A FUELSCAPE FOR COLORADO ALL-LANDS

PREPARED FOR:
Rocky Mountain Region
United States Forest Service

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1 EXECUTIVE SUMMARY

The effort to produce a quantitative wildfire risk assessment across all land ownerships in Colorado began in February 2019 when the Rocky Mountain Region of the USDA Forest Service contracted with Pyrologix. The foundation of any wildfire hazard or risk assessment is a current-condition fuelscape, updated for recent disturbances and calibrated to reflect the fire behavior potential observed 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 Colorado All-Lands (COAL) statewide assessment.

LF Remap was released in the spring of 2019 with significant improvements over previous versions of LANDFIRE, including the use of new satellite imagery and continuous vegetation cover and height classifications[1]. The COAL fuelscape was first produced for use in the 2020 fire season and wildfire hazard modeling using this fuelscape had begun. However, the unprecedented wildfire season of 2020 had a significant impact on the fuelscape used to represent the "current conditions." In light of this, Pyrologix generated a new fuelscape to incorporate the fuel changes from the 2020 wildfires and bring the fuelscape forward to a "2021 capable" timeframe.

LF Remap data represents ground conditions circa 2016, based on 2013-2017 Landsat 8 satellite imagery with priority given to 2016 imagery[2]. Although the most recent release from LANDFIRE is 2019L which includes 2017 through 2019 fuel disturbances, it was a "limited" release[3] and did not include the intermediate disturbance data needed to account for 2020 fuel disturbances. Therefore, in order to make the fuelscape as current as possible, we leveraged the full Remap 2016 released data. Starting from LF Remap, we aimed to calibrate the fuel mapping to observed fire behavior, maximize the use of the LF Remap data and features, update the fuelscape to reflect recent disturbances, and produce a landscape absent of seamlines resulting from LANDFIRE mapping 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 required vegetation inputs from vintage LANDFIRE products. We wished to leverage the new imagery wherever possible and devised a method to back-calculate pre-disturbance conditions using post-disturbance information and disturbance severity

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[1] Additional information can be found at http://www.landfire.gov/.
[2] https://www.landfire.gov/faqprint.php
[3] https://landfire.gov/documents/LF_2019L_Executive_Summary.pdf

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 increments) and height (1-meter increments) rather than pre-defined bins (e.g., 10-percent cover classes) to calculate canopy fuel layers. This allows for more precise values of canopy cover, canopy height, canopy bulk density, and canopy base height.

Using the customizations discussed above, Pyrologix applied the calibration workshop modifications to edit fuel mapping rules by vegetation type. Calibration to produce locally accurate fire behavior results was completed through a two-day fuel calibration workshop, held on February 4-5, 2020 in Lakewood, CO. At this workshop, we received feedback from a group of interagency fire and fuels personnel across the state.

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 2020; and fuel treatments from 2017 through 2020. The addition of recent disturbances and adjustment to time since disturbance for past disturbances render the fuelscape suitable for use in the 2021 fire season and beyond.

Notable customizations of the COAL fuelscape include the addition of burnable wheat fields in areas otherwise mapped as non-burnable agriculture, the mapping of short-season fuel types in high elevations, and incorporating limited wildfire spread into urban areas.

The following sections of this report detail the process used to develop this custom COAL fuelscape. A full wildfire hazard assessment report will accompany the final fire modeling results. This document contains further details regarding the fuelscape development and customization process used by Pyrologix and highlights differences and similarities to the fuelscape development approaches employed by LANDFIRE. The final fuelscape is available via ftp link[4].

[4] COAL Fuelscape:
http://www.pyrologix.com/ftp/R2/COAL/1_1_current_condition_fuelscape_2021_Capable.zip

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 (slope, aspect, elevation). These datasets can be combined into a single landscape file (LCP) and used as a fuelscape input in fire behavior modeling programs.

Through the combined efforts of the USFS Rocky Mountain Region (R2), multiple agency partners, and Pyrologix, an updated, calibrated fuelscape was produced as part of the Colorado All-Lands Risk Assessment (COAL). This fuelscape covers all lands in the state of Colorado (Figure 1) and can be used in the 2021 fire season and beyond to support fire operations in response to wildfire incidents. Pyrologix will also use the COAL fuelscape to complete wildfire hazard and risk assessment across all ownerships in addition to Forest Service lands in Colorado, the results of which can be used to aid in the planning, prioritization, and implementation of prevention and mitigation activities.

In the following sections (sections 2.1 - 2.3), we discuss the Pyrologix process of generating a fuelscape.

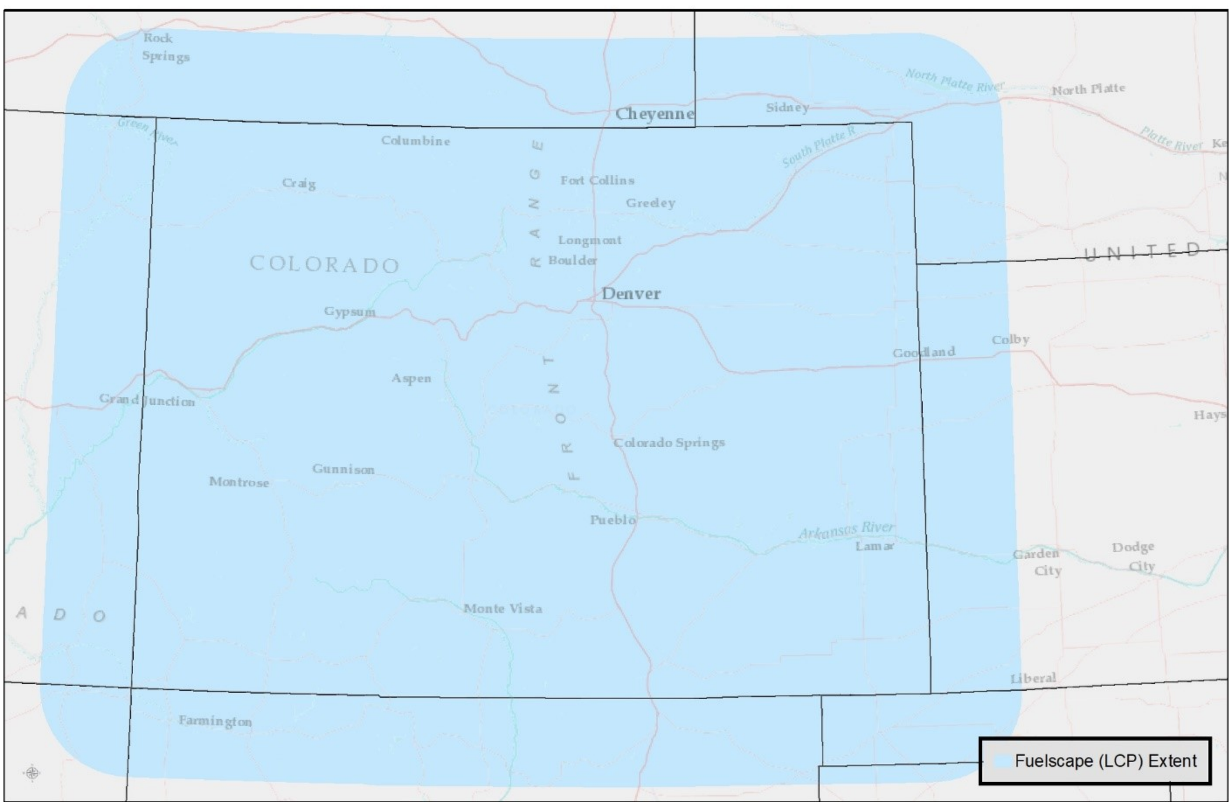

Figure 1. Overview of the fuelscape extent for COAL wildfire hazard assessment.

2.1 FUELSCAPE INPUTS OVERVIEW

The vegetation and disturbance inputs for COAL were derived from the LF Remap 30-m raster data. The LF Remap release had significant changes from previous versions of LANDFIRE, including the use of new imagery and continuous vegetation cover and height classifications[1]. 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) using the LANDFIRE Total Fuel Change Tool (LFTFCT, Smail et al. (2011)). LFTFCT 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 LFTFCT. Using these inputs, LFTFCT 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). Similarly, Pyrologix derived the COAL 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 from 2010 to 2016, 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 frame, 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 LFTFCT inputs. In the Pyrologix method, we wished to retain as much information from the new imagery – to the extent possible – and 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[5] to add back cover for disturbed tree and shrub FVTs. Maximum values of tree and shrub cover were calculated in the

[5] 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.

COAL project area for each FVT to ensure values did not exceed observed cover in the project area. Herbaceous cover was not adjusted, as the recovery time for herbaceous FVTs is relatively short. To determine the pre-disturbance height for FVTs that experienced a high severity disturbance, we calculated the overall maximum post-disturbance height as well as the mean non-disturbed height in the COAL project area. If the post-disturbance height was less than the mean non-disturbed height, the pre-disturbance height was set to the mean non-disturbance height. Otherwise, the pre-disturbance height was set to the overall maximum post-disturbance 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 in standardized bins. Therefore, 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[6] 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[1].

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.

For 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

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[6] 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.

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.

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^3 and the default value of 0.01 kg/m^3 for CG 2. We changed the default for CG 3 from 0.05 kg/m^3 to 0.02 kg/m^3 to further reduce the 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 the 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 insects and disease. Both the CBH coefficients and the input cover value were adjusted 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 fire behavior that was more active 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. 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 with more volatile fuel models where a CBH of two-thirds of 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. We also adjusted the default CBH for CG 2 to be 9.9 m rather than 10 m to make pixels with CG 2 easier to identify.

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 COAL FUELSCAPE CALIBRATION

Fuelscapes require calibration to ensure that the derived fuels datasets 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

In the LANDFIRE fuel mapping process, fuel model and canopy characteristics are assigned using two primary input layers: Existing Vegetation Type[7] (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 COAL, 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 conducted fuelscape calibration workshops with local fire and fuels personnel 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[8] 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 (FLI), 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.

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[7] 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.

[8] gNexus is a custom spatial implementation of the fire behavior calculator software, NEXUS 2.1 (available at http://pyrologix.com/downloads)

2.2.3 CALIBRATION WORKSHOP

Calibration efforts were focused on a prioritized list of EVTs. 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 experience surface fire under all observable windspeeds).

The COAL fuel calibration workshop was held on February 4-5, 2020 in Lakewood, CO. At the workshop, we solicited feedback from local fire and fuels staff from R2 as well as interagency partners across the state. The intent was to review the preliminary fire modeling results and refine the unified rulesets to produce fire behavior results consistent with the experience of workshop participants for the dominant EVTs that experience fire. The EVTs reviewed covered the majority of the burnable portion of the state. Completed rulesets for the calibrated EVTs are listed in the final 'Fuel Boxes' spreadsheet[9] and should be referenced to view final ruleset calibrations. Additionally, we discuss notable LFTFCT ruleset modifications below.

2.3 POST-WORKSHOP FUELSCAPE MODIFICATIONS

2.3.1 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 COAL fuelscape for use past the 2020 fire season we added disturbances occurring between 2017 and 2020, inclusively. 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 including the USFS Forest Service Activity Tracking System (FACTS), Department of Interior National Fire Plan Operations & Reporting System (NFPORS),

Pyrologix incorporated recent wildfire disturbances using three different 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 crosswalked MTBS and RAVG severity to the appropriate disturbance code (112, 122, or 132) corresponding with fire disturbances of low, moderate, or high severity, occurring in the previous one to five years. GeoMAC perimeters were assigned a severity disturbance code of 122.

[9] COAL Fuel Boxes: http://www.pyrologix.com/ftp/R2/COAL/COAL_Calibrated_FuelRuleBoxes.xlsx

It should be noted that a review of the wildfire disturbance data highlighted the need for an adjustment to a prescribed fire perimeter near Breckenridge, CO. The initial perimeter was an over-representation of the area burned.

2.3.2 DEVELOPED RUDERAL VEGETATION TYPES

In LF Remap, there are developed ruderal vegetation types adjacent to at-risk communities that have reduced fire behavior fuel rules. We found these EVTs to be over-mapped, especially in more remote towns, compared to earlier versions of LANDFIRE. This misrepresented the wildfire risk and required the development of a methodology for reducing the extent of these developed ruderal vegetation types.

Working with local fuels specialists, we identified at-risk communities (e.g. Estes Park, Evergreen, Woodland Park, Steamboat Springs) surrounded by developed ruderal vegetation types. We then identified pixels in the surrounding areas that would be appropriate to update by limiting the area to developed ruderal EVTs with a tree lifeform. A review of these ‘eligible’ pixels showed the majority of over-mapped developed ruderal pixels fell within EVT 2924 (Developed Ruderal Evergreen Forest). We then identified locations for adjustment with a number of qualifications. The qualifications included: 1) the EVT in the pixel must be 2924, 2) the EVC in the pixel must be a tree lifeform, 3) the LANDFIRE Biophysical Setting[10] (BPS) vegetation group in that pixel must correspond to a tree lifeform (e.g. “conifer”). All eligible pixels were flagged and EVT assignments were updated, replacing the existing vegetation type with the BPS vegetation type assignment.

2.4 CALIBRATED FUELSCAPE

After all workshop edits and recent disturbances were incorporated into the fuelscape inputs, Pyrologix produced a fuelscape for COAL using the calibration method and fuelscape development process discussed in section 2.1. This calibrated fuelscape was then further modified as described in section 2.5 for use in fire modeling.

2.5 CUSTOMIZATIONS FOR PYROLOGIX FIRE MODELING

Before using the fuelscape in the Pyrologix fire modeling and, ultimately, the Wildfire Hazard Assessment, Pyrologix made additional customizations, including a CBD adjustment for areas affected by insect and disease and custom fuel model assignments for high elevation-subalpine vegetation types, burnable agriculture, and burnable urban. These customizations are discussed in the following sections.

2.5.1 CANOPY BULK DENSITY ADJUSTMENT FOR INSECT & DISEASE

During the calibration workshop, participants highlighted the need to capture areas affected by insect and disease with increased fire behavior. The areas of concern were not captured in the

[10] Landfire Biophysical Setting - https://landfire.gov/bps.php

disturbance data and are difficult to represent spatially due to the dead needles remaining on the trees, creating a 'grey stage'. To capture these areas, insect and disease disturbance polygons were derived from the Forest Service, Detection Survey. A spatial review by local fire management planning specialists indicated the potential for an over-mapping of the affected area but also highlighted the areas of concern fall predominantly within the Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland EVT (2055).

To represent these 'grey stage' areas in the fuelscape (and avoid over-mapping) a post-processing CBD adjustment factor of 2.5 was applied to increase CBD rather than adjusting the current disturbance data. Using a post-processing approach we were able to limit the adjustment to EVT 2055 and only areas falling within the detection survey polygon with 10-40% canopy cover. This adjustment allows the fuelscape to capture the increased fire behavior associated with the 'grey stage' areas and limits the footprint of the area affected.

2.5.2 CUSTOM FUEL MODEL ASSIGNMENTS

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. By mapping such areas using custom fuel models with a fuel model number different than the standard model on which they were based, we were able to control the weather scenarios during which simulated fire spread could take place.

2.5.2.1 HIGH ELEVATION-SUBALPINE VEGETATION

In line with the purposes listed above, the COAL fuelscape required custom fuel models for high elevation, subalpine vegetation types to account for the shortened fire season associated with the cooler temperatures and later snowmelt. The COAL high-elevation vegetation types were originally mapped as burnable and given assignments using the standard Scott and Burgan 40 fuel models. To accurately capture the truncated fire season associated with these sites required custom fuels model to limit the conditions under which these areas could burn.

The high-elevation vegetation custom fuel models were identified during the calibration workshop using LANDFIRE EVTs designated as Subalpine: Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (2055) areas are represented with 175/TU5 fuel model; identical to 165/TU5, Rocky Mountain Subalpine-Montane Mesic Meadow (2145) are represented with 111/GR1 fuel model; identical to 101/GR1, and Southern Rocky Mountain Montane-Subalpine Grassland (2146) is represented with 111/GR1 & 112/GR2 fuel models; identical to 101/GR1 & 102/GR2.

2.5.2.2 BURNABLE AGRICULTURE & URBAN FUEL MODELS

Overlap of historical fire occurrence and wheat fields mapping in the COAL fuelscape warranted consideration of the burnability of agricultural fields – particularly wheat. These areas were originally mapped by LANDFIRE as non-burnable and therefore would 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. To allow some opportunity for wheat to burn, we mapped pixels in the Wheat EVT (2968) identified by LANDFIRE as AG2/242 with identical parameters to fuel model GR2.

The COAL fuelscape also used custom fuel models to represent the potential for wildfire spread into burnable urban areas. The burnable-urban custom fuel models were spatially identified using the LANDFIRE EVTs 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 fuel model for burnable urban and agriculture allows for the transmission of wildfire in simulation across these areas. To prevent overestimating the likelihood of wildfire in custom fuel models, FSim fuel moisture inputs were modified to allow for wildfire only under 97th percentile ERC conditions and above.

2.5.3 FINAL COAL FUELSCAPE

Using the methods described above we generated the final version of the COAL fuelscape for use in our wildfire hazard modeling. The fuel raster is displayed using fuel model groups in Figure 2. CC, CH, CBD, and CBH are shown in Figure 3 through Figure 6.

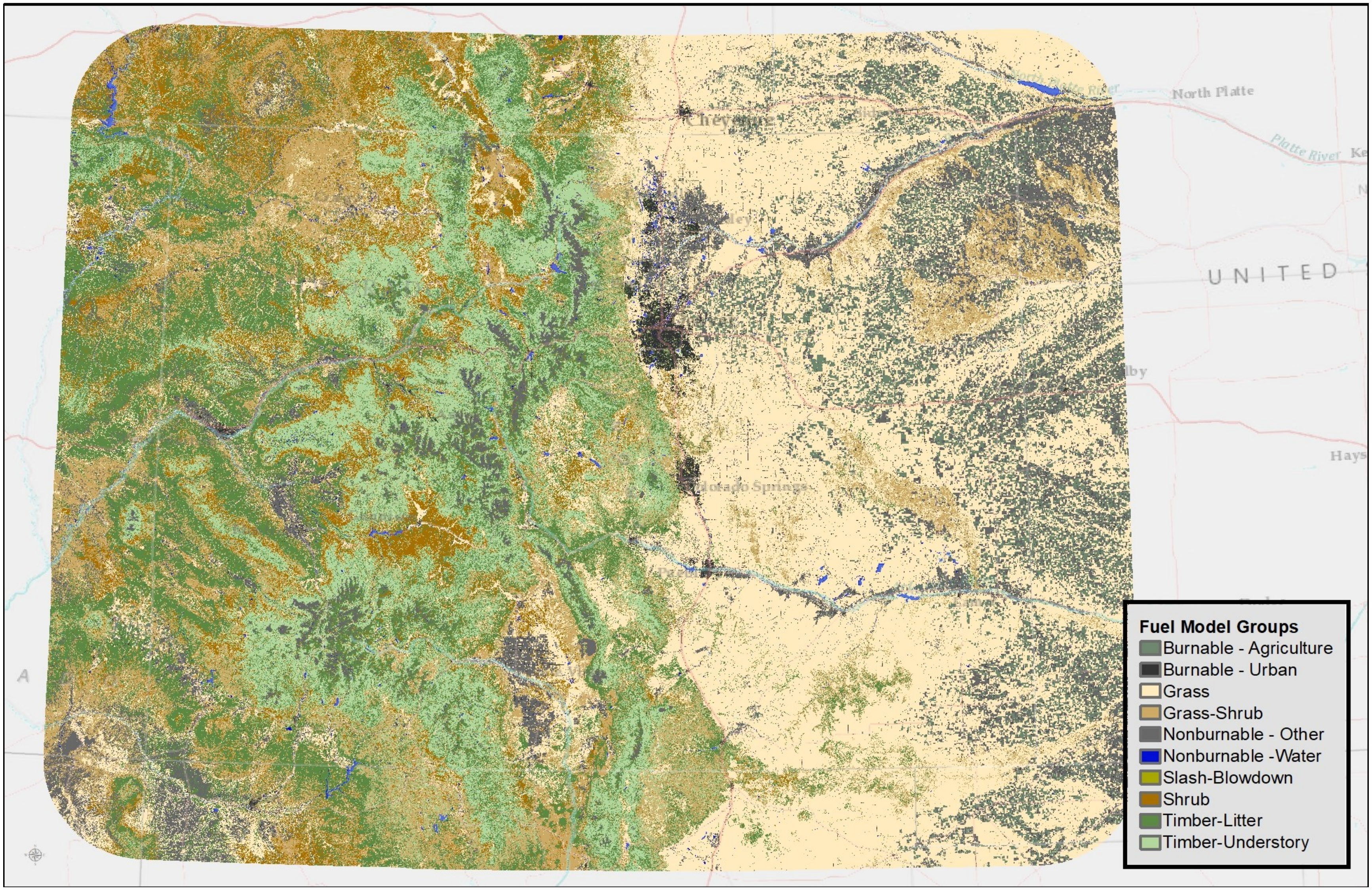

Figure 2. Map of fuel model groups across the COAL LCP extent.

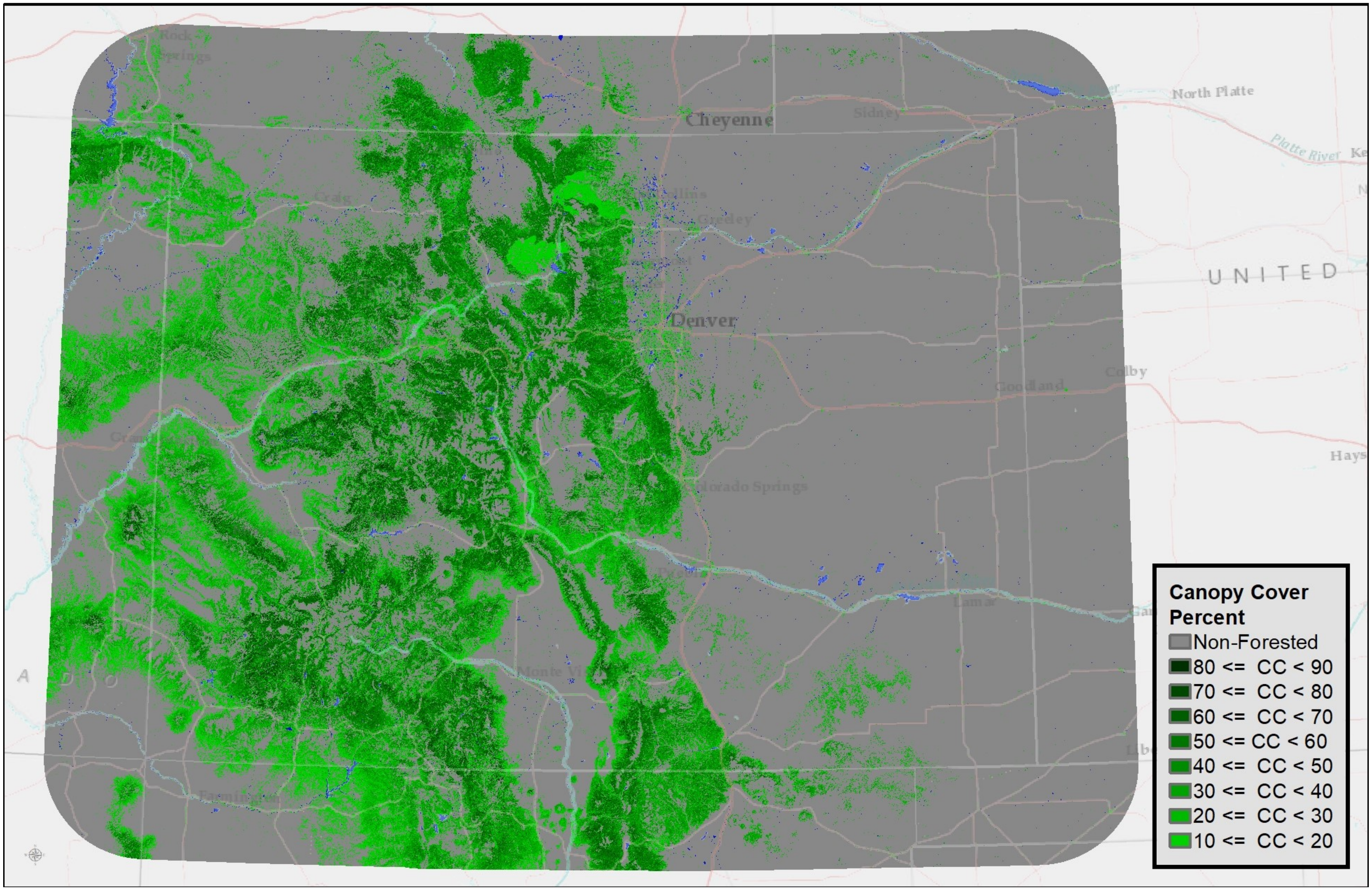

Figure 3. Map of canopy cover (CC) across the COAL LCP extent. CC is continuous but is displayed in the standard LANDFIRE 10-percent classes for ease of viewing.

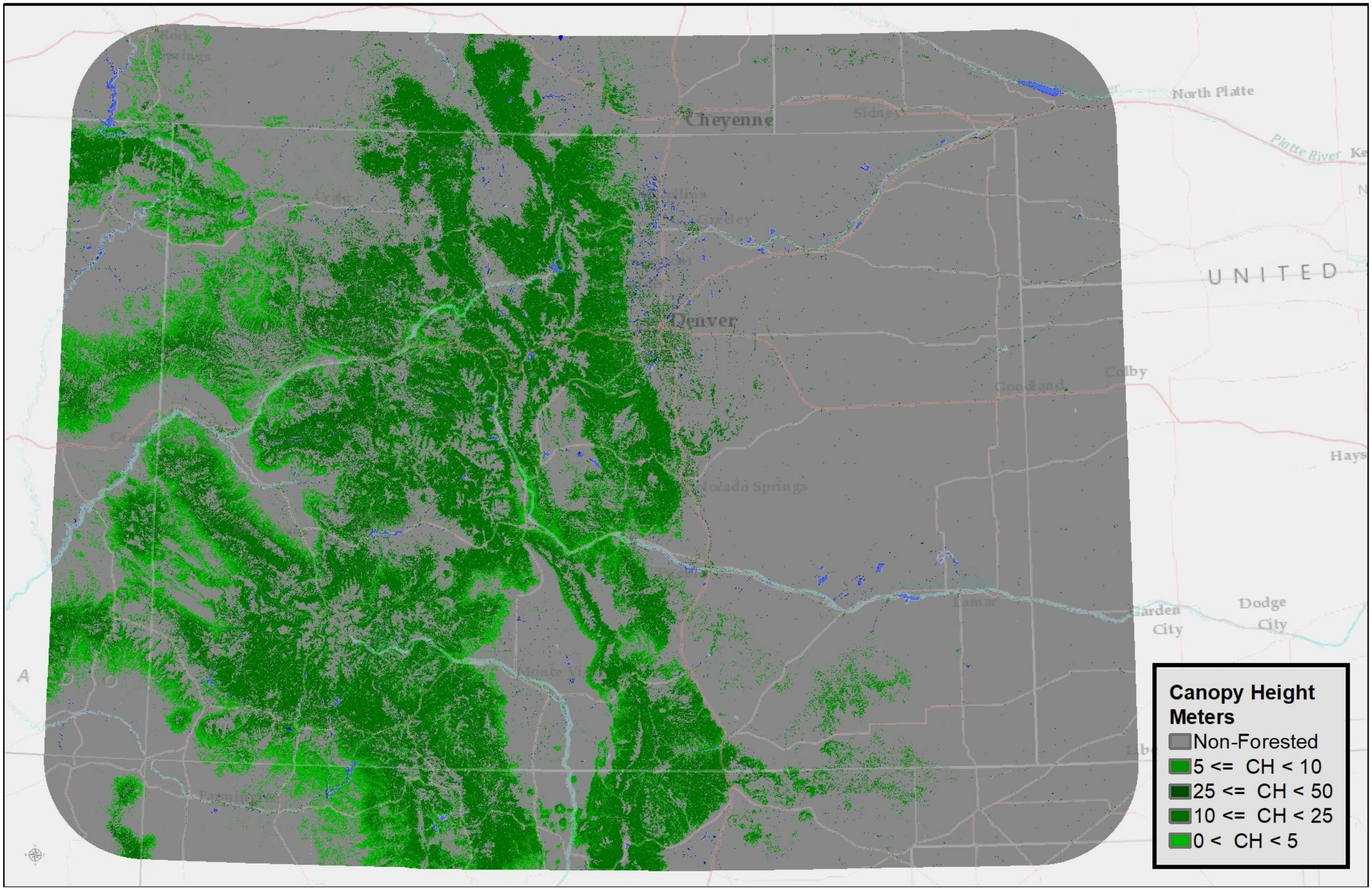

Figure 4. Map of canopy height (CH) across the COAL LCP extent. CH is continuous but is displayed in the standard LANDFIRE height classes for ease of viewing.

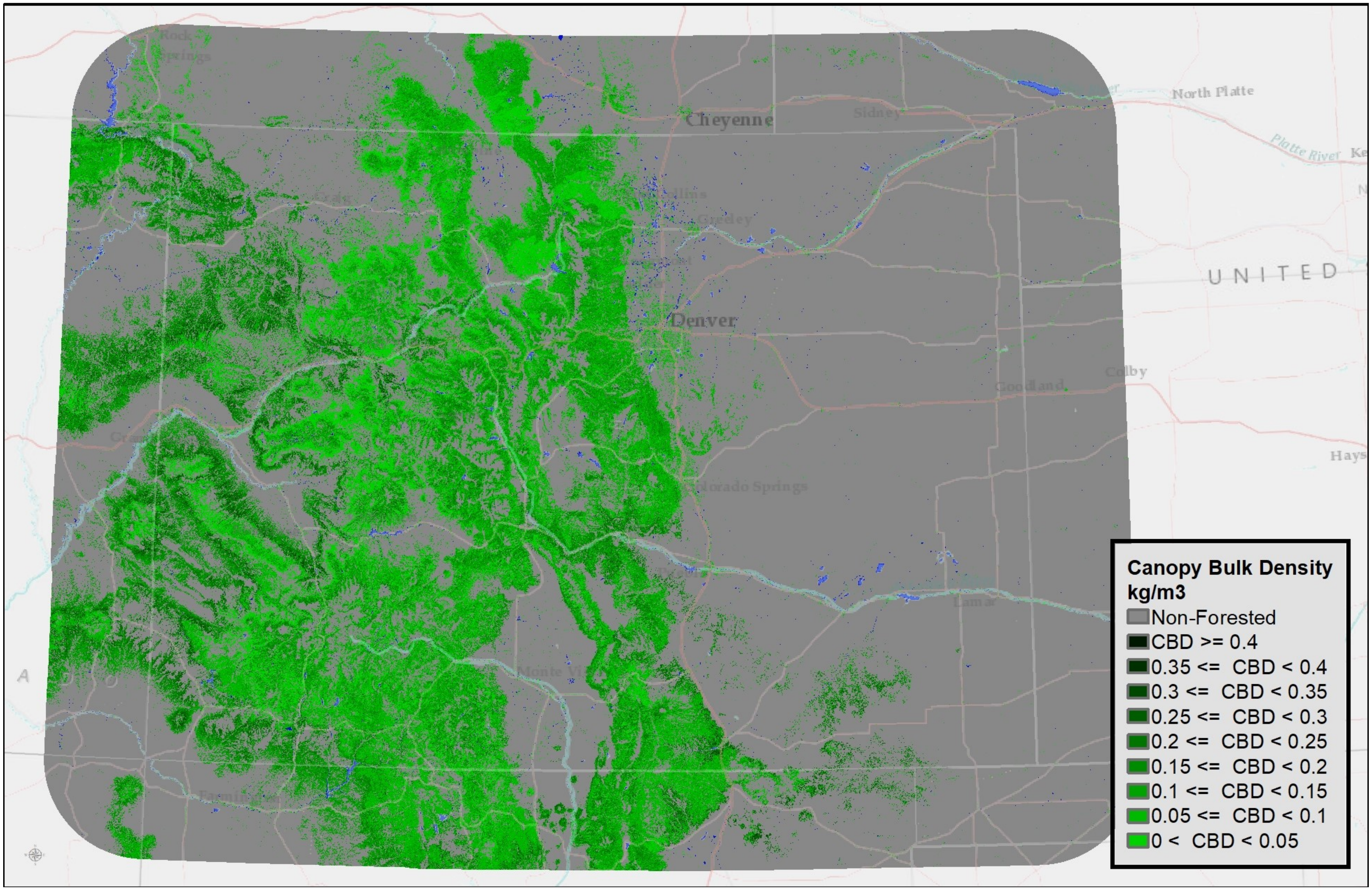

Figure 5. Map of canopy bulk density (CBD) across the COAL LCP extent.

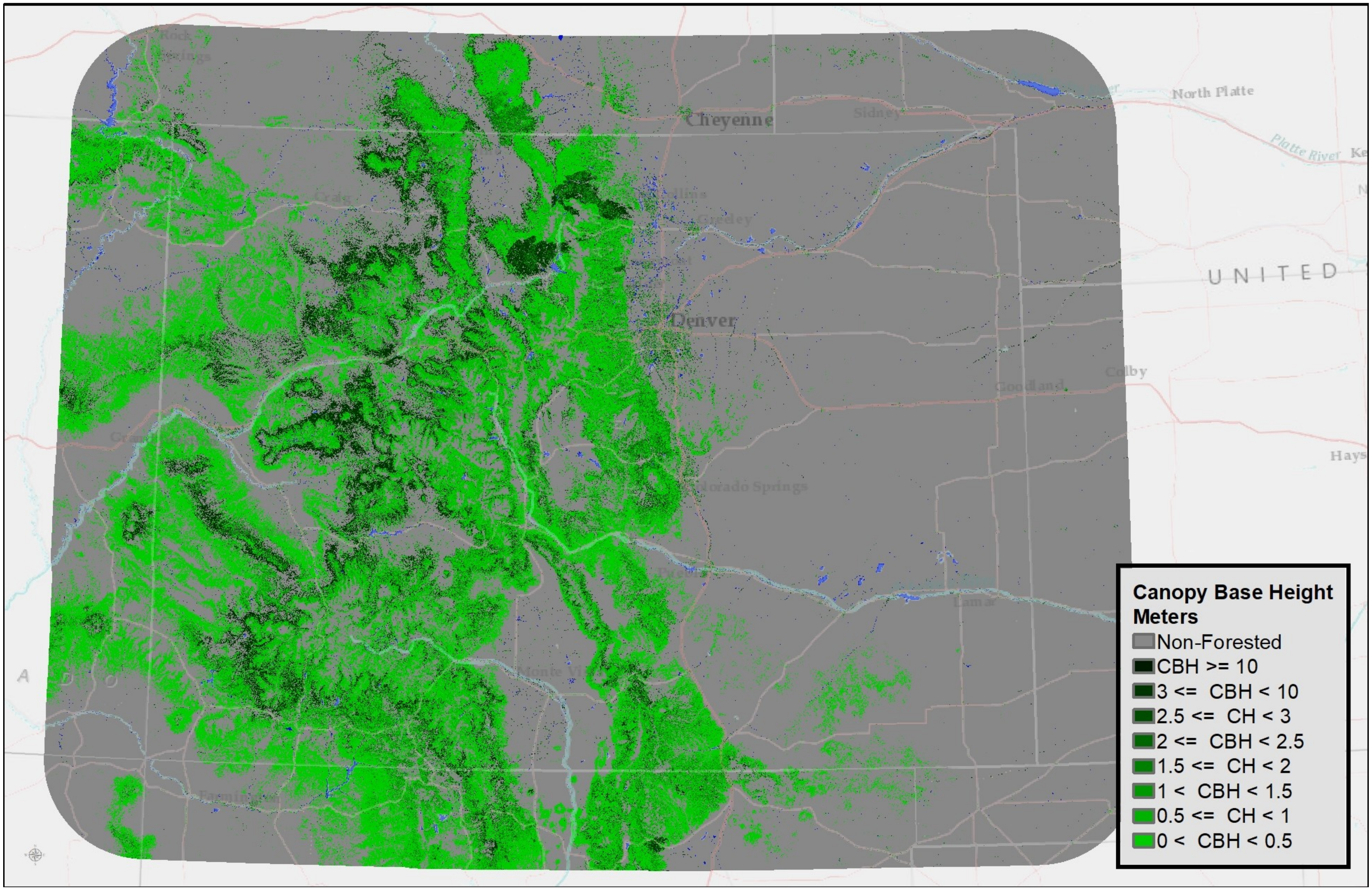

Figure 6. Map of canopy base height (CBH) across the COAL LCP extent.

2.5.4 TREATED FUELSCAPE

The COAL treated fuelscape is a hypothetically ‘treated’ fuelscape, representing the theoretical condition where all treatable areas of the landscape have been subjected to some form of treatment. Hypothetical treatment assignments were limited to LANDFIRE’s ‘Fire’ or ‘Mechanical Remove’ fuel disturbance (FDIST) types.

A comprehensive review of the current condition fuelscape was conducted to determine appropriate hypothetical treatments. Treatable areas were restricted to EVTs with tree or shrub cover types. Areas without a current-condition FDIST were designated as ‘treatable’, while areas with a current-condition FDIST were only treatable when the FDIST was deemed “not recently significant”. For instance, due to the already high reduction in aboveground biomass and associated fuel model, areas with recent, high severity fires or clear cuts in the current-condition FDIST would be designated as non-treatable and no action was taken. Attempting to ‘re-treat’ such sites would have little-to-no effect and misrepresent the potential for hazard reduction.

Treatment scenarios were applied to the fuelscape through LFTFCT by updating or adjusting the current-condition FDIST and re-processing the fuelscape. The resulting treated fuelscape reflects hypothetical disturbances as treatments. These treated areas will result in a reduction in canopy cover and a change in the fire behavior fuel model assignment (Figure 7).

It is important to highlight that the treated fuelscape is designed to be used at the scale of the whole project area, identifying areas of the landscape where fuel treatments are likely to have the greatest benefit. Once these areas have been identified, additional analysis may be required to refine the treatment type and severity to appropriately reflect local constraints on operability and other practical considerations on treatment implementations.

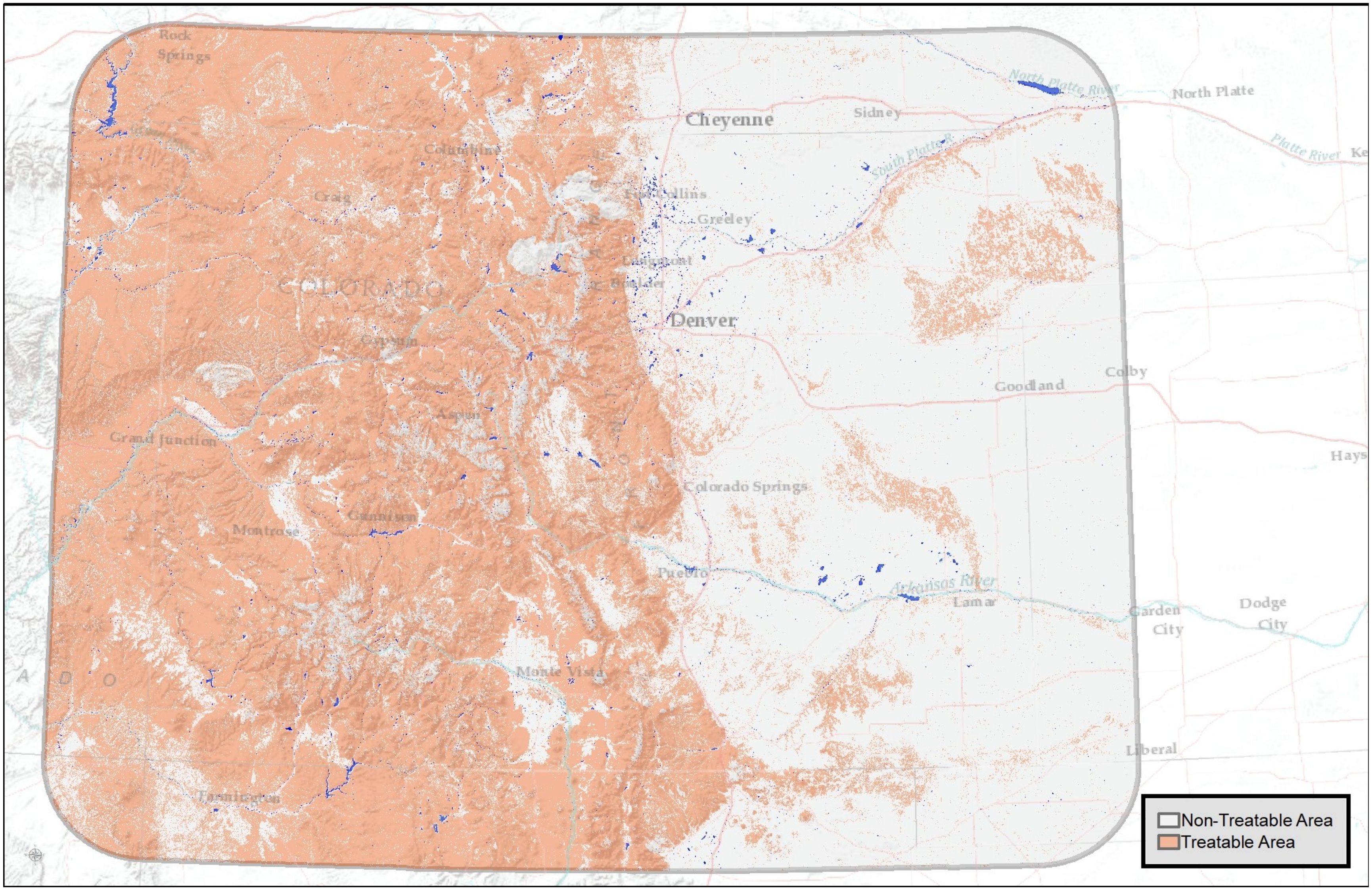

Figure 7. Map of treatable area across the COAL LCP extent.

3 CONCLUSION

The process described in this document outlines 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 we hope that 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 COAL fuelscape, for use in the 2021 fire season and beyond, is available with the final project deliverables.

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

Finally, the COAL fuelscape is current for the 2021 fire season and beyond. 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) for further questions on the customizations used in producing this fuelscape.

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THANK YOU

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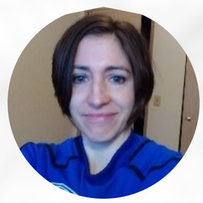

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The COAL all-lands wildfire risk assessment was conducted by Pyrologix, a wildfire hazard and risk assessment research firm based in Missoula, Montana.

For More Information Please Visit:

www.pyrologix.com

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