Department of the Interior
U.S. Geological Survey

LF 2016 Remap
PROJECT CLOSE-OUT REPORT

Contents

Section 1 INTRODUCTION

This is the Project Close-Out Report (PCR) for LF 2016 Remap (LF 2.0.0). The technical work of LF 2016 Remap was completed in August 2021. This report provides documentation of the overall LF 2016 project scope, schedule, results, lessons learned, open issues, and project closure.

LF 2016 Remap was a project conducted by the LF program. LANDFIRE (Landscape Fire and Resource Management Planning Tools) is an inter-agency program that provides comprehensive biological, ecological, and geospatial data and databases for the contiguous United States (CONUS), Alaska, Hawaii, and insular areas. LANDFIRE is a vegetation, fire, and fuels characteristic mapping program managed by the U.S. Department of Agriculture (USDA) Forest Service (FS) as the lead agency along with the U.S. Department of the Interior (DOI), and cooperative involvement from The Nature Conservancy (TNC) with production management via the U.S. Geological Survey (USGS) at the Earth Resources Observation and Science (EROS) Center.

Guidance for LF 2016 Remap was outlined via numerous discussions both in person and virtually through efforts such as the LF Business Group (LBG), the LF Technical Group (LTG), white paper guidance documents (Appendix 4), discussions with interagency partners and user groups before and during the mapping process, summary information in the DOI Office of Wildland Fire Reimbursable Support Agreements (RSAs) to USGS-EROS, and activities and deliverables outlined in Statement of Objectives and Task Plan through contractors.

LANDFIRE Product development and distribution was a formal deliverable for the USGS at USGS-EROS. Contracting support was provided to the USGS by a number of contractors, but principally by Kellogg, Brown & Root (KBR) through a Technical Services Support Contract (TSSC) and Arctic Slope Regional Corporation through a Science Services Support Contract (SSSC). The contractors were responsible for meeting scope, schedule and budget outlined in guidance/direction documents, multiple meetings/discussions, and Statement of Objectives and Task Plans (for TSSC) or Science Review Document (for SSSC).

USDA FS, USGS, and contracted resources provided LF with prototyping support for the LF 2016 Remap vegetation mapping process. Methodologies and approaches resulting from this work were documented in posters (Appendix 6), reports, and peer-reviewed publications. TNC's Team also supported critically important Fire Regime data, agreement assessments for mapped vegetation products (see Table 2) and led multiple outreach aspects for the program.

This PCR focuses primarily on the efforts of the LF data products produced at EROS as that is where the majority of the work was done.

1.1 LANDFIRE: Developed to Answer a Need

In 2000, the Government Accountability Office (GAO) stated that "Federal land management agencies do not have adequate data for making informed decisions and measuring the agencies' progress in reducing fuels." In 2002, GAO reported (GAO-02-259) that "Data are not available to better prioritize communities and projects for funding," and concluded that "On the basis of our review, LANDFIRE is the only proposed research project so far that appears capable of producing consistent national inventory data for improving the prioritization of fuel projects and communities." Beginning with a prototype in 2002, LF was officially chartered in 2004 (LANDFIRE Executive Charter 2004) by the Wildland Fire Leadership Council (WFLC) based on the need for accurate, complete, and comparable data for all lands.

LANDFIRE represents the first and only complete, nationally consistent collection of more than 25 geospatial layers (e.g., vegetation, fuel, disturbance, etc.), databases, and ecological models that can be used across multiple disciplines to support cross-boundary planning, management, and operations across all lands (30-meter pixel resolution) of the U.S. and insular areas. The first version, LF National (circa) 2001, was completed in 2009. Updates to the product suite (LF 2008, 2010, 2012, and 2014) were made to capture changes in the landscape by using disturbance/change detection information and incorporating anticipated vegetation succession and growth. Although LF National products were updated regularly to represent current conditions and account more accurately for these landscape disturbances, subtle vegetation changes were not reflected in the updated versions.

Since its first release, LF's detailed geospatial mapping products have become a critical component of wildland fire modeling, fire analyses/assessments, land management planning/decision, fire risk assessments, and firefighter safety. The datasets have also proven useful across a wide variety of scientific disciplines and applications; where LF has been cited in more than 1,000 peer-reviewed publications.

1.2 Charters

LANDFIRE has two charters dated 2004 and 2012 (LANDFIRE Executive Charter 2012), both of which were approved through WFLC. The 2004 charter outlined program elements such as scope, sponsorship, product deliverables, quality objectives, key milestones, organization and responsibilities with executive sponsors/oversight committee, business, and project groups. The 2012 charter was a continuation of the charter with additions on authority and justification, program governance and oversight, details on quality objectives and standards with identified targets, advisory process, an increased emphasis on communication and technology transfer for the program, and alignment with strategic initiatives.

These charters outlined the following broad goals where LF will provide datasets, models, procedures and tools to help land managers:

- Identify and prioritize fuel reduction areas to support fire and fuels management
- Support the identification of areas at risk to wildfire within the vicinity of local communities and assist with firefighter protection
- Support natural resources management such as environmental analysis, biological evaluations, etc.
- Provide consistent information for monitoring and improved interagency collaboration

The 2012 Charter outlined the vision and mission of the LF program, where LF provides national-level landscape scale vegetation and fuels geospatial data products that support fire and fuels management planning, analysis, and budgeting to evaluate fire management alternatives and secondarily natural resource management. LANDFIRE is a cornerstone of a fully integrated national data information framework, supporting an all-lands landscape conservation approach based on inter-agency / inter-organizational collaboration and cooperation. LANDFIRE is acknowledged for management excellence and effective mission delivery. LANDFIRE's mission is to provide agency leaders and managers with a common "all-lands" data set of vegetation and wildland fire/fuels information for strategic fire and resource management planning and analysis. LANDFIRE applies consistent methods to develop comprehensive geospatial data products across all 50 United States and the territories including current plot/polygon, land change, vegetation, fire behavior, fire regime, and fire effects data products that support a wide range of applications and programs.

1.3 Why Remap?

It was more than 15 years since the original LF base map, LF National (circa 2001), was developed. As such, it was determined that to maintain the functionality and relevance of the LF products, a remapping effort of the nationwide suite of national-scale land cover, vegetation, fuel, and fire products was needed. The effort was initially planned to be called LF 2015 (Appendix 4), however coordination at USGS with the Land Change Monitoring, Assessment, and Projection (LCMAP) effort indicated that it would be able to provide an Analysis Ready Data (ARD) land change product that would be beneficial in LF disturbance mapping work, so the program delayed production for a year. As such, this effort became known as LF 2016 Remap. Although this delay was strategic, it did not result in the intended benefits to the LF program because the LCMAP ARD was not delivered and not incorporated into LF 2016.

1.4 Remap vs. Update

Why did LF decide to undertake a full remapping effort instead of doing another update? For LF, an update is a short-term improvement to the National Product suite focused on areas of change or disturbance. These updates were focused on biennial (e.g., LF2012, LF2014) changes and products were delivered approximately every two to three years. Updates focused primarily on identifying landscape changes and disturbances from a variety of sources or activities including wildland fire, fuel and vegetation treatments, mortality from insects and disease, storm damage, invasive plants, or other natural or anthropogenic events. Product updates included responses to vegetation successional change in forested types, revisions to address discrepancies between existing products and known field conditions, as well as specific systematic improvements to the original product suite.

The LF 2016 Remap mapping effort used new data (e.g., Landsat 8, point, polygon, and field data) to create an updated base map that represented contemporary landscape conditions. These conditions were based on the gradual changes of continual vegetation growth, rather than solely focusing on areas of change where disturbances occurred (e.g., fire, windthrow, drought, etc.) to map and represent broad landscape conditions representing circa 2016 vegetation and fuels.

1.5 Scope and Requirements

In the early days of 2015 Remap, the USGS and USDA FS Technical Leads created a Remap Strategy Team (RST) that focused solely on the Remap without also having to focus on production or operations (an R&D model borrowed from the NLCD program). RST members included the following: USGS Technical Lead, USDA FS Technical Lead, SSSC LF scientists, TSSC SMEs, and USGS Gap Analysis Program (GAP) modelers/mappers. The GAP team was fully integrated into the LF remap work because of the LF/GAP Memorandum of Understanding. RST pulled together a list of issues that LF had compiled over some years from LF data users (among others), information about new data and mapping methods, and a wish list for Remap.

Initially, fourteen study areas were chosen for prototyping LF 2015 Remap (Long et al. 2017, Picotte et al. 2017), but two became the foundation of the prototype effort. The process is summarized in Picotte et al. 2019:

The aim of the LANDFIRE Remap prototyping effort was to better represent current landscape conditions (e.g. LF base maps) based on the latest data to address known issues within the existing LF datasets. Specifically, the LF Remap effort was planned to fix seam-line artifacts in LF's data products and introduce a new NVC Group product. The efforts were planned to result in more current base maps, independent of LF 2001 products, with all products being "remapped" from start to finish. In 2015, an initial small-scale pilot effort was undertaken in the Clear Creek, Idaho, area to investigate new datasets and mapping methodologies (Picotte et al. 2017). The prototype area was subsequently expanded to a larger area in the NW. The majority of the Grand Canyon (GC; Arizona, USA) was later added as an additional prototype site to test methods in a different ecosystem and to take advantage of extensive lidar datasets that were available in that area. The large-scale LF Remap prototyping effort began in summer 2016 with the overall goal to develop the foundational techniques to produce new LF EVT, EVH, EVC, and NVC base products. The prototype was concluded one year later to kick off the Remap production effort.

Findings from this prototyping effort were subsequently discussed during a Sept. 2016 LF all hands meeting. This meeting was organized by the FS Technical lead and hosted by USDA FS at the Lubrecht Experimental Forest near Missoula, MT. This meeting included conference room deliberations and several field trips to the Lubrecht Experimental Forest that allowed the mapping teams to compare Landsat imagery to ground conditions in preparation for their mapping work. It was at this meeting where the LF Team made final decisions on how to implement the LF 2016 Remap.

LF 2016 Remap was initiated shortly thereafter with the LF TSSC taking the lead on modeling and mapping of disturbance, vegetation, and fuels. While the methodologies developed during the prototyping effort were largely adopted by the TSSC mapping teams, they did have discretion to adjust the modeling and mapping approach with the goal of producing the best maps for any given region. As a result, not all the predictor variables, including Landsat bands (such as thermal, coastal blue, etc.), used in the Remap Prototype were implemented in LF 2016 Remap.

1.6 Improvements and Innovations

LF 2016 Remap took advantage of new processes and leveraged changes and advancements in input data and science to support the production of next generation products. These advancements incorporated contemporary satellite imagery circa 2016, image compositing algorithms, new data sources, and (where feasible) the latest technologies. The remapping effort provided numerous opportunities to improve, enhance and add to the suite of products and databases. These innovations are described by product area in the following section.

1.7 LF2016 Remap's New and Enhanced Products

Imagery:
LF 2016 Remap used improved base imagery comprised of hundreds of thousands of Landsat 7 and 8 scenes. These scenes were processed using EROS High Performance Computing resources and resulted in fewer seamlines and provided a longer time horizon, a method that allowed for the identification of specific vegetation systems.

Additional improvements included:

- Better base imagery for vegetation mapping and stratification – For example, vegetation stratified or restricted by alpine or riparian/wetland classes facilitated improved vegetation identification.
- Reduced clouds – Image composites were created using the best quality pixels from numerous images for each season to create cloud-free (or near-cloud-free) imagery.
    - Percentile composite imagery was developed and used starting in Alaska which resulted in less cloud cover affecting final composites.
- Fewer seamlines – By using input imagery from a longer time horizon, along with improved preprocessing logic and hands-on post-processing, the data retained fewer phenological differences within (and between) imagery tiles.
- Better map masks – Masks of specific land cover types important to fire behavior, such as water (Integration of Landsat Essential Climate Variables, e.g. Dynamic Surface Water Extent), barren/sparse were created to exclude these areas from vegetation and fuels layers (Picotte et al. 2019).

LFRDB:
The number of plots in the LANDFIRE Reference Database (LFRDB) expanded significantly during LF 2016, with the number surpassing 1.25 million. In CONUS, 806,497 plots were from year 2000 to 2008, and 286,675 plots were from year 2010 or later. In the CONUS database there were 775 different data sources contributed by Federal, State, Local, and Private entities. Although data were largely amassed from existing information resources, some of the new data acquired came from the USFS Forest Inventory Analysis (FIA), NPS Inventory and Monitoring and NPS/USDA FS Feat/Firemon Integrated (FFI), NRCS-National Resource Inventory (NRI), BLM-Assessment Inventory and Monitoring (AIM) data, and State Natural Heritage data. The new BLM and NRCS plots were located primarily in non-forest areas, which when combined with FIA and other plot data, resulted in an improvement in plot distribution and significantly helped with shrub and rangeland vegetation mapping.

Auto-Keys:
The LFRDB contains more than one million plots obtained from a variety of sources. To create consistent assignments of Existing Vegetation Type (EVT) the program contracted with NatureServe to create "Auto-Keys". Auto-Keys utilize a dichotomous key-like structure to assign vegetation types to each plot using information stored in the plot record. Prior to the LF 2016 mapping process, LF worked with NatureServe to review and improve these Auto-Keys for all geographies and to add the ability to assign NVC Group to each plot to support future mapping efforts along with Ecological System. During the review/improvement process, LF and NatureServe collaborated to develop 11 homogenous Auto-Key Regions for which a separate assignment program was created. NatureServe also evaluated the quality of the Auto-keys and provided reports for each Auto-Key region.

Disturbance:

Historical Disturbance (HDist) was developed from the base LF Disturbance products (and attribute code system) to represent the 'history of disturbance' for a 10-year span. Each year's disturbance scenarios were compared with time relevant LF vegetation to identify any logical inconsistencies. Errant disturbance codes were flagged and updated to a discard code with the remaining disturbance codes cross-walked to Fuel Disturbance (FDist) codes. HDist development involved a comprehensive review of fuel and disturbance attributes. The latest 10 years of disturbance data was used for this data layer, including disturbance year, original disturbance type and severity. As a result, multiple years of disturbances were captured for each pixel, improving the classification of fuel data assignments and allowing a historical representation of disturbance on the landscape.

Fuel Vegetation Cover (FVC), Height (FVH), and Type (FVT):

FVC, FVH, and FVT were added to LF 2016 to leverage fuel transition assignments related to disturbed areas by accounting for pre-disturbance vegetation states. However, there is not complete alignment between these products and the regular vegetation products. This is an area that will require work in the future. The LF 2016 Fuel Vegetation products represent pre-disturbance conditions in disturbed areas by filling the area with (EVT), (EVC), or (EVH) products from previous LF versions.

Fuel Vegetation products also incorporated the capable fuels functionality that calculates Time Since Disturbance (TSD) assignments for disturbed areas using an "effective year". This new process considered all the existing disturbances included in LF 2016 and adjusted the TSD to the effective year, making the products 2019 or 2020 capable fuels for example.

Vegetation:

Ecological Systems mapping models were augmented by the addition of several hundred thousand field plots in LF 2016; many of these were for rare or uncommon vegetation types. In addition, the EVT legend was expanded to include over 200 additional ecological types that consisted of more than 850 classes, including agricultural, developed land, and natural vegetation, 750 natural or semi-natural types representing over 550 individual Ecological Systems, 180 new types that were previously aggregated types within sparsely vegetated and riparian or wetland areas, and 30 new semi-natural or ruderal vegetation types that follow the National Vegetation Classification (NVC)

Groups (see National Vegetation Standard below) to maintain consistency across the United States.

Additionally, for LF 2016, Existing Vegetation mapping image classification was based on Omernik III/IV Ecoregions instead of National Land Cover Database map zones. This included more ecoregional breakouts that better matched the distribution of major vegetation types and in turn produced improved model outputs that resulted in less manual mapping techniques. The USGS GAP team was helpful in mapping vegetation and providing input on unique vegetation types.

LF 2016 used new and improved vegetation mapping techniques and modeling approaches with expanded LF products including the following:

- New Landsat compositing process for seasonal imagery and 5-year NDVI statistics
- Revised and expanded Auto-Keys and crosswalks for labeling field plots to vegetation classification
- New ruderal vegetation type classes identified semi-natural vegetation types using a standardized legend within the U.S. NVC (see more on NVC below)
- New methods for mapping riparian and wetland vegetation types using classification tree modeling and ancillary layers such as hydric soils, National Wetland Inventory (NWI), and floodplain maps
- Improved methods for mapping persistent open water using USGS Dynamic Surface Water Extent (DSWE) product
- Improved methods for distinguishing physiognomy of tree, shrub, and herbaceous vegetation
- Better separation of natural barren (e.g. scree slopes, bedrock outcrops) vs. anthropogenic barren (e.g. quarries, well pads)
- Expert review and feedback process that informed revisions to final vegetation type maps
- Incorporating LiDAR data and NLCD fractional cover to improve structure mapping
- Continuous canopy structure EVC and EVH products – Developed methods to create continuous cover and height products to better inform fuels products

National Vegetation Classification (NVC) EVT layer (created for the first time with LF 2016), used a new mapping process and was delivered as a separate spatial data layer. NVC used vegetation groups within the U.S. NVC circa 2016. LF Remap used U.S. NVC 2.0 to map LF NVC.

NVC groups were initially mapped using decision tree models informed by field reference data, Landsat imagery, elevation data, and biophysical gradient inputs. Decision tree models were developed separately for each lifeform, including sparse vegetation, and for each Environmental Protection Agency (EPA) Level III Ecoregion. Disturbance products were included in LF Remap products to describe areas on the landscape that had experienced change within the previous 10-year period.

LF NVC was reconciled through QA/QC measures to ensure lifeform was synchronized with both EVC and EVH. When modeled results were poor for modeled NVC classes, rectification and/or cross-walking from existing ancillary datasets or Ecological Systems was performed to improve the quality of the product. This change of cross-walking data, however, was not elevated to LF leadership until the products were produced and delivered.

Fuel:

Capable Fuels work improved the performance of fire behavior models and reduced the need for local LF users to update the vegetation and fuel conditions to represent local conditions. As such, in disturbed areas, LF 2016 fuels products were revised to expected 2019 or 2020 vegetation conditions (for disturbances that occurred between 2009-2016 or 2010-2016), making the fuels products 2019 or 2020 capable.

A discrepancy in Time Since Disturbance (TSD) 1 (0-1 years) for surface and canopy fuels in disturbed areas existed in previous versions of LF Update products. However, TSD was not truly representative of the release date. For example, fuel layers created from 2012 disturbance data were released in 2014, meaning TSD lagged two years behind, as a result users had to adjust accordingly. This issue was corrected in LF 2016 fuel products by synchronizing TSDs for surface and canopy fuels in disturbed areas.

As a result, LF 2016 capable fuels layers better represented active and potential wildfire behavior on the landscape. The fuel products with the capable fuels functionality were Fuel Disturbance, Canopy Height, Canopy Cover/Base Density/Base Height, Fire Behavior Fuel Model 13 and 40, Fuel Vegetation Cover/Type/Height, and Fuel Characteristic Classification System.

BioPhysical Settings (BpS) & Fire Regime:

Biophysical Settings (BpS) represent the most likely Ecological System that occurred on the landscape prior to significant European colonization. The BpS suite is composed of several products: BpS spatial data layer, quantitative state-and-transition ecosystems dynamics models, detailed BpS descriptions including historic Fire Regime (Fire Regime Group, fire return intervals and percent of fires by severity type), Succession Class Rules and Reference Condition table. These products are useful as delivered but also contribute to the development of the Vegetation Departure and Vegetation Condition Class layers.

From 2015 – 2019, TNC conducted a multi-year review of the LANDFIRE BpS product suite for CONUS and HI. The revised BpS products for those geographies were posted for download on the program website with LF 2016 products. A separate website where users can search for and download BpS model/descriptions with specific criteria was developed (and is maintained) by TNC.

The BpS review consisted of two primary phases. In the first phase, TNC’s LANDFIRE Team examined all 2,000+ BpSs to find and correct any product errors or inconsistencies. TNC also sought to “collapse” the set into a more manageable product suite by merging identical BpSs across NLCD map zones. The final BpS model/description product suite now has approximately 950 unique models, including Alaska. In the second phase, the models/descriptions were made available for public review for one year at the website provided above. A communications campaign was conducted to solicit reviews from all interested parties. Approximately half of all BpSs received some level of outside review. TNC reviewed and incorporated these edits before delivering the final BpS suite to the LANDFIRE Program.

These new data and enhancements improved the quality of LANDFIRE products, especially in areas where limited plot data were available for LF National.

Section 2 SCOPE AND SCHEDULE

2.1 Scope and Requirements

The scope of LF 2016 Remap was to go beyond mapping disturbances and to create a new wall-to-wall base map across all lands reflecting circa 2016 ground conditions. This Remap effort mapped most of the original data product suite to create LF's second image-based map product suite consisting of 28 vegetation and fuels layers (also called “Themes,” see Appendix 1). Requirements were key in developing LF 2016 Remap and formed the basis from which performance and results were measured. To generate these requirements, input was solicited and incorporated from participants, stakeholders, and Subject Matter Experts (SMEs) into a final project approach that directed the effort. Associated information was included in the 2015 LF Technical Plan, but this was in advance of production work, and as noted in the prototype section, some adjustments were made during LF 2016 production. Over time, additional requirements were documented as part of the LF Concept of Operations and Requirements (CONOPs) document. It should be noted that neither the Technical Plan nor the CONOPS document captures the entire scope or the breadth of complexities involved in the LF 2016 production work.

2.2 Work Breakdown Structure

After gathering and reviewing the requirements, a Work Breakdown Structure (WBS) and associated dictionary was created to provide a detailed description of project scope. The WBS provided the details necessary to generate accurate cost and schedule estimates, fully and provide for contract deliverables tracking and delivery.

The LF WBS captured activities and deliverables across four major work areas:

1) LF Program Management
2) LF Operations
3) LF Production
4) LF Improvements and Innovations

LF 2016 Remap scope was captured and defined within the following seven work and product categories:

1) Planning
2) Reference
3) Vegetation
4) Fuel
5) Fire Regimes
6) Distribution
7) Disturbance

The following information was created for each work and product category:

1) A summary statement that provided a brief description of the work
2) Decisions and assumptions that documented guidance about how the work was to be achieved including the identification of activities or external factors that might impact progress
3) Activities that described the primary steps needed to create the deliverables and establish schedules
4) Deliverables that listed specific output(s) from the work or product category

Having provided the detailed list of tasks required to accomplish LF 2016 Remap, the WBS was combined with Level-Of-Effort (LOE) estimates, timing needs, and staffing requirements to form the basis for the LF 2016 Remap schedule.

2.3 Schedule

Schedule management provided a strategy to ensure LF 2016 Remap activities were organized to achieve timely completion. For LF, the basis for project schedule development was the WBS, and specifically the activities and deliverables for each project work area.

Project activities defined the specific actions required to create the deliverables. They also provided manageable-sized work items to allow for scheduling and LOE estimates. Activities were created based on expert judgement. The LF 2016 Remap processes of production, testing, and delivery followed this same life cycle. Products were created and tested (see section 3.2 Product Review) by GeoArea (Figure 1) and delivered to the LF website and Data Distribution Site (DDS) by geographic area extent (CONUS, AK, HI, IA). The LF 2016 Remap products were planned, produced, tested, and released in the order shown in Appendix 3.

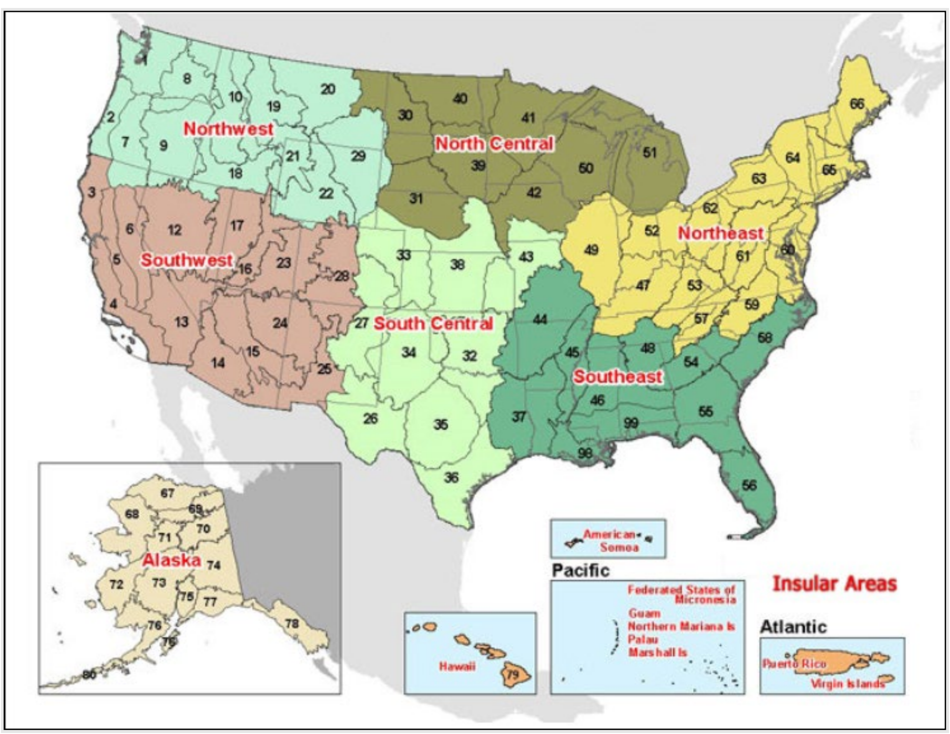

Figure 1. LANDFIRE Geographic Areas and Map Zones

Theme(s)	GeoAreas	Extent
Reference	NC, SC, SW, NW, NE, SE	CONUS
Reference	AK	AK
Reference	HI	HI
Reference	IA	IA
Vegetation	NC, SC, SW, NW, NE, SE	CONUS
Fuel	NC, SC, SW, NW, NE, SE	CONUS
Fire Regimes	NC, SC, SW, NW, NE, SE	CONUS
Vegetation, Fuel, Fire Regimes	AK	AK
Vegetation, Fuel, Fire Regimes	HI	HI
Vegetation, Fuel, Fire Regimes	IA	IA

Table 1: LF 2016 – Production Themes, GeoAreas, and Extent

Section 3 RESULTS

3.1 Delivered Data Products

LANDFIRE began delivery of LF 2016 Remap data products in February of 2019 and continued incrementally through August of 2021. Information on the delivery schedule of LF products are contained in Appendix 3 of this document. More detailed information on the specific data layers (Themes) provided in the Schedule/Versions table is found here LANDFIRE Data Products Comparison Table, while more information about the products themselves can be found here LANDFIRE Program: Products - Overview.

3.2 Product Review

Product Acceptance Reports (PARs) were generated for each data product at the time of release. The purpose of the PAR was to document product content and accessibility from the website. The PAR also documented that website updates for these products were functioning and that updates (new products and website changes) did not disrupt any existing capabilities or data. These tests were performed by a Systems Engineer and Testers; Testing Summaries were provided with each PAR. The Summary Test provides additional information on:

- Basic File characteristics - checked that data were in the intended output file format, bit depth, and had the expected geospatial projection characteristics.
- Product Coverage - checked that the products contained valid data for the intended extent or footprint of the earth's surface and not data for anywhere outside that area.
- Product Characteristics - checked the data contained within the files to ensure the values were within an acceptable range and there were no unexpected values.

The USGS PM and the LBG members approved the LF 2016 Product Acceptance Reports per GeoArea, signifying their acceptance of the final project deliverables based on the information provided in the PAR.

After product acceptance, the products were published to LANDFIRE.gov website making them readily accessible to the public.

3.3 Data Standards

LANDFIRE's 2012 Charter states that "Products and practices will comply with relevant Federal Geographic Data Committee (FGDC) and National Wildfire Coordinating Group (NWCG) standards."

Metadata: Information on how LF follows FGDC guidelines for metadata is provided in Appendix 2 and summarized here. LF 2016 Remap metadata was created with guidance from the USGS Metadata Creation website. This metadata was then checked for FGDC compliance and errors with Metadata Wizard 2.0.6 'Run Validation' tool and with the USGS Geospatial Metadata Validation

Service detailed here. Additionally, LF metadata underwent internal and external review following the metadata review procedures outlined by the USGS Review Page. Finally, after the release of each dataset, LF published its metadata to the Data.Gov site, so it could be made available to Geoplatform. Posting metadata to the Geoplatform is also a requirement of this standard.

3.4 Data Quality

The LF 2012 Charter states that "Product quality agreement assessments will be performed at appropriate times based on available and applicable data. The target assessment quality was 60-80% agreement at the group level within the NVC vegetation hierarchy and 70-90% agreement at the macro-group level in the hierarchy at the Geographic area or Super Zone level for existing vegetation types or cover types based on an adequate statistical sample of ground plots. Products and practices will comply with relevant FGDC and NWCG standards."

LF 2016 Remap EVT Agreement Assessment was provided for each LF GeoArea, including contingency and category agreement tables for Ecological systems, and a crosswalk to Society of American Foresters-Society for Range Management (SAF-SRM) Cover Types. Direct assessment of NVC Group and NVC Macrogroup EVT products were also performed and were included with the other assessments results on the LF website LANDFIRE Program: Data Products - Data Quality - LF Remap EVT Agreement Assessment. Users that visited the site were encouraged to review the ReadMe information available in each spreadsheet and included white papers (LANDFIRE Remap Vegetation Type Agreement Assessment Summary) which provide context for this information. As stated in the posted white paper: Goals of the LANDFIRE 2016 Remap Agreement Assessment Summary were to:

- Provide timely information on the quality and usability of the EVT spatial data.
- Ensure a consistent approach across each of the EVT product classifications, including Ecological Systems classification (ES), NVC, and the SAF/SRM system.
- Provide this information in a consistent way across each GeoArea product as the spatial data products are released for distribution.

The process of this assessment was to provide a comparison of the LF EVT product for a pixel with the LF Auto-Key EVT assignment for a sample plot contained in that pixel. The assessment plot database for each GeoArea was composed of a 10% random sample of LFRDB plots within each Vegetation Production Unit (VPU). Plots were distributed across VPUs to ensure as much geographic diversity as possible within a GeoArea. The maximum number of assessment plots drawn for a category was 300. If a category had fewer than 300 total LFRDB plots in a GeoArea, no assessment plots were withdrawn to conserve plots for the mapping process. An agreement assessment was done as part of the LF2016 work with results shown in table 2.

GeoArea	Total Number of Assessment Plots	ES Product Categories With An Assessment Plot	Overall ES Product Agreement	NVCG Product Categories With An Assessment Plot	Overall NVCG Product Agreement
NW	9,724	169	47%	130	48%
SW	12,949	202	42%	173	46%
NC	7,155	141	40%	96	42%
SC	3,236	154	46%	123	44%
NE	10,945	195	43%	140	43%
SE	10,152	208	43%	50	50%
AK	5,069	89	38%	63	41%
HI	411	25	60%	12	73%

Table 2. LF2016 map agreement assessment result by GeoArea

Results shown in Table 2 indicate that the target assessment quality levels outlined in the LF 2012 Charter were not met. It is acknowledged that many factors impact the agreement results and the documentation available for each GeoArea provide contextual information (e.g. for some EVT and NVC categories, the agreement was high while others were only slightly off target). For example, a pixel could be mapped as a very similar ES or NVC category but was classified as a full error in this assessment. Additionally, over half of mapped EVT or NVC were too rare to perform an agreement assessment (e.g. those for which there wasn't enough training data to withhold for testing). LANDFIRE's thematic resolution is unprecedented and is often orders of magnitude greater that other national mapping programs given the number of classes being mapped.

Section 4 LESSONS LEARNED

This section provides information on lessons learned as part of pulling this report together and documenting what happened with the LF2016 project.

NE LF Liaison:

Element: Although the position was not specific to producing LF 2016, the addition of the NE LF liaison was very helpful in gathering additional field plot data. As a result of this effort, new data sharing agreements were established. The collection of additional plots helped in several ways (e.g. direct mapping of both common and rare EVT types increasing the quality of the products).

Lesson learned: Where possible, establishing dedicated area liaisons can provide an array of benefits where focused attention is not feasible for national efforts such as LANDFIRE.

LCMAP Coordination:

Element: The pre-planning between LF and LCMAP was important for the strategic incorporation of the best available data into the LF mapping processes. Analysis Ready Disturbance data contributed to the detection of changes that were key for vegetation and fuel mapping.

Lesson learned: Ensure that data are available before starting mapping work. Although the delay allowed more preparation time for remapping, it was costly to the program due to lost time.

NVCS Independently Mapped:

Element: Coordination for mapping the NVC as part of the product suite was underway in 2015, as noted in the prototyping report (Picotte, J.J. et al. 2019 - LANDFIRE Remap Proto-type Mapping Effort). A series of reviews and meetings with stakeholders were conducted to support these efforts. As part of this planning, a whitepaper was developed with the USGS Technical Lead playing a major role in breaking out these options. The principal two options were to either map NVC as part of a crosswalk from the Ecological Systems vegetation legend or to map it independently. The paper written by Birgit Peterson outlined options (Appendix 5) and the outcome of the mentioned stakeholder engagements were to map NVC independently. LF 2016 production progressed, and NVC was reported as mapped and delivered in the PAR. As a number of geographic areas were completed and the data were reviewed/assessed (particularly for the quality agreement assessment), it came to light that although NVC was required to be mapped (see Prototyping section), it was not being universally mapped independently per the business direction. It is important to note that some portions of it were mapped independently, while others were cross-walked from Ecological Systems. Given the course of events that transpired with this NVC mapping work, things were coordinated with USGS but timing to re-work things was not a viable option and products had to be accepted as delivered. As a result, business leadership worked with the FGDC Vegetation Subcommittee on a potential prospectus to conduct a review. As of the completion of this report, the prospectus was being deliberated but no specific outcome.

Lessons learned: Reviews of NVC draft vegetation products by experts in vegetation outside of EROS were not adequately communicated to business leads at the time of review by anyone involved, including NatureServe directly or via TNC partners or TSSC contractors. These reviews indicated that some NVC group concepts were essentially identical to ES class concepts or that the edited ES map better represented the intended NVC group concept than what was indicated in draft modeled NVC group maps. It is incumbent upon government project managers (particularly in this case USGS PM and USGS Technical Lead) and business leads (particularly in this case DOI-Office of Wildland Fire and USDA- Fire and Aviation Management) to make certain the intent and requirements are clearly understood and to modify the contract should directives change during the Period of Performance. It is important to note that during this time in the LF program there had been multiple USGS project managers that transitioned to other positions. Consistency in following through as well as communicating across the program was lacking. As a result, the business leads were not included in many key development decisions or statement reviews during this time and were unable to check or verify the changing situation. Those managing the LF work at USGS (both project management and science) need to be tracking things to ensure they are in place as planned, prototyped, and directed. When there are deviations from the plan, USGS needs to be coordinating and communicating to business leads when there may be differences with government direction (requirements, meetings, white papers, etc.) so options to rectify the situation may be identified. Similarly, business leads need to be tracking results and understanding the work, (including that of contractors, subcontractors and grant recipients) with timely, open communication so they can effectively support these efforts, Conversely, it is critical that the contractors understand they are to communicate to government project management and business leads and to get clarity as work is done. If there is any uncertainty concerning government provided directives, contractors should not proceed with work or methodologies that are not agreed to by the government business leadership.

90KM Buffer:

Element: This element was identified as part of the RSAs before and during LF 2016 remap. Work was not implemented on this as it should have been in CONUS and only occurred with mapping in Alaska after multiple business lead discussions. As a result, additional review and input from business leaders was required to reinforce this work.

Lesson learned: Like the NVC element, this was a time in the LF program when a few USGS project managers transitioned to other positions, resulting in inconsistencies with follow through and program communication. Consistent and direct communication is required to preserve historical knowledge of the work and ensure people in positions of authority at USGS follow through on tasks. Ensuring that all LF management can access and address issues across the organization, even when there are gaps in positions, is paramount to this work.

Product Acceptance Reports (PARs):

Element: It is good that PARs were generated for each data product at the time of release to document product content and accessibility from the website.

Lesson learned: PARs served as general product documentation, but further improvements are needed to capture more detailed information about functions and capabilities of the work process while also incorporating quality measures (even if qualitative) with mapping updates. This work will be emphasized and implemented in the future.

Contractor Team feedback on what went well:

- Stakeholder responses to final mapped product was positive.
- Jira and Confluence project task organization was effective in helping team organize and track progress.
- Regular scrum meetings were beneficial for communication and progress. Frequent daily stand ups enabled better work coordination, identification of issues and quicker problem solving.
- HPC Denali was a better processing method than the EROS HPC.
- New Imagery method increased efficiency.
- Standardized attribution tables, metadata, made compliant, standardized, established naming conventions.
- Alaska reviews and user involvement created an improved process however this was a time intensive effort.
- Establishing a process for final products to be handed off to distribution was defined and helped the flow of data.
- Communications were strong for the Remap release. The "jumanji drums" video was effective along with several other short communications. During this time the LANDFIRE YouTube channel expanded significantly.
- Reference (LFRDB and Events):
    - Over 770,000 new plots were added to the LFRDB for Remap. This increased the training data available for Remap.
    - An additional staff member was added to the Reference team to help process plot data which allowed us to add more data to the LFRDB.
    - Shrubland and grassland plots were added to the LFRDB through data share agreements with National Resource Inventory (NRI), BLM Assessment, Inventory, and Monitoring Data (AIM), and Natural Heritage Program Data.
    - Auto-Keys for NVCS Group were created and Auto-Keys for Ecological System were improved so plots would key out more accurately. Most of the plots run through the Auto-Key, keyed out to an Ecological System and NVCS group.
    - NatureServe helped to crosswalk element occurrence plots which was an essential and valuable service.
    - A new public version of the LFRDB was released, representing first public update to the LFRDB since National.
    - Treatment and disturbance data for Events geodatabase was processed, in addition to the Plot data for the LFRDB.
    - Over 230,000 Event perimeters were processed for Remap.
    - A new public version of the Events Data was released.

- Vegetation:
    - Python scripting was very important for vegetation production, and it will be critical for future production to include staff with this ability.

<u>Contractor Team Feedback on what could have been done better:</u>

- Time constraints negatively impacted some product areas more than others.
- External dependencies introduced challenges (e.g. determining how to coordinate receiving data in timely fashion could have eliminated the need for ‘go backs’).
- Clearly defining and baselining project scope and deliverables to set expectations and avoid mid-production changes.
- As much as possible, addressing and recording all product requirements early in planning and prior to contract creation.
- Reviews with multiple areas could help improve the product. Adding time into our schedule for the reviews.
- When miscommunications led to work being excluded from contracts and thus not completed by contractors due to insufficient contractor resources, the desired additional work should have been addressed through contract modifications.
- Mechanisms to incorporate scientific and technological advances into production during a contract period need to be accounted for.
- Fuels in the west were impacted by having little to no chapparal in final EVT product and all sparse vegetation having EVC between 10% and 29%, which needs to be addressed in the future.
- Reference (LFRDB and Events):
    - Processing plot data was time consuming, so planning was necessary. Starting data processing early and adding an additional staff member are essential.
    - Many plots were added to the LFRDB but not all of them were current. Some of the plots were older; finding new, current data was a challenge.
    - Continuing to acquire high quality shrubland and grassland plots will continue to be important for future updates.
    - There is still room for improvement with the Auto-Keys. The vegetation mappers have suggestions about how they could be improved and should be included in any future evaluations.
    - Having NatureServe available to crosswalk the data is essential if Element Occurrence data is acquired for future updates.
- Vegetation:
    - Prior to beginning production in 2017, the production team participated in numerous meetings, field trips, and prototyping work, making them somewhat ill prepared for the production process. The team took additional time to develop a process to complete the first Vegetation Production Unit. It is recommended that the production team be better prepared before starting production.
    - Producing EVT-NVC required one Full-Time-Equivalent (FTE) and represented 1/3 of vegetation production (1 of 3 people modeling vegetation). It is recommended that one EVT be produced instead of two for more efficient use of resources.
    - Vegetation Production Units (VPUs) and Mapzones/GeoAreas did not line up. As such, the first 6 VPUs had to be completed to cover the first GeoArea causing delays and extra production steps. If Fuels are going to continue to use Mapzones

and Distribution is going to continue to use GeoAreas, then it is recommended that Vegetation use the same production units.

- Excessive time was spent mapping EVT-ES that did not impact fuels. Many time-intensive EVT-ES were riparian/wetland, barren/sparse, or rare EVTs that were aggregated in the past and are important to identifying fuels. It is recommended that difficult EVTs be reviewed prior to mapping to confirm their value justifies the means of producing them.

Section 5 CONCLUSION

Most of the scope of LF 2016 Remap project was accomplished and completed on schedule. Deliverables were reviewed for acceptance through the product acceptance reports based on the information provided. Based on the product release timing, some elements (e.g. not mapping NVCS independently) had to be accepted and approved by the LBG and then published to the LANDFIRE.gov website as is. The best available science and applicable data and metadata standards were followed. All required documentation was completed and accepted by the LBG. LANDFIRE 2016 Remap is administratively closed.

Section 6 REFERENCES

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Section 7 APPENDICES

APPENDIX 1 – LF 2016 Remap Products

Theme	Acronym
REFERENCE	
LFRDB	LFRDB
Events (Exotics, Raw, ModelReady)	EventsDB
DISTURBANCE	
Disturbance Grids	DISTyyyy
Historical Disturbance	HDist
VEGETATION	
Biophysical Settings	BPS
Existing Vegetation Cover	EVT
Existing Vegetation Height	EVH
Existing Vegetation Type	EVT
National Vegetation Classification	NVC
FUEL	
Surface Fuel	
13 Anderson Fire Behavior Fuel Models	FBFM13
40 Scott and Burgan Fire Behavior Fuel Models	FBFM40
Canadian Forest Fire Danger Rating System	CFFDRS
Fuel Characteristic Classification System Fuelbeds	FCCS
Canopy Fuel	
Forest Canopy Cover	CC
Forest Canopy Height	CH
Forest Canopy Bulk Density	CBD
Forest Canopy Base Height	CBH
Fuel Vegetation	
Fuel Vegetation Cover	FVC
Fuel Vegetation Height	FVH
Fuel Vegetation Type	FVT
Fuel Disturbance	FDist

Theme	Acronym
Fuel Rulesets Database	FRDB
FIRE REGIMES	
Vegetation Condition Class	VCC
Vegetation Departure Index	VDep
Succession Classes	SClass
TOPOGRAPHIC	
Aspect	Asp
Elevation	Elev
Slope	Slp

APPENDIX 2 – LF 2016 Remap Requirements

5.1	Capability Requirements	
5.1.1	Compliance	LANDFIRE shall comply with applicable data standards and requirements for geospatial and ground reference data.
	5.1.1.1	LANDFIRE shall comply with all applicable requirements for archiving data and information per Handbook for Managing USGS Records, 432-1-H.
	5.1.1.2	LANDFIRE shall comply with National Spatial Data Infrastructure and Federal Geographic Data Committee standards for production of metadata per Content Standard for Remote Sensing Swath Data, FGDC-STD-009-1999.
	5.1.1.3	LANDFIRE shall comply with the National Vegetation Classification Standard (NVCS)
	5.1.1.4	LANDFIRE shall comply with the National Wildfire Coordinating Group (NWCG) data standards
5.1.2	Security	LANDFIRE shall provide physical and Information Security for facilities, equipment, and data in accordance with NIST SP 800-53 and all relevant annexes.
	5.1.2.1	LANDFIRE shall provide physical and Information Security for FIA data in accordance with LANDFIRE_1500-15DSP_v2.4
5.1.3	Spatial Coverage	The LANDFIRE Program is national and includes all lands within the United States and Insular Areas.
5.1.4	Spatial Scale	LANDFIRE data is at the 30-meter pixel level.
5.1.5	Temporal Resolution	LANDFIRE products can be compared against previous versions and to be updated and remapped to maintain currency and relevance.

5.1.6	Collaboration	Work is developed and completed in partnership with other experts within and outside of the government; a coordinated approach to allow for field point and polygon data integration with remote sensing change detection. The LANDFIRE program will not produce “custom” products for specific customers but is responsive to customer needs that provide a broad benefit to many users.	
5.1.7	Relevancy	LANDFIRE products are scientifically defensible for monitoring and characterizing change over time. Data are developed and designed such that the data can be analyzed and compared across different areas of the U.S.	
5.1.8	Management	The LANDFIRE Program is managed to maintain costs, scope, and schedule.	
5.1.9	Compatibility	LANDFIRE program deliverables will be compatible with previous versions to assist in monitoring changes over time. Map data will be produced based on peer-reviewed science related to remote sensing, geospatial analysis, vegetation and fuel modeling, land change dynamics, and fire behavior/effects. Consistency across all ownerships and iterative data improvements are key quality objectives of the program.	
5.1.10	Accuracy	LANDFIRE product quality assessments will be performed at appropriate times based on available and applicable data. The target assessment quality is 60-80% agreement at the group level within the National Vegetation Classification System (NVCS) vegetation hierarchy and 70-90% agreement at the macro-group level in the hierarchy at the Geographic area level.	
5.2	System Operations Requirements		
5.2.1	Product Delivery	Operations will provide and manage the computer infrastructure to support LANDFIRE data archiving, access, and distribution capability. The system will require a minimum of human interactions where data access and distribution occur, without the need for in-depth interface with the user, except for basic customer support. The operational paradigm also includes equipment and services to provide continuity of operations for uninterrupted data distribution services and data backup.	
	5.2.1.1	Data Distribution Site	
	5.2.1.2	Other	
		5.2.1.2.1	WCS
		5.2.1.2.2	FST Drive
		5.2.1.2.3	WFDSS
		5.2.1.2.4	Mosaics
	5.2.1.3	Equipment and Infrastructure	

5.2.2	Product Maintenance	Operation service providers are responsible for archiving data products from the initial cycle of LANDFIRE including the LANDFIRE reference database. The operations paradigm includes addition of new data as LANDFIRE data products are updated and remapped and the addition of LANDFIRE updates while maintaining a separate database of the initial cycle of LANDFIRE.	
	5.2.2.1	Data Versioning	
	5.2.2.2	Alerts	
	5.2.2.3	Notifications	
	5.2.2.4	Bulletins, Postcards	
	5.2.2.5	Archiving	
5.2.3	Product Support	Operation service providers are responsible for providing support to product web pages.	
	5.2.3.1	Website	
		5.2.3.1.1	Product Pages
		5.2.3.1.2	Metadata Elements
		5.2.3.1.3	Applications
	5.2.3.2	Help Desk	
	5.2.3.3	Tools and Training	
5.3	Product Requirements		
5.3.1	Reference Data	Reference products represent data collected from public, government, and proprietary sources to inform the LANDFIRE (LF) mapping processes and update LF products.	
	5.3.1.1	Reference data sources	
		5.3.1.1.1	Forest Inventory and Analysis (FIA) data
		5.3.1.1.2	National Resource Inventory (NRI) data
		5.3.1.1.3	Bureau of Land Management (BLM) AIM data
		5.3.1.1.4	FEAT/FIREMON Integration (FFI) data
		5.3.1.1.5	National Park Service (NPS) Inventory and Monitoring (I&M) data
		5.3.1.1.6	Forest Service FSVeg data
		5.3.1.1.7	Bureau of Indian Affairs (BIA) Continuous Forest Inventory (SFI) data
		5.3.1.1.8	State-based Heritage program data
		5.3.1.1.9	Plot data available through VegBank

		5.3.1.1.10	Miscellaneous plot data acquired through LANDFIRE yearly data call
		5.3.1.1.11	FACTS data from the Forest Service
		5.3.1.1.12	NFPORS from the BLM
		5.3.1.1.13	Insects and disease activity data available through the FHTET project
		5.3.1.1.14	Miscellaneous activities data acquired through LANDFIRE yearly data call
	5.3.1.2	Reference data products	
		5.3.1.2.1	LANDFIRE Reference Database (LFRDB)
		5.3.1.2.2	Events Geodatabase (Raw, Model Ready, Exotics)
5.3.2	Disturbance Data	Disturbance products are developed to help inform updates to LANDFIRE (LF) data to reflect change on the landscape caused by management activities and natural disturbances. They are a compilation of data from: Landsat satellite imagery Burned Area Reflectance Classification (BARC) Rapid Assessment of Vegetation Condition after Wildfire (RAVG) Monitoring Trends in Burn Severity (MTBS) LF Events Geodatabase User contributed data Other ancillary data	
	5.3.2.1	Disturbance Data Sources. Landsat imagery provides improved sources of data to derive LANDFIRE products and will be evaluated for analysis and potential use in the LANDFIRE production process. Remotely sensed data products generally reflect existing vegetation conditions but also leverage times series data available through the Landsat archive. These data will be the primary source of spectral data to map current vegetation conditions in terms of species composition and structure. These data provide centralized processing and a ready source of analysis data for mapping teams. Data are consistently formatted across all geo-areas in terms of available bands and geographic extent.	
		5.3.2.1.1	Landsat Imagery. Three-year archive of Landsat 8 data Ten-year archive of Landsat 7 data converted into NDVI and other indices
		5.3.2.1.2	LCMAP analysis ready data available in fall of 2016
		5.3.2.1.3	NLCD 2016 data as the coarsest level of vegetation land use
		5.3.2.1.4	Cropland Data Layer (CDL) for agricultural areas

		5.3.2.1.5	Tree Canopy Cover (TCC) data available through the FIA/RSAC collaboration
		5.3.2.1.6	Continuous herb and shrub data available through NLCD
		5.3.2.1.7	Wetland and riparian area available through NOAA CCAP program
		5.3.2.1.8	Scaled-down MODIS data available through EROS (Wylie)
		5.3.2.1.9	Lidar available through a wide range of mapping efforts across the country
		5.3.2.1.10	Burned Area Reflectance Classification (BARC) data
		5.3.2.1.11	Rapid Assessment of Vegetation Condition after Wildfire (RAVG) data
		5.3.2.1.12	Monitoring Trends in Burn Severity (MTBS) data
		5.3.2.1.13	Land Use Land Cover data
	5.3.2.2	Disturbance Data	
		5.3.2.2.1	Disturbances need to be captured and used for mapping sooner and more frequently
		5.3.2.2.2	Rulesets used to change maps due to disturbance need to be reviewed and refined
		5.3.2.2.3	Leverage the efforts of LCMAP to capture disturbance
		5.3.2.2.4	Leverage the efforts of NAFMD to more consistently predict disturbance causality
		5.3.2.2.5	Leverage the efforts of LCMS to more consistently predict disturbance causality
	5.3.2.3	Disturbance data products	
		5.3.2.3.1	Disturbance (D2017, D2018, D2019)
		5.3.2.3.2	Fuel Disturbance (FDist)
		5.3.2.3.3	Historical Disturbance (HDist)
5.3.3	Vegetation Data	<u>Existing</u> vegetation layers are created using predictive landscape models based on extensive field-referenced data, satellite imagery and biophysical gradient layers using classification and regression trees. <u>Potential</u> vegetation layers are created using predictive landscape models based on extensive field-referenced data and biophysical gradient layers using classification and regression trees.	
	5.3.3.1	Vegetation data sources	
		5.3.3.1.1	Gradients data available through the LANDFIRE National project

		5.3.3.1.2	TOPO WX data available
		5.3.3.1.3	STATSGO as the coarsest sources of soils data
		5.3.3.1.4	More recent STATSGO2 product, improvement of the original
		5.3.3.1.5	Most recent SSURGO data and key attributes
		5.3.3.1.6	SSURGO derivatives including soil productivity and drainage
		5.3.3.1.7	Most recent elevation data available through NED
		5.3.3.1.8	Simple elevation derivatives created from NED data
		5.3.3.1.9	More advanced terrain derivatives created from NED
		5.3.3.1.10	Landform data – either off the shelf or derived
	5.3.3.2	Vegetation data	
		5.3.3.2.1	Vegetation types need to portray one life-form only
		5.3.3.2.2	Vegetation types need to portray one leaf-form only
		5.3.3.2.3	Life-form and leaf-form should clearly tier to NLCD source data
		5.3.3.2.4	Complete definitions-descriptions of all vegetation types need to be provided
		5.3.3.2.5	Geographic distributions of types must be clearly identified
		5.3.3.2.6	Provide a separate legend portraying existing vegetation as dominant vegetation
		5.3.3.2.7	Provide a separate legend portraying existing vegetation as an ecological system
		5.3.3.2.8	Provide a separate legend portraying existing vegetation as classes in the NVC
		5.3.3.2.9	Adjustments in existing vegetation height legends need to be considered
		5.3.3.2.10	Shared/merged legends between LANDFIRE and GAP needs to be implemented
		5.3.3.2.11	Clarify how type definitions relate to cover and height
		5.3.3.2.12	Vegetation types need to portray one life-form only
		5.3.3.2.13	Vegetation types need to portray one leaf-form only
	5.3.3.3	Vegetation data products	

		5.3.3.3.1	Existing Vegetation Type (EVT)
		5.3.3.3.2	Existing Vegetation Cover (EVC)
		5.3.3.3.3	Existing Vegetation Height (EVH)
		5.3.3.3.4	National Vegetation Classification (NVC)
		5.3.3.3.3	Biophysical Settings (BPS)
5.3.4	Fuel Data	LANDFIRE (LF) fuel data describe the composition and characteristics of surface and canopy fuel. They provide consistent fuel data to support fire planning, analysis, and budgeting to evaluate fire management alternatives, and supplement strategic and tactical planning for fire operations.	
	5.3.4.1	Fuel data products	
		5.3.4.1.1	13 Anderson Fire Behavior Fuel Models (FBFM13)
		5.3.4.1.2	40 Scott and Burgan Fire Behavior Fuel Models (FBFM40)
		5.3.4.1.3	Canadian Forest Fire Danger Rating System (CFFDRS)
		5.3.4.1.4	Fuel Characteristic Classification System (FCCS)
		5.3.4.1.5	Fuel Loading Models (FLM)
		5.3.4.1.6	Forest Canopy Cover (CC)
		5.3.4.1.7	Forest Canopy Height (CH)
		5.3.4.1.8	Forest Canopy Bulk Density (CBD)
		5.3.4.1.9	Forest Canopy Base Height (CBH)
		5.3.4.1.9	Fuel Vegetation Cover (FVC)
		5.3.4.1.9	Fuel Vegetation Height (FVH)
		5.3.4.1.9	Fuel Vegetation Type (FVT)
5.3.5	Seasonal Fuel Mapping	Average fire conditions have more limited utility in areas where seasonal conditions have profound impacts on the available fuels. Methodologies are being developed to address this limitation, recognizing that fuel conditions in different regions of the country are affected by different processes. These data will be produced operationally and made available through the LANDFIRE data distribution site.	
	5.3.5.1	Southeast Seasonal Fuel Map	
	5.3.5.2	Great Basin/Southwest Seasonal Fuel Map	
5.3.6	Fire Regimes Data	Historical fire regimes, intervals, and vegetation conditions are mapped using the Vegetation Dynamics Development Tool (VDDT). These data support fire and landscape management planning goals in the National Cohesive Wildland Fire Management Strategy, the Federal Wildland Fire Management Policy, and the Healthy Forests Restoration Act.	

	5.3.6.1	Fire Regimes data	
		5.3.6.1.1	Need to capture seasonal fluctuations in annual grasses that influence available fuel
		5.3.6.1.2	Need to capture seasonal fluctuations in organic fuel availability due to drought
		5.3.6.1.3	The data needs to characterize seasonal modulations in leaf phenology
		5.3.6.1.4	Review/refinement of rulesets used to map surface fuel models
		5.3.6.1.5	Review/refinement of rulesets used to map surface fuel models post disturbance
		5.3.6.1.6	The data needs to characterize seasonal modulations in available agricultural fuel
		5.3.6.1.7	Fire danger rating fuel models need to be mapped across all lands
		5.3.6.1.8	Need to capture seasonal fluctuations in coarse fuel availability due to drought
		5.3.6.1.9	Need to account for fuel loading variability across the landscape in fuel maps
		5.3.6.1.10	Refinement of rulesets used to map fuel loads after disturbance
		5.3.6.1.11	Characterize available fuel loads in agricultural landscapes
		5.3.6.1.12	Characterize available fuel loads in urban landscapes
		5.3.6.1.13	Review and refine relationships between fuel loads and fuel load classifications
		5.3.6.1.14	Need to capture seasonal fluctuations in coarse fuel availability due to drought
		5.3.6.1.15	Characterize available crown fuel loads in forests using crown biomass
		5.3.6.1.16	Capture more accurate fire regimes based on soil moisture and productivity
		5.3.6.1.17	Capture more consistent spatial pattern of fire regimes on the landscape
		5.3.6.1.18	More definitive links between landscape fire regimes and BpS models
		5.3.6.1.19	Review/refinement of rulesets used to map succession class products
		5.3.6.1.20	Review/refinement of departure mapping techniques

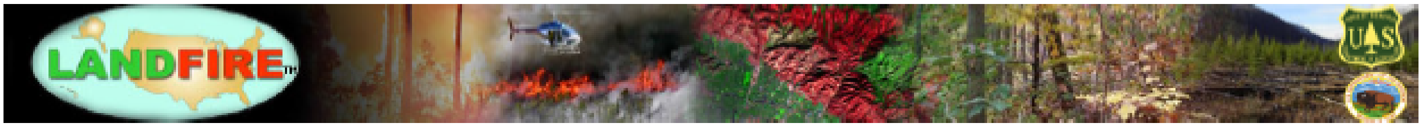
		5.3.6.1.21	Characterize departure in fire frequency and fire severity in addition to vegetation
		5.3.6.1.22	Capture current distribution of exotics species on the landscape
		5.3.6.1.23	Account for human modified vegetation in the departure mapping process
		5.3.6.1.24	Account for disturbance in the departure mapping process
	5.3.6.2	Fire Regimes data products	
		5.3.6.2.6	Vegetation Condition Class (VCC)
		5.3.6.2.7	Vegetation Departure (VDep)
		5.3.6.2.8	Succession Classes (SClass)
5.3.7	Topographic Data		
	5.3.7.1	Topographic data products	
		5.3.7.1.1	Aspect (Asp)
		5.3.7.1.2	Elevation (Elev)
		5.3.7.1.3	Slope (Slp)

APPENDIX 3 – LF 2016 Remap Schedule and Releases

LF 2016 Remap				
Release #	Release Area	Data	Name/Version	Release Date
1	NW	Disturbance, Vegetation, Fuel	LF 2016 Remap/LF 2.0.0	02/2019
1	CONUS	Topographic	LF 2016 Remap/LF 2.0.0	02/2019
2	NW	Adjusted Fuels (Version Alert)	LF 2016 Remap/LF 2.0.0	06/2019
2	SW	Disturbance, Vegetation, Fuel	LF 2016 Remap/LF 2.0.0	06/2019
3	SC	Disturbance, Vegetation, Fuel	LF 2016 Remap/LF 2.0.0	08/2019
4	NC	Disturbance, Vegetation, Fuel	LF 2016 Remap/LF 2.0.0	10/2019
5	SE	Disturbance, Vegetation, Fuel	LF 2016 Remap/LF 2.0.0	04/2020
6	NE	Disturbance, Vegetation, Fuel	LF 2016 Remap/LF 2.0.0	07/2020
7	CONUS	Disturbance, Vegetation, Fuel, Reference (Public Events Geodatabase)	LF 2016 Remap/LF 2.0.0	07/2020
7	CONUS	Fire Regime (SClass, VCC, VDep), Vegetation (BPS updated attribute table), Fuel (FCCS)	LF 2016 Remap/LF 2.0.0	10/2020
8	HI	Disturbance, Vegetation, Fuel, Topographic, Fire Regime, BPS	LF 2016 Remap/LF 2.0.0	10/2020
9	IA	Disturbance, Vegetation, Fuel, Topographic	LF 2016 Remap/LF 2.0.0	03/2021
10	CONUS, AK, HI	Reference, Fuel (FRDB)	LF 2016 Remap/LF 2.0.0	08/2021
10	AK	Disturbance, Vegetation, Fuel, Topographic	LF 2016 Remap/LF 2.0.0	08/2021

APPENDIX 4 – LF 2015 Remap Summary Description

This whitepaper was developed to provide guidance and direction for the remap project. The effort was initially planned to be called LF 2015 however coordination at USGS with the Land Change Monitoring, Assessment, and Projection (LCMAP) effort indicated that it would be able to provide an Analysis Ready Data (ARD) land change product that would be beneficial in LF disturbance mapping work, so the program delayed production for a year. As such, this effort became known as LF 2016 Remap.



LANDFIRE Remap, Summary Description

September 2015

Introduction

The purpose of this summary paper is to provide information about the current plan to remap the nationwide LANDFIRE products of vegetation and fuels data.

The LANDFIRE Program, since 2004, has strived to produce comprehensive, consistent, and scientifically based suites of mapped products and associated databases for the United States and territories. These products depict the nation's major ecosystems and wildlife habitats with the highest accuracy and currency possible. Over a decade has passed since the development of the first LANDFIRE base map, LANDFIRE National circa 2001 (LF c2001), and an overhaul of the data products is needed to maintain their functionality and relevance. An evaluation was conducted to identify needs, costs, and benefits for a remap which resulted in a business plan for remap. The business plan identifies the remap effort and the overall vision and purpose for the LANDFIRE Program. Opportunities have been identified, as a part of this remap, to enhance the suite of national-scale land cover, vegetation, fuel, and fire products to meet needs for decision making and sustainable planning processes.

This document is presented in a question and answer format addressing questions likely to be posed by current and potential LANDFIRE users.

What is LANDFIRE?

LANDFIRE, also known as the Landscape Fire and Resource Management Planning Tools Program, is a vegetation, fire, and fuel characteristic data creation program managed by both the U.S. Department of Agriculture (USDA) Forest Service (FS) and the U.S. Department of the Interior (DOI) with involvement from The Nature Conservancy (TNC). LANDFIRE represents the first and only complete, nationally consistent collection of over 20 geo-spatial layers (e.g. vegetation, fuel, disturbance, etc.), databases, and ecological models that can be used across multiple disciplines to support cross-boundary planning, management, and operations across all lands (30 meter pixel resolution) of the United States and insular areas (Figure 1). LANDFIRE data products are designed to be used at a large landscape-scale in support of strategic vegetation, fire, and fuels management planning to evaluate management alternatives across boundaries. LANDFIRE data products facilitate national- and regional-level strategic planning and reporting of wildland fire and natural resource management activities.

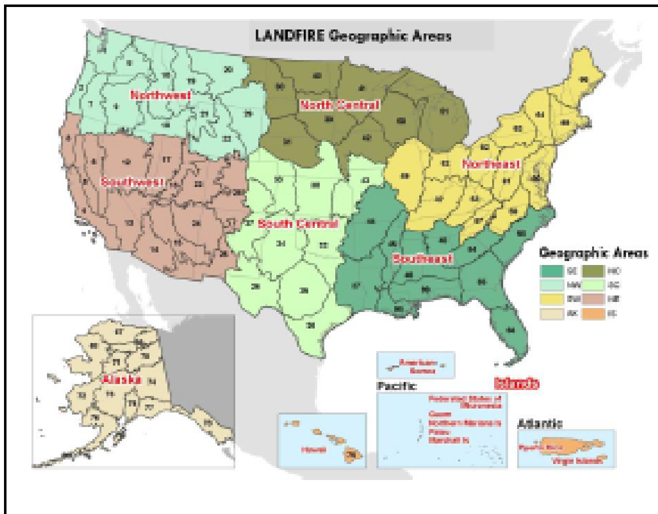


Figure 1. Map of the LANDFIRE geographic areas across the United States and insular areas.

Why was LANDFIRE developed?

In 2000, the Government Accountability Office (GAO) stated that "Federal land management agencies do not have adequate data for making informed decisions and measuring the agencies' progress in reducing fuels." In 2002, GAO reported (GAO-02-259) that "Data are not available to better prioritize communities and projects for funding," and concluded that "On the basis of our review, LANDFIRE is the only proposed research project so far that appears capable of producing consistent national inventory data for improving the prioritization of fuel projects and communities." LANDFIRE began with a prototype in 2002 and was officially chartered in 2004 by the Wildland Fire Leadership Council based on the need of accurate, complete, and comparable data for all lands.

How is LANDFIRE data made and how is it being used?

There are several documents that detail how LANDFIRE data is produced and how data are used and they are available through these websites: http://landfire.gov/library_list.php and http://www.landfire.gov/lf_applications.php.

What is a "Remap" in LANDFIRE?

According to the Merriam-Webster dictionary the definition of REMAP is: *to map again*; also: *to lay out in a new pattern.*

A LANDFIRE remap is defined as performing a comprehensive mapping effort that uses new data (e.g., Landsat 8 and new point and field data) to create a new base map data suite that represents contemporary conditions, rather than using change detection techniques, look up table transitions, or modeling to represent current conditions. A remap differs from an update, which is a vegetation and fuels mapping effort focused primarily on the existing base product suite to more accurately represent current conditions and account for landscape disturbances.

The simple response to the question – "What is a LANDFIRE remap?" is LANDFIRE will produce a completely new base map data suite that is as reflective of ground conditions as possible for a given time period.

The remap effort will provide an opportunity for the LANDFIRE Program to evaluate past production processes and methods of using remotely sensed and field data for map development. This review includes exploring mapping methods to maximize the use of the available data and past mapping efforts, and provide a characteristic representation of contemporary conditions for areas that are undergoing change. Much of this change has been invisible to date due to the gradual changes of continual vegetation growth occurring across the landscape. Organizing existing data will facilitate the identification of new aspects that need to be considered and potentially incorporated into this remap.

LANDFIRE will retain data that meets certain quality standards and remains valid for current conditions. This will be integrated with new data from Landsat 8, field evaluations, and disturbance polygons.

Why should a LANDFIRE remap be started now and when would it be completed?

The first LANDFIRE mapping effort began in 2004 based on Landsat data with a time stamp of 2001. As a result, today's LANDFIRE mapped data products maintain this 2001 foundation. The data are approximately 15 years old and as much as 10-20% of the landscape has experienced change. Many changes have been captured using disturbance/change detection information and incorporating anticipated vegetation succession and growth. However, subtle vegetation and landscape changes may not be reflected in the current LANDFIRE product versions. New data (remotely sensed and field plot) are available from Landsat 8 with data from NRCS / NRI, FIA and other contributors or partners which will result in improved data products.

LANDFIRE was developed through an interagency partnership between DOI, USFS, and TNC and the original plan was to conduct a remap after 10 years as outlined in the operations and maintenance plans. The remap didn't start as scheduled due to budget sequestration and budget reductions from 2011 through 2013. The current plan is to begin a three year remap effort in 2016 or 2017. The uncertainty with a specific year is due to a new project at the United States Geological Survey (USGS) called Land Change Monitoring, Assessment and Projection (LCMAP). LCMAP has USGS leadership support and is focused on providing data of historical land change with contemporary land change as it occurs using all available data in a continuous change detection and classification which enable detection of changes when pixels deviate from the "normal" condition. The remap will take approximately three years to complete. This length of time is needed to gather, review and process new data sources, and create comprehensive national products. Under this plan, accounting for uncertainty with the start, remapped products will be delivered incrementally as they are produced approximately 2018 through 2020 when the last areas are completed.

Starting soon provides future benefits where contemporary data with improved quality are available for analyses and planning decisions; otherwise the alternative is to continue to rely on updated vegetation and fuels data using change detection techniques, look up table transitions, or modeling to represent contemporary conditions.

What will happen in the LANDFIRE remap?

The remap effort will not simply repeat steps and efforts of past processes but will leverage changes and advancements in data and science to support the development and production of the next generation of data products. This remap will include review of previous LANDFIRE versions, LF c2001, LF 2008, LF 2010, LF 2012, and assess the quality of each (inclusive of quality assessments, after action reviews, questionnaires, customer feedback, etc.).

Elements of the remap include:

- Use Landsat 8 (space-based moderate-resolution land remote sensing and increased number of data bands) data with a 2015 circa date.
- Use ground-based field plot and polygon data
  - Previously contributed data that has been archived in preparation for this remap.
  - Forest Inventory Analysis (FIA) data – based on Memorandum of Understanding (MOU) with USDA FS.
  - National Resource Inventory (NRI) data – based on a MOU with Natural Resources Conservation Service (NRCS).
  - Additional data obtained or contributed (http://www.landfire.gov/participate_refdata_sub.php) as part of the January 31, 2015 data call or a follow on data call in 2016 as the schedule is finalized based on assessing LCMAP capability. If you have missed previous submission dates, please get your data in as soon as possible. More information on how these data may be used is available at: (http://www.landfire.gov/participate_refdata.php).
- Work with new partner such as the USGS Gap Analysis Program (signed MOU).
- Common/nation-wide vegetation mapping classifications
  - Use of Ecological Systems classification and alignment with the National Vegetation Classification Standard (NVCS).
    - Includes additional map units to address non-natural land cover, such as urban or agriculture, or non-vegetated lands, such as barren, rock, or water.
    - Use sequence tables and auto-keys to assign plot data to Ecological Systems and NVCS vegetation classifications.
- Vegetation changes in areas or landscapes where vegetation is not changing as rapidly as other areas.
- New or updated data sets such as new imagery, new or updated field/plot data, partnership data and improvements in algorithms.
  - The addition of these new or updated data have great potential to improve the quality of the LANDFIRE data products especially in areas where lower or limited plot data were available for LF c2001.
- Produce a new foundational base to work from for subsequent updates and inform future remaps.
- The remap effort will deliver the full suite of products for vegetation, fire behavior, fire effects, and fire regime, as well as some products added in recent updates. Table 1 illustrates products under consideration for delivery with remap.

Table 1. LANDFIRE 2015 Remap Draft Deliverables list provides an outline of possible information that will be produced by data theme, product name, product name abbreviation, number of product, as well as deliverables by portion of the country and insular areas.

Theme	Product Name	Abbreviation	LF 2015 (LF 2.0.0)			
			CONUS	AK	HI	IA
Reference	LF Reference Database	LFRDB	x	x	x	x
	Public Events Geodatabase_1999_YEAR		x	x	x	x
	Forest Vegetation Simulator Ready Database	FVSRDB	x	x	x	x
Disturbance	Disturbance (YEAR)	DISTYEAR	x	x	x	x
	Fuel Disturbance	FDISYEAR	x	x	x	x
	Vegetation Disturbance	VDISTYEAR	x	x	x	x
	Vegetation Transition Magnitude	VTMYEAR	x	x	x	x
	Forest Vegetation Transitions Database	FVTDB	x	x	x	x
	Non-Forest Vegetation Transitions Database	NFVTDB	x	x	x	x
	Forest Vegetation Simulator Disturbance Database	FVSDDB	x	x	x	x
Vegetation	Biophysical Settings	BPS	x	x	x	x
	Environmental Site Potential	ESP	-	-	-	x
	Existing Vegetation Cover	EVC	x	x	x	x
	Existing Vegetation Height	EVH	x	x	x	x
	Existing Vegetation Type	EVT	x	x	x	x
	Dominant Cover Type	DCT	x	x	?	?
	Attributed data – Crosswalks to Society of American Foresters/Society for Range Management/NVCS > for EVC, EVH, EVT, DCT	XW	x	x	?	?
Fuel	13 Anderson Fire Behavior Fuel Models	FBFM13	x	x	x	x
	40 Scott and Burgan Fire Behavior Fuel Models	FBFM40	x	x	x	x
	Landscape File	LCP	x	x	x	x
	Canadian Forest Fire Danger Rating System	CFFDRS	x^	x	--	--
	Forest Canopy Bulk Density	CBD	x	x	x	x
	Forest Canopy Base Height	CBH	x	x	x	x
	Forest Canopy Cover	CC	x	x	x	x
	Forest Canopy Height	CH	x	x	x	x
	Fuel Characteristic Classification System Fuelbeds	FCCS	x	x	?	?
	Fuel Loading Models	FLM	?	?	?	?
	Fuel Ruleset Database	FRD	x	x	x	x
Fire Regimes	Fire Regime Groups	FRG	x	x	x	x

Theme	Product Name	Abbreviation	LF 2015 (LF 2.0.0)			
			CONUS	AK	HI	IA
	Mean Fire Return Interval	MFRI	x	x	x	x
	Percent Low-Severity Fire	PLS	x	x	x	x
	Percent Mixed-Severity Fire	PMS	x	x	x	x
	Percent Replacement-Severity Fire	PRS	x	x	x	x
	Succession Classes	SCLASS	x	x	x	x
	Vegetation Condition Class	VCC	x	x	x	x
	Vegetation Departure Index	VDEP	x	x	x	x
	Vegetation Dynamics Models	VDM	x	x	x	x
Topographic	Aspect	ASP	x	x	x	x
	Elevation	DEM	x	x	x	x
	Slope	SLP	x	x	x	x

CONUS = Continental United States
AK = Alaska
HI = Hawaii
IA = Insular areas of the United States
x = Products likely to be done as part of the remap
- = Not likely to be done as part of a remap given historical potential vegetation has not changed
-- = Not available or produced for this area
x^ = As applicable based on data, geography, and improvements
? = Question of data availability and/or future inclusion

More information on each of the LANDFIRE data products can be found at: http://www.landfire.gov/data_overviews.php.

What is the potential for improvement in data quality by incorporating Landsat 8?

Data from the Landsat 8 Operational Land Imager (OLI) have somewhat different characteristics from previous Landsat sensors. OLI collects data in bands similar to previous sensors with slightly different wavelengths that provide greater ability to differentiate spectral data. OLI also collects data in additional bands, such as a coastal/aerosol band and a cirrus cloud detection band that when included with a quality assessment (QA) band will indicate areas of data anomalies, clouds, cloud shadows, etc. thus refining the quality of the data. This information will make combining multiple dates of imagery easier because pixels containing unwanted features can be masked out using the QA band and replaced by data from other scenes. The signal to noise ratio of OLI is higher than that of previous sensors and the data are yielding increased radiometric resolution that provides for an increased ability to discriminate vegetation and land cover types, leading to increased quality of LANDFIRE data products.

Why is the remap being called LANDFIRE 2015 or LF 2015?

LANDFIRE existing vegetation products portray vegetation composition and structure conditions of a given time period. The time period is determined by the average date of Landsat satellite imagery acquisition used for the mapping. In the case of LF c2001 date which indicated that the imagery comprised years 2000 to 2002.

This three year period was necessary in order to piece together a wall-to-wall image across the nation. Data anomalies such as clouds or cloud shadows required data from other years to fill in the gaps. In the case of LANDFIRE 2015 (circa 2015 date), the date or name indicates that the imagery will comprise years 2014 to 2016. The need to build this composite image results in the LANDFIRE remap starting in 2016 or 2017.

Will there be LANDFIRE 2014 or LANDFIRE 2016 updates or do users have to wait until the remap is completed to have updated data?

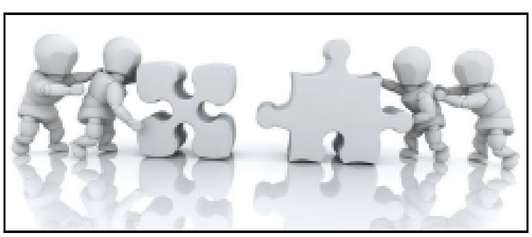
The LANDFIRE team is completing a plan and drafting the schedule for a LANDFIRE 2014 update, which will be similar to previous updates. For LANDFIRE 2016, the plan is to evaluate how to integrate 2016 disturbances (or possibly annual disturbances) into the remap data so when the LANDFIRE remap product suite is delivered, it would account for these disturbances. Similar to previous schedules, information on these projects will be discussed on the LANDFIRE community call and will be posted at http://www.landfire.gov/lf_schedule.php with information on expected delivery dates.

What will happen with previous versions (LF c2001 through LF 2012) of LANDFIRE?

The current LANDFIRE policy is that at least three versions of the data are available and accessible on the Data Distribution Site. These versions include the foundational base map version (LF 2001 until remap effort LF 2015 is complete and delivered) and the two most recent update products, LF 2010, LF 2012, etc.). Previous versions are archived and more information can be obtained about these archives at http://www.landfire.gov/lf_archive.php. Additionally, versions LF 2001 to the most current update will be available as bulk mosaics in zip file format.

Will previous versions of LANDFIRE be compatible with the remap products?

As stated in the program charter, (July 2012, at http://www.landfire.gov/about.php#planning) "LANDFIRE program deliverables will be compatible with previous products to assist in monitoring changes over time."



LANDFIRE remap LF 2015 products will be comparable, but not identical, to previous versions. There may not be a one-to-one comparison with some of the data or layers given changes to the data through the incorporation of disturbances, addition of new field plot data, or changes with definitions or summary units. However, the production process of products will have a scientific approach that allows them to be defensible for monitoring change over time. Also, for the purposes of monitoring change over time, the data are developed and designed so they can be analyzed and comparable across different areas of the United States for national and regional planning.

What is the difference between updating vs remapping?

An update is a short-term improvement to the data focusing on areas of change or disturbances and successional vegetation growth approximately every two years.

A remap is a longer-term product which incorporates improvements, innovations, and new data to provide for national currency of the products. A remap is done approximately every 10 -15 years.

Update: A LANDFIRE update effort is a vegetation and fuels mapping effort focused primarily on updates to the base product suite due to landscape changes and disturbances. These disturbances might result from a variety of sources or activities including: wildland fire, fuel and vegetation treatments, mortality from insects and disease, storm damage, invasive plants, or other natural or anthropogenic events. Product updates may also include responses to vegetation successional change in forested types, revisions to address discrepancies between map products and known field conditions, as well as specific systematic improvements to the original data. The update strategy applies a consistent approach that combines change detection methods using satellite imagery to detect and characterize landscape disturbances. The primary benefit of an update effort is to reflect recent landscape change and the acquisition of new data. LANDFIRE has been "updating" the data approximately every two years for both location-specific changes with disturbances such as vegetation treatments, forestry harvest, wildland fires, etc., as well as modeling for successional vegetation growth. Updates are produced to provide a representative vegetation state and current fire behavior fuel models.

Updates include these types of elements:

- *DISTURBANCE:* For locations that have experienced a disturbance to vegetation due to management treatments like mechanical projects or environmental disturbances (fire, weather, insects) the LANDFIRE existing vegetation type layer is updated to reflect conditions representative of years of the data being mapped or updated (e.g. 2011 & 2012 data). These updates feed into the creation of the next LANDFIRE version. More information on LANDFIRE versions can be found at http://www.landfire.gov/version_comparison.php. The update process takes polygon disturbances or changes where they exist and transitions the vegetation over the time period to provide the updated product. This is done by integrating the annual disturbance layers. The effect of these disturbances on the vegetation is then modeled or predicted using tables of rules for vegetation transitions. These rules link pre-disturbance existing vegetation type, height, and cover and possible disturbance types and severities with post-disturbance existing vegetation type, height, and cover. These combinations result in updated vegetation data as well as fire behavior fuel models. Forested vegetation tables and rules are informed by computer simulations in the Forest Vegetation Simulator (FVS) while non-forest vegetation is informed by a series of simple rule-sets. The FVS approach provides additional data and peer reviewed models that underpin these LANDFIRE deliverables. More information on this process can be found at http://www.landfire.gov/notifications40.php

- *VEGETATION GROWTH:* The update process includes updates for vegetation succession to account for growth across the landscape. This is a modeled effort which takes into account data from the state and transition models and grows vegetation over-time in the absence of disturbance.

Remap: LF 2015 will be the first national remap. LF 2015 will use consistent methodologies and processes including access to the most current satellite imagery, contemporary data sources, software, and hardware technologies, and will be combined to create a new version that significantly improves upon the updated versions of the legacy LF c2001 products.

The remap will include these types of elements:

- Vegetation changes in areas or landscapes where vegetation is not changing as rapidly as other areas.
- Incorporation of data sets such as new imagery, new or updated field/plot data, partnership data and improvements in algorithms.
    - The addition of these new or updated data have great potential to improve the quality of the LANDFIRE data products, especially in areas where lower or limited plot data were available for LF National (LF c2001).
- Foundational base to work from for subsequent updates and inform future remaps.

As technology improves and data become more available, the need to differentiate between short-term updates versus long-term remaps may no longer exist. The best technology and data may be accommodated more quickly in the future so the map products may be able to reflect national currency of the products faster.

CONCLUSION: What are the highlights of the LANDFIRE remap?

- Current LANDFIRE data products have circa 2001 (Landsat imagery) base data foundation.
- The base data are approximately 15 years old.
- Although only about 10-20% of the landscape has experienced a change, subtle vegetation growth and landscape changes may not be reflective of current conditions.
- The current plan is to begin a three year remap effort in 2016 or 2017.
- The LANDFIRE remap LF 2015 would begin delivery in 2018 (approximately) and finish in 2019 or 2020.

Materials written by Henry Bastian, DOI Business Lead.

Please contact the LANDFIRE Help Desk with any questions.

APPENDIX 5 – LF Vegetation Classification Mapping Options Paper

This was paper was developed by Birgit Peterson. It was then coordinated with NWCG, agency leads, FAM, and OWF and the selected option was number one because it was in alignment with the direction FGDC was taking and would position the LF program to have it products based off this standard.

LANDFIRE Vegetation Classification Mapping Options

Prepared by Birgit Peterson - March 24, 2017

BACKGROUND

As the LANDFIRE program has been preparing for a remap project, a number of activities have been happening over the past years. These have included work on refining Ecological System vegetation classification auto-keys (keys to process and key plot data to the classification), contributing to the Federal Geographic Data Committee – Vegetation Sub-Committee work on the National Vegetation Classification Standard (approved in 2008) with descriptions in the hierarchy, developing a new NVC group auto-key, etc.

As a result, this has set the stage where the LANDFIRE program needs to decide what direction to take for the LANDFIRE remap vegetation mapping. This paper outlines three options that have been pulled together to help people evaluate which option or mix of options should be selected for the LANDFIRE remap.

It is important to know that regardless of the option or mix of options that are ultimately selected, LANDFIRE will be mapping option one A (See figure 1) as part of the remap as everything has been engineered and structured around this vegetation classification.

The key question for consideration when evaluating these options is how NVCS should be considered as part of the remap. Some caveats/considerations have been provided but a thorough listing of pros and cons has not been developed. It is hoped that this type of feedback can be obtained as this document is shared to develop a list of pros and cons in helping determine the direction LANDFIRE should take.

OPTION DESCRIPTIONS

Three options for mapping National Vegetation Classification System (NVCS) Group alongside Ecological Systems (EcolSys) have been identified (Figure 1). Option 1 and Option 2 have been implemented as of 3.21.17 as part of LANDFIRE prototyping efforts to generate draft Existing Vegetation Type (EVT) products for the Northwest prototype study area.

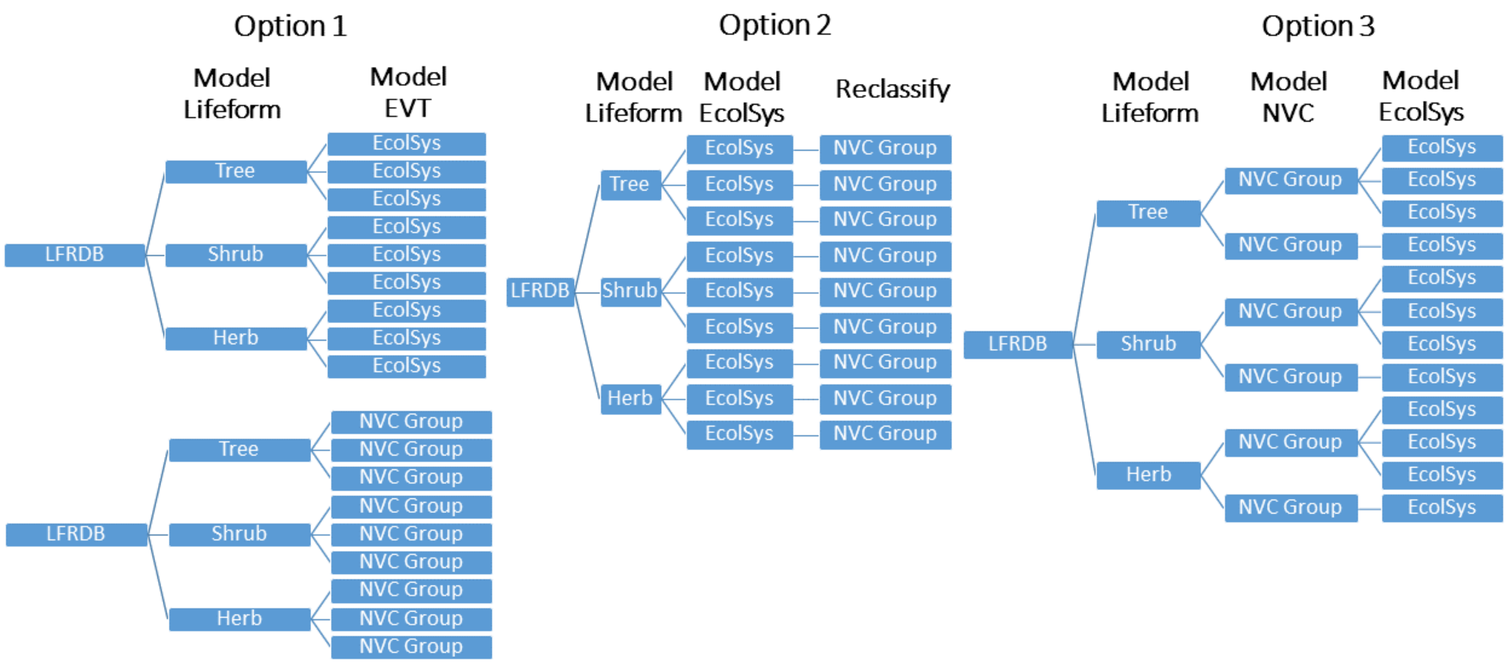


Figure 1. Schematic illustrating a simplified data flow to generate EcolSys and NVCS Group EVT products for LANDFIRE Remap using three different mapping option.

<u>Option 1</u>

This option maps to the two legends, grouped by lifeform, through two separate modeling pathways. The plots within the LANDFIRE Reference Database (LFRDB), keyed to both EcolSys and NVCS Group, largely inform the See5 based models. Option 1 A is mapping using the refined auto-keys for Ecological Systems to the ES vegetation classification. Option 1B is mapping using a newly developed auto-key for NVC groups to the NVCS.

Separate models are generated depending on whether EcolSys or NVCS Group is being mapped. The models are then applied spatially to the training data layers to generate the maps. This is a relatively simple option to implement and has been used to generate draft NVCS Group products.

<u>Caveats/Consideration points:</u> This option is currently considered the second most resource intensive option because it requires the separate generation of two distinct maps and all the seamline rectification and system distribution cleanup this requires.

Depending on how the data layers are provided there may be some refinement that would be necessary where the relationship between NVCS Group and EcolSys is not one-to-one if the desire is to see a relationship between beyond what is already outlined in the hierarchy.

There is concern that the NVCS Group keys may not as well developed as those for EcolSys.

User Community: Because of the independence between the two mapping pathways and the separate AutoKey processes for plot assignment, the final EcolSys and NVCS Group products may look dissimilar for mapping units with similar names. There is a concern as to how this will be received by users expecting the EcolSys and NVCS Group classes with similar names to be mapped the same. The cause of this difference would need to be explained and communicated with the user community.

Researchers, Scientists, Experts Community: Because of the independence between the two mapping pathways and the separate AutoKey processes for plot assignment, the final EcolSys and NVCS Group products may look dissimilar for mapping units with similar names. This would provide an opportunity to evaluate each of the classifications, the auto-keys (not as well developed), and where improvements need to be made. The opportunity to look at a separate, stand alone data set would enable this group to explore the merits and weaknesses of this data layer. By doing so, it would help move the entire community forward in refining a standard that has been approved and accepted. It is important to note that NatureServe has identified that the underlying logic of the two legends is different and that users should not expect the two maps to look the same. This would again provide an opportunity to evaluate the new standard and provide for improvements.

Option 2

This option uses the plots in the LFRDB keyed to EcolSys, again grouped by lifeform, to generate an EcolSys-EVT product. A crosswalk is then applied that walks individual EcolSys classes to an NVCS Group.

Caveats/Consideration points: This process would reduce modeling efforts and would potentially reduce the time to generate an NVCS Group product. However, there are several EcolSys classes that crosswalk to multiple NVCS Groups which may require some modeling.

Option 2 would provide a link between the two EVT products, making them more similar. As noted in option 1 caveats/consideration points, NatureServe has noted that the underlying logic of the two legends is different and that users should not expect the two maps to look the same. There is no perfect crosswalk between the two classification systems and implementing this approach would require some interpretation of the classification systems and compromises to ensure a fit. This approach would rely solely on the existing crosswalk rather than the LFRDB plot data to produce the NVCS Group EVT.

Option 3

This option has not yet been implemented. In this approach, NVCS Group is modeled using the keyed plot data in the LFRDB, grouped by lifeform. The EcolSys classes are then modeled within or crosswalked from each NVCS Group. This option requires the development of a separate model for each NVCS Group with multiple component ecological systems, to determine the distribution of these components.

Caveats/Consideration points: Because of the number of NVCS Groups that crosswalk to multiple Ecological Systems this process will take more time to implement.

Also, logic would need to be worked out for cases where there is a many-to-many relationship between EcolSys and NVCS Group, however, this may be addressed through intersections of lifeform and geography.

This approach would largely nest the two legends, allowing the two EVT products to sync-up. Similar to option one, there is concern that the NVCS Group keys are not as well developed as those for EcolSys. This method would cause the less defined and vetted keys to drive the modeling process.

APPENDIX 6 – LANDFIRE Acronyms

AK	Alaska
BAECV	Burned Area Essential Climate Variable
BAER	Burned Area Emergency Response
BARC	Burned Area Reflectance Classification
LBG	LANDFIRE Business Group
CBD	Canopy Bulk Density
CBH	Canopy Base Height
CDL	Cropland Data Layer
CFFDRS	Canadian Forest Fire Danger Rating System
CONUS	Conterminous United States
DDS	Data Distribution System
EROS	Earth Resources Observation and Science
ETM	Enhanced Thematic Mapper
EVC	Existing Vegetation Cover
EVH	Existing Vegetation Height
EVT	Existing Vegetation Type
FBFM	Fire Behavior Fuel Models
FCC	Forest Canopy Cover
FCCS	Fuel Characteristic Classification System
FCH	Forest Canopy Height
FDIST	Fuel Disturbance
FL	Flame Length
FLM	Fuel Loading Models
FTYP	Fire Type
FVS	Forest Vegetation Simulator
GAP	USGS Gap Analysis Program
HI	Hawaii
LF	LANDFIRE
LFRDB	LF Reference Database
MTBS	Monitoring Trends in Burn Severity

NASS	National Agricultural Statistics Service
NLCD	National Land Cover Database
NW	Northwest
OLI	Operational Land Imager
PAD-US	Protected Area Database of the United States
PAR	Product Acceptance Report
PCR	Project Close-Out Report
RAVG	Rapid Assessment of Vegetation Condition after Wildfire
ROS	Rate of Spread
RSLC	Remote Sensing of Landscape Change
SC	South Central
SCLASS	Succession Classes
U.S.	United States
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VDIST	Vegetation Disturbance
VTM	Vegetation Transition Magnitude
WBS	Work Breakdown Structure

APPENDIX 7 – LANDFIRE Remap Prototyping Poster

Poster describing the LF Remap Prototyping effort (Long et al. 2017)