A FUELSCAPE FOR ALL-LANDS IN UTAH

PREPARED FOR:
Utah Department of Natural Resources
Division of Forestry, Fire and State Lands

PREPARED BY:
Jim Napoli, Julie W. Gilbertson-Day, Joe H. Scott

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PYROLOGIX | UTAH DNR TIMMONS GROUP

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1 EXECUTIVE SUMMARY

The effort to produce a wildfire hazard assessment across all land ownerships in Utah began in October 2021 when the Timmons Group and Utah Department of Natural Resources 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 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 Utah fuelscape was produced for use in the 2021 fire season and wildfire hazard modeling.

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, 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 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

[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

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 virtual fuel calibration workshop, held on January 19-20, 2022. 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 2021; and fuel treatments from 2017 through 2021. 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.

The following sections of this report detail the process used to develop this custom fuelscape for Utah. A wildfire hazard assessment report describing the methods and results of the fire modeling is also available[4]. 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.

[4] Hazard report: http://pyrologix.com/reports/Utah_WildfireHazardReport.pdf

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. LANDFIRE 2.0.0 (LF Remap) was the source for the fuel and vegetation data for the Utah fuelscape. To take advantage of recent corrections in calculating aspect from true north,[5] slope, aspect, and elevation rasters were extracted from the LANDFIRE 2.2.0 (LF2020) data release.

Through the combined efforts of the Utah Department of Natural Resources, federal agency partners, and Pyrologix, an updated and calibrated fuelscape was produced as part of the Utah Wildfire Hazard Assessment. This fuelscape covers all lands in the state of Utah (Figure 1) and can be used in the 2022 fire season and beyond to support fire operations in response to wildfire incidents. Pyrologix will also use the Utah fuelscape to complete wildfire hazard assessment across the State; the results of which can be used to aid in the planning, prioritization, and implementation of prevention and mitigation activities.

Figure 1. Overview of the fuelscape extent for the Utah Wildfire Hazard Assessment.

[5] https://landfire.gov/lf_220.php

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

2.1 FUELSCAPE INPUTS OVERVIEW

The vegetation and disturbance inputs for Utah 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 Utah 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 as 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[6] to add back cover for disturbed tree and shrub FVTs. Maximum values of tree and shrub cover were calculated in the Utah 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 Utah 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[7] 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

[6] 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.

[7] 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.

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 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 UTAH 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[8] (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 Utah, 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.

[8] 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.

2.2.2 FIRE BEHAVIOR SUMMARY

Prior to the fuel calibration workshops, we produced an initial set of fire behavior results with gNexus[9] 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.

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 Utah preliminary fuelscape was built using fuel rules recently calibrated in a Sagebrush Vegetation modeling effort. Because many of the prevalent vegetation types were reviewed in that mapping effort, we focused our calibration on tree-lifeform vegetation types.

The Utah virtual fuel calibration workshop was held on January 19-20, 2022. At the workshop, we solicited feedback from local fire and fuels staff from Utah DNR 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. 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[10] 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 Utah fuelscape, we added disturbances occurring between 2017 and 2021, 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

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

[10] Utah Fuel Boxes: http://www.pyrologix.com/ftp/Timmons/UWRAP/UWRAP_Calibrated_FuelRuleBoxes.xlsx

(FACTS), and the 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 National Interagency Fire Center (NIFC) perimeter data. We gathered severity data as available from MTBS, then RAVG, and where severity data was unavailable, we relied on final perimeters from NIFC. 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. NIFC perimeters were assigned a severity disturbance code of 122.

2.3.2 DEVELOPED RUDERAL AND RECENTLY DISTURBED VEGETATION TYPES

In LF Remap, two vegetation mapping issues were highlighted in previous fuelscape calibration efforts: Developed Ruderal and Recently Disturbed vegetation types.

Developed Ruderal vegetation types are found adjacent to at-risk communities and due to the mapping process used in LF Remap, these areas 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 hazard possible in these areas and necessitated a methodology for reducing the extent of these developed ruderal vegetation types.

Working with the LANDFIRE Technical Lead, we developed a process to revert these ruderal EVTs to their "Modeled EVT" value and correct the fire behavior results in these fuels. To avoid an over-correction of the developed ruderal areas, we used an additional classification of building cover (Scott et al. 2020) to avoid reverting truly 'developed' areas. For areas with greater than five percent building cover, we kept the original developed EVT assigned by LF Remap.

Similarly, the Modeled EVT was used as an override to the Recently Disturbed vegetation types. These are areas where disturbances made vegetation classification difficult and the pixels were classified into a 'Recently Disturbed' vegetation class by lifeform.

2.4 CALIBRATED FUELSCAPE

After all workshop edits and recent disturbances were incorporated into the fuelscape inputs, Pyrologix produced a fuelscape for Utah 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 custom fuel model assignments for high elevation-subalpine vegetation types, identification of irrigated agricultural lands, and burnable urban fuel models. These customizations are discussed in the following sections.

2.5.1 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.

2.5.1.1 HIGH ELEVATION-SUBALPINE VEGETATION

In line with the purposes listed above, the Utah 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 Utah 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.

2.5.1.2 BURNABLE URBAN FUEL MODELS

The Utah 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.

2.5.1.3 GREENNESS MASK

In the standard fuel mapping process, some vegetation can be mapped with a burnable fuel model even when the fuel is perpetually green (i.e. not available to burn). Examples of this include city parks, watered golf courses, and irrigated agricultural fields. These areas are often mapped with the slowest-spreading, grass fuel model (101/GR1), but this is often still an overprediction of the fire behavior potential in these areas.

To identify these areas in the Utah fuelscape, we applied Landsat satellite-based annual composites of median and maximum growing season NDVI, NBR, and tasseled cap indices, developed in Moran et al. (2020), along with training polygon data developed from areas of known golf courses, parks, and wildland vegetation to develop a Random Forest machine learning model. Composites and predictions were for 2016 to correspond with the satellite imagery utilized for Landfire data development. The model gave binary class predictions for whether the selected pixels match the spectral signals of landscaped and irrigated areas (e.g. golf courses) and therefore act as barriers to fire spread rather than propagate fire as a wildland fuel. The updates were constrained to grass and grass-shrub fuel models in urban EVTs. In the Utah fuelscape, we converted pixels from a burnable fuel model to a nonburnable fuel model (91/NB1) in the following "urban" EVTs: 2916, 2917, 2926, 2927, 2946, 2947.

In a similar vein, we made updates to agricultural areas that we identified as irrigated using the IrrMapper dataset for the western US (Ketchum et al. 2020). To reduce the effects of annual variability in the satellite data, we updated pixels in agricultural areas that were identified as irrigated for at least three out of the five years from 2014-2018.

In agricultural areas (EVTs 2966 and 2967), we kept a burnable fuel model but used a custom version of 101/GR1 (241/AG1) to limit the portion of the season those pixels would be available for burning. We reasoned that during the growing season, the agricultural fields would be irrigated, and therefore, unavailable for igniting and spreading wildfires.

2.5.2 FINAL UTAH FUELSCAPE

Using the methods described above we generated the final version of the Utah 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.

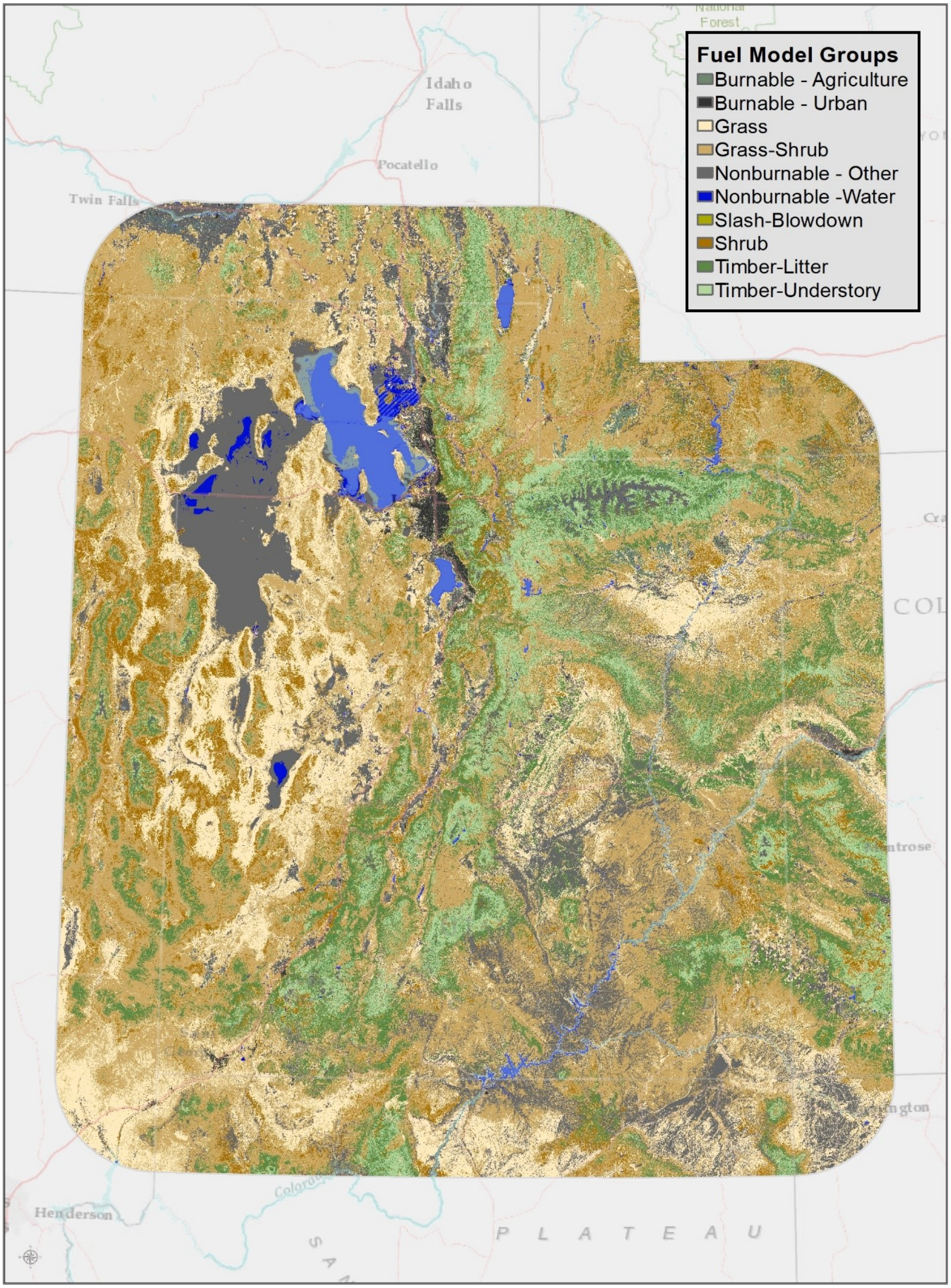


Figure 2. Map of fuel model groups across the Utah LCP extent.

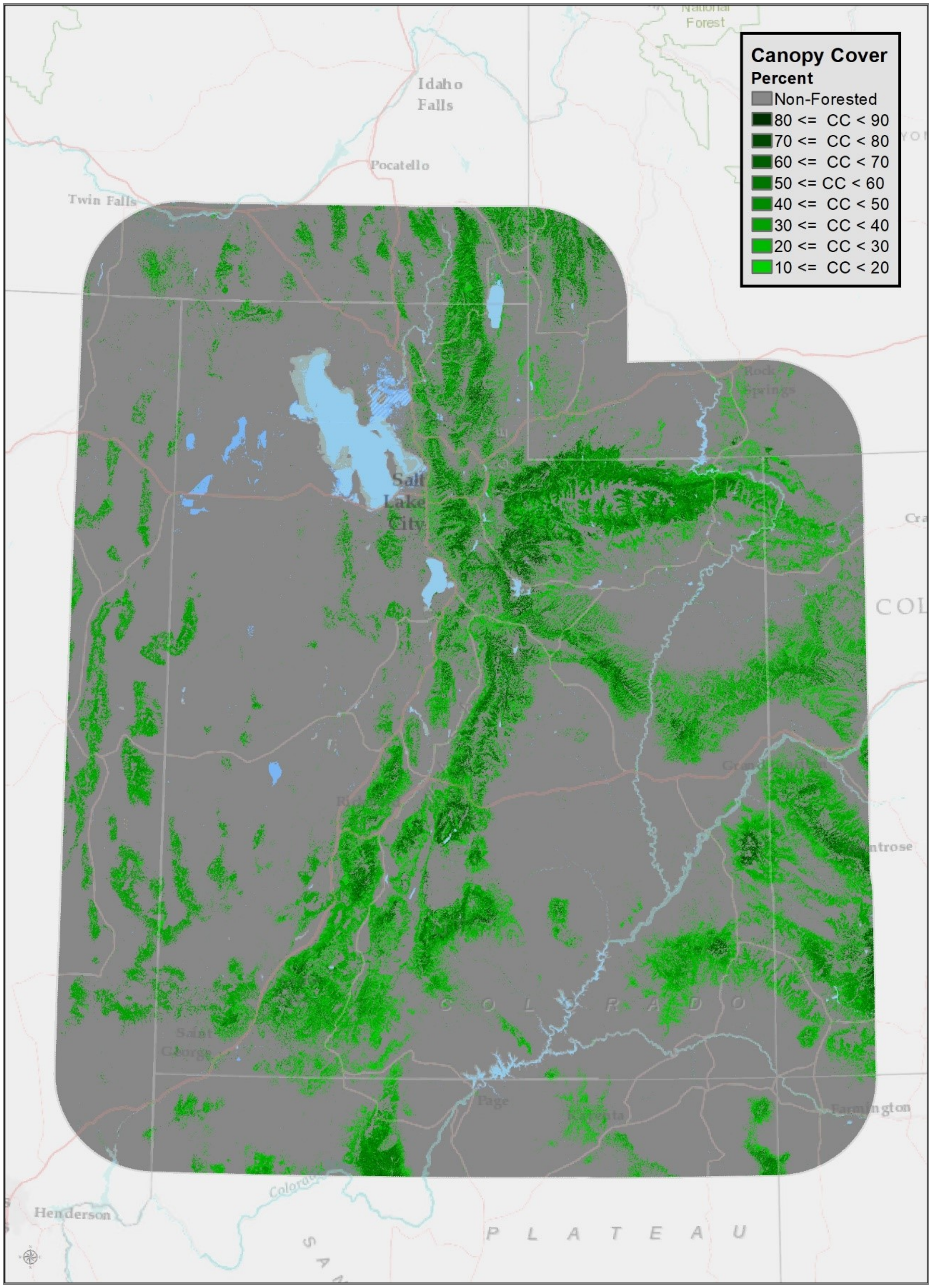


Figure 3. Map of canopy cover (CC) across the Utah LCP extent. CC is continuous but is displayed in the standard LANDFIRE 10-percent classes for ease of viewing.

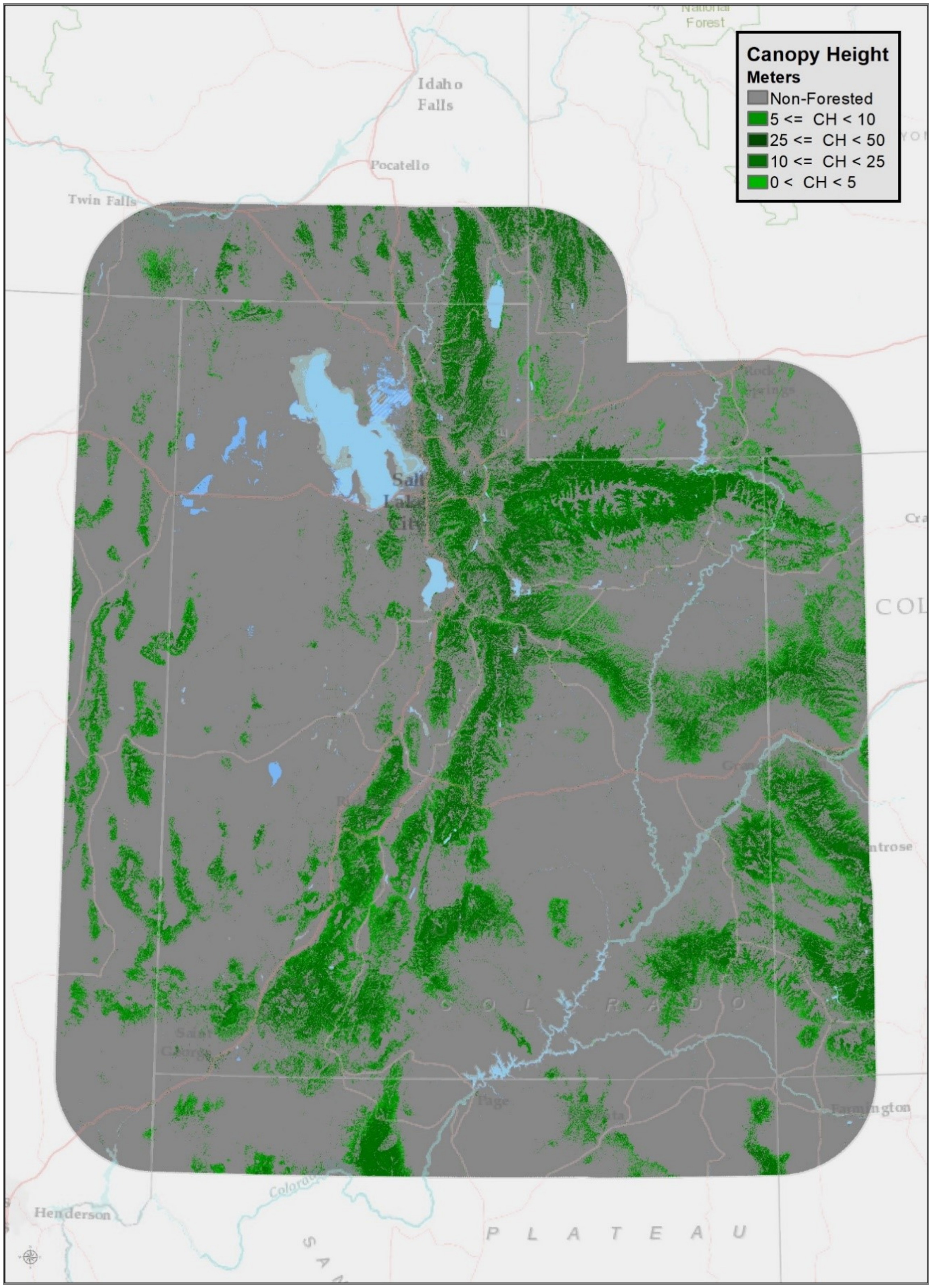


Figure 4. Map of canopy height (CH) across the Utah LCP extent. CH is continuous but is displayed in the standard LANDFIRE height classes for ease of viewing.

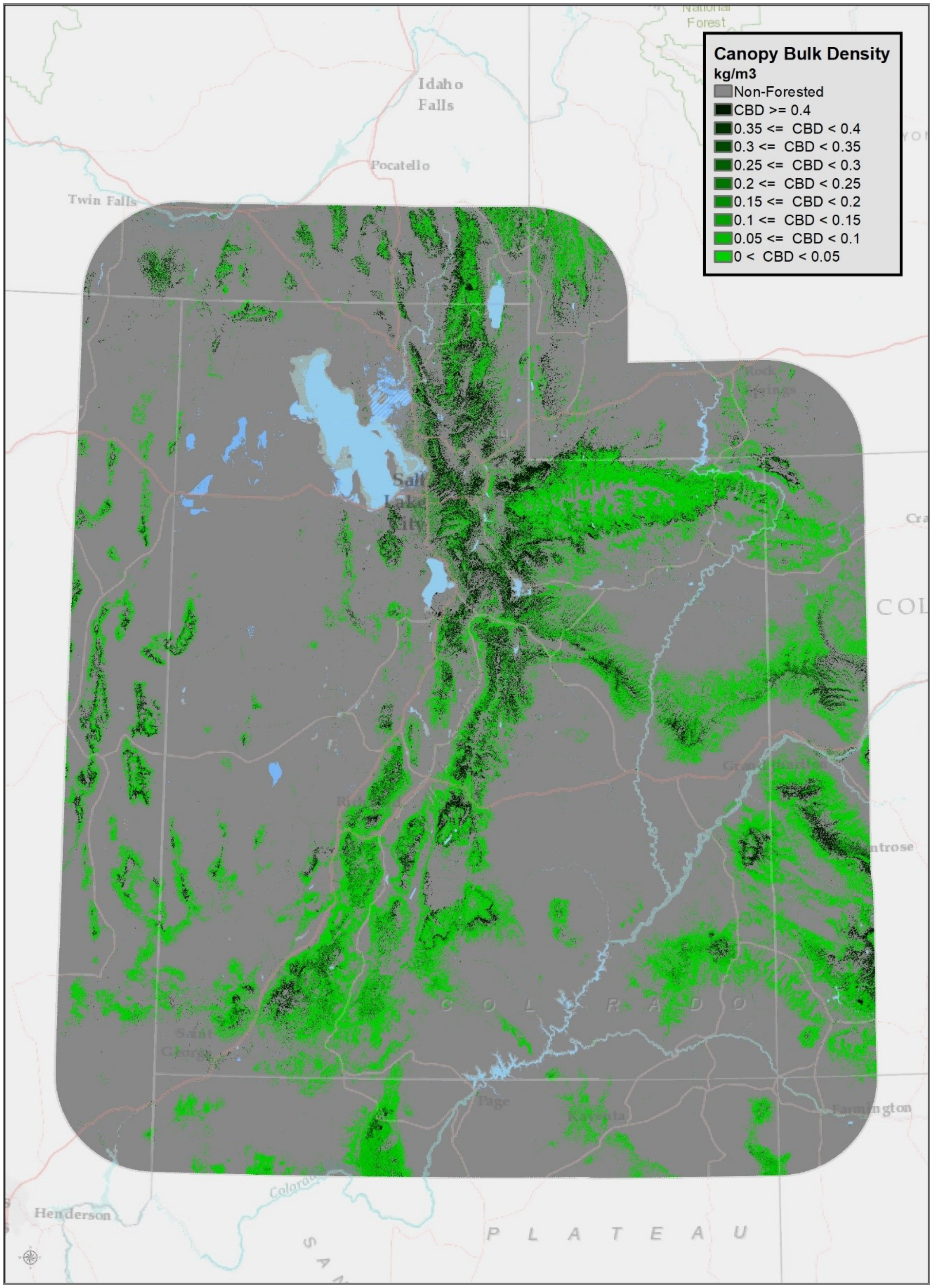


Figure 5. Map of canopy bulk density (CBD) across the Utah LCP extent.

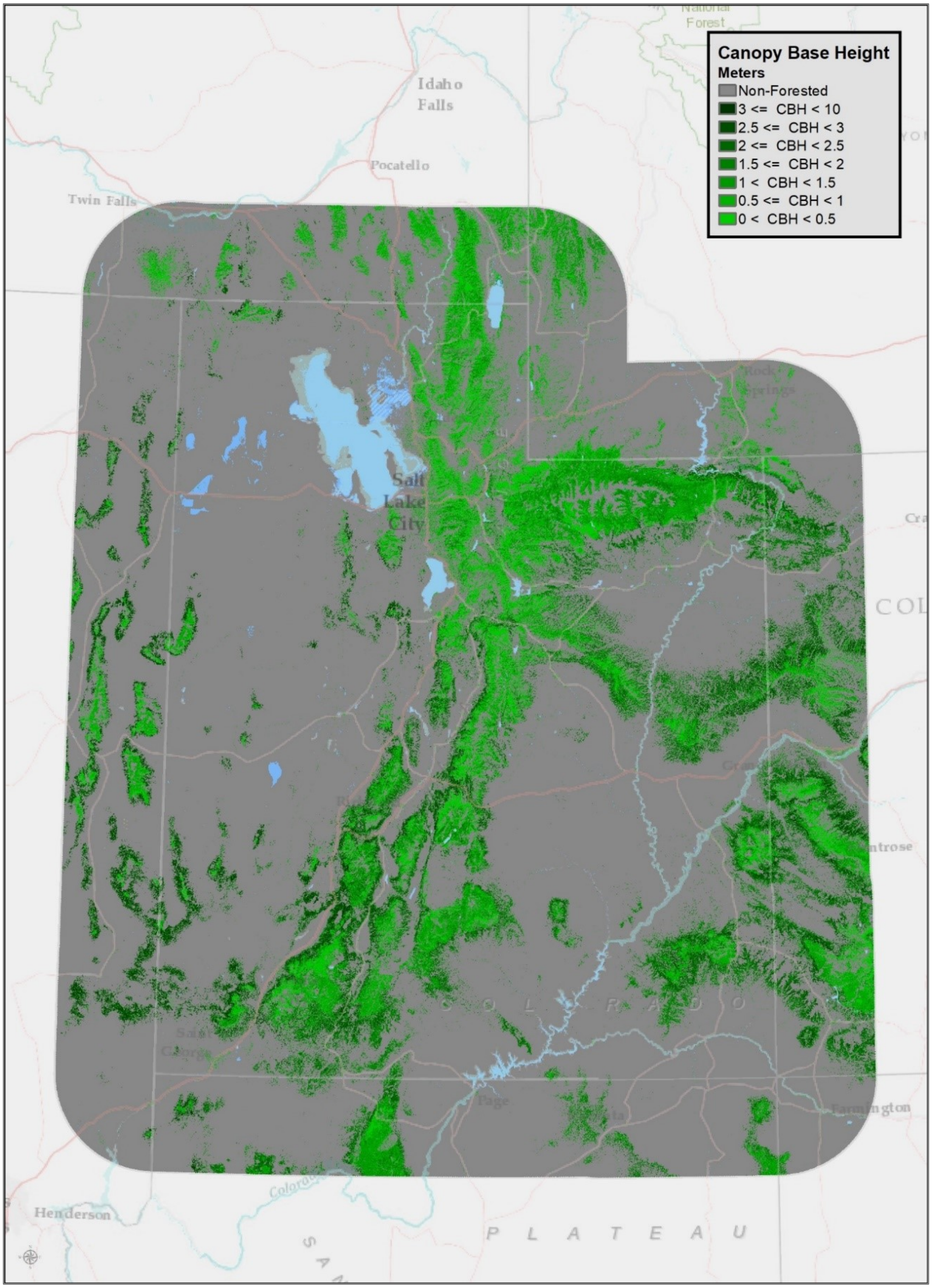


Figure 6. Map of canopy base height (CBH) across the Utah LCP extent.

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 Utah fuelscape, for use in the 2022 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 Utah 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 Utah fuelscape is current for the 2022 fire season and beyond. With frequent wildfires 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.

4 REFERENCES

Helmbrecht, D., Blankenship, K., 2016. Modifying Landfire Geospatial Data for Local Applications. In, Online Report, p. 75. Available at https://www.conservationgateway.org/ConservationPractices/FireLandscapes/LANDFIRE/Documents/ModifyingLF_DataGuide_V1.pdf.

Ketchum, D, K Jencso, MP Maneta, F Melton, MO Jones, and J Huntington. 2020. IrrMapper: A machine learning approach for high-resolution mapping of irrigated agriculture across the western U.S. Remote Sensing 12(14): 2328.

Moran, CJ, VR Kane, and CA Seielstad. 2020. Mapping forest canopy fuels in the western United States with LiDAR-Landsat covariance. Remote Sensing 12(6): 1000.

Reeves, M., Ryan, K., Rollins, M., Thompson, T., 2009. Spatial fuel products of the LANDFIRE Project. International Journal of Wildland Fire 18, 250-267.

Scott, Joe H.; Brough, April M.; Gilbertson-Day, Julie W.; Dillon, Gregory K.; Moran, Christopher. 2020b. Wildfire Risk to Communities: Spatial datasets of wildfire risk for populated areas in the United States. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2020-0060

Smail, T., Martin, C., Napoli, J., 2011. The LANDFIRE Total Fuel Change Tool User's Guide. In. Online Report. Available at https://www.landfire.gov/documents/LFTFC_Users_Guide.pdf.

USDA National Agricultural Statistics Service Cropland Data Layer. 2018. Published crop-specific data layer [Online]. Available at https://www.nass.usda.gov/Research_and_Science/Cropland/Release/index.php (accessed April 25, 2019). USDA-NASS, Washington, DC.

5 CHANGE LOG

The change log documents changes made to this document after the initial submission.

Date	Location of Change	Author	Description of Change
10/21/2022	-	-	Initial submission
10/24/2022	Page 2	JN	Changed date of included disturbances from 2020 to 2021
10/24/2022	Page 9	JN	Corrected logic regarding building cover layer usage.

THANK YOU

Assessment and Report Contributors:

Joe H. Scott
Principal Wildfire Analyst

Julie Gilbertson-Day
Program Manager

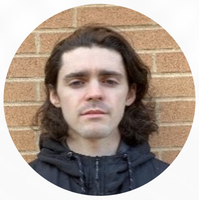
Kevin Vogler
Fire Modeling Lead

Jim Napoli
Spatial Wildfire Analyst

Chris Moran, PhD
Chief Fire Scientist

Michael Callahan
Software Engineer

Julia Olszewski
Spatial Wildfire Analyst



Jack Campanella
Software Engineer

Melissa Jaffe
Spatial Wildfire Analyst

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

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www.pyrologix.com

www.wildfirehazard.com