March 2019

LANDFIRE Product Descriptions with References

Reference

LANDFIRE Reference Database

The LANDFIRE (LF) National (LF 1.X) LF Reference Database (LFRDB) includes vegetation and fuel data from approximately 800,000 geo- referenced sampling units throughout the United States (U.S.). These data are amassed from numerous sources and in large part from existing information resources of outside entities, such as the U.S. Department of Agriculture (USDA) Forest Service (USFS) Forest Inventory and Analysis (FIA) Program, the U.S. Geological Survey (USGS) National Gap Analysis Program (GAP), and state natural heritage programs.

Vegetation data drawn from these sources and used by LF include natural community occurrence records, estimates of canopy cover and height per plant taxon, and measurements (such as diameter, height, crown ratio, crown class, and density) of individual trees. Fuel data used include biomass estimates of downed woody material, percentage cover and height of shrub and herb layers, and canopy base height estimates. Digital photos of the sampled units are archived when available.

Toney and others (2007) explain in *detail* how these types of field data, specifically those collected by the FIA, have been acquired and incorporated into the LFRDB and used in LF. Several key attributes are systematically derived from the acquired data and included in the LFRDB. These attributes include existing and potential vegetation type in the form of NatureServe's Ecological Systems (Comer and others 2003; Toney and others 2007), uncompacted crown ratios (Toney and Reeves 2009), and several canopy fuel metrics (such as bulk density) derived from the FuelCalc program (Reinhardt and others 2006).

Records were carefully screened for information or spatial errors. Accepted data points were processed for associations with ancillary data via a series of spatial overlays, including unlimited access to the Landsat archive, the National Land Cover Database (NLCD, Homer and others 2004), the digital elevation model and derivatives (USGS 2005), soil depth and texture layers (for example, USDA Natural Resources Conservation Service (NRCS) 2005), and a set of 42 simulated biophysical gradient layers (such as evapotranspiration, soil temperature, and degree days). These biophysical gradient layers were generated using WX-BGC, an ecosystem simulator derived from BIOME-BGC (Running and Hunt 1993) and GMRS-BGC (Keane and others 2002). Extracted values from each of these overlays are archived in the LFRDB as predictor variables for LF mapping.

For LF Remap (LF 2.0), new and updated plot information are being compiled and used to inform existing vegetation mapping. The entire LF Remap Public LFRDB will be made available for download at the completion the LF Remap effort, expected in mid to late 2020.

Public Events Geodatabase

The LF National (LF 1.X) Public Events Geodatabase is a collection of recent natural disturbance and land management activities used to update existing vegetation and fuel layers during LF Program deliverables. Public Events exclude proprietary and/or sensitive data.

This geodatabase includes three feature classes - Raw Events, Model Ready Events, and Exotics. The Public Raw and Model Ready Event feature classes include natural disturbance and vegetation/fuel treatment data. The Public Exotics feature class contains data on the occurrence of exotic or invasive plant species. There is also a look up table for the source code (lutSource_Code), an attribute found in all three feature classes. The source code is an LF internal code assigned to each data source. Consult the table "lutSource_Code" in the geodatabases for more information about the data sources included in, and excluded from, releases.

The data compiled in the three feature classes are collected from disparate sources including federal, state, local, and private organizations. All data submitted to LF are evaluated for inclusion into the LF Events geodatabase. Acceptable Event data must have the following minimum requirements to be included in the Events geodatabase:

1) be represented by a polygon on the landscape and have a defined spatial coordinate system
2) have an acceptable event type (Appendix B) or exotics plant species
3) be attributed with year of occurrence or observation of the current data call.

For LF Remap (LF 2.0), this collection of treatments on the landscape is being compiled and events are being produced for the years 2015 and 2016. These polygons are being used to inform Annual Disturbance products for LF Remap. The entire LF Events Geodatabase will be released to the public at the end of the LF Remap effort, expected in mid to late 2020.

Forest Vegetation Simulator Ready Database (FVSRDB)

A public version of the LF National (LF 1.X) FVSRDB is available containing attributes for Forest Vegetation Simulator (FVS) simulations. The Public FVSRDB includes plot level data for all FVS variants nationwide. All data were collected from the LFRDB and contain no proprietary and/or sensitive information.

Data archived in the Public FVSRDB includes predefined input tables used for initializing stand/plot information (StandInit and TreeInit tables).

Disturbance

Annual Disturbance - 1999-Current Year (DistYear)

DistYear products reflect change on the landscape caused by management activities and natural disturbance, providing temporal and spatial information related to landscape change.

LF National (LF 1.X) DistYear products were developed through a multistep process using varied geospatial datasets to identify and label changes in vegetation cover. This process utilized Landsat change detection methods; Landsat-derived indices (e.g., Normalized Difference Vegetation Index (NDVI) and Difference Normalized Burn Ratio (dNBR)); disturbance Event perimeters; fire severity and extent mapping from Monitoring Trends in Burn Severity (MTBS), Burned Area Reflectance Classification (BARC), and Rapid Assessment of Vegetation Condition after Wildfire (RAVG) fire mapping; Protected Area Database (PAD) ownership data; and Burned Area Essential Climate Variable (BAECV) data.

MTBS, BARC, and RAVG data provided extent, cause, and severity of fire-related disturbance. Event perimeters collected from local, state, and federal agencies, along with other cooperators were integrated into the LF Events Geodatabase. They were processed by disturbance type priority and rasterized to provide disturbance-specific causality. PAD data provided management-level information and BAECV offered a possible causality to disturbances detected using processed Landsat imagery.

Disturbances not identified by Events or fire mapping efforts were mapped by processing Landsat best- pixel image composite tiles (98 tiles covering the contiguous U.S. and 4 tiles covering Hawaii.) Image tiles were also created for selected areas to address MTBS gap filling in Alaska.

Change was primarily identified using the Multi-Index Integrated Change Algorithm (MIICA) methods (Jin, et. al. 2013). This process identified changed pixels. Landsat-derived dNBR provided an estimate of severity for all changed pixels including LF Events and were also used to mitigate the Landsat 7 Scan Line Corrector (SLC)-off and cloud gap issues within the MTBS datasets. These data and additional Landsat scenes were used in combination to create regression-based models. In areas where modeling could not be used a 12x12 focal majority process was used to fill MTBS data gaps. The final disturbance products are grid files, defined by year (i.e., 2013, 2014). Disturbance raster attributes include; year, type (causality, if known), severity (low, medium, and high), data source(s), and additional attributes associated with causality and severity confidence.

Starting in LF ReMap (LF 2.0), a varied approach was adopted to more accurately represent disturbances within the Fuels environment. To ensure disturbance data were correctly utilized in this process, a series of collaboration meetings (Reference, Disturbance, Vegetation and Fuels Teams) were held reviewing the suite of disturbance data components. From these discussions three adjustments were implemented prior to HDist/FDist development: disturbance attribute assignment updates, use/not use logic updates, and development of a disturbance hierarchy for multiple disturbance entries.

LF Remap DistYear products are attributed with disturbance type and severity and used to inform and update LF vegetation and fuel products. The final Annual Disturbance products depict disturbances that occurred in that year. Disturbance attribute information is provided by cooperators from local, state, and federal agencies, private organizations, as well as national fire mapping programs (e.g., MTBS). These data offered information regarding the location, extent, and type of disturbances and were consolidated into the LF Events Geodatabase.

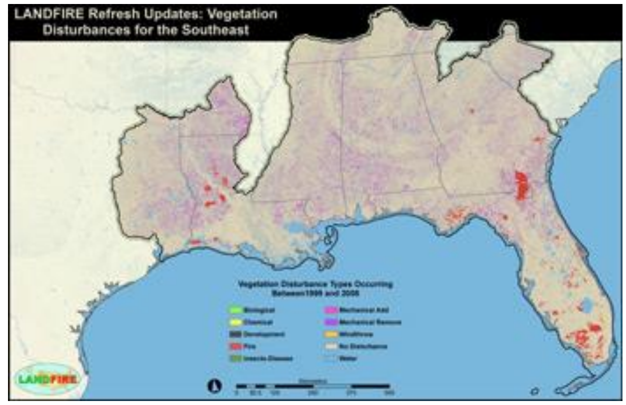
Landsat image-based change detection was used to locate disturbances not included in the LF Events Geodatabase or provided by other fire mapping programs. It also provided an estimate of severity for both satellite-based change and LF Events. Landsat imagery for two seasons (centered near June 24/25 and September 7/8) spanning four years (e.g., 2014, 2015, 2016, 2017) were processed into best-pixel composite images (98 tiles covering the conterminous U.S., each composite a nominal tile size of 10,000 x 10,000 pixels, and 4 tiles of varying size covering the Hawaiian Islands). No image-based change detection was performed for Alaska.

The image composites were used to create vegetation indices (i.e., Normalized Difference Vegetation Index (NDVI) and Normalized Burn Ratio (NBR)) and other derivatives which serve as inputs into MIICA. The MIICA outputs and differenced products (e.g., dNDVI) and dNBR) were used by image analysts to identify where change was located on the landscape. Classification and regression modelling were also used to identify disturbances.

Fire severity and extent disturbances were sourced from MTBS, BARC, and RAVG programs. Any no-data gaps caused by clouds, water, or Landsat 7 SLC-off artifacts were filled using spectral modeling techniques utilizing Landsat image composites as input. The result was continuous and consistent severity and extent information for fire scars. In rare cases where modeling is ineffective at filling gaps, a 13x13 focal majority filter was used. Smaller fires were identified using the BAECV product and included as determined by the analyst.

Causality and severity information assigned to a disturbance was prioritized by the data source. Highest priorities came from fire mapping programs (i.e., MTBS, BARC, RAVG), followed by the LF Event Geodatabase descriptions, and lastly, Landsat image-based change detection. Additional attribution was provided by BAECV where identified disturbances that intersect BAECV detections were assigned a fire causality. PAD information helped determine remaining causality assignments.

Vegetation Disturbance (VDist)



LF National (LF 1.X) VDist products are composites of DistYear products for the previous 10 years. Disturbances were grouped by disturbance type, or cause, (i.e. fire or mechanical treatment), disturbance severity (Low, Moderate, or High), and time since disturbance. These combinations of type, severity, and time since disturbance were used to inform LF vegetation transitions and to update existing vegetation products (Type, Cover, and Height) for disturbances on the landscape. Fire occurrences were assumed to be the most impactful and take precedence, followed by the more recent disturbances taking precedence for a given location.

To leverage disturbance data within the fuel's environment for LF Remap (LF 2.0), an updated VDist product was developed called Historical Disturbance (HDist). HDist replaces VDIST in LF Remap.

Fuel Disturbance (FDist)

LF National (LF 1.X) FDist products are composites of the latest 10 years of DistYear products representing disturbance year and original disturbance code to meet LF fuel mapping needs and serve as input to the LF Total Fuel Change Tool (LFTFC). The product development involves a comprehensive review of disturbance attributes. and does not include chemical, biological, or development disturbances. Filtering to remove logically inconsistent disturbance/EVT combinations such as insect and disease within herbaceous landscapes was implemented. Fire occurrences take precedence, followed by the most recent disturbance.

Developed for FDist, the Use/Not Use Disturbance logic was developed to check for logical inconsistencies between disturbance types and the underlying vegetation. (i.e. If a fire disturbance falls within a body of water). If a discrepancy was found, the disturbance was flagged and removed from the FDist data layer. For LF ReMap (LF 2.0), development included updating/adding additional disturbance logic checks related to: lifeform, shrub-mastication and insect & disease to ensure logical inconsistencies would not persist between disturbance type and vegetation lifeform or type:

- Lifeform Use/Not Use - limits disturbances to logical vegetation lifeforms
- Shrub Mastication Use/Not Use - limits mastication in shrubs to commonly masticated existing vegetation types
- Insect & Disease Use/Not Use - limits insect & disease disturbances to existing vegetation types affected by bug infestations (conifer species) or disease mortality

FDist is a refinement of VDist in LF 1.X products and is a refinement of Historical Disturbance in LF Remap (LF 2.0) to more accurately represent disturbance scenarios within the fuels' environment.

Historical Disturbance (HDist)

New with LF Remap (LF 2.0) the HDist product uses the latest 10 years of DistYear data (and attribute code system) to identify disturbance year, type, and severity, representing the history of disturbance for a 10-year span. HDist development involves a comprehensive review of fuel and disturbance attribute assignments, use/not use scenarios and the development of a disturbance hierarchy. Each year's disturbance scenarios were checked against time relevant LF vegetation to check for logical inconsistencies. Errant disturbance codes were flagged and updated to a discard code with the remaining disturbance codes cross walked to FDist codes.

HDist replaces VDist from previous LF versions incorporating pre-disturbance vegetation logic (based on disturbance year and vegetation type).

Vegetation Transition Magnitude (VTM)

The LF National (LF 1.X) VTM represents the relative magnitude of change applied to a pixel during the LF vegetation updating process and provides information regarding disturbance type and the resulting impact on vegetation life-form or tree canopy cover through LF 2014. Information about the disturbance type and the resulting change to vegetation life-form or tree canopy cover were used to characterize this change. VTM was generated concurrent with the updating process using tables and a series of database queries on a spatial overlay of vegetation and disturbance raster data. To keep LF vegetation products current, subsequent versions of these data were updated with mapped occurrences of known disturbance and severity. The mapping process integrates disturbances mapped using remote sensing of landscape change paired with user contributed polygons with management activities over a two-year period.

The effect of these disturbances on the vegetation were modeled or predicted using a series of tables that link pre-disturbance Existing Vegetation Type (EVT), Existing Vegetation Height (EVH), and Existing Vegetation Cover (EVC), and a range of possible disturbance types and severities with post-disturbance EVT, EVH, and EVC. For forested vegetation, these tables were informed by computer simulations in the Forest Vegetation Simulator (FVS - www.fs.fed.us/fmsc/fvs/) while non-forest vegetation were informed by a series of simple rule-sets generated heuristically for each individual map zone. Final updating occurred when the tables were linked with a spatial overlay of vegetation and mapped occurrences of disturbance and used to assign EVT, EVH, and EVC. Finally, a unique code was assigned to all pixels that associate them with a disturbance type as well as categories of change magnitude expressed either in a change in vegetation life-form or a change in tree cover.

Forest Vegetation Transition Database (FVTDB)

The LF National (LF 1.X) FVTDB contains information that describes post-disturbance vegetation changes. The forest vegetation was described by EVT, EVH, and EVC. Information archived in the FVTDB includes the disturbance tables and tools to summarize and sort post disturbance vegetation transitions resulting from FireData, Mechanical, Insects Disease, and Windthrow.

Non-forest Vegetation Transition Database (NFVTDB)

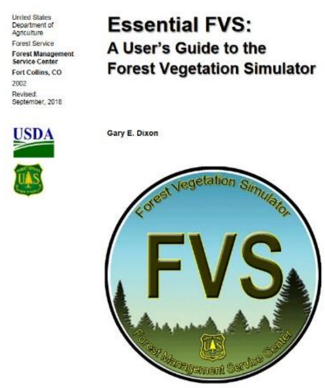
The LF National (LF 1.X) NFVTDB contains information that describes both post-disturbance vegetation changes and vegetation changes resulting from succession without disturbance. The non-forest vegetation is described by EVT, EVC, and EVH. Information archived in the NVSTDB includes the disturbance and no disturbance data tables and tools to summarize and sort post disturbance vegetation transitions.

Forest Vegetation Simulator Disturbance Database (FVSDDB)

A public version of the LF National (LF 1.X) FVSDDB is available containing FVS disturbance simulation outputs. The database contains no proprietary and/or sensitive information and is derived from FVS analysis of the FVSRDB. The Public FVSDDB includes disturbance analysis outputs covering all FVS Variants at multiple severities and time-steps.

Outputs archived in the Public FVSDDB include predefined outputs used for stand/plot analysis post disturbance using the STANDSQL keyword in FVS.

More detailed output data descriptions can be found in the Essential FVS Guide.


Essential FVS:
A User's Guide to the Forest Vegetation Simulator

Gary E. Dixon

Vegetation

Existing Vegetation Type (EVT)

LF National (LF 1.X) EVT products represent the species composition currently present at a given site. LF vegetation map units were derived from NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units (Comer and others 2003). Existing vegetation was mapped through a predictive modeling approach using a combination of field reference information, Landsat imagery, and spatially explicit biophysical gradient data.

Field data keyed to dominant vegetation type at the plot level were used as "training data" to drive the modeling process. Attribute information linked the LF EVT map units to existing classifications such as the U.S. National Vegetation Classification System (USNVC)and those of the Society of American Foresters and Society for Range Management.

LF Remap (LF 2.0) EVT products represent the current distribution of the terrestrial ecological systems classification developed by NatureServe for the western hemisphere.

LF Remap EVT includes ruderal or semi-natural vegetation types within the USNVC and were mapped using decision tree models informed by field reference data, Landsat imagery, elevation/topographic and biophysical gradient inputs. The models were developed separately for each life-form including tree, shrub, herbaceous, and sparse vegetation and were generated for each Environmental Protection Agency (EPA) Level III Ecoregion.

Riparian, alpine, sparse, and other site-specific EVTs were constrained by predetermined masks. Urban and developed areas were derived from the NLCD, whereas agricultural lands originate from the Cropland Data Layer (CDL) and Common Land Unit (CLU) database. Developed ruderal classes were identified by combining wildland-urban-interface (WUI) data with population density information from the U.S. Census Bureau. The final EVT product was reconciled through QA/QC measures to ensure life-form is synchronized with both EVC and EVH.

Disturbance data were included in LF Remap products to describe areas on the landscape that experienced change within the previous 10-year period. Among the 18 types of disturbances mapped were fire, timber harvest, weather-driven events, and insect and disease. Final disturbance products contain data assembled from remotely sensed land change products, MTBS program data, and the LF Events Geodatabase.

National Vegetation Classification (NVC)

New with LF Remap (LF 2.0), the NVC product represents the current distribution of vegetation groups within the USNVC. Groups within the NVC hierarchy are defined as combinations of relatively narrow sets of diagnostic plant species, including dominants and co-dominants, broadly similar composition, and diagnostic growth forms. NVC groups were mapped using decision tree models informed by field reference data, Landsat imagery, elevation/topographic and biophysical gradient inputs. The models were developed separately for each life-form including tree, shrub, herbaceous, and sparse vegetation. Models were generated for each individual EPA Level III Ecoregion. Riparian, alpine, sparse, and other site-specific EVTs were constrained by predetermined masks.

Urban and developed areas were derived from the NLCD, whereas agricultural lands originate from the CDL and CLU database. Developed ruderal classes were identified by combining WUI data with population density information from the US Census Bureau. The final NVC Groups product was reconciled through QA/QC measures to ensure life-form is synchronized with both EVC and EVH.

Disturbance data were included in LF Remap products to describe areas that experienced change within the previous 10-year period. Among the 18 types of disturbances mapped were fire, timber harvest, weather-driven events, and insect and disease. Final disturbance products contain data assembled from remotely sensed land change products, MTBS, and the LF Events Geodatabase

Existing Vegetation Cover (EVC)

The LF National (LF 1.X) EVC products represent the vertically projected percent cover of the live canopy layer for a 30-m grid cell. EVC was generated using a predictive modeling approach that related Landsat imagery and spatially explicit biophysical gradients to calculated values of average canopy cover from field training sites and digital orthophoto quadrangles.

LF Remap (LF 2.0) EVC products depict percent canopy cover by life-form and is an important input to other LF mapping efforts. Canopy cover was modeled separately for tree, shrub, and herbaceous life-forms. Lidar observations, FIA program plot data, multi-temporal Landsat imagery, vegetation indices, and other geospatial data sets were used to inform regression-tree models. Rule-based predictive models were used to generate life-form-specific cover classes. These model outputs were then merged into a single existing cover product. The EVC product was reconciled through QA/QC measures to ensure life-form is synchronized with both EVH and EVT products.

Disturbance data were included in LF Remap products to describe areas that experienced change within the previous 10-year period. Among the 18 types of disturbances mapped were fire, timber harvest, weather-driven events, and insect and disease. Final disturbance products contain data assembled from remotely sensed land change products, MTBS, and the LF Events Geodatabase.

Existing Vegetation Height (EVH)

LF National (LF1.X) EVH products represent the average height of the dominant vegetation for a 30-m grid cell. EVH was generated using a predictive modeling approach that related Landsat imagery and spatially explicit biophysical gradients to calculated values of average dominant height from field training sites.

LF Remap (LF 2.0) EVH products depict the canopy height by life-form and serves as a primary input to other LF products. Canopy height was modeled separately for tree, shrub, and herbaceous life-forms. Lidar observations, USFS FIA program plot data, multi-temporal Landsat imagery, vegetation indices, and other geospatial data sets were used to inform regression-tree models. Rule-based predictive models were used to generate life-form-specific height classes. These model outputs were then merged into a single existing height product. The EVH product was reconciled through QA/QC measures to ensure life-form is synchronized with EVC and EVT products.

Disturbance data were included in LF Remap products to describe areas that experienced change within the previous 10-year period. Among the 18 types of disturbances mapped were fire, timber harvest, weather-driven events, and insect and disease. Final disturbance products contain data assembled from remotely sensed land change products, MTBS, and the LF Events Geodatabase.

Biophysical Settings (BPS)

LF National (LF 1.X) BPS products represent the vegetation that may have been dominant on the landscape prior to Euro-American settlement and was based on both the current biophysical environment and an approximation of the historical disturbance regime. Map units were based on NatureServe's Ecological Systems classification and represent the natural plant communities that may have been present during the reference period.

Each BPS map unit was matched with a model of vegetation succession and served as key inputs to the LANDSUM landscape succession model. The actual time-period for BPS was a composite of the historical context provided by the fire regime and vegetation dynamics models and the more recent field and geospatial inputs used to create it. BPS is unchanged from LF National's BPS except for updates made to water, barren, and snow classes (additions or removal), so that not-vegetated cover types within the BPS product matches LF existing vegetation and fuel products.

The LF Remap (LF 2.0) update for BPS products is that BPS now includes Mean Fire Return Interval (MFRI), Percent of Low-severity Fire (PLS), Percent of Mixed-severity Fire (PMS), Percent of Replacement-severity Fire (PRS), and Fire Regime Groups (FRG) as attributes.

Environmental Site Potential (ESP)

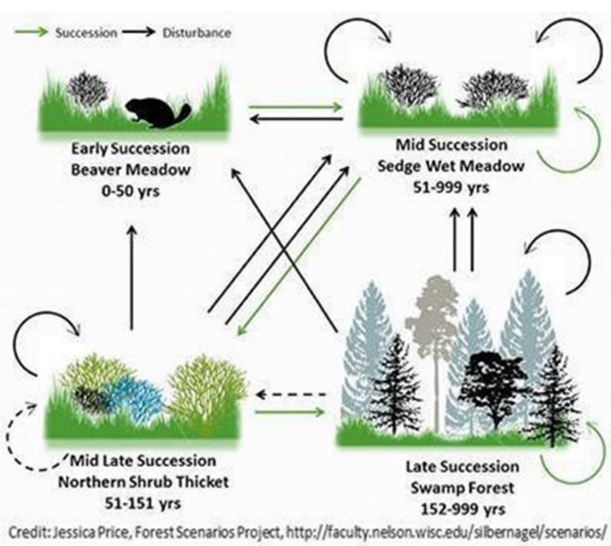
The LF National (LF 1.X) ESP products represent the vegetation that could be supported at a given site based on the biophysical environment. Map units were named according to NatureServe's Ecological Systems classification, a nationally consistent set of mid-scale ecological units, and represent the natural plant communities that would become established at late or climax stages of successional development in the absence of disturbance. In LF, this product was used to inform the existing vegetation and fuel mapping processes.

LF's use of these classification units to describe environmental site potential differs from their intended use as units of existing vegetation. They reflected the current climate and physical environment, as well as the competitive potential of native plant species. The LF ESP concept is similar to the concept used in classifications of potential vegetation, including habitat types (Daubenmire 1968; Pfister and others 1977) and plant associations (Henderson and others 1989). ESP was generated using a predictive modeling approach that relates spatially explicit layers representing biophysical gradients and topography to field training sites assigned to ESP map units. It is important to note that ESP is an abstract concept and represents neither current nor historical vegetation.

Biophysical Settings Models and Descriptions (BpS)

BpS models describe vegetation, geography, biophysical characteristics, succession stages, and disturbance regimes for each BpS and some of the major disturbance types affecting these ecosystems prior to significant alterations by European settlers. BPS helps to synthesize the best available knowledge of vegetation dynamics and quantify the natural range of variability in vegetation composition and structure.

Models consist of two components: (1) a comprehensive biophysical setting (BpS) model description and (2) a quantitative, state-and-transition BpS model, created in the public domain software Vegetation Dynamics Development Tool (VDDT; ESSA Technologies Ltd. 2007). Each model represents a BpS. And a BpS represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime. BpS modeling units are based on NatureServe's Ecological Systems classification, a nationally consistent set of mid-scale ecological units (Comer et al. 2003). LF's use of these classification units to describe BpS differs from their intended use as units of existing vegetation. As used in LF, model unit names represent the natural plant communities that may have been present during the reference period.

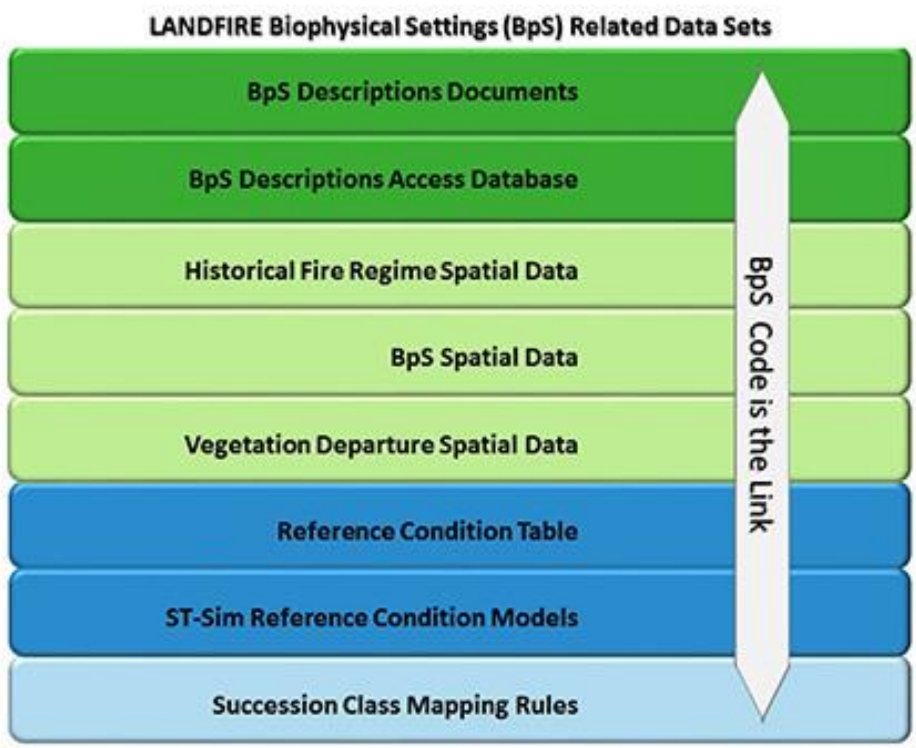


Models were developed during workshops where regional vegetation and fire ecology experts synthesized the best available data on vegetation dynamics and disturbances for vegetation communities in their region. Experts created a BpS model description for each BpS using a customized Access data base application called ModelTracker Data Base (MTDB). Experts used NatureServe's Ecological Systems (Comer et al. 2003) as a starting point for describing BpS, but modified them as needed to represent pre-European, reference conditions and added additional information to ModelTracker to create a comprehensive BpS description document. Experts used the VDDT to quantify the vegetation dynamics of each BpS.

Quantitative models were based on inputs such as fire frequency and severity, the probability of other disturbances, and the rate of vegetation growth and succession. Models were used to simulate several centuries of vegetation dynamics and produce outputs such as the percent of the landscape in each class and the frequency of disturbances. Outputs were checked against available data whenever possible.

ModelTracker descriptions and VDDT inputs were derived from literature review and expert input during and after modeling workshops. A model review process during and/or following workshops garnered additional expert input and offered an opportunity to refine models.

BpS model descriptions and quantitative BpS models, were used in LF 1) to help define and map BpS; 2) to help map succession classes; and 3) as inputs to the spatial fire and succession simulation model, LANDSUM (Keane et al. 2002), which generates reference conditions used to calculate Fire Regime Condition Class (FRCC), a standardized, interagency index to measure the departure of current conditions from reference conditions (Hann et al. 2004).



For a complete description of the methodology used to develop LF vegetation models consult the "LANDFIRE Vegetation Dynamics Modeling Manual" (The Nature Conservancy et al. 2006).

Fuel

13 Anderson Fire Behavior Fuel Models (FBFM13)

Fire behavior fuel models represent distinct distributions of fuel loading found among surface fuel components (live and dead), size classes, and fuel types. Fuel models are described by the most common fire- carrying fuel type (grass, brush, timber litter, or slash), loading and surface area-to-volume ratio by size class and component, fuelbed depth, and moisture of extinction. These standard LF National (LF 1.X) 13 Anderson Fire Behavior Fuel Models (FBFM13) serve as input to Rothermel's mathematical surface fire behavior and spread model (Rothermel 1972). FBFM13 can serve as input to the FARSITE fire growth simulation model (Finney 1998) and FlamMap fire potential simulator (Stratton 2004). Further detail on these original fire behavior fuel models can be found in Anderson (1982) and Rothermel (1983).

In LF Remap (LF 2.0), Fuel Vegetation Type (FVT), Fuel Vegetation Cover (FVC), and Fuel Vegetation Height (FVH) were incorporated in place of EVT, EVC, and EVH in fuel model assignment for disturbed areas to represent pre-disturbance scenarios (dating back to 2007). The combination of pre-disturbance and non-disturbance vegetation were used to assign surface fuel models by informing how much or little and what type of fuels are natural or acted on by a disturbance event.

40 Scott and Burgan Fire Behavior Fuel Models (FBFM40)

This set of standard fire behavior fuel models represents more fuel models in every fuel type (grass, shrub, timber, and slash) than does Anderson's set of 13 fuel models. The main objective in creating LF National (LF 1.X) FBFM40 was to increase the ability to illustrate the effects of fuel treatments using fire behavior modeling. FBFM40 can serve as input to the FARSITE fire growth simulation model (Finney 1998), FlamMap fire potential simulator (Stratton 2004), BehavePlus fire behavior model (Andrews and others 2005), NEXUS crown fire potential model (Scott 2003), and FFE-FVS forest stand simulator (Reinhardt and Crookston 2003).

Nomographs for estimating fire behavior using the new fuel models without the use of a computer are now available (through Rocky Mountain Research Station Publications). Further detail about these 40 fire behavior fuel models can be found in Scott and Burgan (2005).

In LF Remap (LF 2.0), FVT, FVC, and FVH were incorporated in place of EVT, EVC, and EVH in fuel model assignment for disturbed areas to represent pre-disturbance scenarios (dating back to 2007). The combination of pre-disturbance and non-disturbance vegetation were used to assign surface fuel models by informing how much or little and what type of fuels are natural or acted on by a disturbance event.

Fuel Vegetation Type (FVT)

New with LF Remap (LF 2.0), FVT represents a modified version of EVT that more accurately leverages fuel transition assignments related to disturbed areas by re-establishing pre-disturbance vegetation. Linking disturbed areas to pre-disturbance EVTs allows fuel model transition assignments to properly align with logic developed from Fuels Calibration Workshops, giving more accurate representations during fire behavior analysis.

FVT was developed using the full suite of LF vegetation releases and HDist, the most recent 10 years of disturbance data.

Fuel Vegetation Cover (FVC)

New with LF Remap (LF 2.0), FVC represents a modified version of EVC that was mapped as continuous estimates of canopy cover for tree, shrub, and herbaceous lifeforms with a potential range from 0-100 percent. To translate continuous EVC values into fuel model assignments, EVC values were binned to correspond with the bins for previous LF versions.

FVC was developed using the full suite of LF vegetation releases and HDist, the most recent 10 years of disturbance data. FVC more accurately leverages fuel transition assignments related to disturbed areas to properly align with logic developed from Fuels Calibration Workshops.

Fuel Vegetation Height (FVH)

New with LF Remap (LF 2.0), FVH represents a modified version of EVH that was mapped as continuous estimates of canopy height for tree, shrub, and herbaceous lifeforms. To translate continuous EVH values into fuel model assignments, EVH values were binned to correspond with the bins for previous LF versions.

FVH was developed using the full suite of LF vegetation releases and HDist, the most recent 10 years of disturbance data. FVH more accurately leverages fuel transition assignments related to disturbed areas to properly align with logic developed from Fuels Calibration Workshops.

Forest Canopy Bulk Density (CBD)

CBD describes the density of available canopy fuel in a stand. It is defined as the mass of available canopy fuel per canopy volume unit that would burn in a crown fire. Geospatial data describing canopy bulk density supplies information for fire behavior models, such as FARSITE (Finney 1998), to determine the initiation and spread characteristics of crown fires across landscapes (VanWagner 1977, 1993). LF National (LF 1.X) CBD was generated using a predictive modeling approach that relates Landsat imagery and spatially explicit biophysical gradients to calculated values of CBD from field training sites. Because of model requirements, these data are provided for forested areas only.

The units of measurement for the CBD products are kg m-3 * 100.

In LF Remap (LF 2.0), FVT, FVC, and FVH were incorporated in place of EVT, EVC, and EVH for disturbed areas to represent pre-disturbance scenarios (dating back to 2007). The combination of pre-disturbance and non-disturbance vegetation were used to calculate CBD by informing how much or little and what type of fuels are natural or acted on by a disturbance event.

Forest Canopy Base Height (CBH)

CBH describes the average height from the ground to a forest stand's canopy bottom. Specifically, it is the lowest height in a stand at which there is enough forest canopy fuel to propagate fire vertically into the canopy. Geospatial data describing canopy base height provides information for fire behavior models, such as FARSITE (Finney 1998), to determine areas in which a surface fire is likely to transition to a crown fire (VanWagner 1977, 1993). LF National (LF 1.X) CBH was generated using a predictive modeling approach that relates Landsat imagery and spatially explicit biophysical gradients to calculated values of CBH from field training sites. Because of model requirements, these data are provided for forested areas only. The units of measurement for the CBH products are meters * 10.

In LF Remap (LF 2.0), FVT, FVC, and FVH were incorporated in place of EVT, EVC, and EVH for disturbed areas to represent pre-disturbance scenarios (dating back to 2007). The combination of pre-disturbance and non-disturbance vegetation are used to calculate CBH by informing how much or little and what type of fuels are natural or acted on by a disturbance event.

Forest Canopy Height (CH)

CH describes the average height of the top of the vegetated canopy. Geospatial data describing canopy height supplies information to fire behavior models, such as FARSITE (Finney 1998), to determine the probability of crown fire ignition, calculate wind reductions, and compute the volume of crown fuel (VanWagner 1977, 1993). LF National (LF 1.X) CH was generated using a predictive modeling approach that relates Landsat imagery and spatially explicit biophysical gradients to calculated values of average dominant height from field training sites. Because of model requirements, these data are provided for forested areas only. The units of measurement for the LF CH layer are meters * 10.

In LF Remap (LF 2.0), FVT, FVC, and FVH were incorporated in place of EVT, EVC, and EVH for disturbed areas to represent pre-disturbance scenarios (dating back to 2007). The combination of pre-disturbance and non-disturbance vegetation are used to calculate CH by informing how much or little and what type of fuels are natural or acted on by a disturbance event.

Forest Canopy Cover (CC)

CC describes the percent cover of the tree canopy in a stand. Specifically, canopy cover describes the vertical projection of the tree canopy onto an imaginary horizontal surface representing the ground's surface. A spatially explicit map of CC supplies information to fire behavior models, such as FARSITE (Finney 1998), to determine surface fuel shading for calculating dead fuel moisture and for calculating wind reductions. LF National (LF 1.X) CC was generated using a predictive modeling approach that relates Landsat imagery and spatially explicit biophysical gradients to calculated values of average canopy cover from field training sites and digital orthophoto quadrangles. The units of measurement for the LF CC layer are percent.

In LF Remap (LF 2.0), FVT, FVC, and FVH were incorporated in place of EVT, EVC, and EVH for disturbed areas to represent pre-disturbance scenarios (dating back to 2007). The combination of pre-disturbance and non-disturbance vegetation are used to calculate CC by informing how much or little and what type of fuels are natural or acted on by a disturbance event.

Canadian Forest Fire Danger Rating System (CFFDRS)

LF National (LF 1.X) CFFDRS depicts fuel types "as an identifiable association of fuel elements of distinctive species, form, size, arrangement, and continuity that will exhibit characteristic fire behavior under defined burning conditions" (Pyne, Andrews, and Laven, 1996; Stocks and others 1989). The CFFDRS arranges fuel types into five major groups with 16 discrete fuel types that are qualitatively distinguished by variations in their forest floor and organic layer, their surface and ladder fuels, and their stand structure and composition.

The CFFDRS assignments for Alaska were made by fire behavior and fuels experts based on Existing Vegetation Type (EVT) descriptions and representative photos.

The CFFDRS product is currently created for Alaska only.

Fuel Loading Models (FLM)

LF National (LF 1.X) FLM surface fuel classification system characterizes wildland surface fuel. FLMs provide a simple and consistent way for managers to describe onsite fuel for input into fire behavior and effects software and contain representative loading for each fuel component (e.g., woody and non-woody) for typical vegetation classification systems. They characterize fuel loading across all vegetation and ecological types. FLM may be used to simulate wildland fire effects using applications such as FOFEM (Reinhardt and others 1997) and CONSUME (Ottmar and others 1993).

FLM are assigned to the LF vegetation map unit classification systems. Geospatial representation of fire effects fuel models may be used to prioritize fuel treatment areas, evaluate fire hazard and potential status, and examine past, present, and future fuel loading characterizations.

Fuel Characteristics Classification System Fuelbeds (FCCS)

LF National (LF 1.X) FCCS was developed by the USDA, Pacific Northwest Experiment Station, Pacific Wildland Fire Sciences Laboratory (PWFSL) in Seattle, WA. FCCS is a system for describing wildland fuels. Fire managers can use the FCCS to assign fuelbed characteristics for the purposes of predicting fuel consumption and smoke production through PWFSL's CONSUME software. Upon full implementation, the LF team plans to work with FCCS staff to provide crosswalk assignments of FCCS fuelbed numbers to LF existing vegetation layers.

FCCS fuel beds have been mapped in LF and are preloaded in the Fuel and Fire Tools (FFT) application.

For LF Remap (LF 2.0), FCCS is planned to be produced with production occurring after fuels production and released as part of the final release for CONUS in mid to late 2020.

Fuel Rulesets Database

The Fuel Rulesets Database is a standalone database exported from LFTFC in Microsoft Access Form format and displays LF fuel rules by EVT, non-disturbance or disturbance type, and LF map zone. Fuel rulesets are comprised of the described EVT, combinations of ranges of cover and height, and Biophysical Setting (BpS) within each EVT. Information regarding whether canopy is available for crown fire activity is also provided

Fire Regime

Fire Regime Groups (FRG)

LF National (LF 1.X) FRG represents an integration of the spatial fire regime characteristics of frequency and severity simulated using the vegetation and disturbance dynamics model LANDSUM (Keane and others 2002). These groups are intended to characterize the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context (Hann and others 2004). FRG definitions have been altered from previous applications (Hann & Bunnell 2001; Schmidt and others 2002; Wildland Fire Communicator's Guide) to best approximate the definitions outlined in the Interagency Fire Regime Condition Class Guidebook (Hann and others 2004). These definitions were refined to create discrete, mutually exclusive criteria appropriate for use with LF's fire frequency and severity data products.

FRG is created by linking the BpS Group attribute in the BpS layer with the Refresh Model Tracker (RMT) data and assigning the FRG attribute. This geospatial product should display a reasonable approximation of FRG, as documented in the RMT.

For LF Remap (LF 2.0), this product, along with Mean Fire Return Interval, Percent Low-severity Fire, Percent Mixed-severity Fire, and Percent Replacement-severity Fire are part of the BPS Attribute Table.

Mean Fire Return Interval (MFRI)

LF National 9LF 1.X) MFRI quantifies the average period between fires under the presumed historical fire regime. This frequency is derived from vegetation and disturbance dynamics simulations using LANDSUM (Keane and others 2002, Hann and others 2004). The MFRI layer is intended to represent one component of the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context.

For LF Remap (LF 2.0), this product, along with FRG, Percent Low-severity Fire, Percent Mixed-severity Fire, and Percent Replacement-severity Fire are part of the BPS Attribute Table.

Percent Low-severity Fire (PLS)

LF National (LF 1.X) PSL quantifies the amount of mixed -severity fires relative to mixed- and replacement-severity fires under the presumed historical fire regime. Low severity is defined as less than 25 percent average top-kill within a typical fire perimeter for a given vegetation type (Hann and others 2004). This percent is derived from vegetation and disturbance dynamics simulations using LANDSUM (Keane and others 2002). The PLS layer is intended to represent one component of the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context.

For LF Remap (LF 2.0), this product, along with FRG, MFRI, Percent Mixed-severity Fire, and Percent Replacement-severity Fire are part of the BPS Attribute Table.

Percent Mixed-severity Fire (PMS)

LF National (LF 1.X) PMS quantifies the amount of low-severity fires relative to low- and replacement-severity fires under the presumed historical fire regime. Mixed severity is defined as between 25 and 75 percent average top-kill within a typical fire perimeter for a given vegetation type (Hann and others 2004). This percent is derived from vegetation and disturbance dynamics simulations using LANDSUM (Keane and others 2002). The PMS layer is intended to represent one component of the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context.

For LF Remap (LF 2.0), this product, along with FRG, MFRI, PLS, and Percent Replacement-severity Fire are part of the BPS Attribute Table.

Percent Replacement-severity Fire (PRS)

LF National (LF 1.X) PRS quantifies the amount of replacement-severity fires relative to low- and mixed-severity fires under the presumed historical fire regime. Replacement severity is defined as greater than 75 percent average top-kill within a typical fire perimeter for a given vegetation type (Hann and others 2004). This percent is derived from vegetation and disturbance dynamics simulations using LANDSUM (Keane and others 2002). The PRS layer is intended to represent one component of the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context.

For LF Remap (LF 2.0), this product, along with FRG, MFRI, PLS, and PMS are part of the BPS Attribute Table.

Succession Classes (SClass)

LF National (LF 1.X) SClass categorizes current vegetation composition and structure into up to five successional states defined for each LF BpS Model. An additional category defines uncharacteristic vegetation components that are not found within the compositional or structural variability of successional states defined for each BpS model, such as exotic species. These succession classes are similar in concept to those defined in the Interagency Fire Regime Condition Class (FRCC) Guidebook. SClass is created by linking the BpS layer with the SClass rulesets. This geospatial product should display a reasonable approximation of SClass, documented in the LF Vegetation Dynamics Models. The current successional classes and their historical reference conditions are compared to assess departure of vegetation characteristics; this departure can be quantified using methods such as FRCC.

Five successional classes, "A" (1) - "E" (5) define successional states represented within a given BpS model. 'UN' (6) represents uncharacteristic native vegetation for the BpS model on which these vegetation conditions are found. These are taken to represent vegetation cover, height, or composition that would not have been expected to occur on the BpS during the reference condition period. 'UE' (7) represents uncharacteristic exotic vegetation for the BpS model on which these vegetation conditions are found. Additional data layer values were included to represent Water (111), Snow / Ice (112), Barren (131), and Sparsely Vegetated (132). Non-burnable Urban (120), Burnable Urban (121), Non- burnable Agriculture (180), and Burnable Agriculture (181) are provided to mask out such areas from analysis of vegetation departure. To use this layer for assessing vegetation departure from historical reference conditions, it is necessary to combine this layer with BpS and LF map zone data layers. The subsequent combination of map zone, BpS, and SClass can then be found within LF Historical Reference Condition tables. Caution is warranted in assessing vegetation departure across map zone boundaries, as the classification schemes used to produce BpS and SClass may vary slightly between adjacent map zones. Furthermore, reference conditions are simulated independently for each map zone, resulting in potentially unique measurements of reference conditions for a given BpS between adjacent mapzones.

For LF Remap (LF 2.0), production for SClass is scheduled to begin after fuels production and will be part of the final release for CONUS in mid to late 2020.

Vegetation Condition Class (VCC)

LF National (LF 1.X) VCC, a reclassification of the Vegetation Departure (VDEP) product, is a discrete metric that quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions (Hann and Bunnell 2001; Hardy and others 2001; Hann and others 2004; Holsinger and others 2006). Refer to the VDEP Data Summary and metadata to review how that data was created.

Vegetation condition classes are defined in two ways, the original 3-category system from Fire Regime Condition Class (FRCC), and a new 6-category system. In the original 3-category system, the VDEP value is reclassified as Condition Class I: VDEP value from 0 to 33 (Low Departure), Class II: VDEP value between 34 - 66 (Moderate Departure), and Condition Class III: VDEP value from 67 to 100 (High Departure). The new 6-category system is defined to provide more resolution to VCC and be collapsible to the old 3-category system. The new VCC categories are Condition Class I.A: VDEP between 0 and 16 (Very Low Departure), Condition Class I.B: VDEP between 17 and 33 (Low to Moderate Departure), Condition Class II.A: VDEP between 34 and 50 (Moderate to Low Departure), Condition Class II.B: VDEP between 51 and 66 (Moderate to High Departure), Condition Class III.A: VDEP between 67 and 83 (High to Moderate Departure), and Condition Class III.B: VDEP between 84 and 100 (High Departure). Current vegetation conditions are derived from a classification of LF layers of existing vegetation type, cover, and height.

For LF Remap (LF 2.0), VCC production is scheduled to begin after fuels production and will be part of the final release for CONUS in mid to late 2020.

Vegetation Departure (VDEP)

LF National (LF 1.X) VDEP categorizes departure between current vegetation conditions and reference vegetation conditions using a range from 0 to 100 according to the methods outlined in the Interagency Fire Regime Condition Class Guidebook (Hann and others 2004). Technical Methods: "Summary units" for the departure computation were defined as a BpS with identical reference condition values regardless of map zone. This is a change from previous versions of LF. For example, speculate that a specific BpS is present in map zone 1, 2, 4, 5, 6 and 8. The reference conditions for this BpS are identical in map zones 1, 2, 4, 5 and 8 so those map zones become a "summary unit" for the departure computation (VDEP) in LF 2014. Since reference conditions are unique for this BpS in map zone 6, it is a separate summary unit for calculating departure (VDEP) in LF 2014. Within each biophysical setting in each summary unit, we compare the reference percentage of each succession class (SClass) to the current percentage, and the smaller of the two is summed to determine the similarity index for the BpS. This value is then subtracted from 100 to determine the departure value. Departure value is between 0 - 100, with 100 representing maximum departure.

The LF VDEP approach differs from that outlined in the Interagency Fire Regime Condition Class Guidebook as follows: LF VDEP is based on departure of current vegetation conditions from reference vegetation conditions only, whereas the Guidebook approach includes departure of current fire regimes from those of the reference period. The reference conditions are derived from quantitative vegetation and disturbance dynamics models developed in VDDT/ST-Sim. The current conditions are derived from the corresponding version of LF SClass; please refer to the product description page at https://landfire.gov for more information. The proportion of the landscape occupied by each SClass in each BpS unit in each summary unit is used to represent the current condition of that SClass in the VDEP calculation. The areas currently mapped to agriculture, urban, water, barren, or sparsely vegetated BpS units are not included in the VDEP calculation; thus, VDEP is based entirely on the remaining area of each BpS unit that is occupied by valid SClasses.

Refer to the VDEP product page for version comparisons. Current vegetation conditions are derived from a classification of LF layers of existing vegetation type, cover, and height.

Topographic

Elevation

Elevation represents land height in meters above mean sea level.

In LF National (LF 1.X) Elevation products, the DEM layer is a derivative of the National Elevation Dataset (NED), the primary elevation data product produced and distributed by the USGS. The NED provided the best available public domain raster elevation data of the conterminous U.S., Alaska, Hawaii, and territorial islands in a seamless format. Derived from diverse source data, NED data was processed to a common coordinate system and unit of vertical measure. All NED data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the North American Datum of 1983 (NAD 83). All elevation values are provided in units of meters and are referenced to the North American Vertical Datum of 1988 (NAVD 88) over the conterminous U.S. The vertical reference will vary in other areas. NED data are available nationally at resolutions of 1 arc-second (approx. 30 meters) and 1/3 arc-second (approx. 10 meters), and in limited areas at 1/9 arc-second (approx. 3 meters). For the LF product the 1 arc second NED digital elevation model (DEM) was projected from Geographic to Albers and clipped out to the LF boundary.

For LF Remap (LF 2.0), Elevation is generated from ⅓ arc-second Digital Elevation Models (DEM), previously referred to as NED. The ⅓ arc-second DEM is part of the USGS 3D Elevation Program (3DEP), which provides the best available public domain raster elevation data of the conterminous U.S., Alaska, Hawaii, and insular areas in a seamless format. The ⅓ arc-second 3DEP DEM data were projected from Geographic to Albers Equal Area, resampled to 30m spatial resolution, and then clipped to the LF boundary. Elevation unit measurements are meters above mean sea level.

Aspect

Aspect represents the azimuth of the sloped surfaces across a landscape.

LF National (LF 1.X) Aspect was generated from NED DEM that was been clipped to the LF boundary. The aspect grid defines downslope direction. Non-defined aspect (slope is less than or =2) are assigned a value of -1. Aspect values range from 0.0 to 359.0 degrees. -9999 indicates NoData. Values have been adjusted to account for the Albers projection. The aspect grid was computed using the aspect function in ArcGIS 10.1.

For LF Remap (LF 2.0) Aspect is generated from 3DEP 1/3rd arc-second DEM that has been clipped to the LF boundary. The aspect grid defines downslope direction. Non-defined aspect (slope is less than or =2) are assigned a value of -1. Aspect values range from 0.0 to 359.0 degrees. -9999 indicates NoData. Values have been adjusted to account for the Albers projection. The aspect grid, computed using the aspect algorithm in GDAL version 2.0.12, defines downslope direction in degrees.

Slope

Slope represents the change of elevation over a specific area.

LF National (LF 1.X) Slope was generated from NED DEM that has been clipped to the LF boundary. The slope grid was generated using the "slope" function. The slope grid was created using the degree option and not with using percent in ArcGIS 10.1.

For LF Remap (LF 2.0), Slope is generated from 3DEP 1/3rd arc-second DEM that has been clipped to the LF boundary. The slope raster data were created using the degree slope algorithm in GDAL version 2.0.12.

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