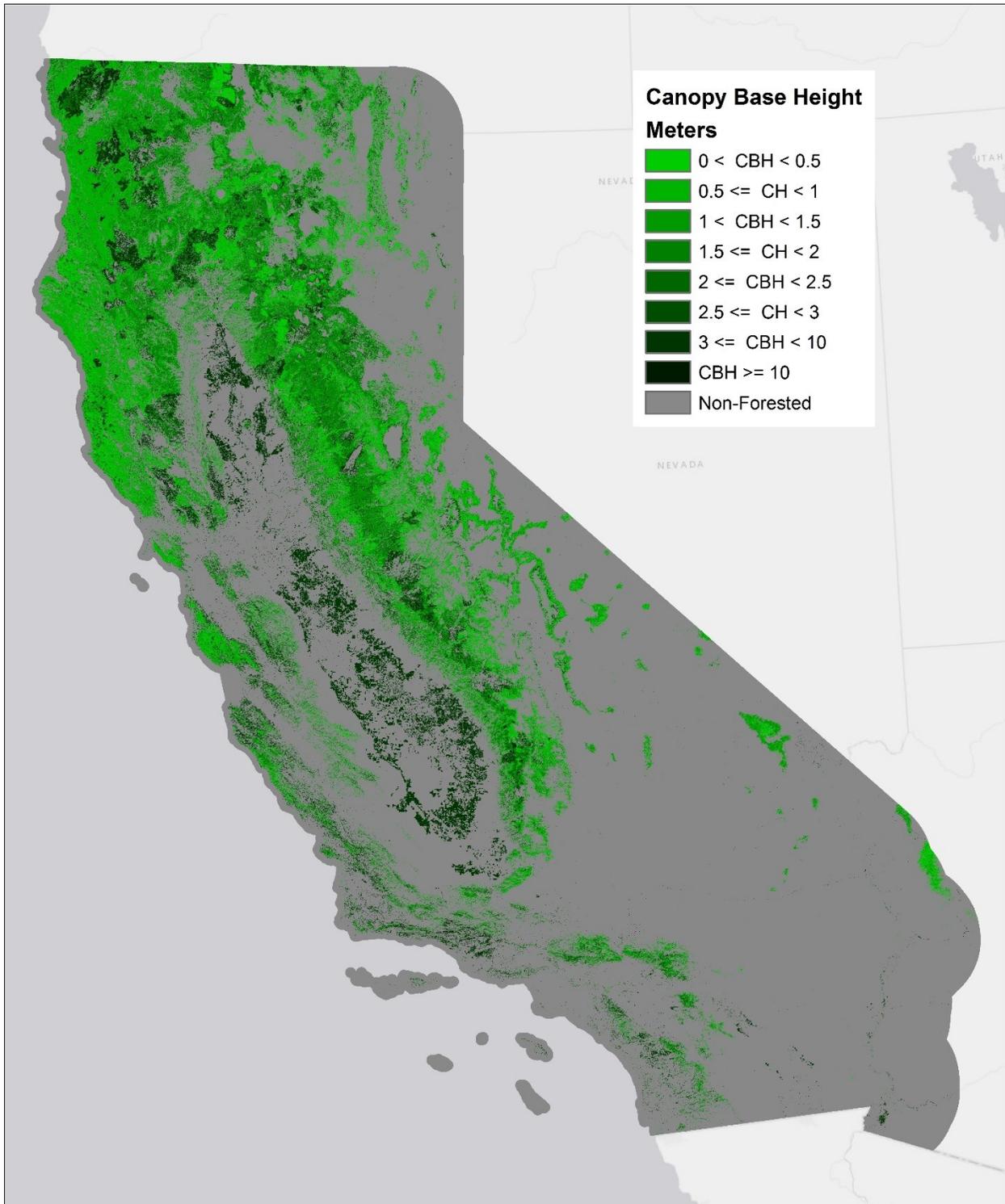


Figure 6. Map of canopy base height (CBH) across the CAL LCP extent.



## 2.5 Customizations for Pyrologix Fire Modeling

Pyrologix produced two fuelscapes using the calibration method and fuelscape development process discussed in the previous sections. The first fuelscape (CAL United States) is for use in the 2020 fire season to support fire operations. The second fuelscape product contains customizations for use in fire modeling by Pyrologix, including custom fuel models and fuelscape expansion into Mexico for use in the FSim fire model and, ultimately, the Wildfire Hazard Assessment. These customizations are discussed in the following sections.

### 2.5.1 *Custom Fuel Models*

The 40 Scott and Burgan Fire Behavior Fuel Models (FBFM40) represent distinct distributions of fuel loading found among surface fuel components, size classes and fuel types. The spatial representation of fuel model assignments serves as input into wildfire simulation modeling systems like FARSITE, FlamMap, and FSim. Although the FBFM40 fuel model set covers a wide array of fuel bed scenarios, it is sometimes necessary to develop custom fuel model assignments for specific instances where one needs to simulate fire behavior not reflected in any standard fuel model.

Many spatial wildfire simulation systems associate certain simulation inputs to the fuel model raster. For example, FSim allows input of live and dead fuel moisture content to vary by fuel model. FSim further allows input of a rate of spread adjustment factor by fuel model. Therefore, it is sometimes necessary to use a “custom” fuel model only so that certain locations can be given different simulation inputs. For example, certain high-elevation locations may be characterized by a standard fuel model, but with different fuel moisture inputs. In that case, a custom fuel model can be made with the same parameters as the standard fuel model but a different fuel model number. Then, because the fuel model number is different, it can be given different fuel moisture inputs.

The CAL fuelscape uses custom fuel models for this second purpose. We used them to represent the potential for wildfire spread into burnable urban areas. By making these areas custom fuel models with a different fuel model number than the standard model on which it was based, we were able to control the weather scenarios during which simulated fire spread could take place. These areas were originally mapped by LANDFIRE as non-burnable, and therefore do not allow simulated wildfire-spread as observed in past wildfire events. In this application of custom fuel models, the parameters are identical to standard FBFM40 fuel models but are labeled with custom numbers to allow for additional customization within FSim. The burnable-urban custom fuel models were spatially identified using the LANDFIRE EVT's designated as low and moderate intensity developed: burnable developed areas are represented with 251/BU1, identical to TL9; and burnable roads are represented with 252/BU2, identical to TL3.

The addition of the custom burnable-urban fuel models allows for the transmission of wildfire in simulation across these areas. To prevent overestimating the likelihood of wildfire in custom fuel models, fuel moisture inputs were modified to allow for wildfire only under 97<sup>th</sup> percentile ERC conditions.

### 2.5.2 *Mapping Fuels in Mexico*

Two methods were used in the development of the CAL fuelscape: one for the lands within the United States where landscape data is readily available nationally, and another for fuels mapped within Mexico,

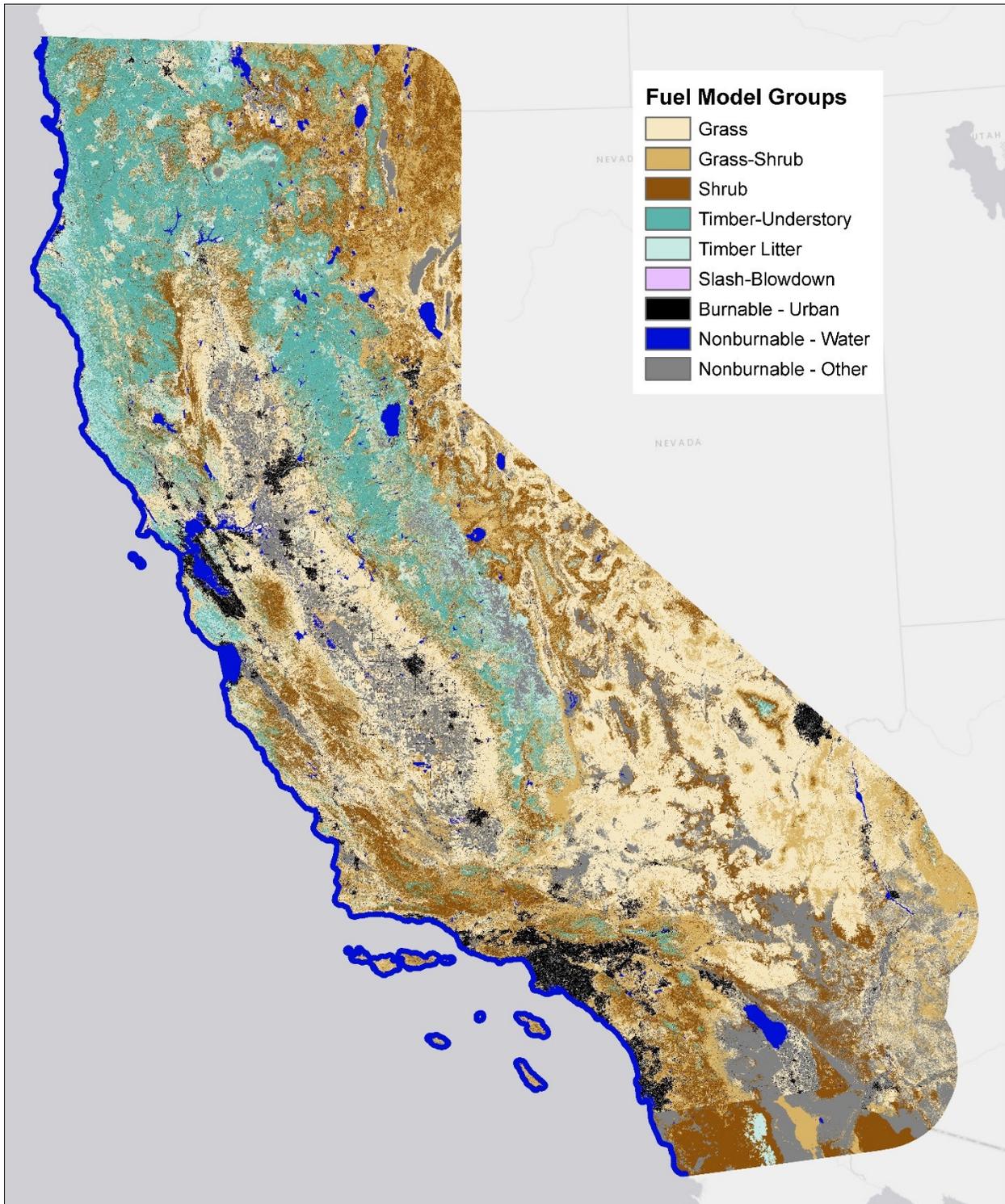
where fuels data is limited. Methods for the United States portion were more rigorous, given that the analysis area is located mainly within the United States. For the portion of the fuelscape in Mexico, we crosswalked the 30-m North American Land Change Monitoring System (NALCMS) 2010 land cover data to obtain surface fuel model, canopy base height, canopy bulk density, canopy cover, and canopy height rasters. Additionally, we extracted the 30-m National Elevation Data (NED) raster for our project extent within Mexico, from which we generated slope and aspect rasters. The fuels and topographic rasters were mosaicked with the final United States fuel rasters to generate a final fuelscape for CAL. The purpose for extending the fuelscape into Mexico, even with limitations on consistent vegetation data, is to minimize edge-effects in the fire modeling. To be consistent with other parts of the fuelscape, simulated fires that start within the United States must have fuelscape in Mexico to spread onto. Without this, edge-effects will be visible in the final modeling results.

Estimates of fuel characteristics in Mexico are much less accurate than those developed from the LANDFIRE methodology within the United States. While it is important to recognize the limitations of the Mexico fuel mapping process, care was taken to map fuels as accurately as possible given the data limitations and to minimize introduced fire modeling seamlines at the Mexican border.

### ***2.5.3 Pyrologix Fire Modeling Fuelscape***

Using the methods above we generated a second version of the fuelscape for use in our wildfire hazard modeling. The fuel raster is displayed using fuel model groups in below. Canopy rasters were very similar to the CAL USA fuelscape, with the addition of Mexico.

Figure 7. Map of fuel model groups in the Pyrologix fire modeling fuelscape.



### 3 Conclusion

The process detailed in this document describes the many steps necessary to produce a customized fuelscape using the Pyrologix methodology. The modifications to the LANDFIRE process were time-consuming and not without effort, but our hope is the results better-reflect the vegetation conditions captured in the LF Remap imagery - a benefit that can be employed at the state-level, but that is not feasible at the national extent covered by LANDFIRE. The final CAL fuelscape, for use in the 2020 fire season, is available for download via ftp [link](#). The version of the fuelscape including burnable-urban custom fuel models is also available via ftp [link](#).

Our calibration covered a large majority of the state but was not inclusive of all EVT's within the CAL fuelscape extent. A great many EVT's cover the remaining burnable portion of the fuelscape. Further calibration of more EVT's, covering little ground, has diminishing returns for a statewide assessment.

Finally, the CAL fuelscape is current for the 2020 fire season, and with frequent wildfire and other disturbances, a regular update interval is advised. We recommend an update interval of 2 - 5 years as programmatic budgets allow and fuel disturbances warrant. Please contact Pyrologix ([www.pyrologix.com](http://www.pyrologix.com)) for further questions on the customizations used in producing this fuelscape.

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