A FUELSCAPE FOR ALL LAND OWNERSHIPS IN THE EASTERN REGION

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Eastern Region, USDA Forest Service

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1 EXECUTIVE SUMMARY

The Eastern Region of the USDA Forest Service contracted with Pyrologix to complete an assessment of wildfire hazard across all land ownerships in the northeastern states. 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 region-wide 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]. Though LF Remap was available for some parts of the country at the outset of the Eastern Region Wildfire Risk Assessment (ERRA) project, the geographic areas needed to cover the entire Eastern Region were not fully available until July of 2020. For this reason, fuel calibration was initially undertaken on the 2014 LANDFIRE data products. Later, when LF Remap became available, the fuel calibration was applied to the LF Remap products to provide a fuelscape based on the best-available LANDFIRE data.

LF Remap data represents ground conditions circa 2016, based on 2013-2017 Landsat 8 satellite imagery with priority given to 2016 imagery[2]. Starting from LF Remap, we aimed to calibrate the fuel mapping to observed fire behavior, maximize 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

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

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 three, two-day workshops held in 2019 on March 14-15, March 18-19, and March 21-22. These workshops were held respectively in Albany NY; Martinsville, IN; and Milwaukee, WI.

At these workshops, we received feedback from a group of interagency fire and fuels personnel across the 20 eastern states. The list of contributing agencies and entities included the U.S. Forest Service; U.S. Fish and Wildlife Service; The Nature Conservancy; National Park Service; Bureau of Indian Affairs; numerous state natural resource, conservation, and forestry departments; state natural heritage programs; and private fire and fuels managers.

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 2019. Additional fuel disturbance data was provided by the Northeast Region LANDFIRE coordinator and staff who gathered additional fuel disturbance data across the region. Datasets were collected from a variety of sources which included FACTS, the National Insect and Disease Survey (IDS), and state departments of natural resources. 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 and beyond.

Notable customizations of the ERRA fuelscape include the addition of burnable cornfields in areas otherwise mapped as non-burnable agriculture. This adjustment was identified by workshop participants as a needed calibration edit to reflect the potential for wildfire in parts of the growing season. Fire modeling parameters in these pixels were adjusted to limit fire-spread to 97th percentile weather and above and to reflect the portion of the fire season the fuel is available to burn. Additionally, to prevent artificial reductions in burn probability and fire spread near the Canadian border, we crosswalked vegetation data to extend the fuelscape and fire modeling 40 km into Canada.

The following sections of this report detail the process used to develop this custom Eastern Region 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[3].

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[3] ERRA Fuelscape: http://www.pyrologix.com/ftp/R9/ERRA/ProjectDeliverables/ERRA-AL/Task_4_M1_Updated_fuelscape/4_1_Fuelscape_Results.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 Eastern Region (R9), multiple agency partners, and Pyrologix, an updated, calibrated fuelscape was produced as part of the Eastern Regional Risk Assessment (ERRA). This fuelscape covers all lands in the Eastern Region (Figure 1) and can be used in the 2020 fire season and beyond to support fire operations in response to wildfire incidents. Pyrologix will also use the ERRA fuelscape to complete wildfire hazard and risk assessment across all ownerships in addition to Forest Service lands in the Region, 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 Canada are discussed below in section 2.5.2.

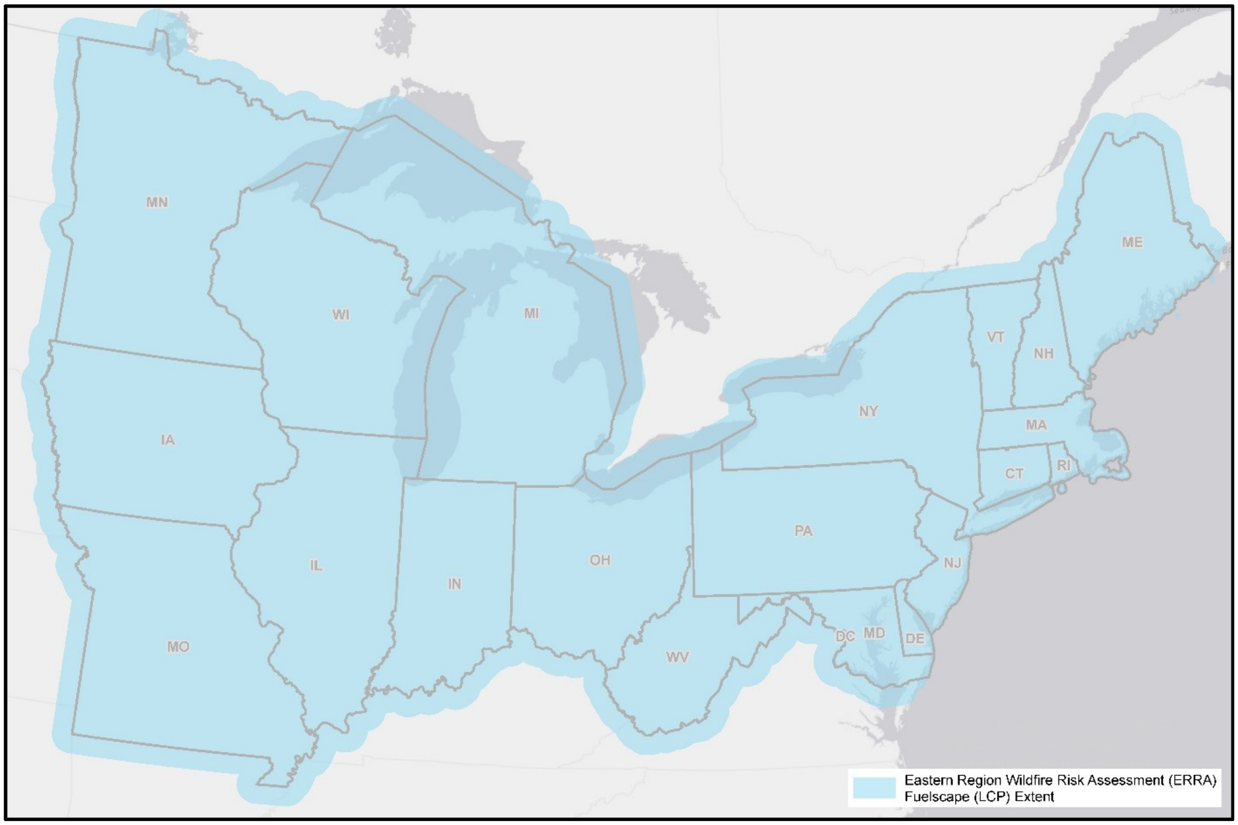

Figure 1. Overview of the fuelscape extent for ERRA wildfire hazard assessment.

2.1 FUELSCAPE INPUTS OVERVIEW

The vegetation and disturbance inputs for the United States portion of ERRA 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 ERRA 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, 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, 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 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[4] to add back cover for disturbed tree and shrub FVTs. Maximum values of tree and shrub cover were calculated in the

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[4] 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.

ERRA project area for each FVT to ensure values did not exceed observed covers in the project area. Herbaceous covers were 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 ERRA 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[5] 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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[5] 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 ERRA 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[6] (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 ERRA, 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[7] 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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[6] 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.

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

2.2.3 WORKSHOPS

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).

Three ERRA fuel calibration workshops were held. The first workshop was held March 14-15, 2019 in Albany, NY, the second was held March 18-19, 2019 in Martinsville, IN, and the third was held March 21-22 in Milwaukee, WI. At the workshops, we solicited feedback from local fire and fuels staff from R9 as well as interagency partners across the region. 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 Eastern Region.

As part of the workshop effort, the Northeast Region LANDFIRE Coordinator documented suggested rule edits and associated discussions in a summary report (Sebasky 2019). Note that further review and necessary modifications were made after this written report. Completed rulesets for the calibrated EVTs are listed in the final 'Fuel Boxes' spreadsheet[8] and should be referenced to view final ruleset calibrations. Additionally, we discuss notable LFTFCT wildcard ruleset modifications below.

2.2.4 WILDCARD MASKS

When calibrating rulesets, LFTFCT offers two methods for allowing spatial variation within a ruleset. The first method involves the BpS raster, where a user can identify a biophysical setting whose pixels should receive a different fuel model assignment than the general ruleset for an EVT. Biophysical settings differentiate areas of similar pre-European settlement site characteristics and often reflect differences in fuel conditions on the ground. This is distinctly different than map zone ruleset variations based on an arbitrary boundary. It should also be noted that BpS rules are not separate rulesets but rather a subset of the unified ruleset.

A second method of allowing for spatial variation in rulesets is the use of the optional "Wildcard" LFTFCT input raster. The user provides a wildcard raster as a mask, where a unique value in the raster identifies an area where a ruleset variation is applicable. Any EVT ruleset may then be modified to include a rule variation using the wildcard value. Again, the use of a wildcard raster requires the user's careful discernment to avoid introducing arbitrary seamlines and to ensure appropriate distinctions.

BpS and wildcard rules were used as part of the ERRA calibration effort and were requested and vetted by workshop participants. More information on BpS rules can be found in the Fuel Boxes spreadsheet referenced above. Wildcard rules involved three different wildcard masks relating to phragmites on the east coast, northern hardwoods across the region, and pasture and hayland in

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[8] ERRA Fuel Boxes: http://www.pyrologix.com/ftp/R9/ERRA/ERRAv2_Fuelboxes_Final_20211129.xlsx

the western portion of the region. These masks were created, combined, and used as the LFTFCT wildcard input to allow for a few necessary variations in the spatial implementation of these rules across the region. The three wildcard masks are discussed below.

2.2.4.1 PHRAGMITES

We received feedback from calibration workshop participants that the grass *Phragmites spp.*, a fuel type presenting significant wildfire hazard challenges, was under-mapped in the Northeastern states. Workshop participants provided a spatial mask identifying locations in New Jersey where the grass was most prevalent and identified EVTs where the fuel was to be updated to a GR8. This mask was incorporated into the LFTFCT Wildcard input raster and phragmites wildcard rules were added for the following EVTs: Northern Atlantic Coastal Plain Dune and Swale (2436), Gulf and Atlantic Coastal Plain Tidal Marsh System (2490), and Developed Ruderal Grassland (2927). The affected areas are shown in Figure 2.

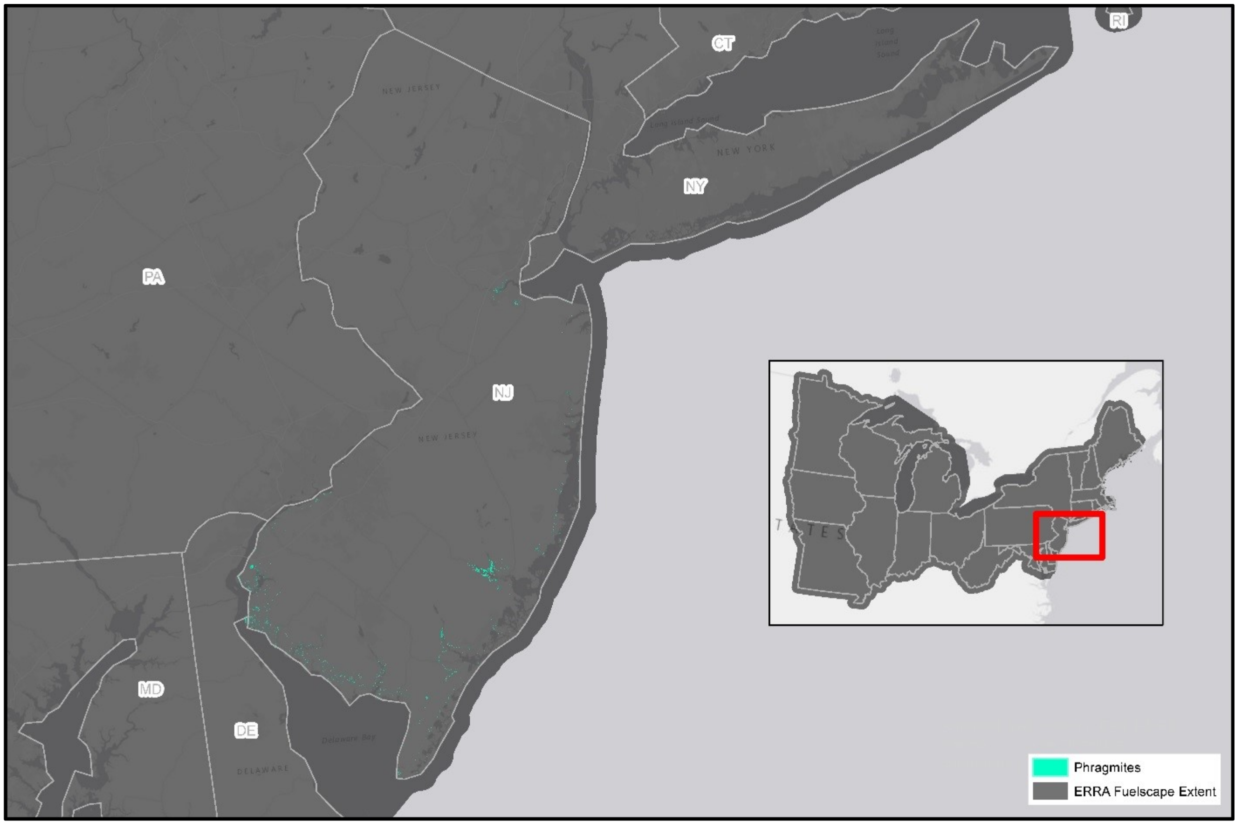

Figure 2. Map of pixels affected by phragmites wildcard edit. Includes EVTs 2436, 2490, and 2927.

2.2.4.2 NORTHERN HARDWOODS (EVT 2302)

One of the more prevalent EVTs across the Eastern Region is the Laurentian-Acadian Northern Hardwoods Forest (EVT 2302). This EVT encountered significant vegetation mapping issues in LANDFIRE 2014 data products (Ziel and Sebasky, personal communication[9]), which prompted close evaluation during initial fuel calibration efforts and received extensive modifications in the LANDFIRE Remap update effort[10]. Additionally, this EVT had numerous rule exceptions defined by LANDFIRE BpS Model numbers which, given the large extent of this EVT, necessitated a different approach. After exploring options available in the LANDFIRE data framework, along with highlights from the vegetation review paper mentioned above, we decided to use the BpS GROUPVEG attribute to refine rulesets. The GROUPVEG attribute is a coarse grouping of BpS models into the following six categories: Grassland, Shrubland, Riparian, Hardwood, Hardwood-Conifer, and Conifer. This allowed calibration efforts to define a different ruleset for each BpS group within the EVT 2302. Additionally, workshop participants split each of the three tree groups (Hardwood, Hardwood-Conifer, Conifer) into two natural distinct rulesets; rulesets in the northeast were named East Coast rulesets, and rulesets to the west of the Great Lakes were named as such. Affected areas are shown in Figure 3, symbolized according to respective ruleset groupings.

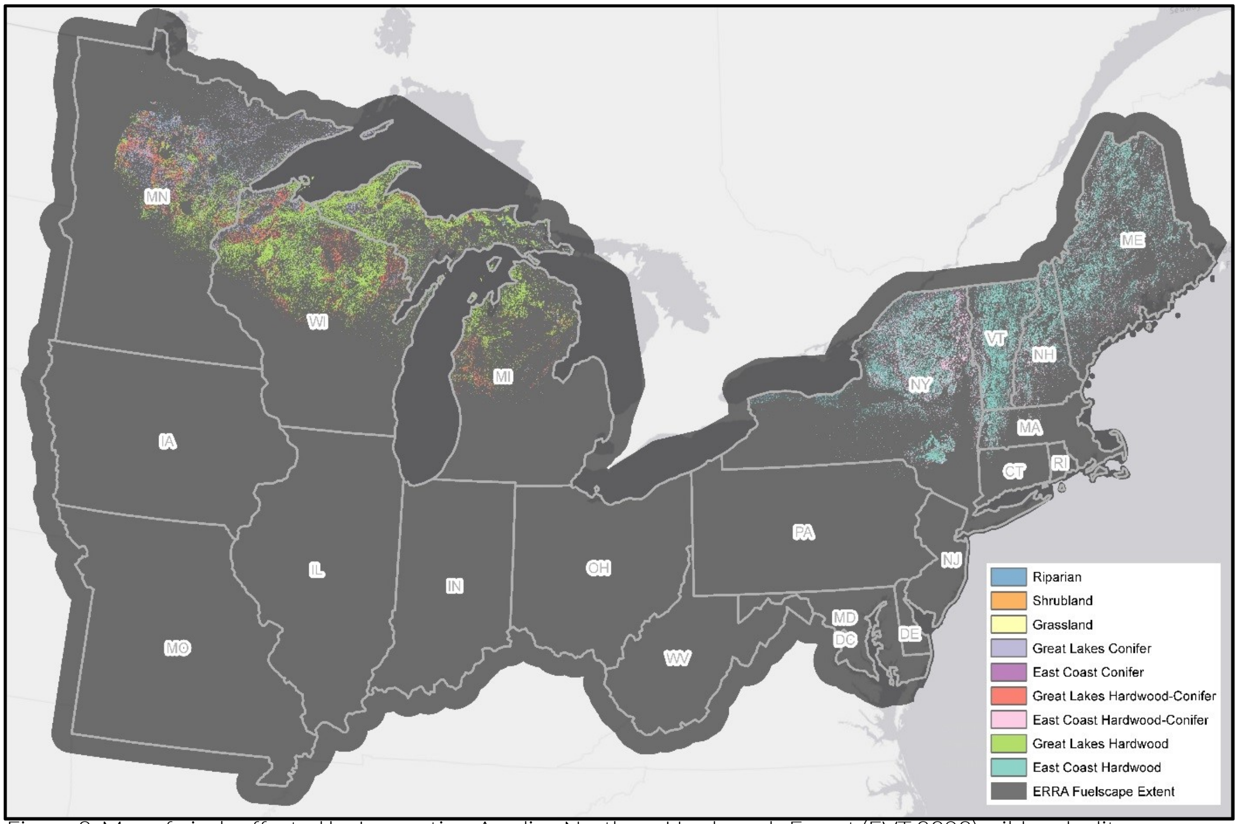

Figure 3. Map of pixels affected by Laurentian-Acadian Northern Hardwoods Forest (EVT 2302) wildcard edit.

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[9] Unpublished report: Lake States LANDFIRE EVT and Fuels Assessment, November 28, 2018.

[10] LF2014 vs Remap Surface Fuels Comparison in the Lake States. https://drive.google.com/file/d/1IAKuQMPnqKD-h5x8h2byFeFodCLKIHd0/view

2.2.4.3 PASTURE AND HAYLAND (EVT 2967)

In the western portion of the ERRA landscape, workshop participants highlighted the influence of cedar shrub invasion on fire behavior in the Pasture and Hayland (2967) EVT. The initial fuel rule consisting of fuel models GR1 and GR2 underestimated the flame-length potential in invaded areas. A wildcard mask of this EVT was generated west of the Illinois and Mississippi Rivers. To capture the increase in fire behavior seen in invaded areas, the wildcard rules modified the fuel model to GS3 for herbaceous cover greater than 40 percent and modified the fuel model to GR4 for herbaceous cover greater than 70 percent and for herbaceous height greater than 1 m. Affected areas are shown in Figure 4, symbolized according to the fuel model update.

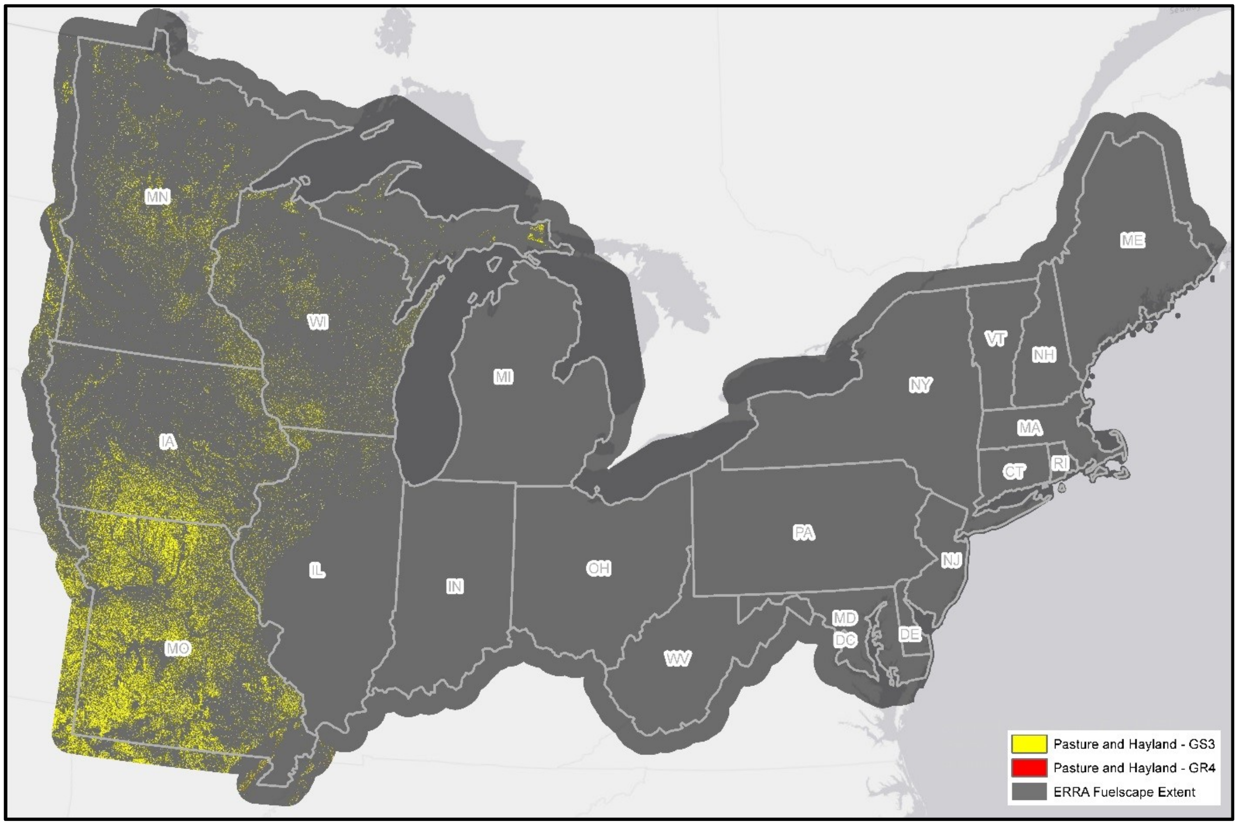

Figure 4. Map of pixels affected by Pasture and Hayland (EVT 2967) wildcard edit.

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 ERRA fuelscape for use past the 2020 fire season we added disturbances occurring between 2017 and 2019, 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), Insect and Disease disturbance data from National Insect and Disease Survey (IDS), and additional fuel disturbance data compiled from state-specific databases by the Northeast Region LANDFIRE Coordinator and staff. Three notable fuel disturbances from the period of interest were identified as missing from the LANDFIRE disturbance data by calibration workshop participants. These disturbances included a wind-throw event due to a derecho in Indiana in 2011, significant flooding in Iowa (leading to dead and down trees) in 2011, and a tornado wind-throw event in Indiana in 2012. Participants provided spatial data to identify these locations as well as the disturbance severity information to update the fuel mapping.

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.

2.4 CALIBRATED FUELSCAPE

After all workshop edits and recent disturbances were incorporated into the fuelscape inputs, Pyrologix produced a fuelscape for the United States portion of the Eastern Region 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 two additional customizations, including a custom fuel model for burnable cornfields and an overall expansion into Canada. These customizations are discussed in the following sections.

2.5.1 CUSTOM FUEL MODEL (AG9)

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 apply inputs to the entire extent of a fuel model. 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 solely so that certain locations with the same fuel model 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.

In line with the purposes listed above, the ERRA fuelscape uses a custom fuel model to represent the potential for wildfire spread into burnable cornfields. Workshop participants highlighted concerns about the underrepresentation of wildfire in agricultural areas in the western portion of the fuelscape due to the mapping of agriculture as non-burnable. Corn crops were identified as the agricultural fuel of greatest concern for the western portion of the Eastern Region. As a result, workshop participants requested a customization to portray the potential for wildfire in cornfields at certain times of the year.

By mapping these 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. 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. Because fire behavior in cornfields is dependent on the time of year relative to harvest, participants discussed using fuel model GR2 to represent corn in its “stubble” form, but GR9 to represent fire behavior prior to harvest. Only one fuel model can be assigned to a pixel, so the final edit used a custom fuel model identical to the GR9 / 109 fuel model but labeled separately as AG9 / 119 to allow for further customization in FSim fire modeling. Separately, in integrated hazard and risk results, AG9 pixels received an adjustment to reduce intensity proportional to the split between GR2 and GR9 to compensate for the different fire behavior depending on the time of year. More information on AG9 hazard adjustments is available in the ERRA Wildfire Hazard report [11].

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[11] ERRA Wildfire Hazard report: http://www.pyrologix.com/reports/ERRA_HazardReport.pdf

To implement the edit to burnable cornfields, we used the CropScape dataset to identify corn crops (USDA NASS 2018). Because burnable cornfields were identified as a wildfire hazard in the western but not eastern portion of the fuelscape, we located an area with a naturally lower density of corn pixels in the Midwest to use as a border for the alteration. The break occurred west of the Cuyahoga River (near Akron, Ohio) and Interstate 77. West of this break we updated any pixels previously mapped with fuel model NB3 (nonburnable agriculture) to the custom fuel model AG9. The affected areas are shown in Figure 5.

The addition of the custom fuel model for burnable cornfields 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.

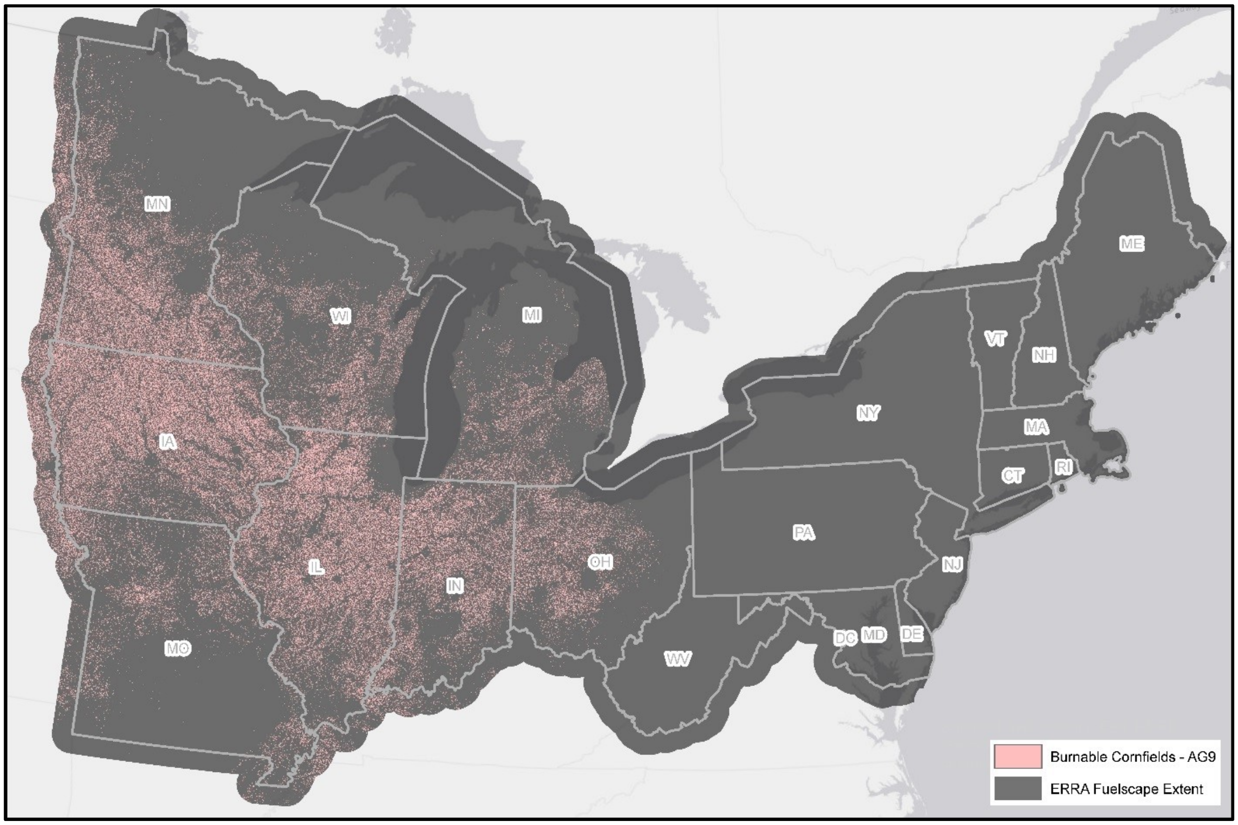

Figure 5. Map of pixels affected by the burnable cornfields custom fuel model AG9 edit.

2.5.2 MAPPING FUELS IN CANADA

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

Digital Elevation Model (CDEM)[12] data for our project extent within Canada, from which we generated elevation, slope, and aspect rasters. The fuels and topographic rasters were mosaicked with the final United States fuel rasters to generate a final fuelscape for ERRA. The purpose for extending the fuelscape into Canada, 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 Canada into which they can spread. Without this, a visible, artificial reduction in burn probability will appear in the final modeling results.

Estimates of fuel characteristics in Canada 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 Canada fuel mapping process, care was taken to map fuels as accurately as possible given the data limitations and to minimize fire modeling seamlines at the Canadian border.

2.5.3 FINAL ERRA FUELSCAPE

Using the methods described above we generated the final version of the ERRA fuelscape for use in our wildfire hazard modeling. The fuel raster is displayed using fuel model groups in Figure 6. CC, CH, CBD, and CBH are shown in Figure 7 through Figure 10.

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[12] Additional information can be found at https://open.canada.ca/data/en/dataset/7f245e4d-76c2-4caa-951a-45d1d2051333

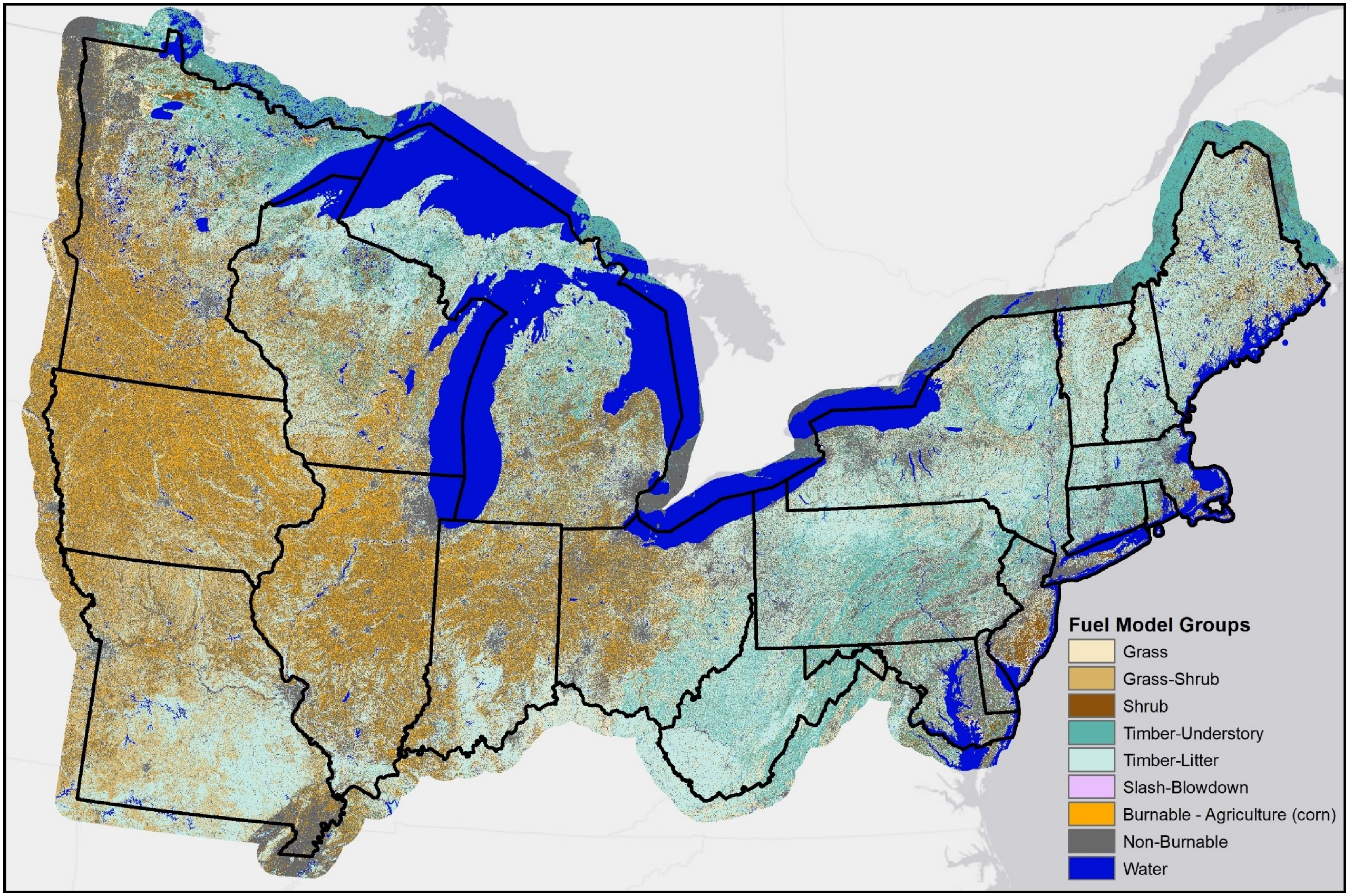

Figure 6. Map of fuel model groups across the ERRA LCP extent.

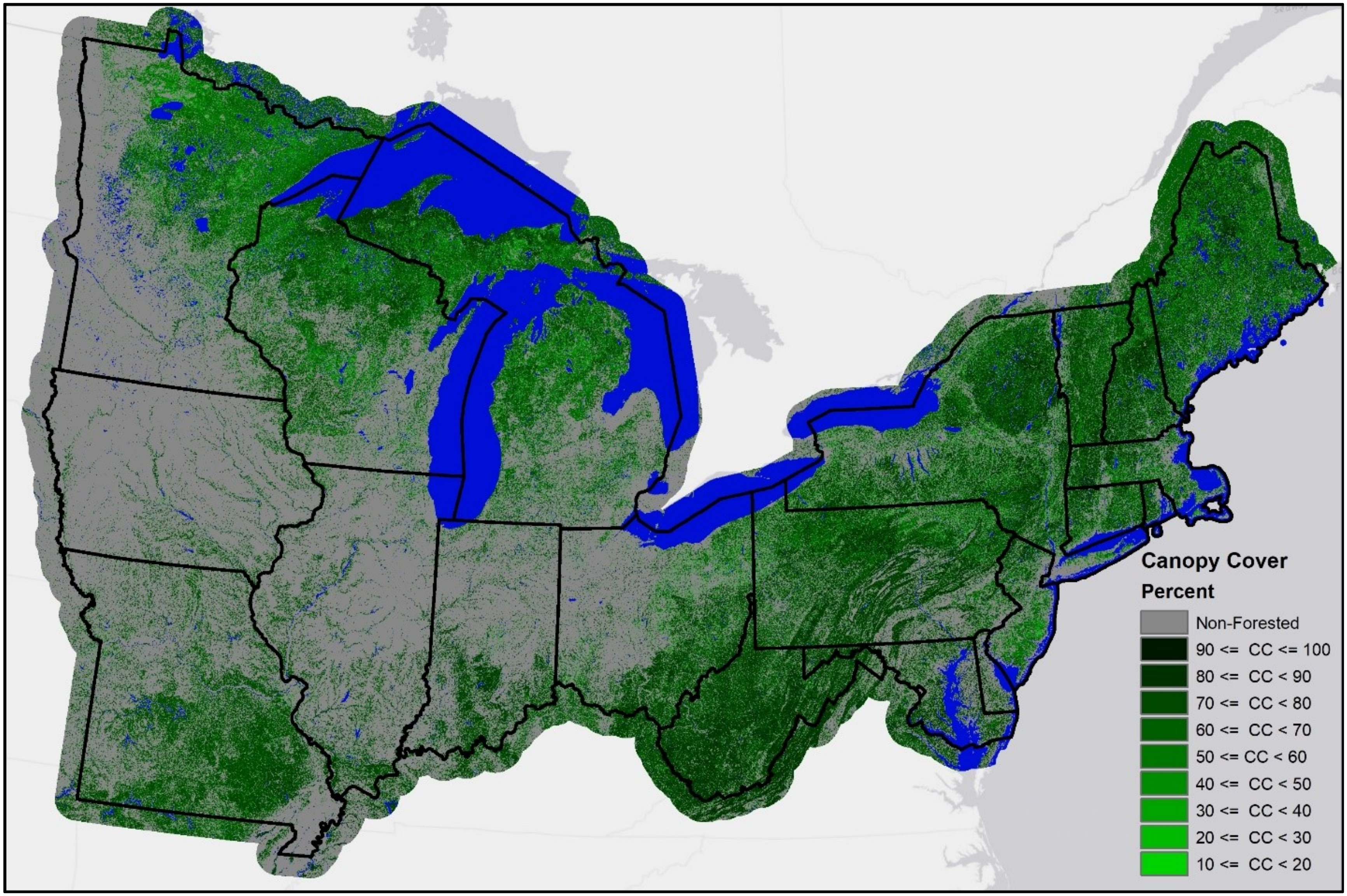

Figure 7. Map of canopy cover (CC) across the ERRA LCP extent. CC is continuous but is displayed in the standard LANDFIRE 10-percent classes for ease of viewing.

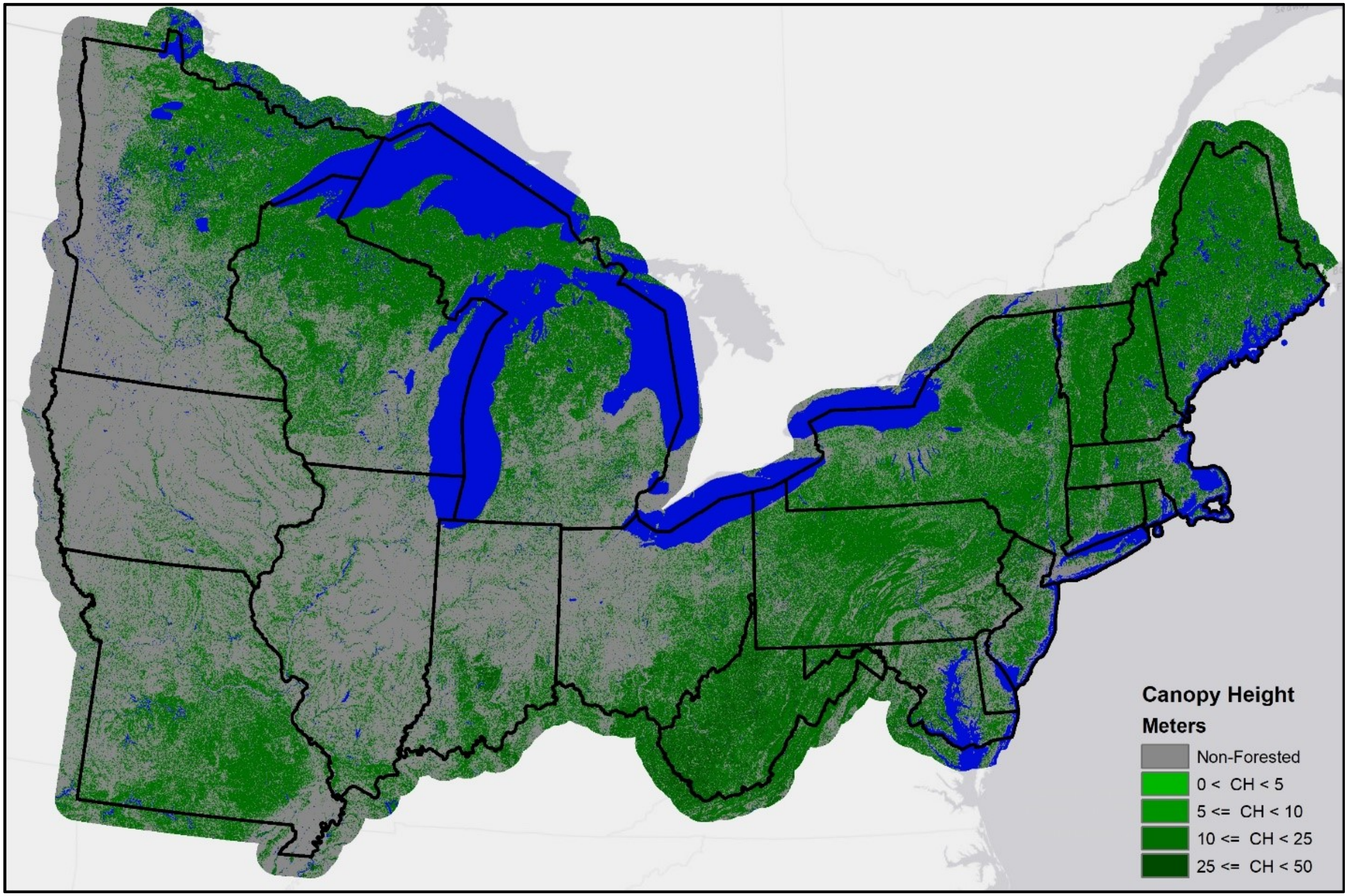

Figure 8. Map of canopy height (CH) across the ERRA LCP extent. CH is continuous but is displayed in the standard LANDFIRE height classes for ease of viewing.

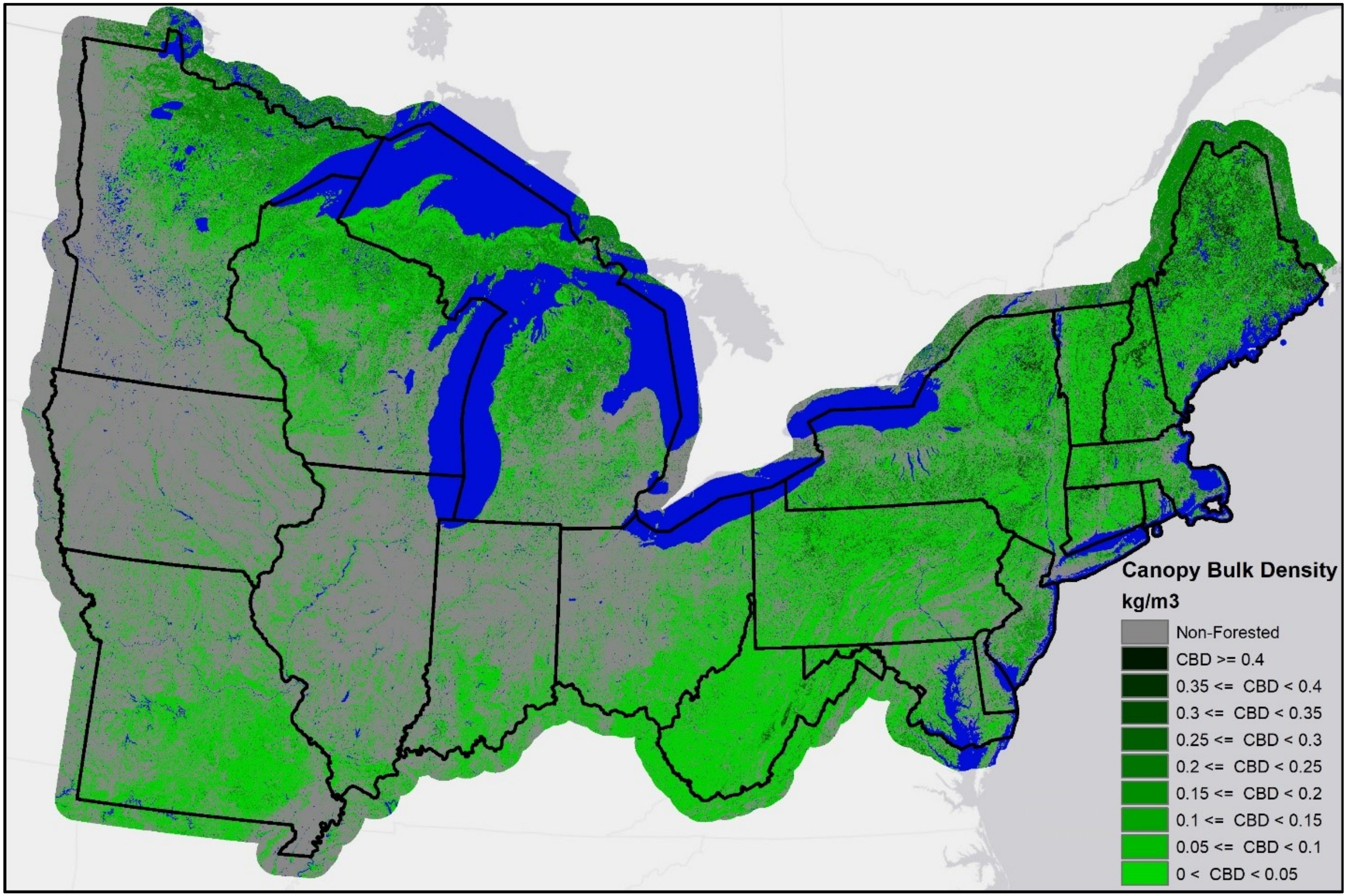

Figure 9. Map of canopy bulk density (CBD) across the ERRA LCP extent.

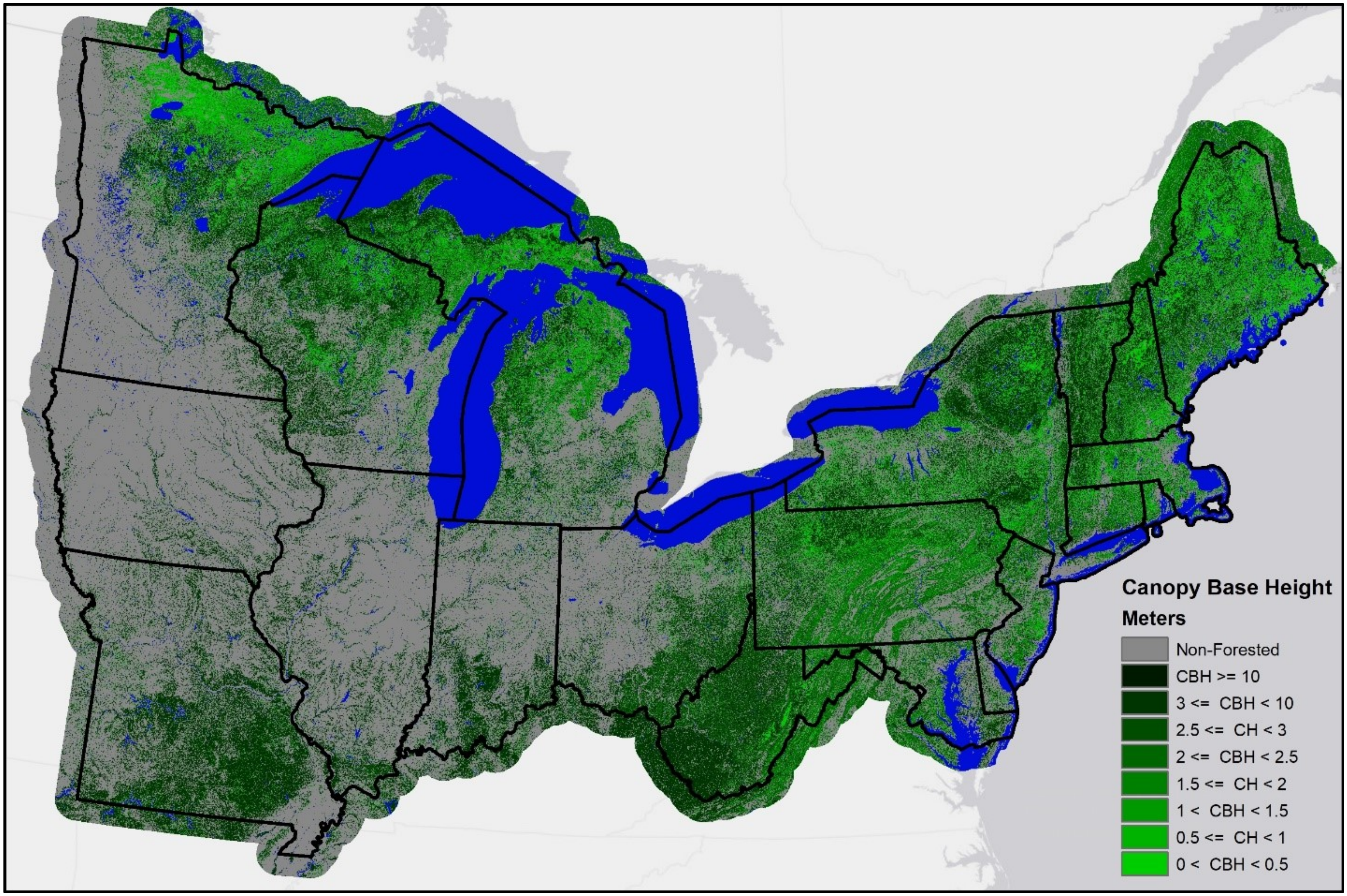

Figure 10. Map of canopy base height (CBH) across the ERRA LCP extent.

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 region level, but that is not feasible at the national extent covered by LANDFIRE. The final ERRA fuelscape, for use in the 2020 fire season and beyond, is available for download via ftp link[3].

Our calibration covered a large majority of the region but was not inclusive of all EVTs within the ERRA 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 region-wide assessment.

Finally, the ERRA fuelscape is current for the 2020 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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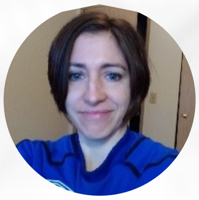

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The Eastern Region all-lands wildfire risk assessment was conducted by Pyrologix, a wildfire hazard and risk assessment research firm based in Missoula, Montana.

For More Information Please Visit:

www.pyrologix.com

www.wildfirehazard.com