LANDFIRE 2015 Remap – Utilization of Remotely Sensed Data to Classify Existing Vegetation Type and Structure to Support Strategic Planning and Tactical Response

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Characterizing vegetation type, cover and height with Earth observation data enhances wildland fuel modelling.

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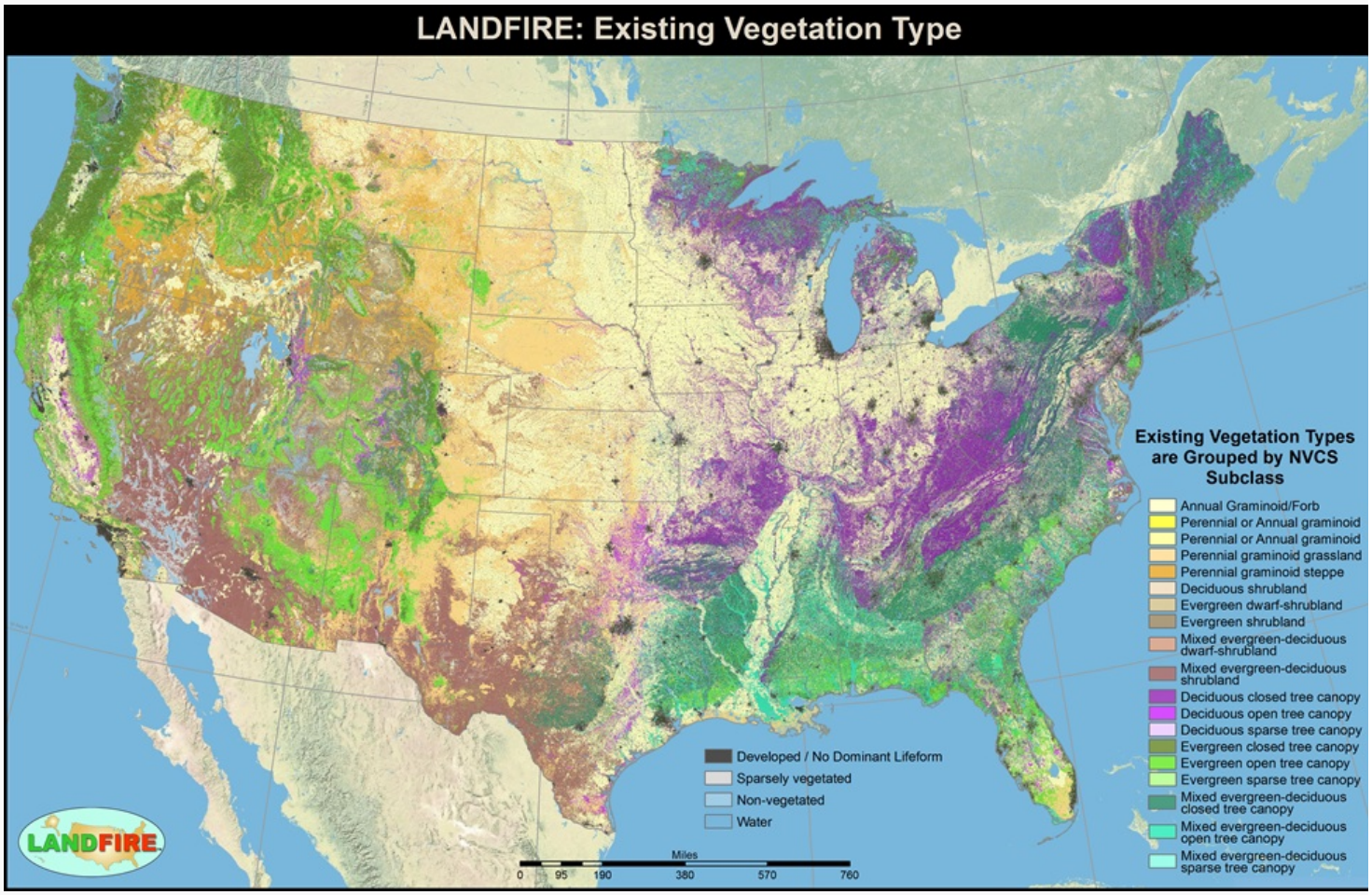

Figure 1 – Existing vegetation types grouped by National Vegetation Classification System (NVCS) for the conterminous US. Image Credit: Landfire.gov

Introduction

The LANDFIRE Program produces national scale vegetation, fuels, fire regimes, and landscape disturbance data for the entire U.S. These data products have been used to model the potential impacts of fire on the landscape [1], the wildfire risks associated with land and resource management [2, 3], and those near population centers and accompanying Wildland Urban Interface zones [4], as well as many other applications. The initial LANDFIRE National Existing Vegetation Type (EVT) and vegetation structure layers, including vegetation percent cover and height, were mapped circa 2001 and released in 2009 [5]. Each EVT is representative of the dominant plant community within a

given area. The EVT layer has since been updated by identifying areas of landscape change and modifying the vegetation types utilizing a series of rules that consider the disturbance type, severity of disturbance, and time since disturbance [6, 7]. Non-disturbed areas were adjusted for vegetation growth and succession. LANDFIRE vegetation structure layers also have been updated by using data modeling techniques [see 6 for a full description]. The subsequent updated versions of LANDFIRE include LANDFIRE 2008, 2010, 2012, and LANDFIRE 2014 is being incrementally released, with all data being released in early 2017. Additionally, a comprehensive remap of the baseline data, LANDFIRE 2015 Remap, is being prototyped, and production is tentatively planned to begin in early 2017 to provide a more current baseline for future updates.

LANDFIRE 2015 Remap

LANDFIRE 2015 Remap is not limited to utilizing the production techniques of the original LANDFIRE National and subsequent update production processes. Instead, it provides an opportunity to use newly available datasets and data processing techniques. The overall goal of LANDFIRE 2015 Remap is therefore to produce new vegetation, fuels, and fire regime base layers that are representative of the circa 2015 ground conditions. The LANDFIRE 2015 Remap prototyping efforts are split into several topical areas.

Reference Data

The LANDFIRE Reference Database (LFRDB) consists of field validated plot reference data covering the U.S. Reference data are collected from a variety of contributors including federal, state, local, and tribal government agencies, universities, non-governmental organizations, and private groups. Plot information compiled in the LFRDB includes estimates of forest canopy cover, forest canopy height, vegetation lifeform (i.e., herbaceous, shrub, tree), and EVT. These data will be primarily used for 1) training classification models to predict, vegetation lifeform, EVT, and vegetation structure; and 2) validating outputted map products.

Composite Landsat Data

Landsat imagery will be utilized as the primary remotely sensed data source upon which all map products are based. The LANDFIRE 2015 Remap will primarily use Landsat 8 Operational Land Imager (OLI) image products; however, in cases where OLI data are not available, Landsat 7 Enhanced Thematic Mapper Plus (ETM+) also may be used. There are slight differences in the spectral bandwidths between the two sensors, but they are negligible for the bands used in this application. Both OLI and ETM+ data products have a 30 m spatial resolution for the visible and near/middle infrared bands. Because many Landsat images contain clouds, cloud and terrain shadows, snow, ice, and ETM+ contains data gaps, a previously developed temporal compositing algorithm has been utilized to create tiled composites for LANDFIRE 2015 Remap prototyping [7]. Landsat images were selected within defined date ranges by examining their closeness to a defined target date (e.g., date of peak of green vegetation) and their spectral similarity to other pixels within the date range using a cosine spectral similarity function, following the methodology of Nelson and Steinwand [7]. Multiple dates of imagery and different temporal compositing windows also are being investigated.

Ancillary Data

Several ancillary datasets are being investigated for their potential utility in the LANDFIRE 2015 Remap. Some layers being considered include the National Land Cover Database 2011 (NLCD 2011), NLCD 2011 potential wetland index, elevation, slope, aspect, and PRISM derived precipitation, maximum temperature, mean temperature, and minimum temperature.

Vegetation Structure Modeling

Vegetation structure layers consist of vegetation percent cover and height for each lifeform. To prototype 30 m resolution vegetation structure mapping for LANDFIRE 2015 Remap, a series of Classification and Regression Tree (CART) models, both Random Forest and Cubist , are being developed using both airborne lidar-derived height and percent cover training data and plot-based observations from the LFRDB as the dependent variable. Landsat

imagery and ancillary datasets are being used as independent variables. A spatial applier is then used to create geospatial data layers from the model results.

Lifeform Modeling

Plot data from the LFRDB are classified as either herbaceous, shrub, or tree lifeforms. These data are used to train decision tree models (both Random Forest and See5 have been tested with similar results) using Landsat imagery, ancillary datasets, and vegetation structure layers as independent variables. A portion of the plot data is withheld for validation of the final layers. Output models are then applied to the entire study area resulting in a three class lifeform image with 30 m resolution.

Existing Vegetation Type Modeling

Plot data in the LFRDB are classified to Ecological Systems and National Vegetation Classification System Group level EVT classes. These legends are still being refined but there are currently 929 Ecological Systems classes across the US. Similar to lifeform modeling, a portion of the plot data is withheld for validation. The remaining training data are used to build decision tree models with EVT class as the dependent variable and Landsat imagery, ancillary data, and vegetation structure layers as independent variables. Model outputs are then applied to the full study area to produce 30 m continuous maps of EVT.

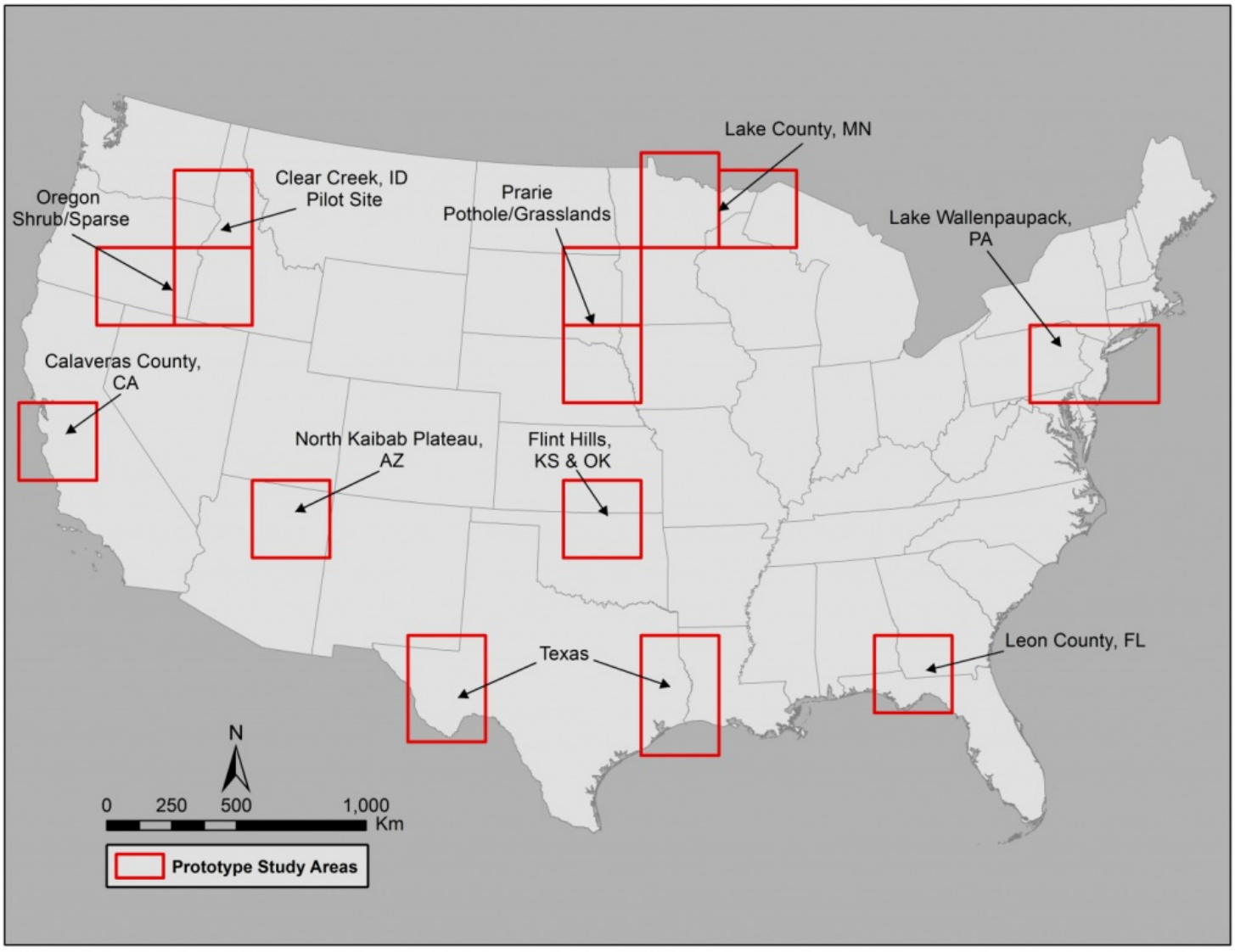

Figure 2 – Prototype study areas for the conterminous US. Associated LANDFIRE image tiles are highlighted. Image Credit: LANDFIRE

Prototypes

Areas

Fourteen study areas (Figure 2) were chosen for prototyping LANDFIRE 2015 Remap, based on their geographic location and EVT class distribution. Existing LANDFIRE image tile boundaries are used to define each of the study areas. The first prototype area to be mapped was in Clear Creek, Idaho, where vegetation type and structure layers were produced. Lessons learned from this area are being applied to subsequent prototype areas.

Case Study: Clear Creek, Idaho

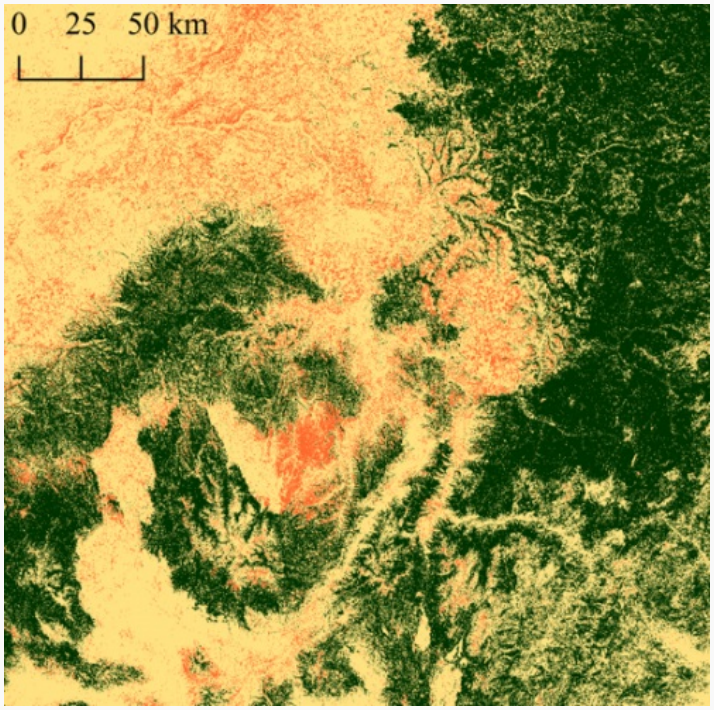

Figure 3 – Example 30 m lifeform output, including tree (dark green), shrub (tan), and herbaceous (orange) lifeforms, for Clear Creek, Idaho. Image Credit: LANDFIRE

Clear Creek, Idaho, was chosen as a study site because of the diversity in its elevation, vegetation structure, and distribution of EVT classes. The availability of a large lidar dataset also provided impetus for using Clear Creek as the initial study area. All previously mentioned LFRDB, Landsat, and ancillary data were compiled for this area. CART models were subsequently developed to model percent vegetation cover, canopy height, lifeform, and EVT. Vegetation cover and canopy height products were mapped continuously for each lifeform. Lifeform and EVT products were mapped thematically with three classes for lifeform (Figure 3) and 64 EVT classes. Once all initial output data products were completed, withheld data were then assessed for map agreement. Preliminary results suggested that the agreement of all LANDFIRE 2015 Remap products were slightly better in comparison with LANDFIRE Update 2010 products. This suggests that prototype processes, including the use of new training data and modelling procedures, are an improvement over past mapping methodologies within the prototype area.

All methods that have been developed for Clear Creek can be easily applied to the additional study areas, which is underway. Additional methods are being evaluated and the final mapping methods will likely combine several options, tailored to the specific area being mapped. Additional ancillary datasets also are being evaluated and will likely be incorporated into the mapping process. We anticipate that future prototype areas will continue to improve.

Data Applications

Fire Risk

LANDFIRE data products have been previously used in the production of fire risk assessments that identify the likelihood of whether a given area will burn [3, 8-10]. This is especially important given ongoing analysis of the effectiveness of fuel treatments in reducing fire risk [10]. Improved accuracy of the LANDFIRE vegetation and fuel products is paramount given that these products will be used in future models that predict fire risk for a given area

Vegetation Recovery

Current vegetation and fuel conditions mapped for LANDFIRE 2015 Remap will serve as the base for future updated LANDFIRE products. Vegetation and fuel conditions are constantly changing depending on the rate of vegetation growth and vegetation succession pathways. These two factors are important to define and will be used for future

iterations of LANDFIRE, where Remap products will be updated with the current year disturbances. Previous and past year disturbances will be taken into account and the vegetation and fuels products will be modified based on the disturbance characteristics and previous EVT class information. These update products will most likely be updated on a one- to two-year interval.

Conclusions

LANDFIRE 2015 Remap provides an opportunity to revise all current LANDFIRE vegetation and fuels products. Currently, the methodology for producing LANDFIRE 2015 Remap products is being developed. Prototype areas have been defined that represent an array of diverse vegetation and fuel types for process development. Vegetation type and structure products for Clear Creek, Idaho, have been successfully produced and the methods used to produce them are being expanded into the other prototype areas. Updated fuels maps also are being developed based on the updated vegetation. Final algorithms will be developed and documented prior to commencement of LANDFIRE 2015 Remap production.

Many of the procedures being developed for LANDFIRE 2015 Remap either have or will be scripted in Python to allow for automation of the product generation. These automated processes could be easily transferred to other vegetation and fuels mapping projects. It is anticipated that these automation processes will eventually be released, which will allow for a more thorough review of the LANDFIRE 2015 Remap methodologies. All LANDFIRE 2015 Remap products are expected to be released in the 2020 to 2021 time frame.

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