LANDFIRE 2001 and 2008 Refresh

Geographic Area Report

North Central

December 2011

Executive Summary

The LANDFIRE National project (LF_1.0.0) was successfully completed in 2009. The goal of LANDFIRE National was to generate consistent 2001 vintage 30 meter spatial data sets for all 50 States for fire and other natural resource applications. This report highlights results from the continuation of LANDFIRE as a program to update the spatial data layers through 2008. The focus of this phase of the program was to improve the data products and account for vegetation change across the landscape caused by wildland fire, fuel and vegetation treatments, and management. In addition, changes caused by insects and disease, storms, invasive plants, and other natural or anthropogenic events were incorporated when data were available. This report describes the LANDFIRE 2001/2008 Refresh effort to update existing map layers to reflect more current conditions, focusing primarily on vegetation changes. The effort incorporated user feedback and new data, producing two comprehensive Refresh data product sets:

1. LANDFIRE 2001 Refresh (LF_1.0.5) enhanced LANDFIRE map layers by incorporating user feedback and additional data to provide a foundation to update data to 2008. It was also designed to provide users with a data set to help facilitate comparisons between 2001 and 2008 (i.e. Refresh LF_1.1.0) data sets.

2. LANDFIRE 2008 Refresh (LF_1.1.0) updated map layers to reflect vegetation changes and disturbances that occurred between 1999 and 2008.

In this report, we (1) address the background and provide details pertaining to why there are two Refresh data sets, (2) explain the requirements, planning, and procedures behind the completion and delivery of the updated products for each of the data product sets, (3) show and describe results, and (4) provide case studies illustrating the performance of LANDFIRE National, LANDFIRE 2001 Refresh and LANDFIRE 2008 Refresh (LF_1.1.0) data products on some example wildland fires.

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1.0 Introduction

1.1 LANDFIRE Program

LANDFIRE (LF), also known as Landscape Fire and Resource Management Planning Tools, is a joint program between the wildland fire management programs of the United States Department of Agriculture (USDA) Forest Service (USFS) and the United States Department of the Interior (DOI), including the following bureaus: the United States Geological Survey (USGS), the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), the Fish and Wildlife Service (FWS), and the National Park Service (NPS). The Nature Conservancy (TNC) serves as a cooperating partner. LF applies consistent methodologies and processes to create comprehensive spatial data and models describing vegetation and wildland fire/fuel characteristics across the United States. Mapped data products are based on Landsat satellite imagery and an extensive database of field-reference data (including USFS Forest Inventory Analysis (FIA) data).

LF provides the first implementation of methodologies and processes to develop and combine intermediate scale (30 m) spatial vegetation and fire information consistently across the entire United States. Such a suite of integrated vegetation, fuel, and fire regime data sets has not previously been created by the public or private sectors. LF data products facilitate National and regional (large landscape level) fire planning activities and the reporting of wildland fire management activities. LF products provide managers with the data needed for collaborative, landscape-scale, cross-boundary, interagency planning and implementation. LF data support land management to 1) identify fuel where fire hazards and fire risks to local communities may be located, 2) identify vegetation and fuel conditions where rehabilitation may benefit fire-dependent landscapes, 3) prioritize resources for National budget formulation and allocation, and 4) enhance management knowledge of fire behavior to improve firefighting safety. Programs within the wildland fire community that use LF data include the National Cohesive Wildland Fire Management Strategy, the Wildland Fire Decision Support System, Fire Program Analysis, and the Hazardous Fuel Prioritization and Allocation System.

While LF has proven highly valuable for the wildland fire community, it also provides value for other land management disciplines. LF data products provide an informational foundation that supports many diverse applications, including land management planning, environmental analyses, biological evaluations, monitoring, and resource assessments. Moreover, LF data are being considered as a key information input to a range of Federal interagency carbon sequestration and climate research initiatives. LF products are used in the land and resource management domains for setting strategic direction, supporting resource and staffing determinations, designing conservation management activities, and assessing risks to the environment and communities.

1.2 LANDFIRE Versions

In an effort to address user feedback and leadership direction, the LF team started from the base collection of data products developed during the LF National Project (circa 2001) to provide an updated collection of LF products. As such, different versions of LF data products were developed, requiring the creation of a data versioning specification. The data versioning table, available on the LF website (http://www.landfire.gov/version_comparison.php), assists users in understanding the differences among the various versions of LF data available on the LF Data Distribution Site (DDS). When LF data products are updated in the future, most of the versions currently available will be removed from the DDS and archived. Previous versions will be made available upon request. At any given point in time, there will be at most three versions of the data products available from the DDS. These will remain available for download on the DDS until the next product update has been completed.

1.2.1 LANDFIRE National (LF_1.0.0) circa 2001

LF National (LF_1.0.0) constitutes the first complete LF mapping of all geospatial data products for the nation. LF National was a five-year project that incorporated Landsat imagery from 1999 through 2003 (circa 2001) and delivered data on vegetation characteristics and condition, fire behavior and effects, fuel models, historical fire regimes, and fire regime conditions class for the United States in 2009. In this report, we refer to this data set simply as “LANDFIRE National” or “LF National.” The final deliverables for LF National included all of the layers required to run fire behavior models, such as the Fire Area Simulator (FARSITE; Finney, 2004). Methods used were consistent and repeatable across all ownerships nationwide. The consistent and comprehensive nature of LF National methods ensured that data were nationally relevant, while the 30-meter grid resolution assured that data had local application. A modified suite of the LF National data products was delivered for Alaska and Hawaii.

1.2.2 LANDFIRE 2001 (LF_1.0.5) and 2008 (LF_1.1.0) Refresh

The LF 2001/2008 Refresh represents the initial effort to enhance and update LF layers to maintain the currency of the data sets across all 50 States. These versions were produced in tandem, starting in fall 2009 with the LF 2001 Refresh (LF_1.0.5), and finishing in calendar year 2011 with the LF 2008 Refresh (LF_1.1.0). LF 2001/2008 enhancements and updates were developed to facilitate comparative analyses, evaluate trends, and potentially monitor changes over time. In this report, we use the following simplified terminology.

When the enhancement and update segments are referred to individually, we use:

- (enhancements) “LANDFIRE 2001” or “LF 2001” for LANDFIRE 2001 Refresh (LF_1.0.5)
- (updates) “LANDFIRE 2008” or “LF 2008” for LANDFIRE 2008 Refresh (LF_1.1.0)

When we refer to both of these segments together in a generic fashion, we use:

- “LANDFIRE 2001 and 2008” or “LANDFIRE 2001/2008”
- “LF 2001 and LF 2008” or “LF 2001/2008”

The LF 2001 version was implemented to enhance the LF National data set and provide a foundation upon which to build the updated geospatial data set.

The LF 2008 version was implemented to update the LF National data set to reflect changes from recent (1999-2008) natural disturbances (such as wildland fires) and management activities using Landsat imagery.

1.3 LANDFIRE 2001/2008

The LF 2001 and LF 2008 components of the LF Program sustain and extend the investment value of the original LF National data products with enhancements and updates to the LF spatial data suite. LF 2001 addressed vegetation discrepancies and areas of concern detected after the initial mapping effort. Problems with LF National products identified by users included discrepancies in vegetated versus non-vegetated lands, vegetation/land use categories, vegetation structure, and water/riparian attribution. Enhancements to address these discrepancies were requested by stakeholders that use LF data. The map layers were enhanced in LF 2001 by leveraging additional data sources, such as Soil Survey Geographic (SSURGO) data.

LF 2008 focused on updates to the suite of LF data products to reflect 2008 conditions. This focus was on updating landscape-level vegetation changes, such as those resulting from wildland fire, fuel and vegetation / silvicultural treatments, mortality from insects and disease, storm damage, invasive plants, and other natural or anthropogenic events where relevant data were available that occurred in the years from 1999 - 2008. To create LF 2008 products, Landsat imagery was used to detect vegetation change and landscape disturbance. A collection of recent natural disturbance and land management activities was compiled and stored in a spatial database. These products were combined along with other data sets to update existing vegetation and fuel layers. These updated vegetation and fuels layers were then used to update other LF data products. LF 2008 did not use new imagery to remap the entire landscape only to identify vegetation change or disturbance. To update products, LF 2001/2008 leveraged information and comments received through various sources, such as the LF help desk (http://www.landfire.gov/contactus.php), after action reviews, fuel calibration workshops, and lessons learned examples. LF 2001/2008 products have been used as inputs to strategic wildland fire management decision support systems and are expected to improve the relevance and reliability of the outcomes generated by these systems.

Nine geographic areas (GeoAreas; Figure 1) were defined to include all of the original mapping zones used from the National Land Cover Database (NLCD; based loosely on Omernik, 1987) for use in the LF National effort. The application of mapping zones as a pre-classification stratification method has been used in many mapping approaches (Homer et al. 1997; Homer et al. 2004). Research has shown that carefully defined mapping zones maximize spectral differentiation, provide a means to facilitate partitioning the workload into logical units, simplify post-classification modeling and improve classification accuracy (Homer et al. 2004). The GeoAreas were not intended to represent standardized analysis units or reporting extents. The primary purpose of the GeoAreas and mapping zones was to define ecologically relevant divisions for data acquisition and production planning.

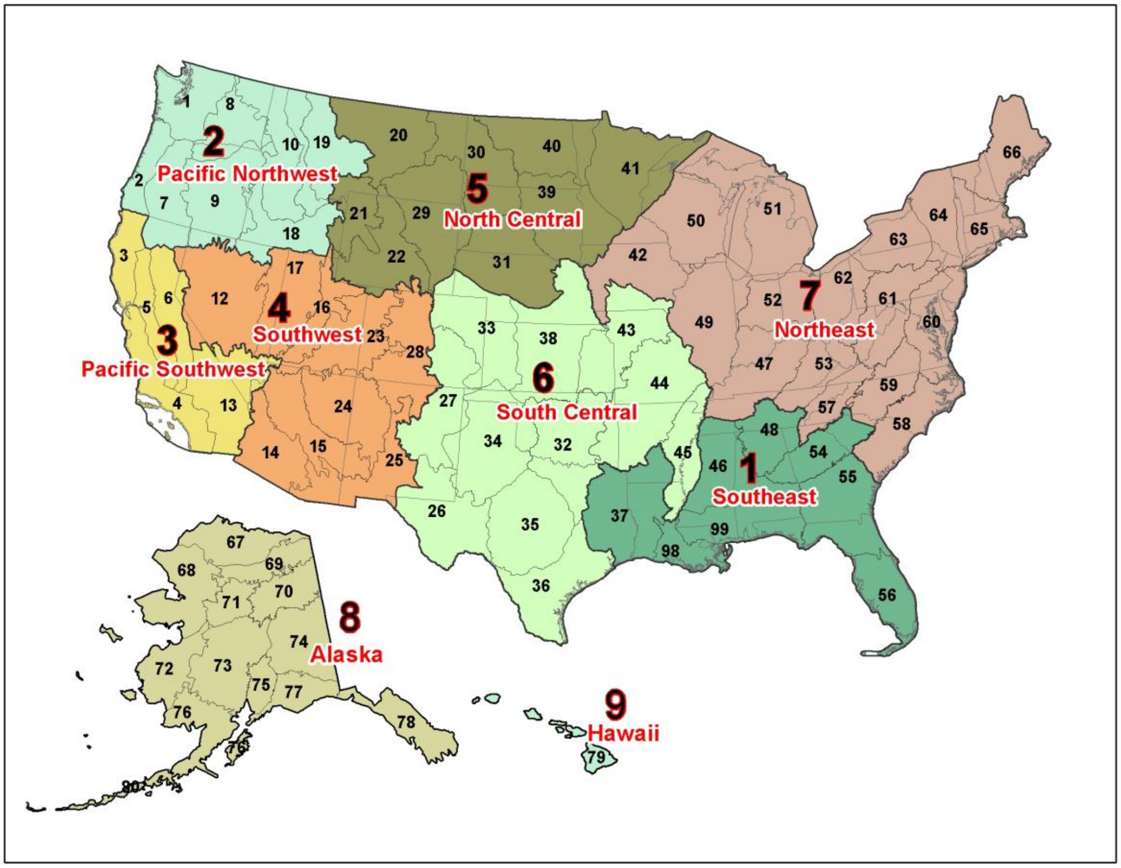

Figure 1 – Map of LF 2001/2008 GeoAreas according to the schedule. This image shows the nine GeoArea boundaries, which are comprised of National Land Cover Database 2001 mapping zones (numbered units), state boundaries are included for reference. GeoArea numbers and corresponding colors relate to the schedule in Table 1 below.

1.4 LANDFIRE 2001/2008 Statement of Work and Work Breakdown Structure

LF 2001/2008 used conventional best practices in project and program management to address the organizational structure, scheduling, and implementation procedures. The effort was faced with uncertainties common to many initiatives in the public and private sectors with regard to funding availability for elements within and outside of the scope of the program, contract acquisition, and prioritization of requirements that would shape the final suite of deliverables.

A statement of work (SOW) approach was used to define the scope of LF 2001/2008 and the data products to be delivered. In essence, the SOW included the development of comprehensive documentation describing the general methodological approach required to develop the suite of LF 2001/2008 intermediate and final products (deliverables). The SOW also included guidelines for quality assurance and quality control procedures, program management and program performance standards, estimates of overall duration, and an independent estimate of cost to the government for the defined scope of work.

A primary element of the SOW was a structured index and definition of work segments and deliverable-scheduled milestones. This structure is referred to as a Work Breakdown Structure (WBS) – also a standard best practice in program planning and management – and is used for effective organization and management of work activities. The SOW document and WBS organization drew upon lessons learned and program management artifacts developed during the completion of the LF National project and the LF 2007 Rapid Refresh project. A summary display of the actual project results in terms of scheduled initiation and completion of project milestones is provided in Figure 2 below. A description of the project milestones (such as GeoAreas and Group A and Group B product segments as outlined in Table 2) is provided in detail in section 1.5 of this report.

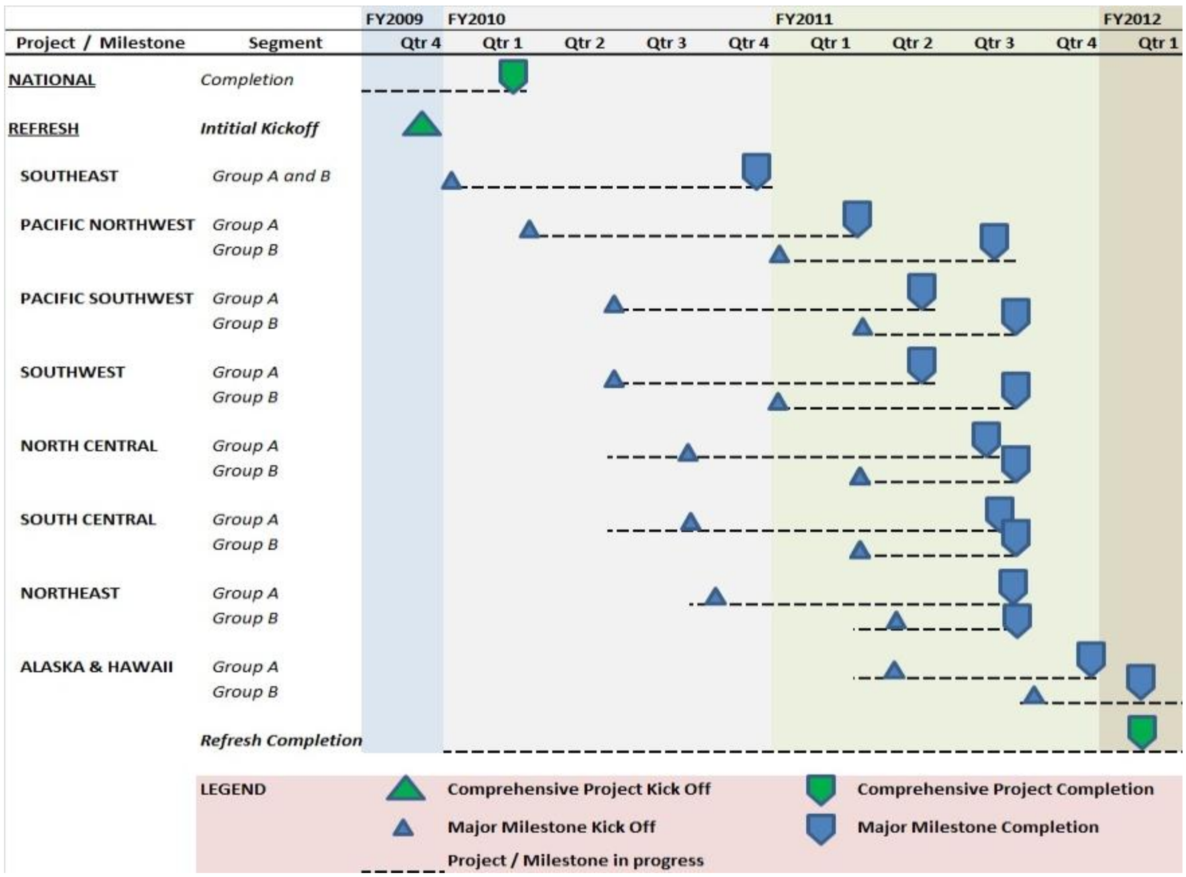

Figure 2 – LF 2001/2008 Gantt chart. This is a summary display of the actual results of the start and finish dates of the milestones and segments [such as GeoArea and Group A and Group B products]. These milestones and segments comprise the WBS discussed in Section 1.4.

The LF 2001/2008 effort was challenged by external factors such as mandatory work stoppages related to contractual reviews at the USFS and access to a range of qualified vendors through contract vehicles at both DOI component agencies and the USFS. Moreover, evolving management requirements resulted in longer periods of time required to complete processes for conducting full and open competitive bidding and finalizing vendor selection and formal work kickoff. Nonetheless, the use of comprehensive SOW documentation and WBS organization permitted the LF program to segment certain elements of development work and allocate these elements to vendor organizations that were best qualified and able to complete the LF 2001/2008 work at an optimal combination of cost, quality, and schedule performance.

At the inception of the LF 2001/2008 effort, there was a tight interdependency in scheduling between LF 2001/2008 and the Monitoring Trends in Burn Severity (MTBS) project. As noted in detail throughout this GeoArea report, LF 2001/2008 used data such as the MTBS mapping products to characterize the landscape changes reflected in LF 2001/2008 data layers. Thus, the structure of LF 2001/2008 production activities as well as product releases were linked to the organization of the original MTBS production schedule, which was segmented by geographic regions across the conterminous United States (CONUS).

1.5 LANDFIRE 2001/2008 Spatial Products

LF 2001/2008 was originally estimated to span 24 months and involve over 500 unique tasks to deliver updated LF data layers. The update was highly dependent upon field data in the form of landscape change polygons and other information regarding landscape conditions. LF partitioned the delivery of the updated LF 2001/2008 products into two segments, "Group A" and "Group B," to facilitate management direction and the fulfillment of user needs. The staggered release of products by GeoArea (Table 1) and grouping of data products (Table 2) was determined to be the most practical approach with respect to scope limitations, cost considerations, and contractual circumstances.

Table 1 – LF 2001/2008 product delivery schedule listing the nine GeoAreas as represented above in and delineating delivery of “Group A” and Group “B” data sets

Table 1. LF 2001/2008 Schedule		
Geographic Area	**Group A**	**Group B**
Southeast	4th Qtr. 2010	4th Qtr. 2010
Pacific Northwest	1st Qtr. 2011	3rd Qtr. 2011
Pacific Southwest	2nd Qtr. 2011	3rd Qtr. 2011
Southwest	2nd Qtr. 2011	3rd Qtr. 2011
North Central	2nd Qtr. 2011	3rd Qtr. 2011
South Central	3rd Qtr. 2011	3rd Qtr. 2011
Northeast	3rd Qtr. 2011	3rd Qtr. 2011
Alaska	3rd Qtr. 2011	4th Qtr. 2011
Hawaii	3rd Qtr. 2011	4th Qtr. 2011

Table 2 - LF 2001/2008 list of data products and how they were grouped (Group A and Group B) to facilitate management direction and user needs.

Table 2. LF 2001/2008 Products and Groupings	
Group A	**Group B**
Fire Behavior Fuel Model 13 (FBFM13) Fire Behavior Fuel Model 40 (FBFM 40) Canadian Forest Fire Danger Rating System (CFFDRS) (Alaska Only) Forest Canopy Bulk Density (CBD) Forest Canopy Base Height (CBH) Forest Canopy Cover (CC) Forest Canopy Height (CH) Fuel Characteristic Classification System Fuelbeds (FCCS) Existing Vegetation Type (EVT) Existing Vegetation Cover (EVC) Existing Vegetation Height (EVH)	Biophysical Settings (BpS) Vegetation Condition Class (VCC) Vegetation Departure Index (VDEP) Fire Regime Groups (FRG) Mean Fire Return Interval (MFRI) Percent Low Severity Fire (PLS) Percent Mixed Severity Fire (PMS) Percent Replacement Severity Fire (PRS) Fuel Loading Models (FLM) Succession Classes (SCLASS)

2.0 LANDFIRE 2001 and 2008 Methods and Results

2.1 Geographic Area Description

The North Central (NC) GeoArea consists of nine mapping zones encompassing large portions of Minnesota, Montana, Nebraska, North Dakota, South Dakota and Wyoming as well as small portions of Colorado, Idaho, Iowa, and Wisconsin, approximately 310 million total acres. The NLCD mapping zones within the NC GeoArea are listed in Table 3.

Table 3– NC GeoArea mapping zone numbers (see below Figure 3) and titles as labeled by the NLCD program.

Table 3. North Central GeoArea Mapping Zones	
Mapping Zone	**Mapping Zone Name**
20	Missouri River Plateau
21	Middle Rocky Mountains
22	Wyoming Basin
29	Wyoming Highlands
30	Northwestern Great Plains
31	Sandhills
39	Prairie Coteau Lands
40	Northern Great Plains
41	Northern Lake Country

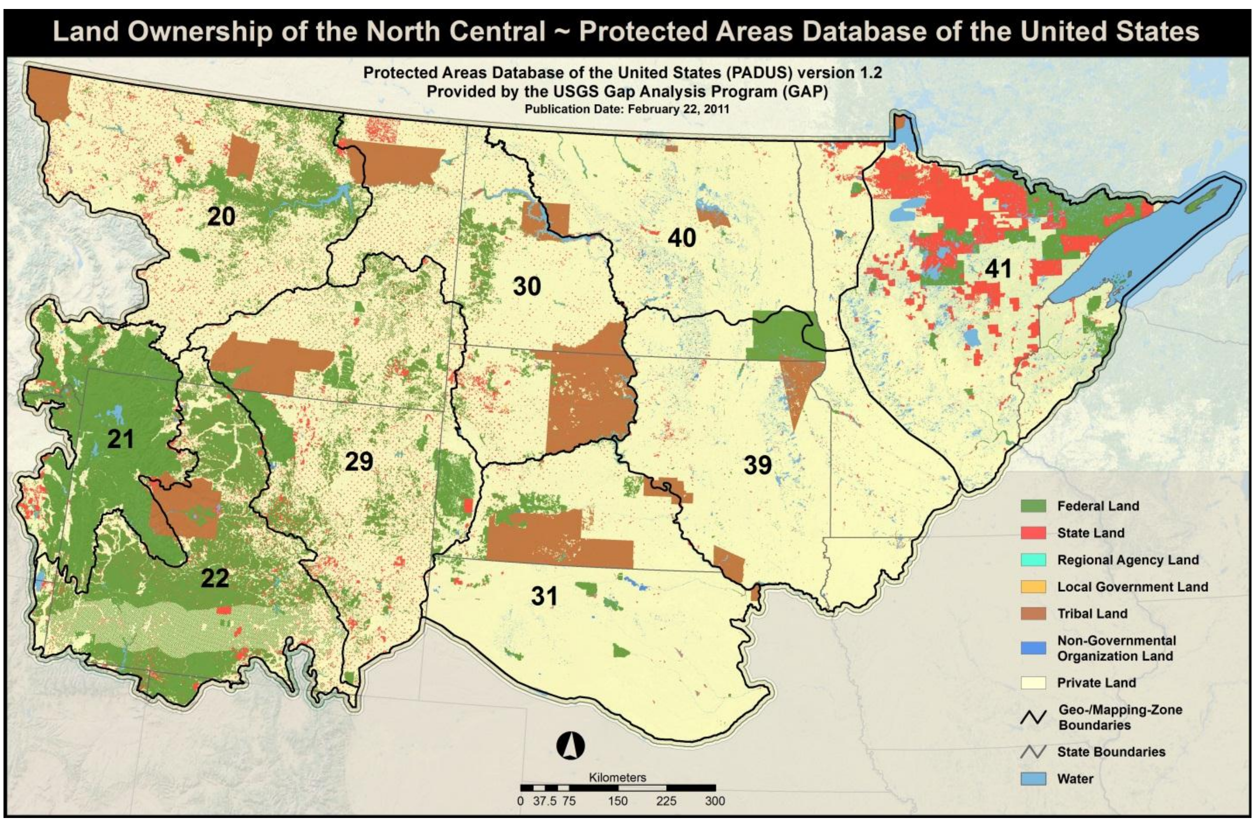

Figure 3 – Land ownership categories for the NC GeoArea.

Within a given GeoArea, land ownership is important because the condition of the landscape, including disturbances, may be a direct result of ownership mission and management activities. A summary of land ownership segmentation across the NC GeoArea is provided in Table 4.

Table 4 – Categories of land ownership, number of acres, and percentages of total GeoArea by category for the LF NC GeoArea.

Table 4. Acreage of Land Ownership Categories for the NC GeoArea.		
Land Ownership	**Acres**	**Percent of GeoArea**
Federal Government	49,954,069	16.2
Government and/or Private	3,401,909	1.1
Local Government	45,854	0.0
Private	223,308,776	72.2
State Government	13,915,404	4.5
Tribal	17,637,930	5.7
Water	775,287	0.3
Total	309,039,230	100.0

2.2 LANDFIRE Reference Database

2.2.1 Product Description

LF 2008 mapping was supported by a large database of field-reference data. The LANDFIRE Reference Database (LFRDB) includes vegetation and fuel data from over 800,000 geo-referenced sampling units located throughout the United States. These data were amassed from numerous sources, and, in large part, from existing information resources of outside entities, such as the USFS FIA Program, the 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 included biomass estimates of Downed Woody Material (DWM), percent cover and height of shrub and herb layers, and canopy base height estimates. Digital photos of the sampled units, when available, were archived.

A subset of the full suite of field-sampled data used in the production of LF deliverables is available for public access, as stipulated in the 2004 LF Executive Charter. In accordance with agreements between LF and its data contributors, certain proprietary or otherwise sensitive data were removed to create this publically available version of the LFRDB. There are over 275,000 sampling units from 260 different sources located throughout the United States available for public use.

2.2.2 LANDFIRE Reference Database Update Process

The following is a summary of key steps the LF production team conducted to complete the LFRDB component of LF 2001/2008. These methods were subject to revision and update upon the completion of all LF 2001/2008 GeoArea processing.

- Acquired geo-referenced, field-sampled vegetation and fuel data from existing national and local programs - This work required extensive communication with representatives of governmental and non-governmental entities throughout the U.S. and work with FIA staff to draw all relevant data
- Maintained a catalog and archive of all acquired data and metadata in their original formats using the existing LF data-catalog template and file structure
- Assessed and prepared acquired data for LF processing - this work required thorough inventorying of acquired geospatial data (in tabular format or as shapefiles, coverages, geodatabases, etc.) with regard to distribution and information content and removal of records with irreconcilable geospatial or information errors/omissions
- Converted relevant/viable data into LF format such that they conformed to standards defined in the data dictionaries for the AutoKey Database to accurately assign EVT to plots that have species composition (species and cover) attributes and LFRDB - this required using intermediate to advanced techniques for relational database management, manipulation and management of point and vector geospatial data, and regular documentation of data-conversion processes and quality-control measures
- Acquired and incorporated into the LFRDB all ancillary spatial data needed for LF production (such as data extracted from LF base and product layers) - this required support from FIA staff and representatives of other entities that provide data with plot locations that must remain confidential
- Derived and incorporated into the LFRDB any attributes necessary for LF production but not acquired as part of the original data sets - this included the derivation of canopy cover and height estimates from FIA tree records, fuel loading estimates from DWM records, un-compacted crown ratios from compacted crown ratios, vegetation map-unit assignments from the Ecological Systems AutoKey, canopy fuel attributes from FuelCalc (Reinhardt, 2006) (a tool to compute surface and canopy fuel loads and characteristics from inventory data), and various attributes from the Forest Vegetation Simulator (FVS; Dixon 2002) and its Fire and Fuels Extension (FFE; Reinhardt and Crookston 2003).
- Checked for information and spatial errors as detailed in the LFRDB Quality Assurance (QA) checklist, and, once removed or appropriately identified, distributed the inaugural LFRDB for LF production
- Maintained and updated the LFRDB after the inaugural posting by archiving relevant LF production information, including results of Quality Assurance / Quality Control (QA/QC) on LFRDB records performed by mapping teams and additional data as requested/permitted by LF mapping teams and leadership

2.2.3 LANDFIRE Reference Database Update Results

Final deliverables for the NC GeoArea consisted of a catalog (spreadsheet) and archive (file system) of all acquired data, an AutoKey Database (Microsoft Access© database) which was developed to quickly and accurately assign EVT to plots that has species composition (species and cover) attributes for the NC GeoArea, a LFRDB (Microsoft Access© database) for the NC GeoArea, and documentation of data conversion processes and QC measures taken during the data-loading stages.

The final LFRDB product for the NC GeoArea resulted in a large number of sampling events derived from various data sources, including the following:

- 166,199 geo-referenced sampling events were contained within the NC LFRDB.

- 105 different sources of data were contributed by Federal, State, and private entities.
- 26% of data were submitted in response to the LF data call (http://www.landfire.gov/participate_refdata.php) and 74% of data were acquired by LF personnel through direct data sharing agreements (USFS FIA), websites such as the NPS Data Store and Northwest and Alaska Fire Research Clearinghouse or agency database systems (USFS-Natural Resource Information System and Field Sampled Vegetation
- 4,942 Forest Inventory and Analysis (FIA) sampling events were added to the LFRDB for LF 2001/2008 (1,661 were new sampling locations and 3,281 were inventoried).

A significant amount of vegetation and fuel data were acquired and compiled from many different sources for LF National and LF 2001/2008. The LFRDB team was able to acquire more than half the data archived in the NC LFRDB from data sharing agreements, websites, and/or agency databases. Data contributions submitted in response to the data call were also important, accounting for 26% of the sampling events. Major data contributions can be accredited to the USFS, the rest of the data came from multiple of sources. Table 5 shows a breakdown of the data contribution profile for the NC LFRDB.

Table 5 – Data contribution profile for the NC LFRDB.

Table 5 NC LANDFIRE Reference Database Data Contributions		
Data Contribution Profile	**Samples**	**Percent**
Multi Agency	93,477	56.2
USFS	51,976	31.3
USGS	6,280	3.8
BLM	5,779	3.5
State	5,718	3.4
NPS	1,085	0.7
BIA/Tribal	1,068	0.6
Department of Defense	312	0.2
Non-Governmental Organizations /Private	258	0.2
FWS	246	0.1
	Total	100.0

For LF 2001/2008, the LFRDB team acquired and incorporated additional data into the existing LFRDB to facilitate the improvement and updating of several LF data products. Data provided by FIA contain a complete set of attributes necessary for updating LF products, so efforts were focused on converting and adding these data. During LF 2001/2008, several improvements were made to FIA data processing procedures, including updates to the way forest canopy cover and height metrics were derived and improvements to the LFRDB database schema that allowed for the archiving of repeat measures. There were 4,942 new FIA sampling events added to the NC LFRDB for LF 2001/2008. The NC LFRDB also contains a significant amount of vegetation data, including information on community occurrence, species composition, vegetation structure, exotic plants, and fuel. Table 6 provides a summary of data types by percent distribution for the NC GeoArea. Community occurrence data include natural community or cover type classifications; species composition data include canopy cover estimates per plant taxon; vegetation structure data include height measurements per life form or plant taxon; exotic plant data include occurrence or cover estimates of exotic plants; and fuel data include composition and characteristics of surface and/or canopy fuel.

Table 6– Percent distribution of data types for NC LFRDB.

Table 6. NC LANDFIRE Reference Database Plot Summary		
Data Type	**Samples**	**Percent***
Community Occurrence Records	12,198	7
Species Composition	61,134	37
Structure	38,283	23
Exotics	92,469	56
Fuels	17,240	10

**Percent occurrence of the listed data types within the LFRDB. The percentages do not total to 100% because a plot may have more than one data type. For example, a plot may have both species composition and fuel data whereas another plot may only have community occurrence records. The 4,942 new FIA plots that were added to the LFRDB provided species composition, structure, and fuel data, but not the other data types listed.*

2.3 Biophysical Settings

2.3.1 Product Description

The Biophysical Settings (BpS) layer represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the biophysical environment and an approximation of the historical disturbance regime. BpS is a refinement of the Environmental Site Potential (ESP) layer. In this update, we attempted to incorporate current scientific knowledge regarding the functioning of ecological processes – such as fire – in the centuries preceding non-indigenous human influence. Map units were based on NatureServe's (NS) Ecological Systems classification; a nationally consistent set of mid-scale ecological units (Comer et al. 2003).

LF used these classification units to describe BpS, which differed from their intended use as units of existing vegetation. As used in LF, map unit names 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. The LF BpS concept is similar to the concept of potential natural vegetation groups used in mapping and modeling efforts related to Fire Regime Condition Class (FRCC; Schmidt et al. 2002; www.frcc.gov).

2.3.2 Biophysical Settings Layer Enhancements

One objective for LF 2001/2008 was to simplify the BpS map layer by reclassifying similar systems into BpS Groups. New names were assigned to better reflect the floristic make-up of the grouped systems and to include the appropriate fire regime (I thru V), and a vegetation model was chosen that best represented the grouped systems.

This task included a review of all BpS model descriptions and the Model Tracker Database (MTDB) for each mapping zone. MTDB is an Access database application developed by TNC specifically for the LF Program. MTDB contains a very detailed description of every Ecological System mapped by LF, including physiographic characteristics, biological characteristics, and disturbance regime of each system and the individual succession classes within that system, as defined by local experts. In addition, all review comments are contained within MTDB to allow readers to understand the evolution of the models through the development and review processes; LF team members assessed all model transition states, reference conditions, fire-regime groups, and ancillary information to determine similarities between

BpS. At the end of this process, a grouping strategy was proposed and implemented. The final step was the development of a lookup table relating LF National BpS map units and LF 2001/2008 Grouped BpS map units. Redundant and/or similar BpS models were collapsed into one group, and the original LF National BpS codes have corresponding LF 2001/2008 grouped BpS codes.

For certain mapping zones, non-forest BpS map units were remapped using SSURGO data that were not available in the West during the LF National BpS mapping process. The process started by establishing a cross-walk between SSURGO Ecological Site polygon data and BpS units. These cross-walk assignments were based primarily on similar dominant vegetation types and additional information such as elevation, ecoregion, and subsection, to distinguish between possible BpS assignments. Next, a map of BpS map units was built and assignments were made to existing SSURGO ecological site polygon data. Based on these data, cross-walked polygons were sampled to develop pseudo plots (a method to address a lack of field data using existing plot and geospatial data) using the ERDAS Imagine© NLCD sampling tool (a remote sensing application for geospatial raster data processing). A map was created for the entire map zone using the models output from See5© using the pseudo plots of BpS map units. The last production step was to combine this new map with the LF National BpS map in order to update BpS in non-forest areas.

2.3.3 Fire Regime Products

Five layers [Mean Return Interval (MFRI), Percent of Low Severity (PLS) fire, Percent of Mixed Severity (PMS) fire, Percent Replacement Severity (PRS) fires, and Fire Regime Groups (FRG)] characterizing modeled historical fire regimes were produced based on the BpS and linkage with the Refresh Model Tracker (RMT). This linkage provides the probability of replacement, mixed, and surface fires. MFRI was calculated as the reciprocal of the sum of these probabilities (which is the probability of fire of any severity), grouped into classes and then combined with the non-vegetated types from the Succession Classes (SCLASS) layer. The PLS, PMS, and PRS layers were calculated respectively as the ratio of the probability of surface, mixed, and replacement fires to the probability of any fire. The FRG was based on a combination of the MFRI and average fire severity from the FRCC Guidebook (FRCC, 2010), as displayed in Table 7 and Table 8 showing the comparisons between LF National and LF 2001.

Table 7– The Fire Regime Groups by frequency and PRS for vegetation types within each regime as described in the FRCC Guidebook.

Table 7. Fire Regime Groups, Frequency, and Severity		
Fire Regime Group Name	**Frequency (years)**	**Severity Percent**
FRG I	0-35	PRS < 75
FRG II	0-35	PRS >= 75
FRG III	35-200	PRS < 75
FRG IV	35-200	PRS >= 75
FRG V	200+	All

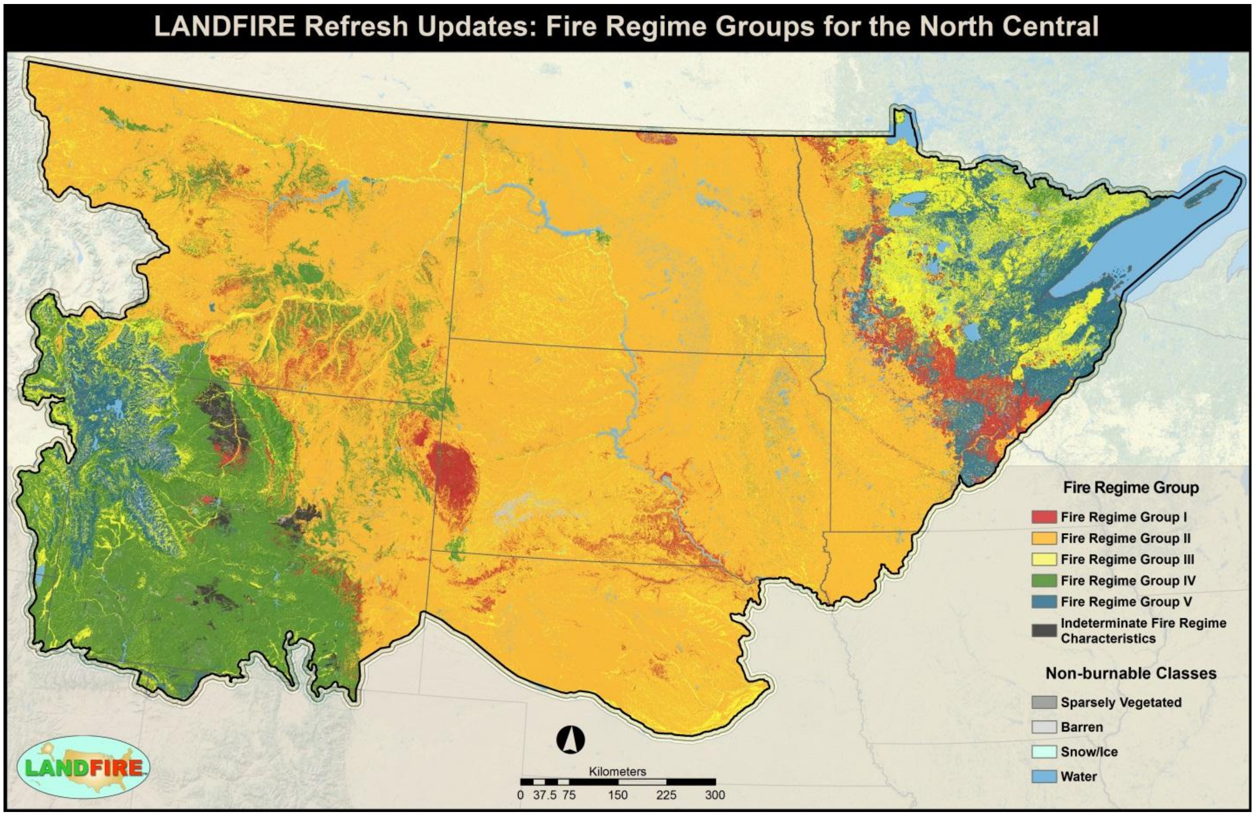

Figure 4 – Map of the NC GeoArea depicting LF Fire Regime Groups in the absence of modern human intervention with possible aboriginal fire use.

Table 8 – Comparison of acreage mapped and percent change by Fire Regime Groups in LF National and LF 2001 versions of LF data.

Table 8. Fire Regime Group Comparison			
Fire Regime Group Name	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
FRG I	27,087,365	13,332,009	-50.8
FRG II	176,859,997	174,565,460	-1.3
FRG III	22,444,660	36,439,483	62.4
FRG IV	45,823,702	46,590,768	1.7
FRG V	19,502,126	21,869,377	12.1
Water	12,787,553	12,078,299	-5.6
Snow / Ice	28,021	23,543	-16.0
Barren	1,652,801	1,411,595	-14.6
Sparsely Vegetated	525,931	508,180	-3.4
Indeterminate Fire Regime Characteristics	2,948,762	2,842,532	-3.6

2.4 Disturbance Mapping

2.4.1 Product Description

LF disturbance data were developed to provide temporal and spatial information related to landscape change for determining vegetation transitions over time and making subsequent updates to LF vegetation, fuel, and other data. Disturbance data include attributes associated with disturbance year, type, and severity. These data were developed through use of Landsat satellite imagery, local agency derived disturbance polygons, and other ancillary data establishing disturbance grids for each year.

2.4.2 Disturbance Mapping Objectives

Changes in the landscape are pervasive and occur continually. For LF data to remain current, a process was needed to integrate spatial temporal landscape changes into the suite of LF products.

The objective of this process was to map the location, extent, type, and severity of major disturbances for the entire United States. To achieve this objective, several data sets needed to be integrated into one product. Not all types of data were available in all areas. The disturbance mapping process was performed at the LF mapping zone scale.

2.4.3 Disturbance Mapping Process

In accordance with a provision in the LF Charter regarding the directive to regularly update LF products, disturbances to the landscape were identified using a process referred to as Remote Sensing of Landscape Change (RSLC; Vogelmann et al. 2010). The RSLC process includes multiple data sources and processes, including remotely sensed imagery, a spatial database of events, and field assessments. In order to capture disturbance on the landscape, LF worked with the University of Maryland researchers on vegetation (forest) change detection using archived Landsat Time Series Stacks (LTSS; Huang et al. 2009). LF used a vegetation change and tracking algorithm called the Vegetation Change Tracker (VCT; Huang et al. 2010). VCT tracks a vegetation index through a LTSS in order to identify landscape changes. VCT data were developed for each year identifying disturbed areas as well as disturbance severity. As part of the VCT processing, the Normalized Burn Ratio (NBR, Key et al. 2006) was calculated for each input scene. Severity was determined from the Landsat imagery by calculating both the minimum and the maximum NBR value for each pixel for the years 1999 to 2008 from the VCT output. The minimum NBR was then subtracted from the maximum NBR. The result was classified into high, medium, and low severity levels based on a statistical comparison with the MTBS, Burned Area Reflectance Classification (BARC), and Rapid Assessment of Vegetation Condition after Wildfire (RAVG) fire severity data also available for the area.

Since disturbance type, or causality, was not determined in the VCT process, a spatial analysis was conducted comparing the VCT output to buffered (1-kilometer) LF 2008 disturbance Event data, which were provided to LF by various local, regional, and national agencies and organizations as part of the LF data contribution opportunity. Disturbance type and year information were included as attributes for each polygon and transferred to the disturbance grids in this process. Data inputs on location of Federal Agency lands were included using the Protected Areas Database of the United States (PAD-US; http://www.protectedlands.net/padus/). PAD-US is a product of GAP, which shows land management status representing public and private land ownership, and conservation lands that are assigned a conservation status for biodiversity preservation and natural, recreational, or cultural uses. PAD-US and its “GAP Status” attribute were used to inform causality for disturbances outside of disturbance Event polygons. While not identifying a precise type of disturbance, this analysis provides information useful for narrowing down the types of disturbance that would be expected to occur in a given location.

LANDFIRE 2001 and 2008 Methods and Results

Wildland fire disturbance data are developed through a multistep process. Inputs to this process include fire mapping data obtained from the MTBS, BARC, and RAVG fire mapping efforts. These three data sets were merged together to map the extent and severity of wildland fires.

Subsequently, all disturbance types were processed, creating ten disturbance grids, one for each year from 1999 to 2008. Each grid was attributed with year, disturbance type (if known, otherwise a description of possible types), severity, and the data sources used to create the data.

In addition to these yearly disturbance grids, an integrated composite of vegetation disturbance data was developed according to the following priorities, in order of importance: time since disturbance, type, and severity for the entire ten year period. The disturbance types included the following:

- Recent fire activity (1999 through 2008)
- Mechanical treatments that do not remove material from the site (Mechanical Add)
- Mechanical treatments that do remove material from the site (Mechanical Remove)
- Wind disturbance
- Insect and disease

The severity of the disturbance was described as high, moderate, or low. Following are the general guidelines for categorizing:

- High = >75% of above-ground vegetation mortality
- Moderate = 25 to 75% above-ground vegetation mortality
- Low = <25% above-ground vegetation mortality

Time since disturbance was separated into three categories (or time steps), including the following:

- 1 year post disturbance
- 2-5 years post disturbance
- 6-10 years post disturbance

2.4.4 Disturbance Mapping Results

Disturbance categories were mapped and tabulated for the entire NC GeoArea (Table 9). Across all lands, 2 percent of the GeoArea was mapped as disturbed from 1999 to 2008, leaving 98 percent undisturbed. On Federa; lands, 5 percent of the GeoArea was mapped as disturbed, leaving 95 percent undisturbed. We recognize that certain types are disturbances are missed in the mapping process, particularly subtle change such as decline of certain forest cover types affected by insects or disease. In Table 10 through Table 14 provides a detailed listing of mapped disturbance by type on all lands and Federal lands.

Table 9 –Total mapped disturbances area and percent by land ownership category for the NC GeoArea.

Table 9. Disturbance Acreage by Land Ownership			
Land Ownership	**Category**	**Acres**	**Percent Ownership**
All Lands	No Disturbance	304,138,302	98
All Lands	All Disturbances	5,522,944	2
Federal Lands	No Disturbance	47,537,363	95
Federal Lands	All Disturbances	2,416,706	5

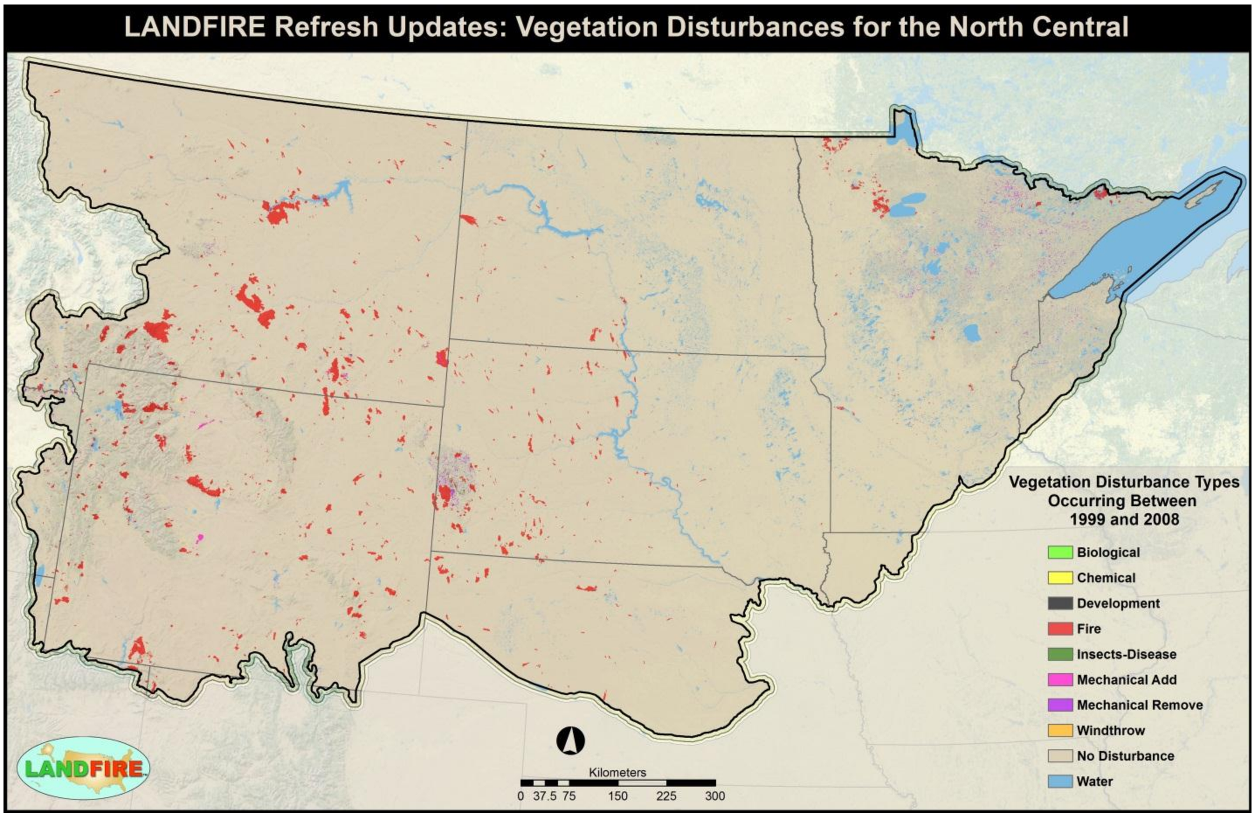

Figure 5 – Map of vegetation disturbance types (fire, mechanical, etc.) mapped for the NC GeoArea from 1999 to 2008.

Table 10 – Number of acres mapped as affected by fire disturbance for severity classes of low, moderate, and high with the period of years since disturbance between All Lands and Federal Land ownership for the NC GeoArea.

Table 10. **Area Affected by Fire Disturbance**				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Fire	Low	One Year	302,664
All Lands	Fire	Low	Two to Five Years	1,262,357
All Lands	Fire	Low	Six to Ten Years	1,748,856
All Lands	Fire	Moderate	One Year	42,764
All Lands	Fire	Moderate	Two to Five Years	517,513
All Lands	Fire	Moderate	Six to Ten Years	444,748
All Lands	Fire	High	One Year	19,949
All Lands	Fire	High	Two to Five Years	210,040
All Lands	Fire	High	Six to Ten Years	179,941
Federal Lands	Fire	Low	One Year	150,872
Federal Lands	Fire	Low	Two to Five Years	508,356
Federal Lands	Fire	Low	Six to Ten Years	676,389
Federal Lands	Fire	Moderate	One Year	32,568
Federal Lands	Fire	Moderate	Two to Five Years	213,925
Federal Lands	Fire	Moderate	Six to Ten Years	243,931
Federal Lands	Fire	High	One Year	16,638
Federal Lands	Fire	High	Two to Five Years	122,293
Federal Lands	Fire	High	Six to Ten Years	130,080

Table 11 – Number of acres mapped as affected by the Mechanical Add disturbance by severity classes of low, moderate, and high with the period of years since disturbance between All Lands and Federal Land ownership for the NC GeoArea.

Table 11. Area Affected by Mechanical Add Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Mechanical Add	Low	One Year	20,332
All Lands	Mechanical Add	Low	Two to Five Years	60,404
All Lands	Mechanical Add	Low	Six to Ten Years	26,505
All Lands	Mechanical Add	Moderate	One Year	1,974
All Lands	Mechanical Add	Moderate	Two to Five Years	7,225
All Lands	Mechanical Add	Moderate	Six to Ten Years	3,359
All Lands	Mechanical Add	High	One Year	1,628
All Lands	Mechanical Add	High	Two to Five Years	7,386
All Lands	Mechanical Add	High	Six to Ten Years	1,999
Federal Lands	Mechanical Add	Low	One Year	18,088
Federal Lands	Mechanical Add	Low	Two to Five Years	55,063
Federal Lands	Mechanical Add	Low	Six to Ten Years	24,589
Federal Lands	Mechanical Add	Moderate	One Year	1,737
Federal Lands	Mechanical Add	Moderate	Two to Five Years	5,995
Federal Lands	Mechanical Add	Moderate	Six to Ten Years	2,734
Federal Lands	Mechanical Add	High	One Year	1,482
Federal Lands	Mechanical Add	High	Two to Five Years	6,638
Federal Lands	Mechanical Add	High	Six to Ten Years	1,683

Table 12 – Number of acres mapped as affected by the Mechanical Remove disturbance by severity of classes of low, moderate, and high with the period of years since disturbance between All Lands and Federal Land ownership for the NC GeoArea.

Table 12. Area Affected by Mechanical Remove Disturbance

Land Ownership	Category	Severity	Time Since Disturbance	Acres
All Lands	Mechanical Remove	Low	One Year	30,446
All Lands	Mechanical Remove	Low	Two to Five Years	58,738
All Lands	Mechanical Remove	Low	Six to Ten Years	57,702
All Lands	Mechanical Remove	Moderate	One Year	44,802
All Lands	Mechanical Remove	Moderate	Two to Five Years	111,686
All Lands	Mechanical Remove	Moderate	Six to Ten Years	136,373
All Lands	Mechanical Remove	High	One Year	14,487
All Lands	Mechanical Remove	High	Two to Five Years	91,200
All Lands	Mechanical Remove	High	Six to Ten Years	80,769
Federal Lands	Mechanical Remove	Low	One Year	7,196
Federal Lands	Mechanical Remove	Low	Two to Five Years	31,190
Federal Lands	Mechanical Remove	Low	Six to Ten Years	19,277
Federal Lands	Mechanical Remove	Moderate	One Year	11,145
Federal Lands	Mechanical Remove	Moderate	Two to Five Years	29,122
Federal Lands	Mechanical Remove	Moderate	Six to Ten Years	34,255
Federal Lands	Mechanical Remove	High	One Year	4,856
Federal Lands	Mechanical Remove	High	Two to Five Years	20,524
Federal Lands	Mechanical Remove	High	Six to Ten Years	14,330

Table 13 – Number of acres mapped as affected by Windthrow and Insects and Disease disturbance with the period of years since disturbance between All Lands and Federal Land ownership for the NC GeoArea.

Table 13. Area Affected by Windthrow and Insect/Disease Disturbances

Land Ownership	Category	Severity	Time Since Disturbance	Acres
All Lands	Insects-Disease	Low	One Year	28,838
All Lands	Insects-Disease	Low	Two to Five Years	58
All Lands	Windthrow	Low	One Year	812
All Lands	Windthrow	Low	Two to Five Years	361
Federal Lands	Insects-Disease	Low	One Year	28,588
Federal Lands	Insects-Disease	Low	Two to Five Years	58
Federal Lands	Windthrow	Low	One Year	621
Federal Lands	Windthrow	Low	Two to Five Years	361

Table 14 – Number of acres mapped as affected by Chemical, Biological and Development disturbances by severity classes of low, moderate, and high with the period of years since disturbance between All Lands and Federal Land ownership for the NC GeoArea.

Table 14. Area Affected by Chemical, Biological, or Development Disturbances				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Chemical	Low	One Year	2,553
All Lands	Chemical	Low	Two to Five Years	1,647
All Lands	Chemical	Low	Six to Ten Years	1,245
All Lands	Development	Low	Two to Five Years	220
All Lands	Development	Low	Six to Ten Years	824
All Lands	Development	Moderate	Two to Five Years	75
All Lands	Development	Moderate	Six to Ten Years	305
All Lands	Development	High	Two to Five Years	56
All Lands	Development	High	Six to Ten Years	103
Federal Lands	Chemical	Low	One Year	268
Federal Lands	Chemical	Low	Two to Five Years	162
Federal Lands	Chemical	Low	Six to Ten Years	152
Federal Lands	Development	Low	Two to Five Years	220
Federal Lands	Development	Low	Six to Ten Years	807
Federal Lands	Development	Moderate	Two to Five Years	66
Federal Lands	Development	Moderate	Six to Ten Years	297
Federal Lands	Development	High	Two to Five Years	51
Federal Lands	Development	High	Six to Ten Years	99

2.5 Existing Vegetation

2.5.1 Product Description

The existing vegetation layers for each LF mapping zone include: Existing Vegetation Type (EVT), Existing Vegetation Cover (EVC), and Existing Vegetation Height (EVH). All three layers were originally mapped using predictive landscape models based on extensive field-reference data, satellite imagery, biophysical gradient predictor layers, and classification and regression trees. Various parts of these existing vegetation layers were edited and refined as part of LF 2001/2008. The EVT layer represents the current dominant vegetation using map units derived from NS's Ecological Systems vegetation classification. The EVC layer represents the average percent cover of existing vegetation for a 30 meter grid cell. The EVH layer represents the average height of the dominant/co-dominant vegetation for a 30 meter grid cell.

2.5.2 LF 2001: Enhancements to Existing Vegetation Products

With the release of LF National data products, several areas in the EVT layer were identified for improvement. In 2009, leadership direction and funding were provided to implement these improvements for the conterminous States. In Table 15 through Table 31 and Table 34 and Table 35 of this report, comparisons are made between the LF National data product and the LF 2001 product and the LF 2001 and the LF 2008 updated products. It is important to note that in the majority of cases, the percent changes between the National and LF 2001 / 2008 are a result of classification and product differences and not actual changes on the ground. LF staff developed a series of steps to improve LF

National vegetation data. In addition, problems with the LF National Forest Canopy Cover (CC) documented by Scott (2008) needed to be addressed. Generally, CC values were too high, accuracy was relatively low, and seam lines sometimes existed within mapping zones or between adjacent mapping zones. New metrics of tree cover and tree height were developed using tree plot data (Toney et al. 2009) and new tree cover and height maps were developed. Also, the amount of barren mapped in the EVT was adjusted by a series of processes, include rectifying barren areas with NLCD, removing water on slopes, classification of surface mines, and reclassifying areas depicted as barren in the fuel layers that were not classified as barren in the LF National EVT layer.

2.5.2a Enhancements to Existing Vegetation Type

As part of the enhancements, revisions were made to the international boundaries to coincide with existing data sets. For the United States/Canada border, data from the International Boundary Commission (http://www.internationalboundarycommission.org/boundary.html) were incorporated. For the United States/Mexico border, data from the International Boundary and Water Commission (http://www.ibwc.state.gov/) and the U.S. - Mexico Border Environmental Health Initiative (http://borderhealth.cr.usgs.gov/projectindex.html) were incorporated. Gaps in LF data were filled with either LF National existing vegetation from the 3-km buffer developed around each mapping zone or NLCD2001 land cover data.

At the beginning of LF National, the NLCD2001 land cover layer was partially complete, creating inconsistencies in land cover classes between the final NLCD2001 land cover and LF National layers. Improvements to the LF existing vegetation layers attempted to synchronize these two layers. First, natural land cover classes were reclassified to anthropogenic land cover classes based on the NLCD2001 land cover product. Where NLCD2001 was classified as a natural land cover class and LF layers were classed anthropogenic land cover, LF data were reclassified to the most dominant natural land cover class. Also in this process, herbaceous wetland vegetation types from the NLCD2001 product were mapped to the LF National EVT product. Riparian EVTs mapped in LF National that coincided with stream networks one pixel wide were removed from the existing vegetation layers.

To address potentially burnable agricultural classes, information from the National Agricultural Statistics Survey (NASS; http://www.nass.usda.gov/ and PAD-US was incorporated into the LF 2001 EVT layer. On non-Federal lands where NASS and NLCD2001 agricultural classes were coincident, NASS classification took precedence. Where NASS and NLCD2001 agricultural classes were not coincident, both classes were retained. Agricultural classes were removed on most Federal lands and assigned a natural EVT. Most revised agricultural classes resulted in burnable fuel models.

In order to address potentially burnable urban the NLCD2001 low and medium intensity urban classes were modeled to “developed” NLCD natural vegetation classes. Roads were reintroduced using the National Transportation Statistics (http://www.bts.gov/) layer and filtered by adjacent lifeform. If canopy fire spread was possible, the roads were removed. NLCD2001 classes 21 and 22 received a burnable fuel model, while classes 23, 24, and 25 remained non-burnable.

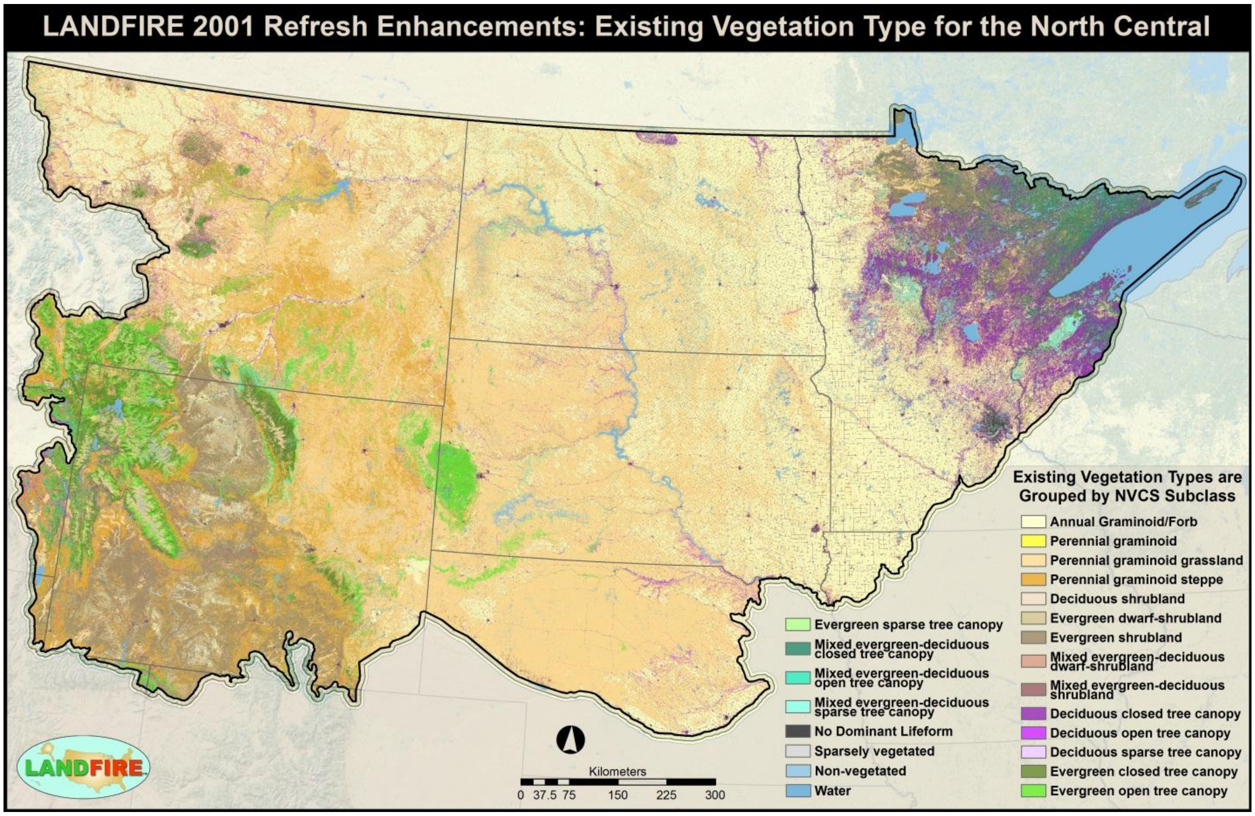

Figure 6 – Map of Existing Vegetation Type layer that was enhanced as part of the LF 2001 updates by incorporating user feedback and additional data.

Table 15 – Acreage of LF agricultural Existing Vegetation Type Groups and percent change on All Land ownerships in the NC GeoArea between LF National and LF 2001.

Table 15. Agricultural Type Comparisons across All Lands

Existing Vegetation Type Groups	LF National (acres)	LF 2001 (acres)	Percent Change
Agriculture-Cultivated Crops and Irrigated Agriculture	69,229,192	14,711,059	-78.8
Agriculture-Fallow*	1,052,100	22	-100.0
Agriculture-General	1,408,819	-	-100.0
Agriculture-Pasture and Hay*	15,126,010	15,130,740	0.0
Agriculture-Small Grains	1,030,660	13	-100.0
NASS-Close Grown Crop	-	19,026,525	100.0
NASS-Fallow/Idle Cropland*	-	3,205,762	100.0
NASS-Orchard**	-	-	-
NASS-Pasture and Hayland*	-	1,099,689	100.0
NASS-Row Crop	-	29,661,023	100.0
NASS-Row Crop-Close Grown Crop	-	2,311,786	100.0
NLCD-Herbaceous Semi-dry*	-	217,813	100.0
NLCD-Herbaceous Semi-wet*	-	189,781	100.0

** Denotes burnable vegetation type in LF 2001*

Table 16 – Acreage of LF agricultural Existing Vegetation Type Groups and percent change on Federal Land ownership in the NC GeoArea between LF National and LF 2001

Table 16. Agricultural Type Comparisons across Federal Lands			
Existing Vegetation Type Groups	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
Agriculture-Cultivated Crops and Irrigated Agriculture	512,591	169,401	-67.0
Agriculture-Fallow*	73,771	-	-100.0
Agriculture-General	17,646	-	-100.0
Agriculture-Pasture and Hay*	380,935	278,360	-26.9
Agriculture-Small Grains	26,222	-	-100.0
NASS-Close Grown Crop	-	159,678	100.0
NASS-Fallow/Idle Cropland*	-	13,927	100.0
NASS-Pasture and Hayland*	-	17,291	100.0
NASS-Row Crop	-	58,983	100.0
NASS-Row Crop-Close Grown Crop	-	19,023	100.0
NLCD-Herbaceous Semi-dry*	-	70,244	100.0
NLCD-Herbaceous Semi-wet*	-	91,804	100.0

** Denotes burnable vegetation type in LF 2001*

Table 17 – Acreage of LF urban (developed) Existing Vegetation Type Groups and percent change on All Lands in the NC GeoArea between LF National and LF 2001.

Table 17. Developed Lands Comparisons across All Lands			
Existing Vegetation Type Groups	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
Developed-General	395	-	-100.0
Developed-High Intensity	123,230	89,995	-27.0
Developed-Low Intensity	1,243,664	-	-100.0
Developed-Medium Intensity	364,002	229,417	-37.0
Developed-Open Space	5,900,650	1	-100.0
Developed-Roads	-	4,559,397	100.0
Developed-Upland Deciduous Forest	-	171,110	100.0
Developed-Upland Evergreen Forest	-	121,984	100.0
Developed-Upland Herbaceous	-	1,833,556	100.0
Developed-Upland Mixed Forest	-	126,887	100.0
Developed-Upland Shrubland	-	640,426	100.0

Table 18 – Acreage of LF urban (developed) Existing Vegetation Type Groups and percent change on Federal Lands in the NC GeoArea between LF National and LF 2001.

Table 18. Developed Lands Comparisons across Federal Lands			
Existing Vegetation Type Groups	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
Developed-General	6	-	-100.0
Developed-High Intensity	1,290	998	-22.6
Developed-Low Intensity	43,312	-	-100.0
Developed-Medium Intensity	6,840	4,102	-40.0
Developed-Open Space	172,910	-	-100.0
Developed-Roads	-	131,049	100.0
Developed-Upland Deciduous Forest	-	5,143	100.0
Developed-Upland Evergreen Forest	-	8,715	100.0
Developed-Upland Herbaceous	-	43,834	100.0
Developed-Upland Mixed Forest	-	4,205	100.0
Developed-Upland Shrubland	-	37,879	100.0

Table 19– Acreage of LF riparian and wetland Existing Vegetation Type Groups and percent change in the NC GeoArea between LF National and LF 2001.

Table 19. Riparian/Wetland Comparisons				
Land Ownership	**Existing Vegetation Type Groups**	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Atlantic Swamp Forests	1,669,423	1,251,728	-25.0
All Lands	Depressional Wetland	4,111,741	1,795,361	-56.3
All Lands	Eastern Floodplain Forests	456,703	231,811	-49.2
All Lands	Inland Marshes and Prairies	1,632,305	502,172	-69.2
All Lands	NLCD-Herbaceous Wetlands	-	8,039,044	100.0
All Lands	Western Riparian Woodland and Shrubland	7,301,768	5,051,578	-30.8
Federal Lands	Atlantic Swamp Forests	166,315	151,059	-9.2
Federal Lands	Depressional Wetland	176,135	123,399	-29.9
Federal Lands	Eastern Floodplain Forests	21,939	11,070	-49.5
Federal Lands	Inland Marshes and Prairies	85,219	29,456	-65.4
Federal Lands	NLCD-Herbaceous Wetlands	-	530,731	100.0
Federal Lands	Western Riparian Woodland and Shrubland	1,336,304	875,314	-34.5

Table 20 – Acreage of LF barren Existing Vegetation Type Groups and percent change in the NC GeoArea between LF National and LF 2001.

Table 20. Barren Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Barren	1,652,801	1,411,595	-14.6
Federal Lands	Barren	746,092	700,607	-6.1

Table 21 – Acreage of LF water Existing Vegetation Type Groups and percent change in the NC GeoArea between LF National and LF 2001.

Table 21. Water Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Open Water	12,787,553	12,078,299	-5.6
Federal Lands	Open Water	712,787	657,628	-7.7

2.5.2b Enhancements to Existing Vegetation Cover

EVC was updated for forested areas using several dates of Landsat imagery and derived layers. Landsat scenes from leaf-off, leaf-on, and spring dates, along with tasseled-cap images and texture images derived from tasseled-cap images of the three image dates were used. Elevation Derivatives for National Applications (EDNA) data products were used, including Digital Elevation Model and derivatives (slope and aspect). EDNA is a multi-layered database derived from a version of the National Elevation Dataset, which has been hydrologically conditioned for improved hydrologic flow representation (http://edna.usgs.gov/).

Training sites derived from FIA plot records were classified to tree canopy cover using a FIA stem-mapping algorithm (Toney et al. 2009). Plot data records were filtered based on FIA disturbance attributes and location-specific Landsat image dates to obtain tree canopy cover training sites. Some plots were omitted from the training set if they had significant disturbances (such as cutting, fire, or wind) recorded after the most recent location-specific image date in the multi-temporal Landsat mosaics.

Regression tree modeling was conducted using Rulequest's© Cubist program. Spatial data layers were then rebuilt to produce the final geospatial layer of CC. Layers were visually checked for seam lines and presence of clouds and other issues or artifacts in the imagery; these were addressed by eliminating problem source data or by making localized revisions to the maps.

The desired outcome of this analysis was to map a statistical distribution of CC values consistent with the distribution expected for spatial wildland fire analysis (Scott and Reinhardt 2005; Stratton 2006). CC rarely exceeds 70 percent in western U.S. forest types, but is somewhat higher in the multi-storied forests of the eastern U.S. The distribution of stem-mapped FIA plot canopy cover was generally consistent with the distribution as evaluated in the wildland fire behavior models. The modeling enhancements based on this FIA approach have improved the data with earlier problems of CC values being too high. The improved CC maps were combined with the existing shrub and herb components to produce the final improved EVC layer.

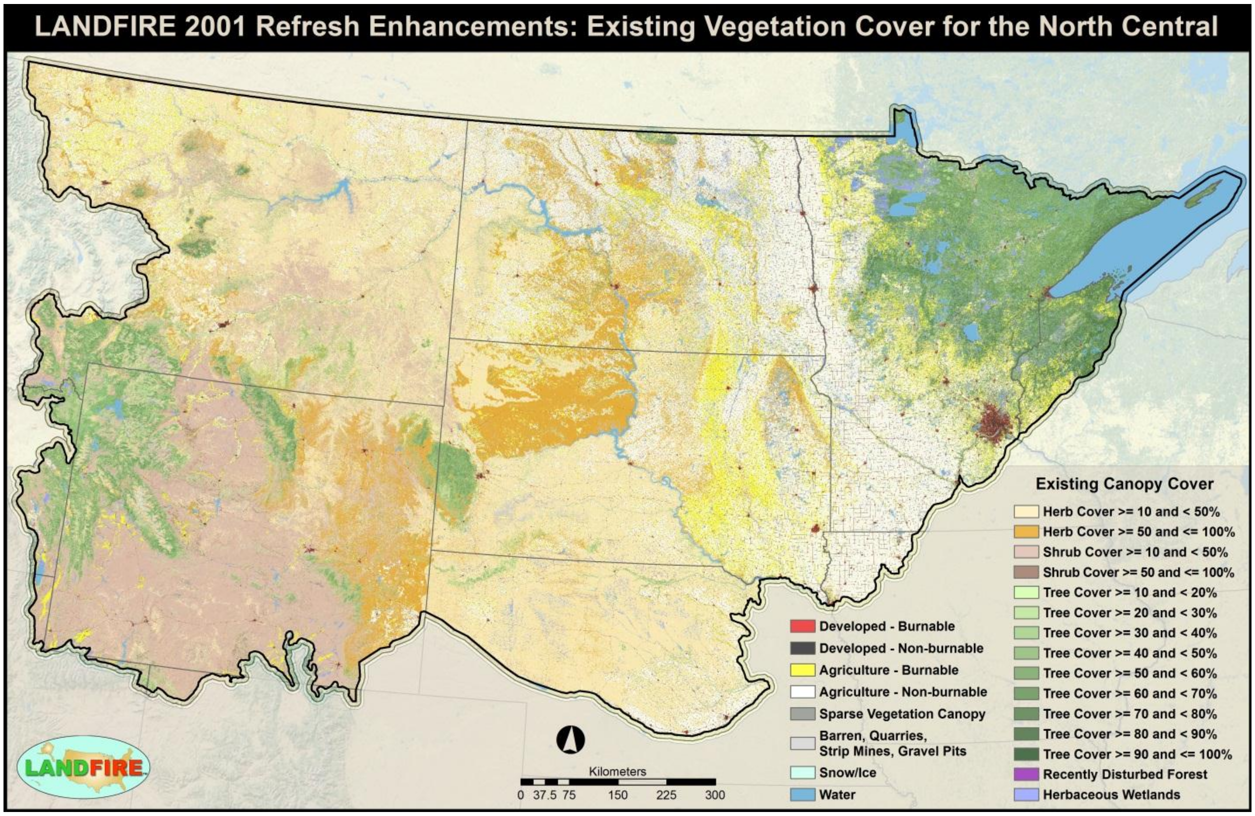

Figure 7 – Map of Existing Vegetation Cover layer that was enhanced as part of the LF 2001 update by incorporating user feedback and additional data.

Table 22 – Existing Vegetation Cover: Forest Canopy Cover – Comparison between LF National and Refresh 2001 tree cover classes and percent change in the NC GeoArea by ownership categories.

Table 22. **Tree Cover Comparison**				
Land Ownership	**Percent Tree Cover**	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	>= 10 and < 20	5,772,568	4,270,286	-26.0
All Lands	>= 20 and < 30	3,012,365	4,734,453	57.2
All Lands	>= 30 and < 40	2,799,824	8,847,974	216.0
All Lands	>= 40 and < 50	2,950,110	10,038,846	240.3
All Lands	>= 50 and < 60	3,033,617	8,880,519	192.7
All Lands	>= 60 and < 70	3,753,356	4,837,146	28.9
All Lands	>= 70 and < 80	7,522,383	1,839,670	-75.5
All Lands	>= 80 and < 90	13,783,986	392,148	-97.2
All Lands	>= 90 and <= 100	5,621,302	30,886	-99.5
Federal Lands	>= 10 and < 20	1,471,756	1,759,261	19.5
Federal Lands	>= 20 and < 30	1,106,829	1,675,068	51.3
Federal Lands	>= 30 and < 40	1,097,760	3,897,225	255.0
Federal Lands	>= 40 and < 50	1,144,837	4,367,538	281.5
Federal Lands	>= 50 and < 60	1,214,669	3,141,971	158.7
Federal Lands	>= 60 and < 70	1,407,411	1,080,194	-23.3
Federal Lands	>= 70 and < 80	2,170,281	291,887	-86.6
Federal Lands	>= 80 and < 90	3,895,776	70,271	-98.2
Federal Lands	>= 90 and <= 100	3,039,231	6,308	-99.8

2.5.2c Enhancements to Existing Vegetation Height

The EVH improvement and enhancement process focused on Forest Canopy Height (CH). The CH remapping relied on values derived from FIA plot data using a stand height algorithm. FIA plots falling within a given map zone (including a 3-km buffer) were included. The buffer was extended outwards for zones that had very few plots within them in an attempt to expand the data pool. Geospatial data used in the modeling of CH included Landsat imagery, topography data, and a basal area weighted canopy height product developed by Kellndorfer et al. (2004) using Shuttle Radar Topography Mission data. For each zone, predictor variables determining CH were identified and used to build a regression tree model. Continuous values of CH were then mapped without regard to underlying life form for each mapping zone in the GeoArea. The final step grouped the predicted continuous CH values into LF EVH classes and merged these with the shrub and herbaceous EVH components from LF National to create the new LF 2001 EVH layer.

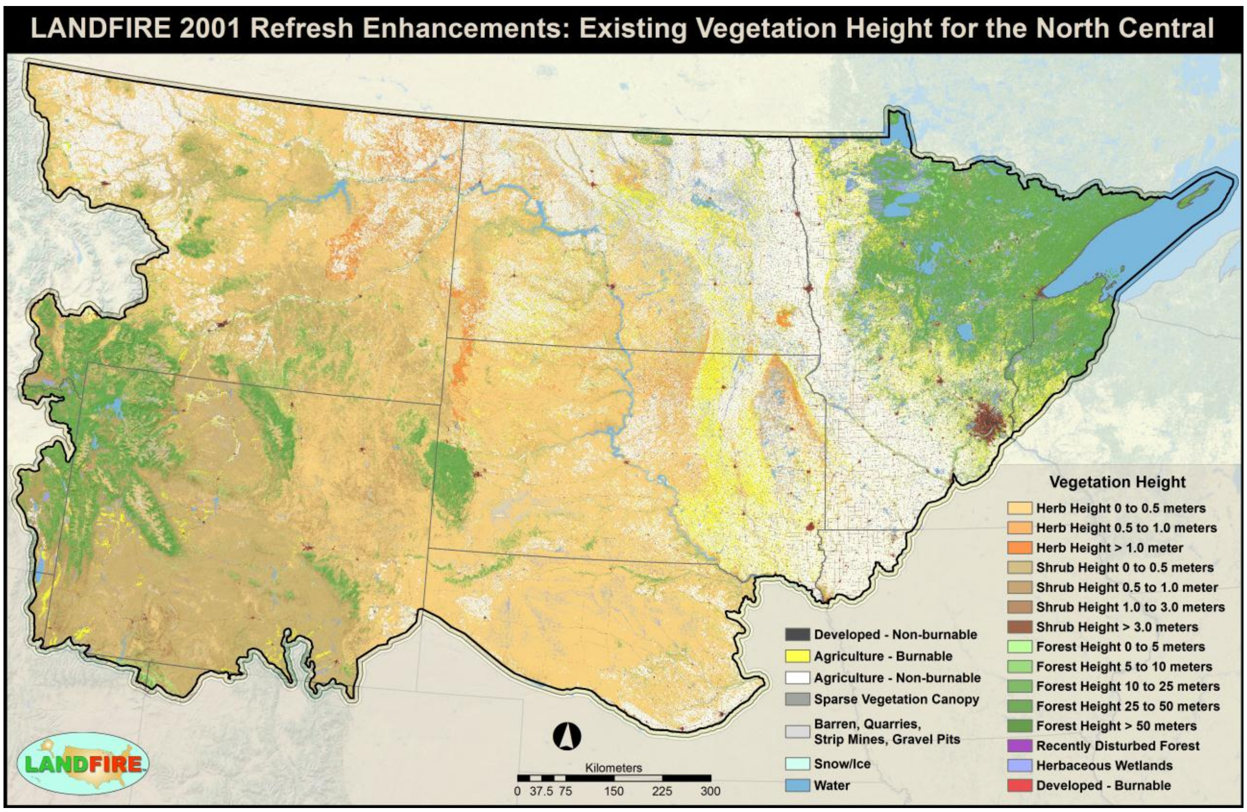

Figure 8 – Map of Existing Vegetation Height layer that was enhanced as part of the LF 2001 update by incorporating user feedback and additional data.

Table 23 – Acreage of LF Forest Canopy Height categories and percent change in the NC GeoArea by ownership categories.

Table 23. Tree Height Comparison				
Land Ownership	**Height (m)**	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	0 to 5	3,442,327	1,733,524	-49.6
All Lands	5 to 10	5,312,688	3,785,564	-28.7
All Lands	10 to 25	39,474,395	38,141,709	-3.4
All Lands	25 to 50	20,102	211,132	950.3
Federal Lands	0 to 5	1,277,602	455,054	-64.4
Federal Lands	5 to 10	2,433,034	924,230	-62.0
Federal Lands	10 to 25	12,833,792	14,729,413	14.8
Federal Lands	25 to 50	4,121	181,025	4,292.7

2.5.3 LANDFIRE 2008: Updates to Existing Vegetation Products

The primary focus for updating the LF existing vegetation layers was to characterize changes in vegetation attributes in areas that had disturbance activities from 1999 - 2008. Additionally, the update included changes in vegetation attributes within these disturbance areas due to tree growth and regeneration.

As discussed in section 2.4, disturbance mapping for LF 2008 was the result of several efforts that included data derived in part from remotely sensed land change methods, MTBS, and the LF 2001/2008 Events data contribution opportunity. Data contributed from various State, Federal and local sources were paired with remote sensing techniques to produce disturbance maps identifying disturbance type, location, and severity.

The spatial layers created by disturbance mapping identified the areas where EVT, EVC, and EVH needed to be transitioned into new vegetation classes. Forest transitions were modeled using FVSFFE. Non-forest transitions were assigned using information from a variety of sources from the literature. A Vegetation Transition Data Base (VTDB) was developed for each GeoArea to generate vegetation transitions that were assigned to each EVT, EVH, and EVC for every disturbance and its severity. The VTDB was used to perform an update query that modified the existing attribute tables associated with EVT, EVH, and EVC layers.

2.5.3a Updates to Existing Vegetation Type

Information from a variety of sources was used to inform vegetation transition assignments. A series of tables created in a VTDB were used to update attribute tables for the LF 2008 EVT layer.

In forested EVTs, low and moderate severity disturbance did not change EVT. Stand-replacing events such as high severity fire and timber harvests in forested EVTs were transitioned to an herbaceous or shrubland EVT with a cover and height appropriate for an early seral expression of that EVT and for that geographic location. It was assumed that some herbaceous and shrub communities would transition to forested communities. These sites were typically within formerly forested communities where non-forested EVTs occurred in areas of older, not recent disturbance. In these situations, shrub and herbaceous communities were transitioned to an appropriate forested EVT. Relationships between ESP and these shrub and herbaceous communities were used to predict the new forested EVT at a particular site. Successional class A in the Vegetation Dynamics Development Tool (VDDT) models (ESSA 2005) informed cover and height estimations for 2008 EVT assignments and 2008 cover and height transitions.

In shrub EVTs , all fire severities were considered stand-replacing, so all burned non-forested polygons were replaced by an herbaceous EVT that would be found in that area. Chemical treatments were assumed to be performed on exotic species, so a native herbaceous community for that local or regional area replaced the introduced EVT. Mechanical treatments were treated similarly to fire disturbances and transitioned to an herbaceous community. Introduced annual grasses replaced some shrub-dominated EVTs in lowland areas (for example, Western U.S. Great Basin and Columbia Plateau shrubland EVTs). In herbaceous EVTs, disturbed areas were not transitioned to different EVTs due to the fact that these communities rapidly reestablish themselves after disturbance.

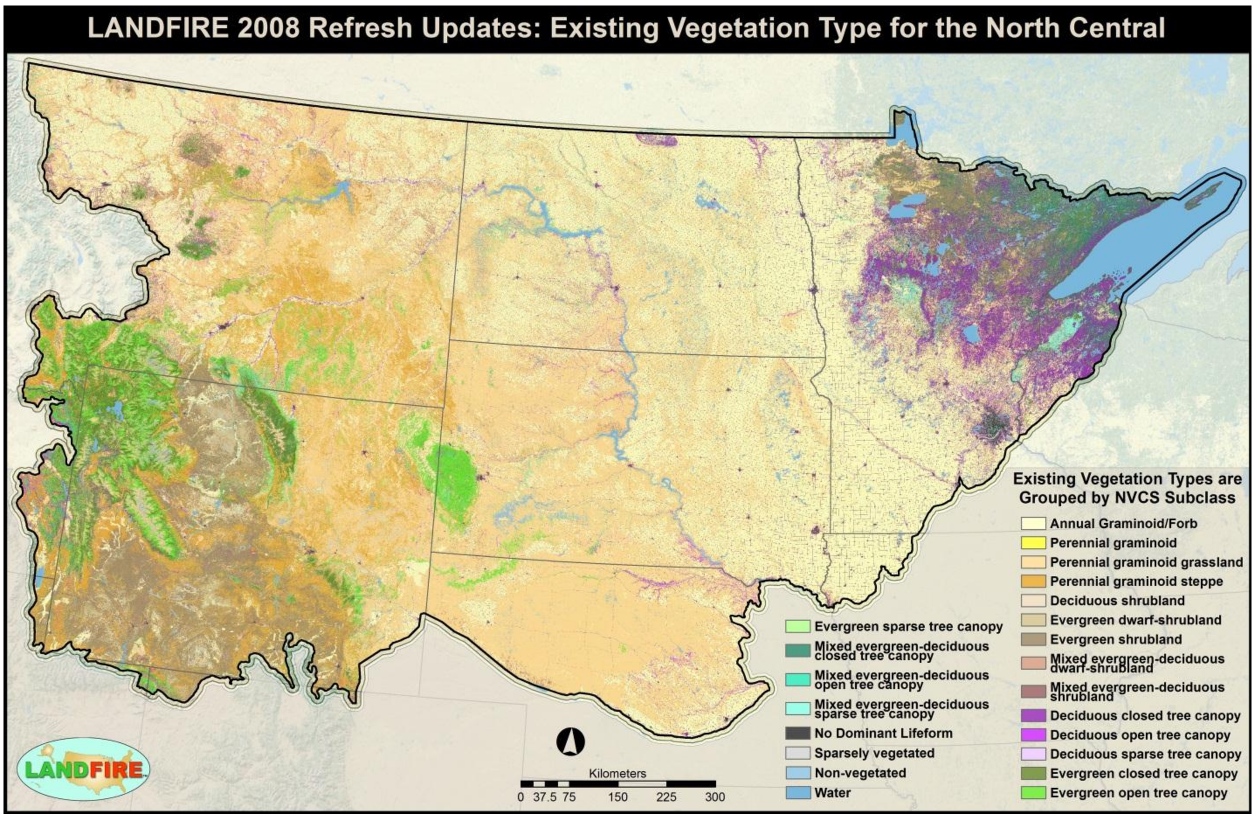

Figure 9 – Map of Existing Vegetation Type layer for the NC GeoArea depicting vegetation changes with disturbances for 1999 - 2008.

Table 24 – Comparison of acreage of forested Existing Vegetation Type Groups between LF 2001 and LF 2008 on All Lands in the NC GeoArea.

Table 24. **Forested Existing Vegetation Type Groups Comparison: All Lands**			
Existing Vegetation Type Groups	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Aspen Forest, Woodland, and Parkland	1,181,635	1,159,328	-1.9
Aspen-Birch Forest	3,211,428	3,200,201	-0.4
Aspen-Mixed Conifer Forest and Woodland	528,669	527,240	-0.3
Atlantic Swamp Forests	184,088	178,710	-2.9
Beech-Maple-Basswood Forest	1,165,009	1,234,811	6.0
Bigtooth Maple Woodland	8,282	8,229	-0.6
Black Oak Woodland and Savanna	176,365	173,373	-1.7
Bur Oak Woodland and Savanna	674,403	667,283	-1.1
Douglas-fir Forest and Woodland	3,229,894	3,329,462	3.1
Douglas-fir-Grand Fir-White Fir Forest and Woodland	44,598	44,411	-0.4
Douglas-fir-Ponderosa Pine-Lodgepole Pine Forest and Woodland	391,767	487,781	24.5
Eastern Floodplain Forests	231,811	226,090	-2.5
Jack Pine Forest	1,143,583	1,137,668	-0.5
Juniper Woodland and Savanna	18,690	19,049	1.9
Limber Pine Woodland	460,627	455,790	-1.1
Lodgepole Pine Forest and Woodland	1,414,310	1,431,656	1.2
Managed Tree Plantation	35,456	28,572	-19.4
Mountain Mahogany Woodland and Shrubland	602,042	592,403	-1.6
Pinyon-Juniper Woodland	130,338	144,809	11.1
Ponderosa Pine Forest Woodland and Savanna	5,049,280	5,019,150	-0.6
Red Pine-White Pine Forest and Woodland	850,812	848,510	-0.3
Spruce-Fir Forest and Woodland	2,342,353	2,661,252	13.6
Spruce-Fir-Hardwood Forest	3,862,942	3,858,409	-0.1
Subalpine Woodland and Parkland	2,482,778	2,464,628	-0.7
Western Riparian Woodland and Shrubland	4,512,782	4,253,764	-5.7
White Oak-Red Oak-Hickory Forest and Woodland	533,874	519,150	-2.8
Yellow Birch-Sugar Maple Forest	4,779,500	4,763,009	-0.4

Table 25 – Comparison of acreage of forested EVT Groups between LF 2001 and LF 2008 on Federal Lands in the NC GeoArea.

Table 25. Forested Existing Vegetation Type Groups Comparison: Federal Lands

Existing Vegetation Type Groups	LF 2001 (acres)	LF 2008 (acres)	Percent Change
Aspen Forest, Woodland, and Parkland	674,245	671,837	-0.4
Aspen-Birch Forest	556,902	556,745	0.0
Aspen-Mixed Conifer Forest and Woodland	423,690	422,787	-0.2
Atlantic Swamp Forests	3,004	2,971	-1.1
Beech-Maple-Basswood Forest	21,837	32,025	46.7
Bigtooth Maple Woodland	5,282	5,273	-0.2
Black Oak Woodland and Savanna	4,729	4,710	-0.4
Bur Oak Woodland and Savanna	14,780	16,686	12.9
Douglas-fir Forest and Woodland	2,599,322	2,694,776	3.7
Douglas-fir-Grand Fir-White Fir Forest and Woodland	42,146	41,968	-0.4
Douglas-fir-Ponderosa Pine-Lodgepole Pine Forest and Woodland	160,839	184,673	14.8
Eastern Floodplain Forests	11,070	11,013	-0.5
Jack Pine Forest	170,256	170,190	0.0
Juniper Woodland and Savanna	10,507	10,649	1.4
Limber Pine Woodland	151,754	151,965	0.1
Lodgepole Pine Forest and Woodland	1,265,413	1,283,094	1.4
Managed Tree Plantation	358	354	-1.1
Mountain Mahogany Woodland and Shrubland	165,113	164,772	-0.2
Pinyon-Juniper Woodland	113,299	115,525	2.0
Ponderosa Pine Forest Woodland and Savanna	1,988,201	1,977,656	-0.5
Red Pine-White Pine Forest and Woodland	220,749	220,715	0.0
Spruce-Fir Forest and Woodland	2,207,278	2,513,735	13.9
Spruce-Fir-Hardwood Forest	1,399,326	1,399,167	0.0
Subalpine Woodland and Parkland	2,350,913	2,332,862	-0.8
Western Riparian Woodland and Shrubland	629,800	656,670	4.3
White Oak-Red Oak-Hickory Forest and Woodland	5,437	5,410	-0.5
Yellow Birch-Sugar Maple Forest	490,757	490,614	0.0

Table 26 – Comparison of acreage of shrubland Existing Vegetation Type Groups between LF 2001 and LF 2008 across land ownerships in the NC GeoArea.

Table 26. Shrubland Existing Vegetation Type Groups Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	380,475	374,394	-1.6
All Lands	Atlantic Swamp Forests	1,067,640	1,047,660	-1.9
All Lands	Big Sagebrush Shrubland and Steppe	39,771,011	37,893,647	-4.7
All Lands	Deciduous Shrubland	1,516,353	1,242,265	-18.1
All Lands	Desert Scrub	323,612	316,409	-2.2
All Lands	Greasewood Shrubland	793,783	722,777	-9.0
All Lands	Introduced Riparian Vegetation	139,399	128,728	-7.7
All Lands	Low Sagebrush Shrubland and Steppe	645,504	625,188	-3.2
All Lands	Peatland Forests	4,295,202	4,213,509	-1.9
All Lands	Salt Desert Scrub	2,643,369	2,612,704	-1.2
All Lands	Sand Shrubland	144,589	142,475	-1.5
All Lands	Western Riparian Woodland and Shrubland	538,796	455,484	-15.5
Federal Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	364,494	358,461	-1.7
Federal Lands	Atlantic Swamp Forests	148,055	145,367	-1.8
Federal Lands	Big Sagebrush Shrubland and Steppe	13,156,697	12,561,813	-4.5
Federal Lands	Deciduous Shrubland	934,741	737,693	-21.1
Federal Lands	Desert Scrub	101,982	99,664	-2.3
Federal Lands	Greasewood Shrubland	278,253	261,377	-6.1
Federal Lands	Introduced Riparian Vegetation	31,135	30,960	-0.6
Federal Lands	Low Sagebrush Shrubland and Steppe	258,353	246,707	-4.5
Federal Lands	Peatland Forests	578,966	559,548	-3.4
Federal Lands	Salt Desert Scrub	1,467,008	1,461,244	-0.4
Federal Lands	Sand Shrubland	24,521	24,352	-0.7
Federal Lands	Western Riparian Woodland and Shrubland	245,514	201,820	-17.8

Table 27 – Comparison of acreage of herbaceous Existing Vegetation Type Groups between LF 2001 and LF 2008 across land ownerships in the NC GeoArea.

Table 27. **Herbaceous Existing Vegetation Type Group Comparison**				
Land Ownership	**Existing Vegetation Type Groups**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	1,295,305	1,214,870	-6.2
All Lands	Depressional Wetland	1,795,361	1,691,778	-5.8
All Lands	Dry Tundra	687,115	672,258	-2.2
All Lands	Grassland	2,850,646	3,141,009	10.2
All Lands	Inland Marshes and Prairies	502,172	575,446	14.6
All Lands	Introduced Annual and Biennial Forbland	778,785	778,068	-0.1
All Lands	Introduced Annual Grassland	694,137	870,444	25.4
All Lands	Introduced Perennial Grassland and Forbland	1,363,916	1,206,396	-11.6
All Lands	Mixedgrass Prairie	62,601,627	57,942,941	-7.4
All Lands	Modified-Managed Prairie Grassland	4,050,263	3,282,789	-19.0
All Lands	NLCD-Herbaceous Semi-dry	217,813	212,705	-2.4
All Lands	NLCD-Herbaceous Semi-wet	189,781	180,354	-5.0
All Lands	NLCD-Herbaceous Wetlands	8,039,044	6,724,464	-16.4
All Lands	Sand Prairie	19,479,872	18,756,860	-3.7
All Lands	Shortgrass Prairie	3,057,941	2,969,251	-2.9
All Lands	Tallgrass Prairie	2,725,462	2,281,664	-16.3
All Lands	Transitional Herbaceous Vegetation	359,271	251,419	-30.0
Federal Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	945,305	877,157	-7.2
Federal Lands	Depressional Wetland	123,399	122,047	-1.1
Federal Lands	Dry Tundra	647,186	632,563	-2.3
Federal Lands	Grassland	888,449	1,089,737	22.7
Federal Lands	Inland Marshes and Prairies	29,456	51,277	74.1
Federal Lands	Introduced Annual and Biennial Forbland	386,394	386,330	0.0
Federal Lands	Introduced Annual Grassland	110,104	204,260	85.5
Federal Lands	Introduced Perennial Grassland and Forbland	194,735	186,163	-4.4
Federal Lands	Mixedgrass Prairie	8,414,608	8,495,949	1.0
Federal Lands	Modified-Managed Prairie Grassland	104,660	98,753	-5.6
Federal Lands	NLCD-Herbaceous Semi-dry	70,244	68,086	-3.1
Federal Lands	NLCD-Herbaceous Semi-wet	91,804	88,305	-3.8
Federal Lands	NLCD-Herbaceous Wetlands	530,731	475,286	-10.5
Federal Lands	Sand Prairie	885,462	883,740	-0.2
Federal Lands	Shortgrass Prairie	531,546	523,967	-1.4
Federal Lands	Tallgrass Prairie	65,894	62,671	-4.9
Federal Lands	Transitional Herbaceous Vegetation	17,657	13,264	-24.9

2.5.3b Updates to Existing Vegetation Cover

LANDFIRE 2001 and 2008 Methods and Results

Transitions in the forested component of EVC due to disturbance and succession were modeled using FVS/ FFE. These transitions were applied to the LF 2001 CC layer to create the LF 2008 CC layer.

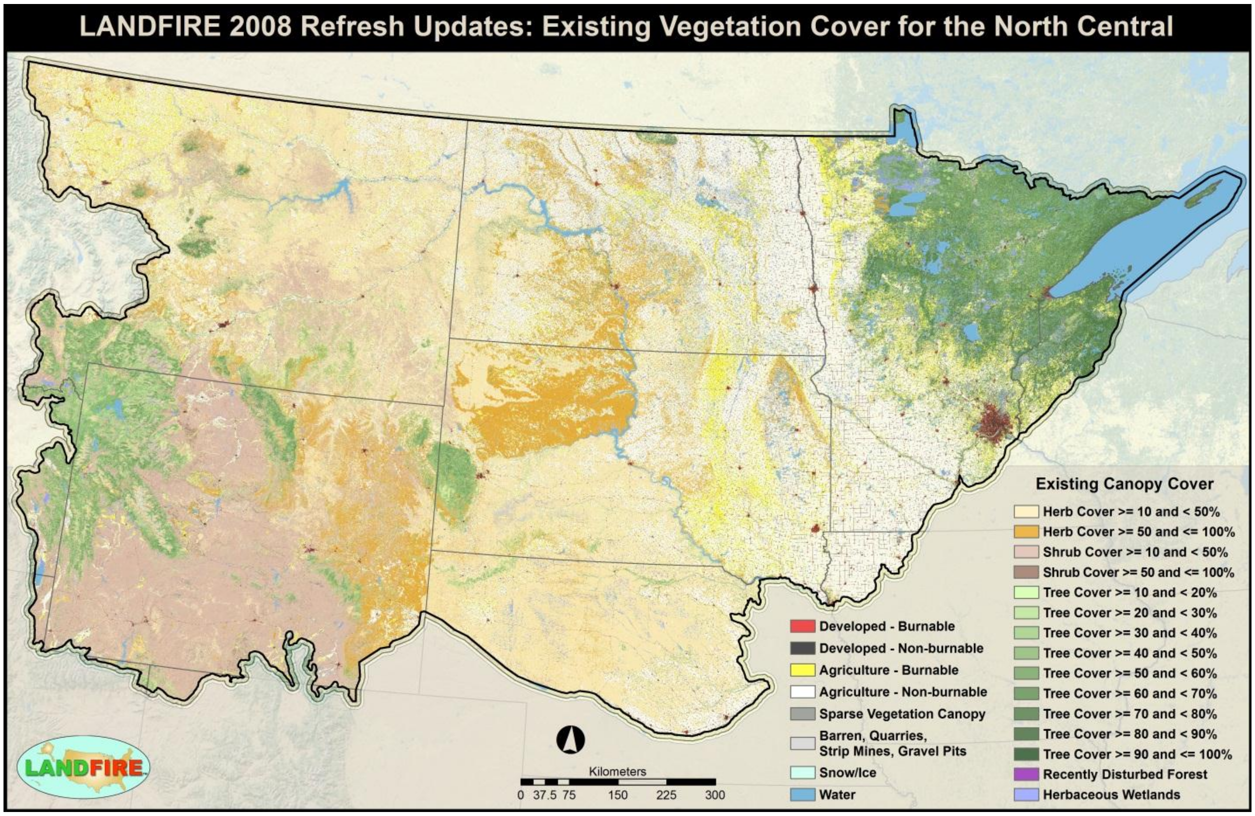

Figure 10 – Map of Existing Vegetation Cover for the NC accounting for vegetation changes with disturbances for 1999 - 2008.

Table 28 – Existing Vegetation Cover: Tree Cover – Comparison between LF 2001 and 2008 Refresh.

Table 28. Tree Cover Comparison				
Land Ownership	**Cover**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	>= 10 and < 20	4,270,286	4,237,233	-0.8
All Lands	>= 20 and < 30	4,734,453	4,359,324	-7.9
All Lands	>= 30 and < 40	8,847,974	8,301,816	-6.2
All Lands	>= 40 and < 50	10,038,846	7,612,094	-24.2
All Lands	>= 50 and < 60	8,880,519	8,617,439	-3.0
All Lands	>= 60 and < 70	4,837,146	4,928,454	1.9
All Lands	>= 70 and < 80	1,839,670	5,331,974	189.8
All Lands	>= 80 and < 90	392,148	514,138	31.1
All Lands	>= 90 and <= 100	30,886	82,275	166.4
Federal Lands	>= 10 and < 20	1,759,261	1,840,617	4.6
Federal Lands	>= 20 and < 30	1,675,068	1,768,077	5.6
Federal Lands	>= 30 and < 40	3,897,225	4,198,330	7.7
Federal Lands	>= 40 and < 50	4,367,538	3,748,951	-14.2
Federal Lands	>= 50 and < 60	3,141,971	2,875,259	-8.5
Federal Lands	>= 60 and < 70	1,080,194	1,166,542	8.0
Federal Lands	>= 70 and < 80	291,887	1,020,805	249.7
Federal Lands	>= 80 and < 90	70,271	86,712	23.4
Federal Lands	>= 90 and <= 100	6,308	18,612	195.1

2.5.3c Updates to Existing Vegetation Height

Transitions in the forested component of EVH due to disturbance and succession were modeled using FVS/FFE. These transitions were applied to the LF 2001 CH layer to create the LF 2008 CH layer. Using FIA plot data for forested vegetation types, the model was calibrated to disturb the sites with a variety of disturbance types and severities.

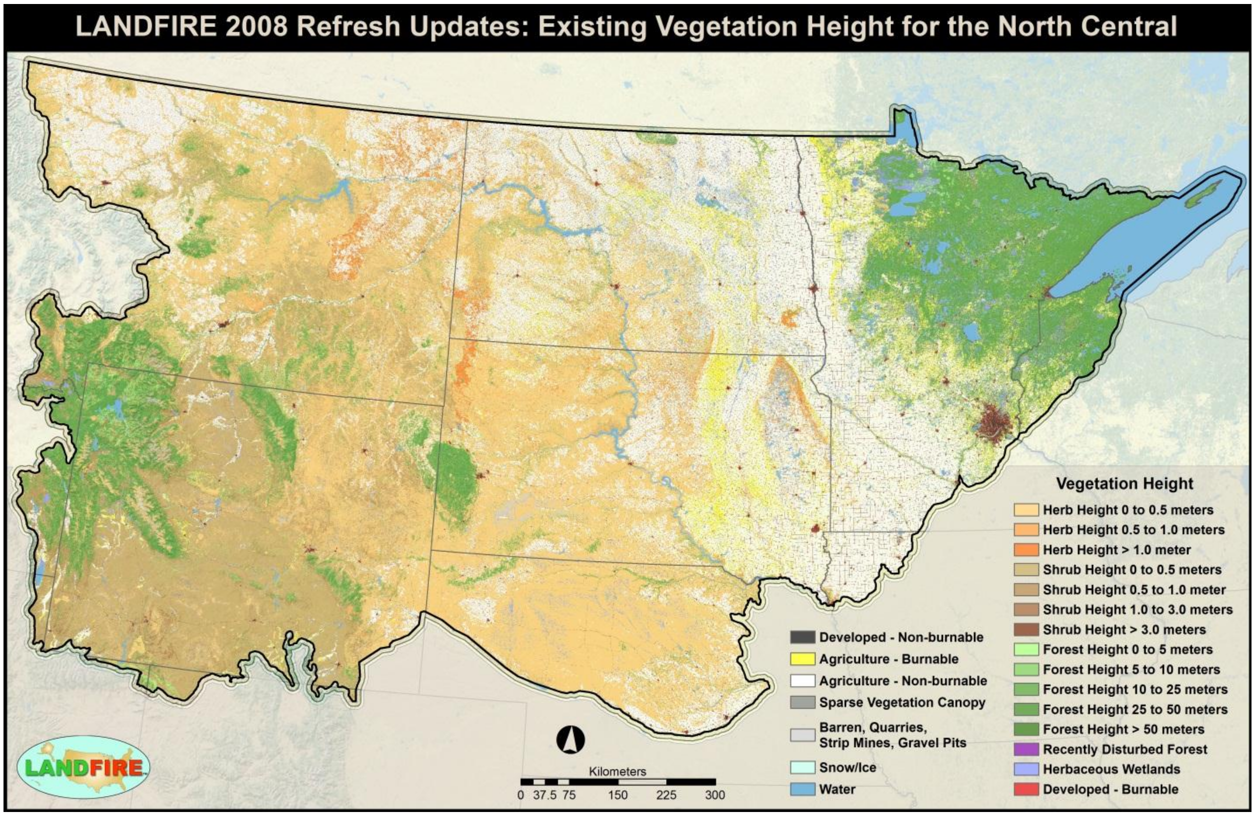

Figure 11 – Map of Existing Vegetation Height for the NC GeoArea accounting for vegetation changes from disturbances for 1999 - 2008.

Table 29 – Existing Vegetation Height: Tree Height – Comparison between LF 2001 and 2008 Refresh.

Table 29. Tree Height Comparison				
Land Ownership	**Height (m)**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	0 to 5	1,733,524	2,550,558	47.1
All Lands	5 to 10	3,785,564	3,492,699	-7.7
All Lands	10 to 25	38,141,709	37,733,113	-1.1
All Lands	25 to 50	211,132	208,377	-1.3
Federal Lands	0 to 5	455,054	1,044,357	129.5
Federal Lands	5 to 10	924,230	887,363	-4.0
Federal Lands	10 to 25	14,729,413	14,612,584	-0.8
Federal Lands	25 to 50	181,025	179,601	-0.8

2.6 Fire Behavior

2.6.1 Product Description

The LF fuels data describe the composition and characteristics of both surface and canopy fuel. Geospatial products include Fire Behavior Fuel Model 13 (FBFM13; Anderson, 1982), Fire Behavior Fuel Model 40 (FBFM40; Scott and Burgan, 2005), and the Canadian Forest Fire Danger Rating System (CFFDRS; Stocks et al. 1989), Forest Canopy Bulk Density (CBD), Forest Canopy Base Height (CBH), CC, and CH. The landscape file (.LCP) is the data format required for many fire behavior and effects models and was provided as well. These data can be implemented within models to predict wildland fire behavior and fire effects and are useful for strategic fuel treatment prioritization and tactical assessment of fire behavior and effects.

The primary effect of the improvements to the LF National layer, from a fuel and fire behavior perspective, was an enhanced mapping of EVC and EVH. The re-mapped EVC had the most effect on the fuel grids and their subsequent modeled fire behavior characteristics.

2.6.2 LF 2001 Enhancements to Fire Behavior Products

With the release of LF National, the user community alerted the LF team to some problems with the fire behavior and fuel attributes. The LF 2001 data set was created in part to address a number of these issues by instilling methods of calculating fuel attributes based on new EVC and EVH layers. Some of the issues raised were:

- CBH was too high for many of the forested systems
- CBD was too low for many of the forested systems
- The combination of FBFM 40/13 and the CBH layers did not produce the expected fire behavior characteristics
- High CC caused high wind reduction factor

2.6.2a Enhancements to Surface Fuel

The FBFM40/13 fuel model grids for LF National were based on input provided by regional fuel specialists and the LF fuel team. Surface fuel models were dependent upon the type of vegetation described in the EVT layer, the amount of cover and/or closure in the overstory of the vegetation from EVC, and the height of the vegetation expressed by EVH. Fuel model assignments were given break points of EVC and EVH for each EVT to determine the fuel model. For instance, in a forested EVT in an open condition, a grass or shrub model would be used in the low cover rule set to describe the surface fuel. As the stand closed in the higher EVC classes, a timber understory or timber litter model would often be used in a subsequent rule set.

With the inclusion of a new method to determine EVC and EVH, the rule sets that were created for FBFM40/13 at workshops with regional specialists remained the same, but the pixels on the map covered by a particular rule set shifted depending on the change in cover and/or height of the vegetation. Although herbaceous, shrub, and tree life forms were mapped in the EVC and EVH products, the forested or treed EVTs were affected by the new approach in cover and height. The change in number and location of pixels that changed fuel models was dependent on the change in cover or height in the forested EVTs.

Many acres in the higher CC classes in LF National were remapped in LF 2001 to lower CC classes, affecting the amount of acres in the various surface fuel assignments. The height classes were also affected, which caused acres to shift from the 0-5 meter class into the higher height classes – often resulting in a change of surface fuel assignment. Some rule sets seemed like duplicates, but were in fact different rules, depending on whether the forested vegetation was available for crown fire.

Upon preliminary completion of the layers and before final processing of LF 2001 fuel layers, all the surface fuel models for CONUS were assembled by EVT and Map Zone. This was done to identify those areas along neighboring map zones having major discrepancies with fire behavior characteristics for surface fuel models of similar EVT and that had resulted from the calibration process. The concern was that new seam lines within the data would exist, in terms of fire behavior outputs, if significant differences in surface fuel models occurred within the same vegetation type and with nothing more than a map zone boundary between them. Some smoothing of the surface fuel model layer was completed within the bounding map zones. This was based on the fuel models selected, average fire season day criteria, and the fire behavior characteristic of rate of spread for the fuel models in question.

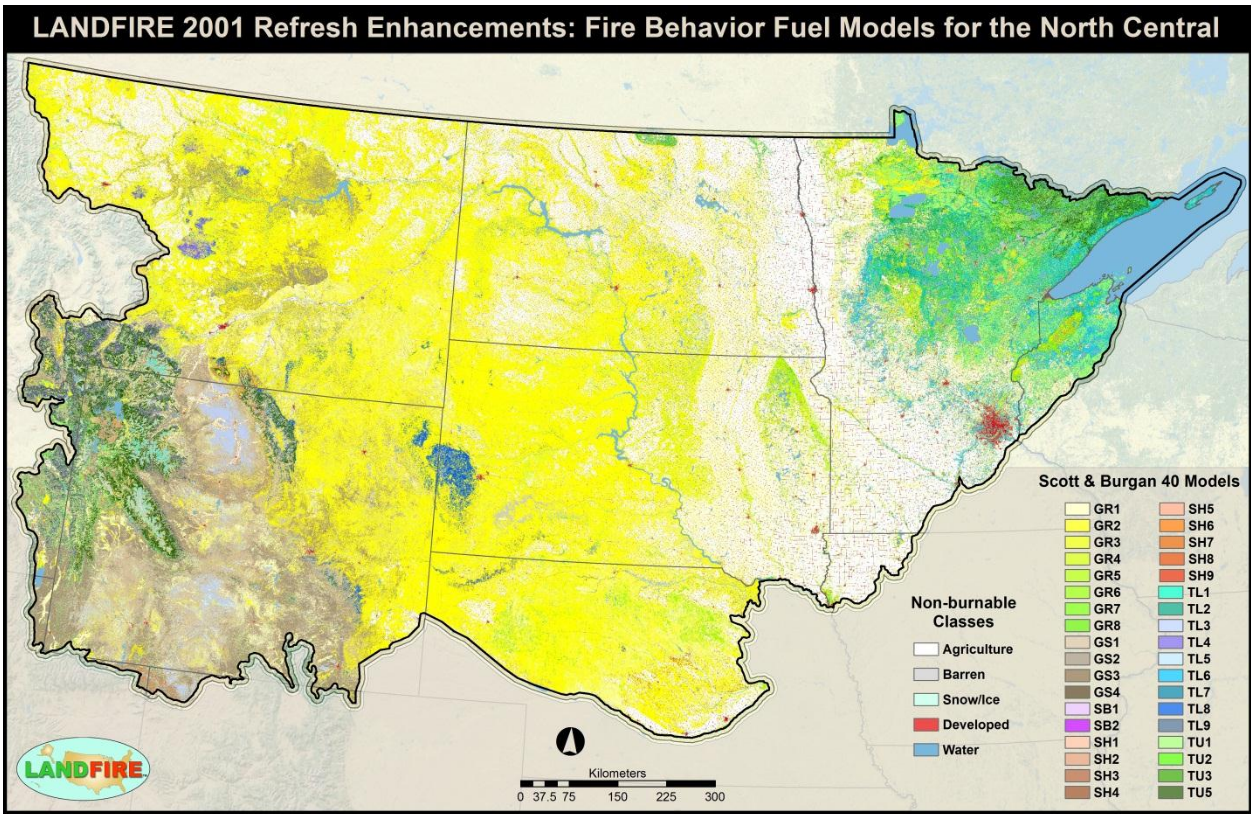

Figure 12 – LF 2001 Fire Behavior Fuel Model 40 for the NC GeoArea

2.6.2b Enhancements to Canopy Fuel

The LF canopy layers CC, CH, CBH, and CBD relate to and were sensitive to changes in EVC and EVH. The CC and CH layers were directly affected by the changes in EVC and EVH, and the grids for CBH and CBD were calculated from the new values in CC and CH. The CBH data layer was developed through exploratory analysis of the LF plot data and statistically analyzed to search for relationships between the plot level variables and CBH. Unfortunately, no such relationship could be gleaned between these variables. It was determined that CBH would be represented through an averaging method based on combinations of EVT and coarser groupings of EVT with EVH and EVC categories.

The CBD data layer was also developed through exploratory analysis of the LF plot data. The entire LF plot data compiled for the western United States were statistically analyzed to search for relationships between the plot level variables and CBD. A General Linear Model (GLM) was developed that expresses the relationship between CBD and CC, CH, and EVT (Reeves et al. 2009).

2.6.2c Modeled Fire Behavior Using LF 2001 Enhanced Products

The Wildland Fire Assessment Tool (WFAT), an ArcMap™ (part of the Esri ArcGIS Desktop suite) tool that uses FlamMap (Finney 2006) to spatially model fire behavior, was used to estimate potential fire behavior using fuel data from LF National and LF 2001. FlamMap is a fire behavior mapping and analysis program that computes potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.) over an entire landscape for constant weather and fuel moisture conditions. Three fire behavior outputs from these simulations were then compared to quantify changes in LF fuel mapping improvements (Table 30). The WFAT runs used a simulation landscape and a representative Remote Automated Weather Station (RAWS) for each analysis. Fire weather data were generated from the RAWS data for the selected station. The 98th percentile fire weather was used as an input to WFAT to ensure that the conditions were adequate and that WFAT would simulate the burning of the vast majority of pixels in FRG 1-4 (see Table 7 above for FRG definitions).

Table 30 – Comparison of fire behavior characteristics derived from LF National and LF 2001 for Federal Lands in the NC GeoArea.

Table 30. Fire Behavior Comparison – LF National and LF 2001			
Fire Behavior Characteristic	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
Flame Length (feet)			
No Fire	4,746,642	3,388,923	-28.6
Low(>0 and <=4)	17,081,251	16,566,084	-3.0
Moderate (>4 and <=11)	22,635,333	23,522,806	3.9
High (> 11)	5,347,463	6,332,876	18.4
Spread Rate (chains/hour)			
No Fire	4,746,642	3,388,923	-28.6
Low (>0 and <=5)	11,643,609	10,443,703	-10.3
Moderate (>5 and <=50)	10,478,912	12,318,557	17.6
High (>50)	22,941,525	23,659,505	3.1
Crown Fire			
No Fire	4,746,642	3,388,923	-28.6
Surface Fire	40,738,667	38,400,215	-5.7
Passive Crown Fire	2,499,123	6,887,662	175.6
Active Crown Fire	1,826,257	1,133,889	-37.9

2.6.3 LF 2008 Updates to Fire Behavior Products

The LF 2008 process was a modeled attempt to update the vegetation and fuel characteristics depicted in the circa 2001 imagery (LF National) to the more current period of 2008. The main purpose of this process was to incorporate vegetation growth and disturbance over the time period. Regarding fuel characteristics, the changes in surface fuel models (FBFM40, FBFM13) in the disturbed areas were incorporated according to expert opinion, whereas the changes in canopy characteristics were modeled through FVS/FFE.

2.6.3a Updates to Surface Fuel

The FBFM40 and FBFM13, canopy fuels were transitioned from their original assignment in LF 2001 based on type, intensity, and the time since disturbance. Vegetation outside of disturbed areas maintained the same surface fuel model unless there was some change in the EVT. Vegetation was transitioned using the process explained in Section 2.4.3.

Time since disturbance was separated into two categories, or time steps, for surface fuel: 0-5 years post disturbance and 6-10 years. The only exceptions to these categories were in geographic areas with very prolific vegetation growth, such as the Southeast and Hawaii. In such areas, the time steps were 0-3 years post disturbance and 4-10 years. For each time step, one FBFM40 and one FBFM13 were assigned to represent the surface fuel characteristic for the period. Generally, the first step was visualized as a full growing season and the second step was seven years post disturbance. The transitions of surface fuel models in disturbed areas were assigned by the LF fuel team and then sent to regional experts for review and editing.

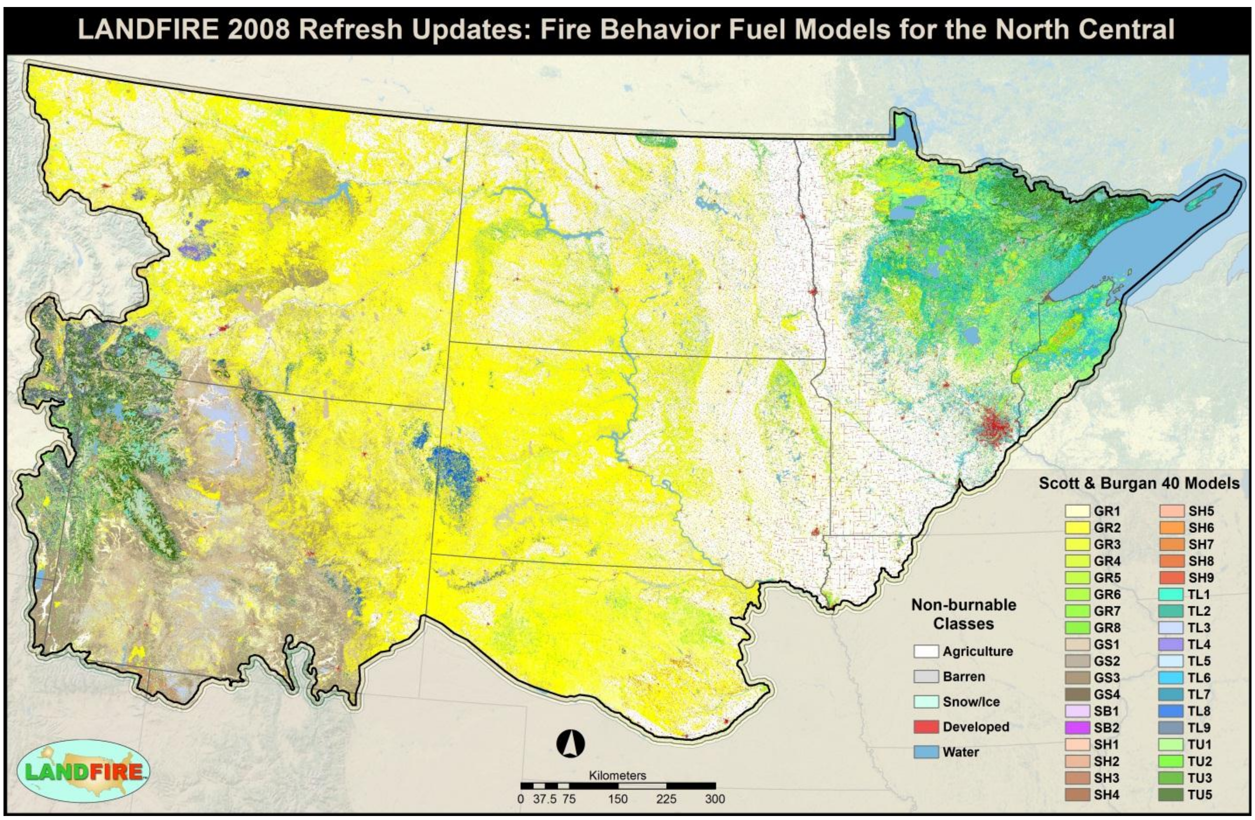

Figure 13 – LF 2008 Fire Behavior Fuel Model 40 for the NC GeoArea.

2.6.3b Updates to Canopy Fuel

The changes in canopy attributes and the growth in non-disturbed areas were modeled through FVS/FFE. Values for CC, CH, and CBD were recalculated using the 2008 EVC, EVH and EVT. The coefficients of change in the CBH attributes were applied to the usual calculation of CBH based on the type, severity, and time since disturbance. Time since disturbance was implemented in three time steps for canopy fuel to reduce the number of fuel model changes to account for 1) immediately after the disturbance, 2) 2-5 years post disturbance and 3) 6-10 years post disturbance. For each time step, a CBD value was calculated using the GLM and the updated LF 2008 EVT, EVC and EVH data layers.

The FVS/FFE outputs from these simulations provided disturbance and succession transitions for LF CBH and forested EVTs. The CBH data layers were updated leveraging a coefficient of change that is calculated using a non-disturbed CBH value (derived from FVS) and a disturbance/severity/time step specific CBH value. This coefficient of change was applied against the LF National data in the LF Total Fuel Change Tool (www.niftt.gov). The vegetation transitions were mapped by intersecting the integrated 10-year disturbance map with the LF 2001 vegetation layers. A transition predicted by FVS/FFE was assigned to every disturbance and EVT, height, and cover class on the map. This transition provides the needed data to map LF 2008 EVT in areas where forested EVTs were disturbed or may have succeeded to different conditions.

2.6.3c Modeled Fire Behavior Using LF 2008 Updated Products

The WFAT was used to estimate potential fire behavior using fuel data from LF 2001 and LF 2008. Three fire behavior outputs from these simulations were then compared to quantify changes in LF fuel mapping improvements (Table 31). The WFAT runs used a simulation landscape and a representative RAWS for each analysis. Fire weather data were generated from the RAWS data for the selected station. The 98^{th} percentile fire weather was used as an input to WFAT to ensure that the conditions were adequate and that WFAT would simulate the burning of the vast majority of pixels in FRG 1-4.

Table 31 – Comparison of fire behavior characteristics derived from LF 2001 and LF 2008 for Federal Lands in the NC GeoArea.

Table 31. Fire Behavior Comparison – LF 2001 and LF 2008			
Fire Behavior Characteristic	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Flame Length (feet)			
No Fire	3,388,923	3,703,374	9.3
Low(>0 and <=4)	16,566,084	15,736,620	-5.0
Moderate (>4 and <=11)	23,522,806	22,179,114	-5.7
High (> 11)	6,332,876	8,191,581	29.4
Spread Rate (chains/hour)			
No Fire	3,388,923	3,703,374	9.3
Low (>0 and <=5)	10,443,703	9,964,290	-4.6
Moderate (>5 and <=50)	12,318,557	11,558,668	-6.2
High (>50)	23,659,505	24,584,357	3.9
Crown Fire			
No Fire	3,388,923	3,703,374	9.3
Surface Fire	38,400,215	38,217,265	-0.5
Passive Crown Fire	6,887,662	6,708,637	-2.6
Active Crown Fire	1,133,889	1,181,413	4.2

2.7 Fire Effects

2.7.1 Product Description

The LF fire effects data layers describe the composition and characteristics of both surface fuel loadings and canopy fuel loadings, including FCCS (Ottmar et al. 2007) and FLM (Lutes et al. 2009). These geospatial products may be used within models to predict the effects of wildland fire. These data are useful for strategic fuel treatment prioritization and tactical assessment of fire behavior and effects.

FCCS defines a fuelbed as the inherent physical characteristics of fuel that contribute to fire behavior and effects (Riccardi et al. 2007). It is a set of measured or averaged physical fuel characteristics of a relatively uniform unit on the landscape that represents a distinct fire environment. An FCCS fuelbed can represent any scale or precision of interest. In FCCS, fuelbeds represent realistic fuel conditions and can accommodate a wide range of fuel characteristics in six horizontal fuel layers called strata (Ottmar et al. 2007). The strata include canopy, shrub, non-woody vegetation, woody fuel, litter/lichen/moss, and ground fuel. Each stratum is further divided into 16 categories and 20 subcategories to represent the complexity of wildland and managed fuel. FCCS fuelbeds were developed by the Fire and Environmental Applications Team (FERA) at the USFS Pacific Wildland Fire Sciences Laboratory to represent important fuel types in the United States. They contain data from the following sources: regional workshops; published literature; USFS photo series, general technical reports, and research papers; other government literature and large databases (such as the NPS and FIA); masters and doctoral theses; white papers, field data, and other unpublished data; and expert opinion.

The LF FLM classification system used for CONUS was based on unique sets of fuel characteristics that simplified the input of fuel loadings into fire effects models. FLMs can be used to simulate smoke emissions and soil heating. An FLM fuelbed is defined as all combustible material below two meters and above mineral soil. These fuels are commonly referred to as surface fuels and include live and dead herbaceous and shrub material, DWM, duff, and litter. Fire behavior and fire effects are the result of the combustion process of the fuel. The size and spatial distribution of smaller diameter combustible material, for example, affects fire behavior, whereas fire effects are dependent on the intensity and duration of the combustion of all fuel. This generalization suggests that a fuel classification system that emphasizes significant differences in fire behavior will not be the same as a classification that identifies differences in fire effects. The FLMs developed for LF were designed to uniquely identify significant differences in two fire effects: maximum surface soil heating and total fine particulate matter emissions less than 2.5 micrometers in diameter (PM2.5).

2.7.2 LF 2001 Enhancements to Fire Effects Products

2.7.2a Enhancements to the Fuel Characterization Classification System fuelbeds

The FCCS fuelbed mapping relied almost entirely on the LF EVT layer. In cases where an FCCS fuelbed represented a certain seral stage or density class of a particular EVT, the LF EVC layer and EVH layer were also used for mapping FCCS fuelbeds. In addition, the NLCD mapping zone layer, which was used for LF mapping, was used to reflect broader eco-regional variation in FCCS fuelbeds. The mapping process was a collaborative effort between LF and FERA.

LANDFIRE 2001 and 2008 Methods and Results

The following were the steps involved in the FCCS mapping process. First, the construction of an initial cross-walk of FCCS fuelbeds to LF EVTs using the Society of American Foresters and Society of Range Management classification scheme was used as a link for each completed LF mapping zone. Second, FCCS fuelbeds were identified that did not match well with LF EVT map units. These new fuelbeds were then created and assigned all FCCS attributes. A final cross-walk was constructed that included all new fuelbeds identified in the previous step. The final step used a map rule set tied to the cross-walk to produce the final FCCS fuelbed layer for each mapping zone.

With the inclusion of a new method to determine EVC and EVH, the rule sets that were created for FCCS remained the same, but the pixels on the map that each rule applied to shifted, depending on the change in tree cover and/or height of the tree cover in forested EVTs. Table 32 and Table 33 display the FCCS rule sets developed for EVT 2027 and 2028 in mapping zone 7. LF National and LF 2001 depict the change in acreage between data versions. For example, Table 32 depicts the rule sets and the appropriate FCCS fuelbeds. The number of acres and the percent of each EVT that meet those criteria are also shown. These are examples of the rulesets for two EVTs in mapping zone 7, Table 33. The amount of area affected by each rule set changed significantly. However, although the area affected by each rule set changed, the rule sets remained the same between LF National and LF 2001.

Table 32 – LF National Mapping Zone 07 Fuel Characteristic Classification System fuel rule sets and number of acres based on the range of Existing Vegetation Cover and Existing Vegetation Height values.

Table 32. LF National Fuel Rule Sets					
EVT	Percent Cover	Range of Height (m)	FCCS	Acres	Percent EVT
2027 Med Dry-Mesic Mixed Conifer	10 - 19	0 - 25	4	43,706	3.9
2027 Med Dry-Mesic Mixed Conifer	10 - 19	25 - 50	16	4,769	0.4
2027 Med Dry-Mesic Mixed Conifer	20 - 100	0 -10	4	62,724	5.6
2027 Med Dry-Mesic Mixed Conifer	20 - 100	10 -50	16	1,013,952	90.1
2028 Med Mesic Mixed Conifer	10 - 19	0 - 25	4	124,959	4.8
2028 Med Mesic Mixed Conifer	10 - 19	25 - 50	7	2,471	0.1
2028 Med Mesic Mixed Conifer	20 - 100	0 -10	4	65,584	2.5
2028 Med Mesic Mixed Conifer	20 - 100	10 -50	7	2,409,345	92.6

Table 33 – LF 2001 Mapping Zone 07 Fuel Characteristic Classification System fuel rule sets and number of acres based on the range of new Existing Vegetation Cover and Existing Vegetation Height values.

Table 33. LF 2001 Fuel Rule Sets

EVT	Percent Cover	Range of Height (m)	FCCS	Acres	Percent EVT
2027 Med Dry-Mesic Mixed Conifer	10 – 19	0 - 25	4	14,036	1.2
2027 Med Dry-Mesic Mixed Conifer	10 – 19	25 - 50	16	205	0.0
2027 Med Dry-Mesic Mixed Conifer	20 – 100	0 -10	4	31587	2.8
2027 Med Dry-Mesic Mixed Conifer	20 – 100	10 -50	16	1,083,071	95.9
2028 Med Mesic Mixed Conifer	10 – 19	0 - 25	4	47,479	1.8
2028 Med Mesic Mixed Conifer	10 – 19	25 - 50	7	1,688	0.1
2028 Med Mesic Mixed Conifer	20 – 100	0 -10	4	10,161	0.4
2028 Med Mesic Mixed Conifer	20 – 100	10 -50	7	2,552,843	97.7

2.7.2b Enhancements to the Fuel Loading Models

Following the methods outlined by Lutes et al. (2009) and Sikkink et al. (2009), fire effects modeling was conducted using the First Order Fire Effects Model (FOFEM) version 5.9 to simulate PM2.5 smoke emissions, soil heating, and fuel consumption. Pseudo-plots (a method to address a lack of field data using existing plot and geospatial data) with loading attributes were developed for grasslands using the loading data from FCCS. For some FLMs, the shrub loading in the LF National attributes from Sikkink et al. (2009) summed shrub and herb loading into shrub loading. Fire effects were run on these data for a comparison with a professional judgment split of the loading between shrub and grass. The burnable agriculture and burnable urban types with loading attributes were also included in these data. A series of iterative cluster analyses of fire effects, fuel loading, and data subsets were then performed to (1) validate the addition of grassland models, (2) separate shrub loading into shrub and herb loading, (3) cross-walk the NLCD types to an FLM, and (4) evaluate whether the classification was adequate to deal with post-disturbance conditions. The results indicated that the addition of three grassland models with low, moderate, and high grass fuel loading, in combination with the separation of shrub and grass loading greatly enhanced the separation of the fire effects clusters and achieved objectives. The burnable agriculture and burnable urban types with fuel loading were cross-walked to an FLM model. These analyses resulted in 30 FLMs, with some adjustment in the loading attributes.

FLM mapping methods applied rules developed from the LFRDB plot data for assignment of a given FLM to various combinations of EVT, EVC, and EVH. For the western U.S., fuel bed measurements of coarse woody debris (CWD), fine woody debris, duff, and litter were compiled from the LFRDB for 24 LF zones. These data and subsequent rules were then used for mapping FLM in the NC GeoArea. Of 17,708 fire effects records, 2,813 had the necessary measurements to key to a FLM. The following procedures outline how plot level data were used to create seamless maps for all LF zones.

A fuelbed measurement majority method was applied to map FLMs. This mapping process included the following steps:

1. Fire effects data were compiled from the LFRDB from all available LF zones.
2. These data were classified to their appropriate FLM.

3. The majority FLM was identified based on existing vegetation database attribute combinations.
4. FLM layers were produced and processed using a pixel populating routine.

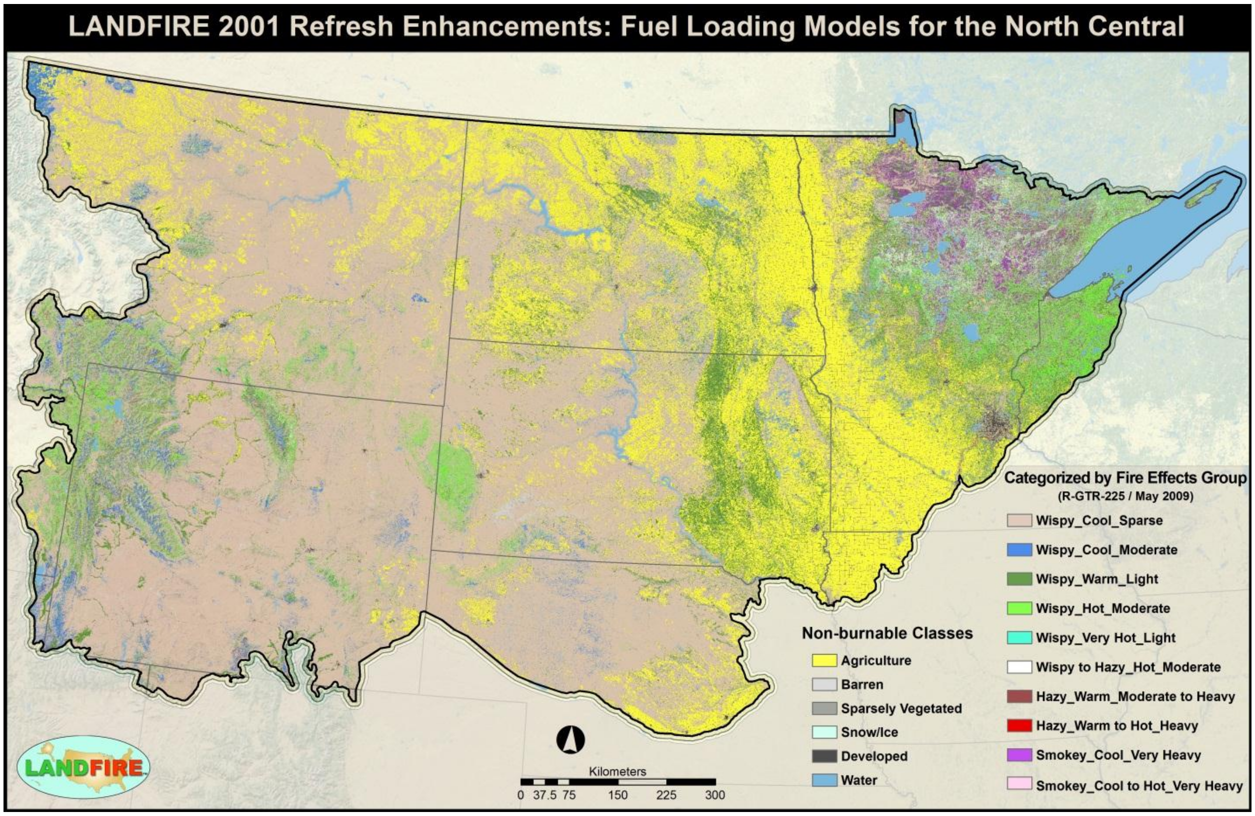

Figure 14 – LF 2001 Fuel Loading Models for the NC GeoArea. FLM categories are from Rocky Mountain Research Station General Technical Report 225.

2.7.2c Modeled Fire Effects Using LF 2001 Enhanced Products

The WFAT can also be used to spatially model fire effects using FOFEM, and was used to estimate potential fire effects using fuel loading data from LF National and LF 2001. Three fire effects outputs from these simulations were then compared to quantify changes in LF FLM mapping improvements (Table 34). The WFAT runs used a simulation landscape and a representative RAWS for each area. Fire weather data were generated from the RAWS data for the selected station. The 98th percentile fire weather was used as an input to WFAT. The FLM grids provided the loadings data for these simulations.

Table 34 –Comparison of fire effect characteristics derived from LF National and LF 2001 for Federal Lands in the NC GeoArea.

Table 34. Fire Effect Characteristics Comparison – LF National to 2001				
Ownership	**Fire Effect Characteristics**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Particulate Production:				
No Burnable Fuels		4,341,306	3,158,006	-27.3
No Burn In Fuels		187,493	230,917	23.2
No Effect		217,788	-	-100.0
Low (>0 and <=250 lb/ac)		573,423	39,525,154	6,792.8
Moderate (>250 and <=1000 lb/ac)		13,436,459	5,760,100	-57.1
High(>1000 lb/ac)		31,054,220	1,136,512	-96.3
Soil Heating:				
No Burnable Fuels		4,341,306	3,158,006	-27.3
No Burn in Fuels		187,493	230,917	23.2
No Effect		26,272,367	36,442,003	38.7
Low (>0 and <=3 cm)		18,947,318	258,374	-98.6
Moderate (>3 and <=8 cm)		56,720	9,264,087	16,233.0
High(>8 cm)		5,486	457,302	8,235.8
Fuel Consumption:				
No Burnable Fuels		4,341,306	3,158,006	-27.3
No Burn in Fuels		187,493	230,917	23.2
No Effect		217,788	-	-100.0
Low (>0 and <=33 %)		8,512	2,498,849	29,256.8
Moderate (>33 and <= 66 %)		142,441	18,830,915	13,120.2
High (>66 %)		44,913,149	25,092,003	-44.1

2.7.3 LF 2008 Updates to Fire Effects Products

2.7.3a Updates to Fuel Characterization Classification System Fuelbeds

The same mapping rules that were used for LF 2001 were used for LF 2008 in areas not disturbed by either fire, mechanical removal of surface fuel, or mechanical or wind addition of surface fuel. However, pixels that were affected by disturbances between 1999 and 2008 were adjusted using a simple rule set that modified the original FCCS assignment based on disturbance type, severity, and time since disturbance.

2.7.3b Updates to Fuel Loading Models

The same mapping rules that were used for LF 2001 were used for LF 2008 in areas not disturbed by either fire, mechanical removal of surface fuel, or mechanical or wind addition of surface fuel. However, pixels that were affected by disturbances prior to 2008 were adjusted using a simple rule set that modified the original FLM assignment based on disturbance type, severity, and time since disturbance.

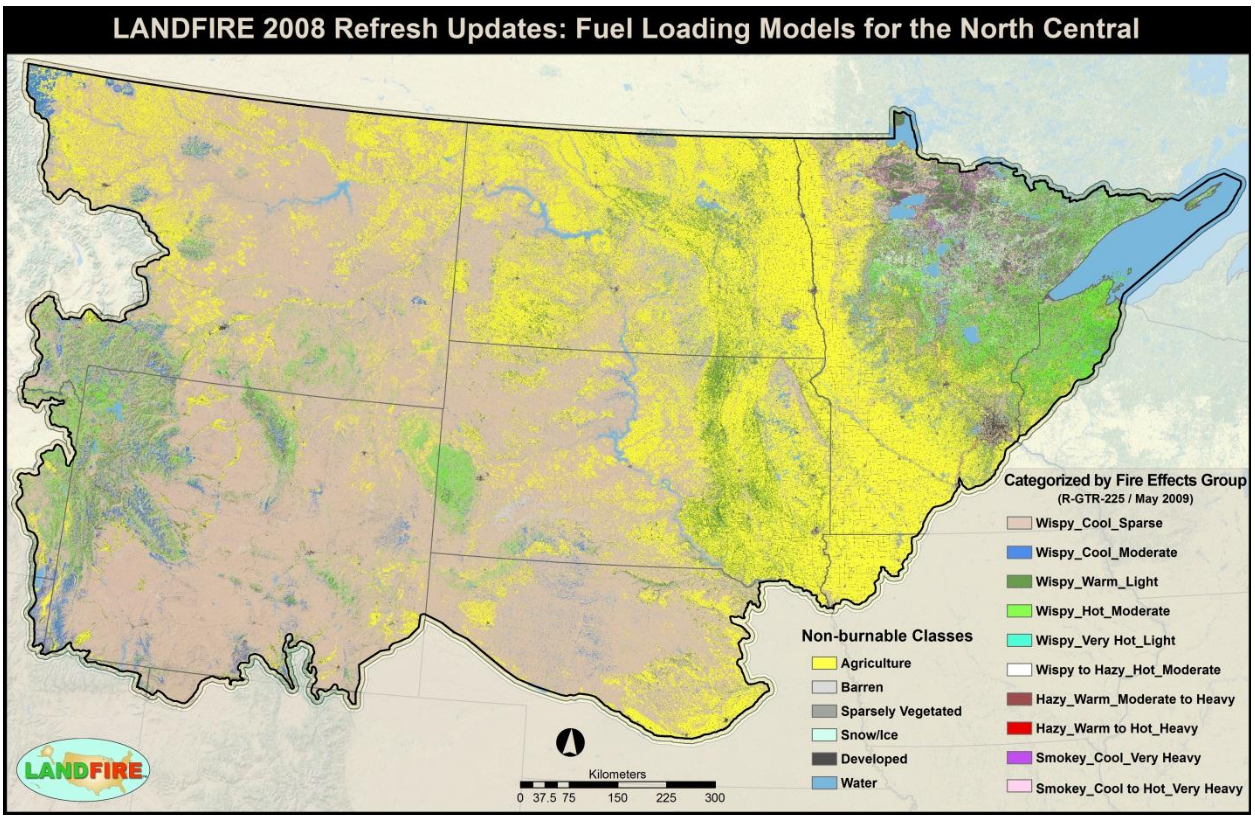

Figure 15 – LF 2008 Fuel Loading Models for the NC GeoArea. Categories are from the Rocky Mountain Research Station General Technical Report 225.

2.7.3c Modeled Fire Effects Using LF 2008 Updated Products

WFAT was used to estimate potential fire effects using fuel loading data from LF 2001 and LF 2008. Three fire effects outputs from these simulations were then compared to quantify changes in LF fuel loading mapping improvements (Table 35). The WFAT runs used a simulation landscape and a representative RAWS for each area. Fire weather data were generated from the RAWS data for the selected station. The 98th percentile fire weather was used as an input to WFAT. The FLM grids provided the loadings data for these simulations.

Table 35 – Comparison of fire effect characteristics derived from LF 2001 and LF 2008 for Federal Lands in the NC GeoArea.

Table 35. Fire Effect Characteristics Comparison– LF 2001 to LF 2008				
Ownership	**Fire Effect Characteristics**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Particulate Production:				
No Burnable Fuels		3,158,006	3,488,359	10.5
No Burn In Fuels		230,917	215,014	-6.9
No Effect		-	-	-
Low (>0 and <=250 lb/ac)		39,525,154	39,313,088	-0.5
Moderate (>250 and <=1000 lb/ac)		5,760,100	5,926,021	2.9
High(>1000 lb/ac)		1,136,512	868,207	-23.6
Soil Heating:				
No Burnable Fuels		3,158,006	3,488,359	10.5
No Burn in Fuels		230,917	215,014	-6.9
No Effect		36,442,003	35,704,280	-2.0
Low (>0 and <=3 cm)		258,374	287,829	11.4
Moderate (>3 and <=8 cm)		9,264,087	9,574,618	3.4
High(>8 cm)		457,302	540,589	18.2
Fuel Consumption:				
No Burnable Fuels		3,158,006	3,488,359	10.5
No Burn in Fuels		230,917	215,014	-6.9
No Effect				
Low (>0 and <=33 %)		2,498,849	2,263,162	-9.4
Moderate (>33 and <= 66 %)		18,830,915	18,601,762	-1.2
High (>66 %)		25,092,003	25,242,391	0.6

2.8 Fire Regime Products

2.8.1 Product Description

Broad-scale alterations of historical fire regimes and vegetation conditions have occurred in many landscapes in the U.S. through the combined influence of land management practices, fire exclusion, ungulate herbivory, insect and disease outbreaks, climate change, and invasion of non-native plant species. The LF program produced maps of historical fire regimes and historical vegetation conditions using a state and transition model, VDDT. The LF program also produced maps of current vegetation and measurements of current vegetation departure from simulated historical reference conditions. The LF 2001/2008 update was accomplished by using the FRCC Mapping Tool (FRCCMT; Jones and Tirmenstein, 2012) to perform the FRCC calculations as defined in the Interagency Fire Regime Condition Class Guidebook (FRCC, 2010). FRCCMT relied on the use of a variety of spatial inputs, including the BpS and SCLASS layers and LF 2001 Fire Regime Landscape layers.

SCLASS categorizes current vegetation composition and structure in up to five successional states defined for each LF BpS Model. Two additional categories define uncharacteristic vegetation components that were not found within the compositional or structural variability of successional states defined for each BpS model, such as exotic species. These succession classes were similar in concept to those defined in the FRCC Guidebook. The FRCC data layer categorizes departure between current vegetation conditions and reference vegetation conditions according to the methods outlined in the FRCC Guidebook. This departure index is represented using a 0 to 100 percent scale, with 100 representing maximum departure. The departure index was then classified into three condition classes. It is important to note that the LF FRCC approach differs from that outlined in the FRCC Guidebook as follows: LF FRCC was based on departure of current vegetation conditions from reference vegetation conditions only, whereas the Guidebook approach also includes departure of current fire regimes from those of the reference period. As such, LF has made a transition from calling these products FRCC data products to Vegetation Condition Class (VCC). Similarly, the FRCC departure has been changed to Vegetation Departure Index (VDEP).

2.8.2 LF 2001 Enhancements to Fire Regime Products

2.8.2a Enhancements to Summary Units

The LF 2001 fire regime product was developed to provide a spatial summary unit for processing within each GeoArea using the FRCCMT. The layer was developed by combining the Hydrologic Unit Code (HUC; USGS and NRCS, 2011) and the FRCC layer and clipping this combined raster to each GeoArea boundary. The FRCC layer was then summarized by HUC codes 8, 10, and 12. The fire regime product is one of five inputs used in analyzing departure with FRCCMT, allowing for scale-appropriate analyses for each stratum according to its associated FRG (FRCC, 2010). The outputs from FRCCMT differ as the landscape used to report those results changes in size and/or shape. It is therefore important to select appropriately sized landscapes when using FRCCMT. In addition to the fire regime product, FRCCMT assesses the FRCC metrics by BpS within the landscape watersheds, using the smaller sub-watersheds denoted by the HUC 12 code to calculate FRCC for BpS in FRG 1 and 2, the watersheds denoted by the HUC 10 code to calculate FRCC for BpS in FRG 3, and the larger sub-basins denoted by the HUC 8 code to calculate FRCC for BpS in FRG 4 and 5.

2.8.2b Enhancements to Succession Classes

The SCLASS layer was created by linking the BpS Group attribute in the BpS layer with the RMT data and assigning the SCLASS attribute. This geospatial product displays a reasonable approximation of SCLASS, documented in the RMT. The current successional classes and their historical reference conditions were compared to assess departure of vegetation characteristics; this departure can be quantified using methods such as FRCC. SCLASS rules for each BpS were designed to meet the following criteria: 1) represent the existing locations of a BpS SCLASS on the landscape and 2) meet the input requirements for the FRCCMT. User feedback had identified two primary issues with the LF National BpS SCLASS rules.

1. Many of the rules in the RMT database conflicted due to overlapping cover and height ranges.

2. Some life-forms that were mapped within a given BpS should not have been included based on the BpS model description for the SCLASS. These cases are referred to as “life-form mismatches.”

BpS models and SCLASS rules were evaluated against the BpS model descriptions and adjusted to accurately reflect the intent of the model. In some cases the cover and height values either matched or remained similar to the original model. In other cases the cover and height values were adjusted considerably. The SCLASS rule revision process eliminated overlap between cover and height ranges of the SCLASS rules for a given BpS. Overlapping rules were edited so that only one rule applied to each pixel. In some cases correcting the overlapping values resulted in cover or height values that were one or more categories above or below the original model.

In the case of life-form mismatches, the life-forms that were mapped as part of the BpS but not allowed by the SCLASS rules were reviewed and reassigned to an uncharacteristic class and the probable source of the error was documented.

The state and transition model for SCLASS is defined as follows: 1) S-Class A: early-seral, post replacement; 2) S-Class B: mid-seral, closed canopy; 3) S-Class C: mid-seral, open canopy; 4) S-Class D: late-seral, open canopy; and 5) S-Class E: late-seral, closed canopy. Not all biophysical settings conform to this model. For example, some grassland types might have only two or three succession classes (FRCC, 2010).

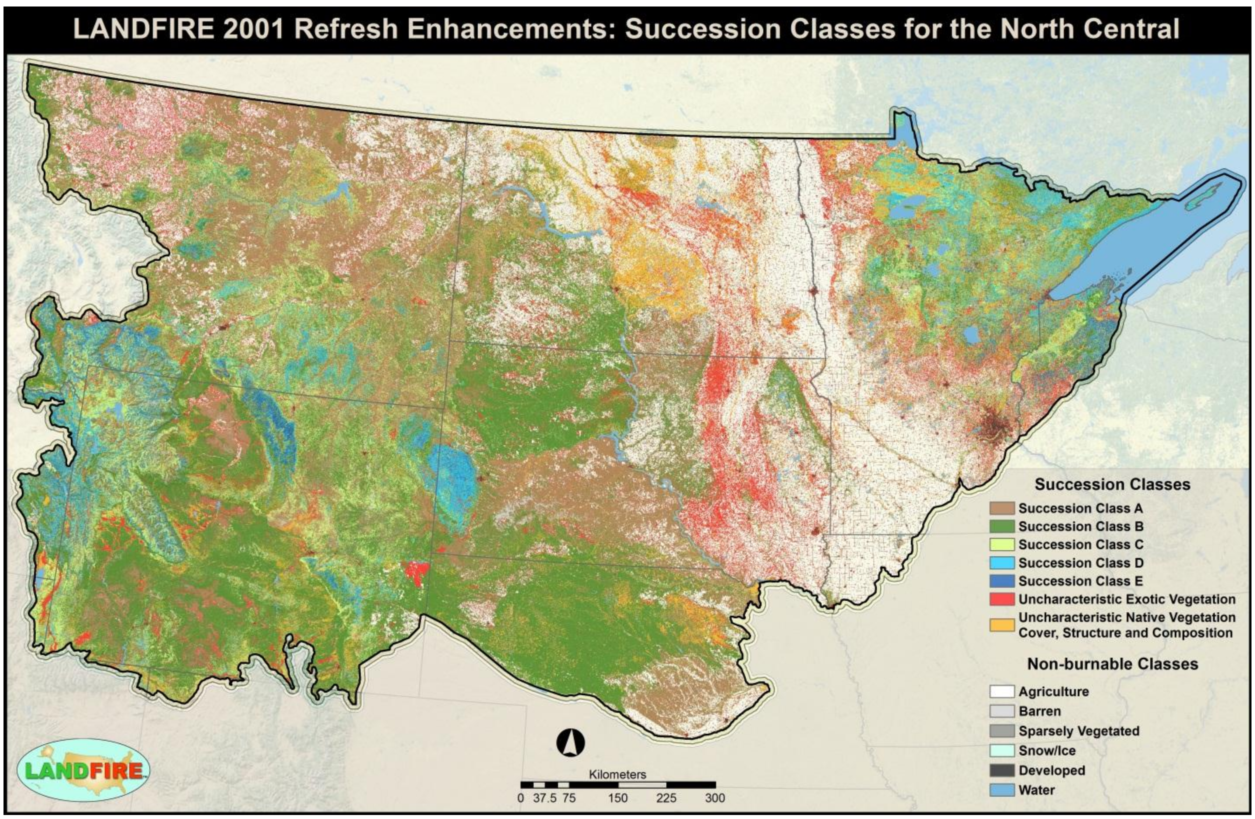

Figure 16 – Map of LF 2001 enhancements of the Succession Classes layer for the NC GeoArea.

2.8.2c Enhancements to Vegetation Departure

Unlike previous versions of LF data, reference conditions of percent composition for each of the characteristic SCLASS were derived from modeling workshops with the intent to approximate the definitions outlined in the FRCC Guidebook. Modelers used the VDDT, which uses state and transition landscape modeling to simulate the effect that disturbance and management actions have on a landscape over time. The results of this modeling are stored in the LF RMT.

The current conditions were derived from the corresponding version of the LF SCLASS data layer. The areas currently mapped to agriculture, urban, water, barren, or sparsely vegetated BpS units were not included in the FRCC calculation; thus, FRCC is based entirely on the remaining area of each BpS unit that is occupied by valid SCLASS. To calculate the Stratum Vegetation Departure, FRCCMT used the BpS layer along with a HUC within the layer to stratify the SCLASS layer. Once the SCLASS layer was stratified by a HUC and BpS, FRCCMT was able to calculate the Current Percent Composition for each SCLASS within each BpS at the appropriate HUC level.

FRCCMT then used the Current Percent Composition for each of the SCLASS within a BpS/HUC along with the corresponding Reference Percent Compositions for that BpS from the Reference Condition Table to calculate the Stratum Vegetation Departure, which is described above. The Stratum Vegetation Departure grid was calculated by comparing the Reference Percent Composition of each SCLASS to the Current Percent Composition, summing the smaller of the two for each of the SCLASS to determine the Stratum Similarity. This value was then subtracted from 100 to determine the Stratum Vegetation Departure. The VCC grid is a 3-category classification of the Stratum Vegetation Departure based on the following thresholds:

1. VCC I: Stratum Vegetation Departure of 0 to 33
2. VCC II: Stratum Vegetation Departure of 34 to 66
3. VCC III: Stratum Vegetation Departure of 67 to 100

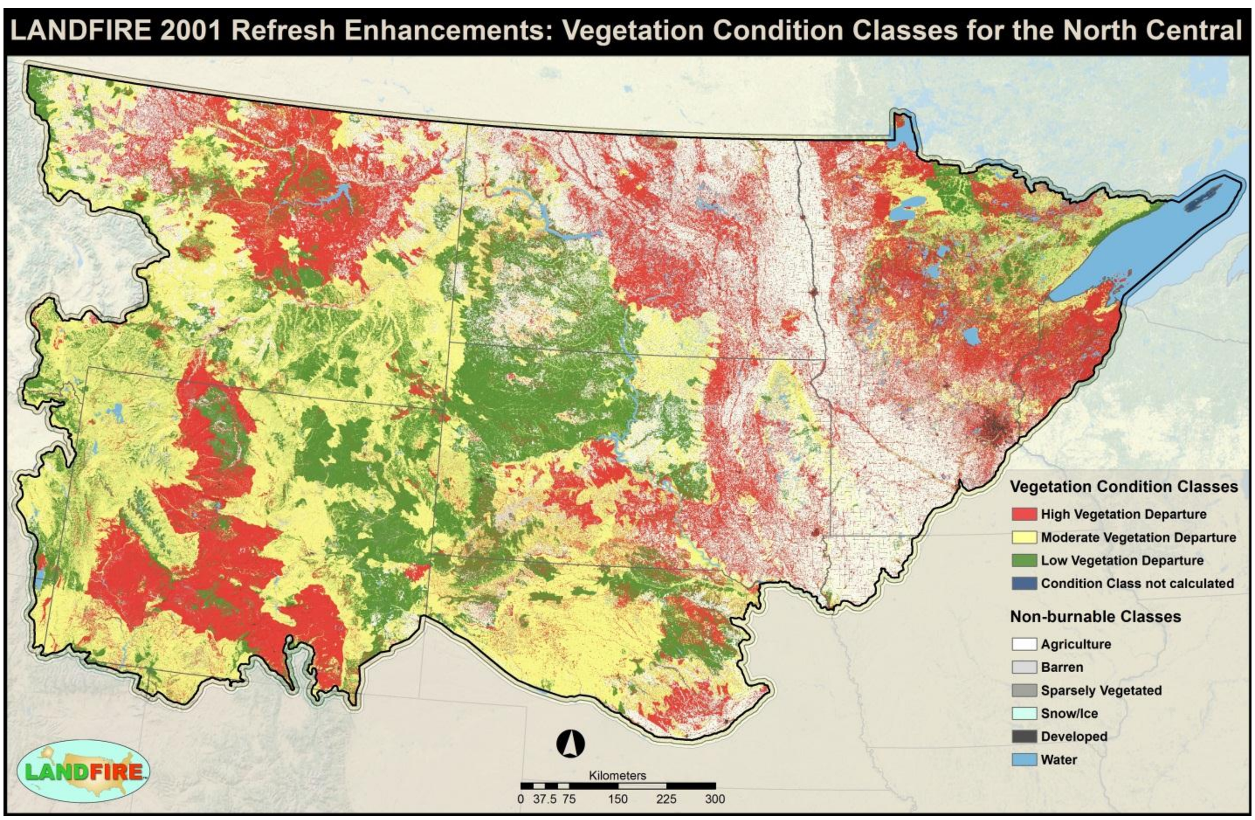

Figure 17 – Map of Vegetation Condition Class for the NC GeoArea from LF 2001 enhancements.

2.8.3 LF 2008 Updates to Fire Regime Products

2.8.3a Updates to Succession Classes

The same SCLASS mapping rules that were used for LF 2001 were used for LF 2008. Mapping rules were applied to LF 2008 EVT, EVC, and EVH layers to map the LF 2008 SCLASS layer.

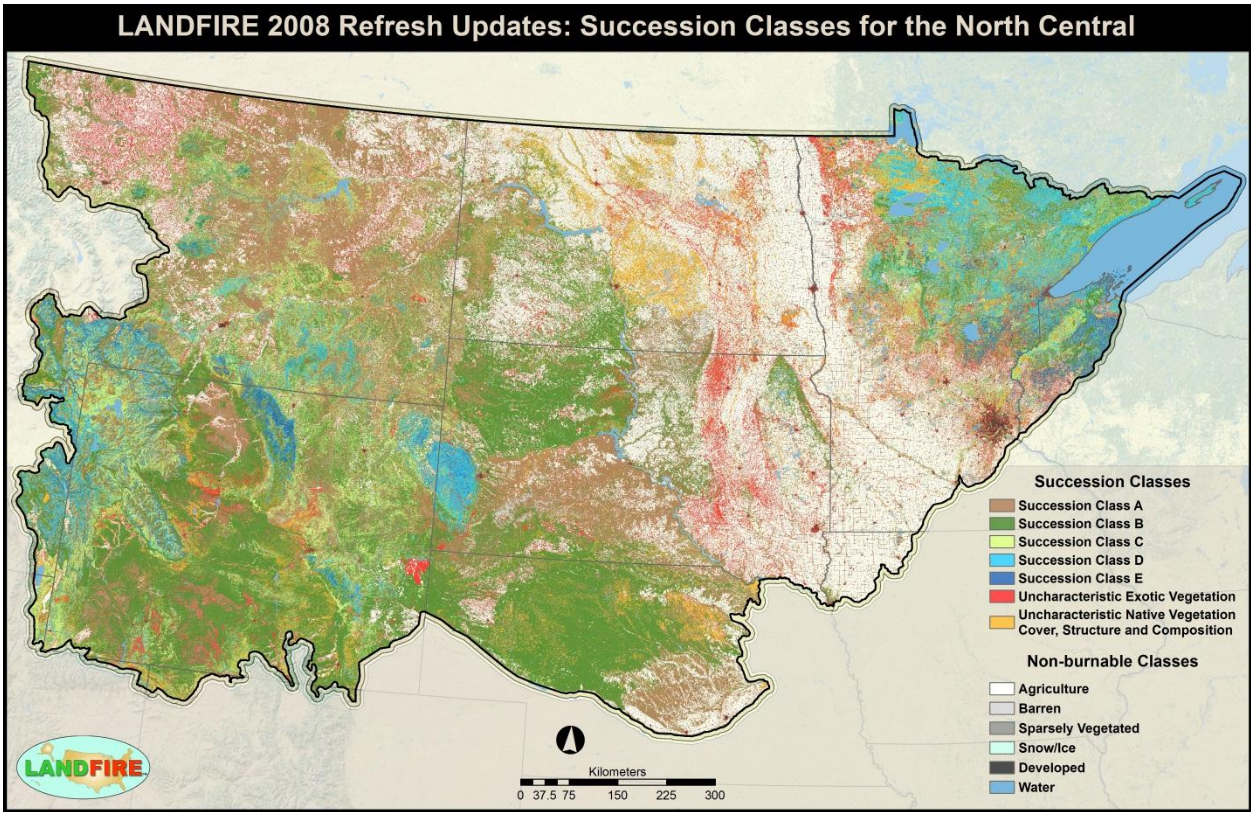

Figure 18 – Map of LF 2008 updates of the Succession Classes layer for the NC GeoArea.

2.8.3b Updates to Vegetation Departure

FRCCMT was used to calculate the current percent composition for each of the LF 2008 SCLASS within a BpS/HUC along with the corresponding reference percent compositions for that BpS from a reference condition table to calculate the LF 2008 stratum vegetation departure. The LF 2008 VCC grid was derived from a 3-category classification of the stratum vegetation departure as defined in Section 2.8.2c.

1. VCC I: Stratum Vegetation Departure of 0 to 33
2. VCC II: Stratum Vegetation Departure of 34 to 66
3. VCC III: Stratum Vegetation Departure of 67 to 100

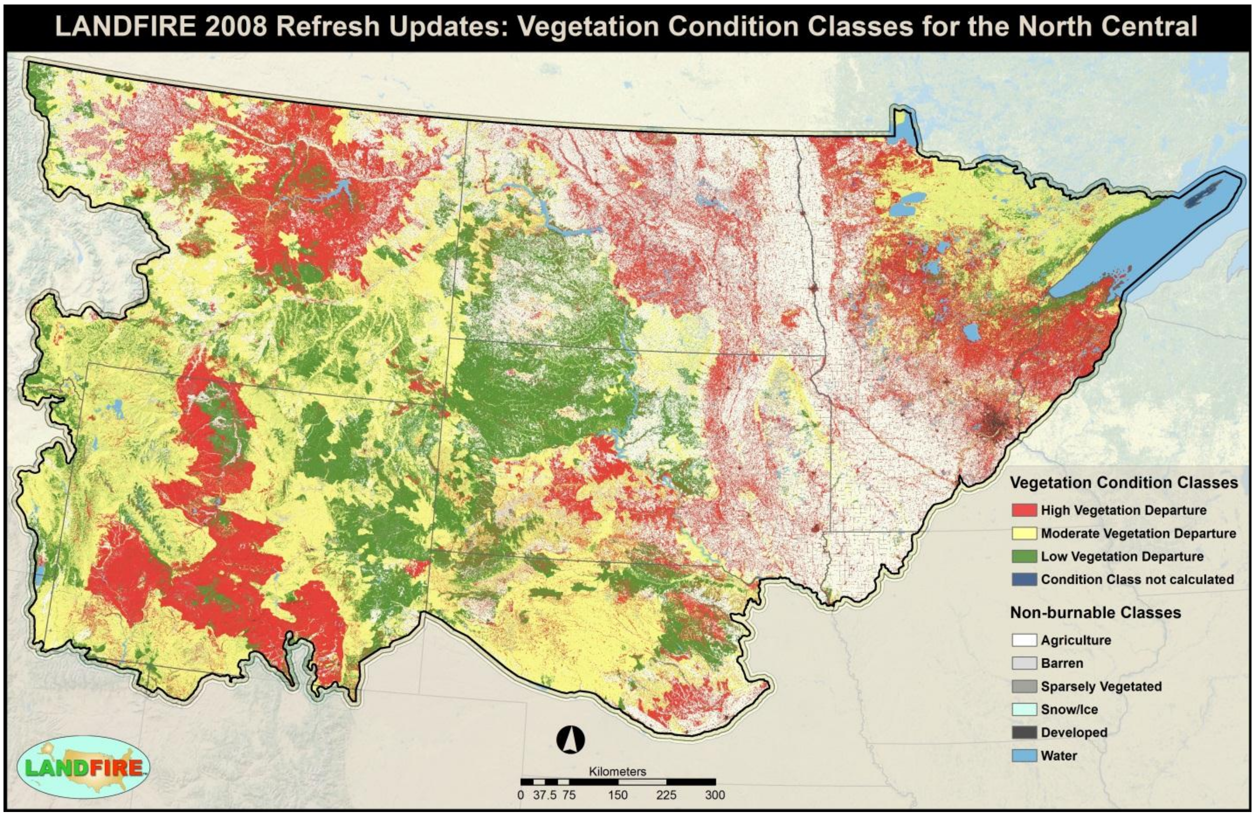

Figure 19 – Map of Vegetation Condition Class for the NC GeoArea from LF 2008 updates.

3.0 FARSITE Comparison of LANDFIRE Fuel Characteristics Versions

This section evaluates one or more of the LF fuel data sets against known wildland fire perimeters, spread distances, and environmental conditions to determine the efficacy of the data for fire analyses using the FARSITE program (Finney 1998). Fires were selected from one of several sources, either the MTBS Fire Occurrence Database (FOD) for each of the representative geographic areas, National Interagency Fire Center or from personal contact with fire personnel related to the fire. The LF data sets that were used throughout this process were FBFM40, CC, CH, CBH, and CBD from LF National, LF 2001, and LF 2008. Slope, elevation, and aspect were also included as inputs. Below are two examples of wildland fires that compare LF data sets with the final perimeters of an actual wildland fire.

3.1 Pagami Creek Fire, 2011

The Pagami Creek Fire occurred in northeastern Minnesota in the Boundary Waters Canoe Area Wilderness, near the town of Ely (map zone 41) in late August 2011. The fire burned to nearly its final size by September 15, 2011. Suppression actions on this fire are unknown, but extensive spread events occurred on September 11 and 12, 2011 and any suppression actions that would have been employed would have had little effect on the fire. National Fire Danger Rating System (NFDRS) Energy Release Component (ERC) figures indicate that the area was at the 90th percentile in fuel dryness over a ten year average for two of the three RAWS located in close proximity to the fire. Windy conditions particularly on September 11th and 12th provided for torching, long range spotting and long runs of active crowning in terms of fire activity. On September 12th, the fire spread approximately 12 miles as a result of these conditions.

The vegetation of the site is characterized by LF as a mixture of Boreal Jack Pine- Black Spruce Forest (approximately 30% of the area is EVT 2344), Boreal White Spruce –Fir- Hardwood Forest (25% of the area is EVT 2365), Boreal Acidic Peatland Systems (25% of area are EVT 2477), Boreal Aspen-Birch Forest (5% of the area are EVT 2301) and water comprises 15% of the remaining landscape. The thermal infrared (IR) map of September 11 fire perimeter was used as the beginning ignition line and a two day simulation with weather inputs from the September 11 and 12 were used for this report. The IR imagery was acquired using the Phoenix airborne thermal infrared sensor acquired by the USFS.

3.1.1 Inputs

Weather, wind, and fuel moisture data used for the fire simulation were derived from a compilation of three RAWS located to the north, south, and east of the fire area. Fernberg RAWS is located 1.5 miles off the Northeast corner of the fire perimeter; Isabella RAWS is 10 miles to the south; and Ely is 17 miles east. Median values from these RAWS were used for fuel moisture, temperature, and relative humidity. The median value for 10 minute average and maximum gust wind speed was determined for each hour for September 11th and 12th for each station. The median value of the three RAWS stations was used as input into the model for the projection across all 3 versions of LF fuel data. The wind speeds at Fernberg were higher than those at the other RAWS (max gust 35 to 40 mph), and due to its close proximity those directions and speeds weighed heavily on the model inputs. Minor adjustments were made to wind direction to ensure that fire spread was in the direction of the final perimeter.

Surface fuel models (FBFM40) in all three versions of LF data are similar and are predominantly: 161 (TU1) 35%, 165 (TU5) 25%, and 162 (TU2) 15% in the forests of the area. The only discrepancy occurs in a lesser amount of 162 (TU2) in LF 2008 compared to the other two versions. In LF 2008 where 162 (TU2) was different it was 165 (TU5). Canopy base heights (CBH) were generally above 4.0 meters in the LF National data, and range between 0.3 and 3.1 meters in LF 2001 and LF 2008.

Surface fuel models (FBFM40) and CBH values in LF 2008 were very similar to LF 2001 with a few FBFM40 pixels changing between the two.

Two 24 hour windows representing September 11th and 12th were simulated with an eight hour maximum burn period on the 11th and a 10 hour burn period on the 12th. These are hours that corresponded to heavy wind events during the height of daytime hours. The ignition line was set to the fire perimeter of the 11th on the east, south, and west sides. Crown fire activity was set to the Scott and Reinhardt method and spotting was enabled at 1.0%. Due to the water interspersed across the landscapes from the lakes, spotting was probably more prevalent than was represented in the model, but processing time for the simulation run on a value higher than 1.0% to model spotting was impractical. A fuel moisture and environmental conditioning period was used from 09/09 through 09/11 and the weather values were the median values of the RAWS heavily weighted to Fernberg.

Depicted in Figure 20 is the site for the Pagami Creek Fire with the perimeters from September 11th and the afternoon and night of September 12th.

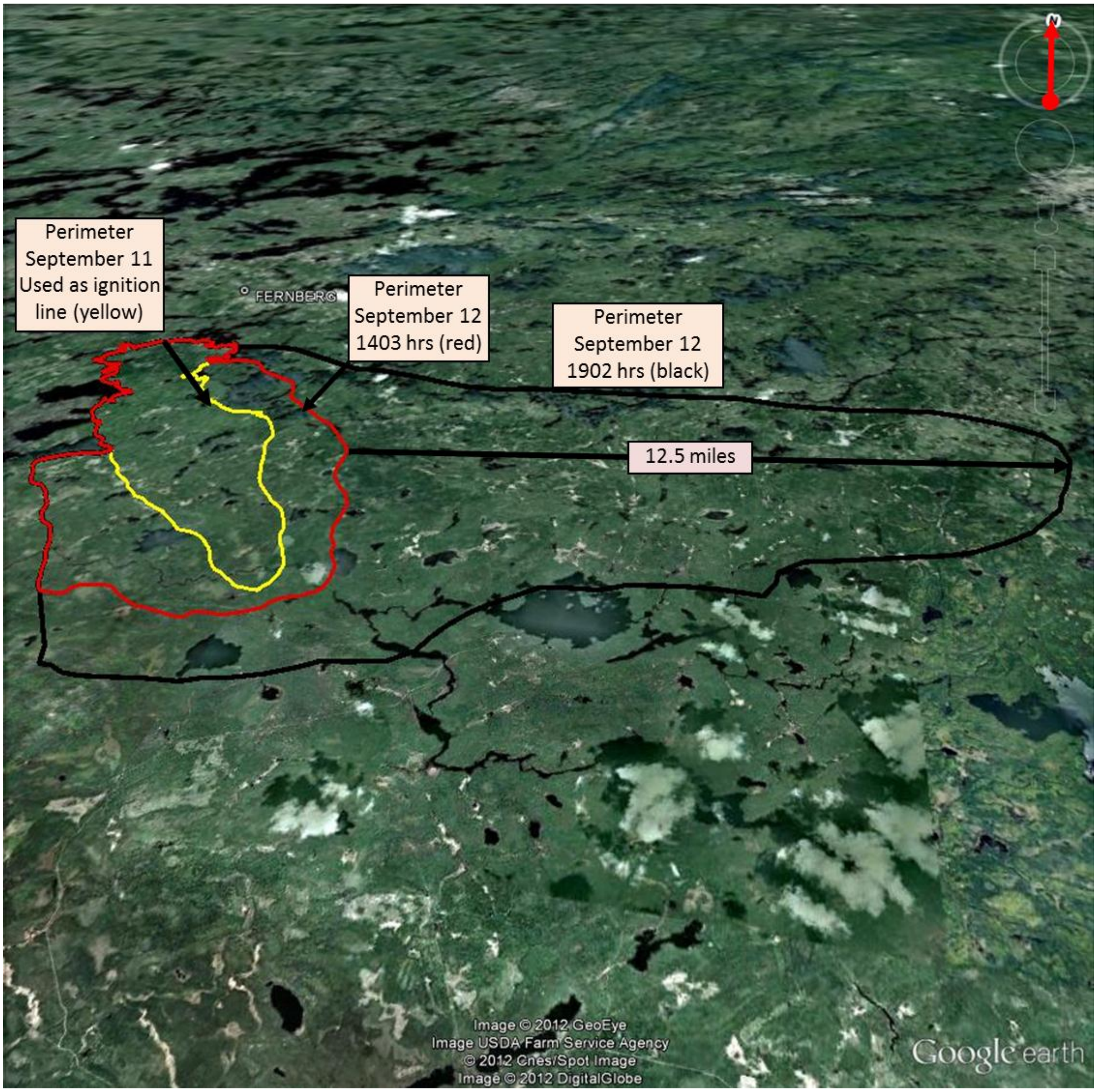

Figure 20 – Pagami Creek Fire Minnesota perimeters for September 11 and 12, 2011. The fire spread polygon from September 11th extended more than 9 miles in length southeast to northwest.

3.1.2 Results

As displayed below, LF National underestimates the fire spread compared to the actual perimeter (Figure 21). The simulation indicates that the fire is spreading as a surface fire with little spotting and no crowning. The lack of crowning and spotting in LF National is due to high CBH even though the high wind speeds from Fernberg RAWS were used in the simulation.

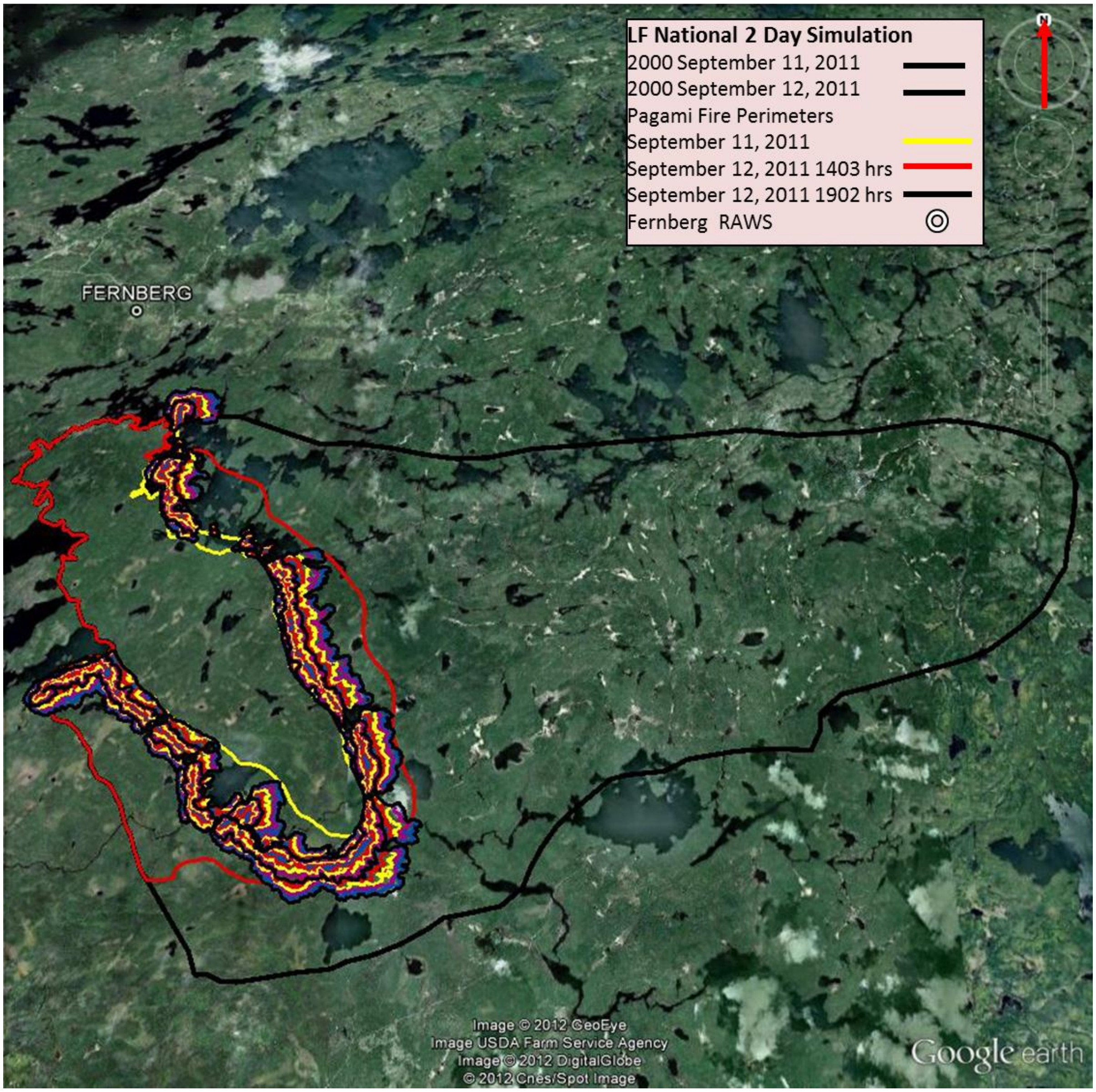

Figure 21 – LF National fire spread simulation for the Pagami Creek Fire for September 11 and 12, 2011. The fire spread polygon from September 11th extended more than 9 miles in length southeast to northwest.

LF 2001 and LF 2008 fuels layers provided much closer fits for fire spread (Figure 22) for the same time window and burn period input than LF National. The lower CBH enabled torching, spotting, and active crowning to occur from the surface fuel models with the wind speed values from the RAWS. No attempt was made in the simulations to create barriers at the flanks of the fire or use attack resources. Figure 22 depicts the LF 2008 landscape file with maximum gust wind speed values from Fernberg. The modeling of LF 2001 data had a similar final extent.

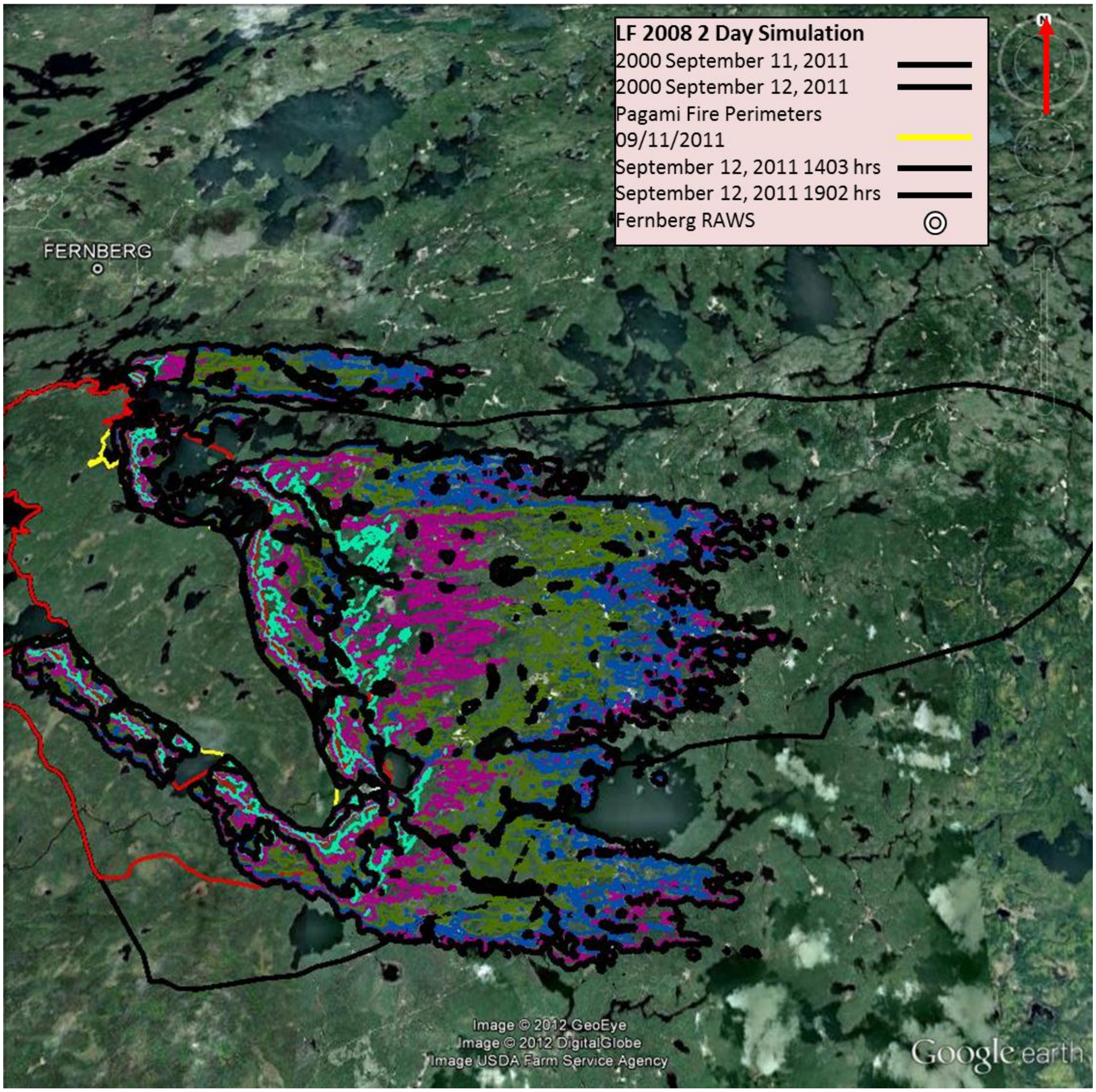

Figure 22 - LF 2008 fire spread simulation for the Pagami Creek Fire for September 11 and 12, 2011. The fire spread polygon from September 11th extended more than 9 miles in length southeast to northwest.

Figure 23 depicts how LF National predicted predominantly surface fire movement across the landscape and within the fire perimeter, followed by LF 2008 in Figure 24. LF 2008 and LF 2001 perform very similarly as expected since there were no disturbances found in this area and they have similar FBFM40 layers and CBH values, so only 2008 is depicted. Both show definite characteristics of crowning, however both fall short of the actual fire spread. Several reasons could account for this shortfall:

- Spotting should have been increased to help the simulation "get around" or cross all the lakes in the area, but an increase in spotting would have made the processing time to run the simulation impractical.
- The current fire models severely reduce the wind speeds from the 20 ft. value from the RAWS to the mid-flame wind speed observed on the ground. The 40 mph values were reduced to 5 to 8mph winds (personal accounts have the mid-flame wind speeds higher than that).

FARSITE Comparison of LANDFIRE Fuel Characteristics Versions

The following FlamMap images show the difference in the amount of active crown fire activity within and around the Pagami Creek Fire area with a 40 mph 20 ft. west wind, and the fuel moistures and condition period from the RAWS.

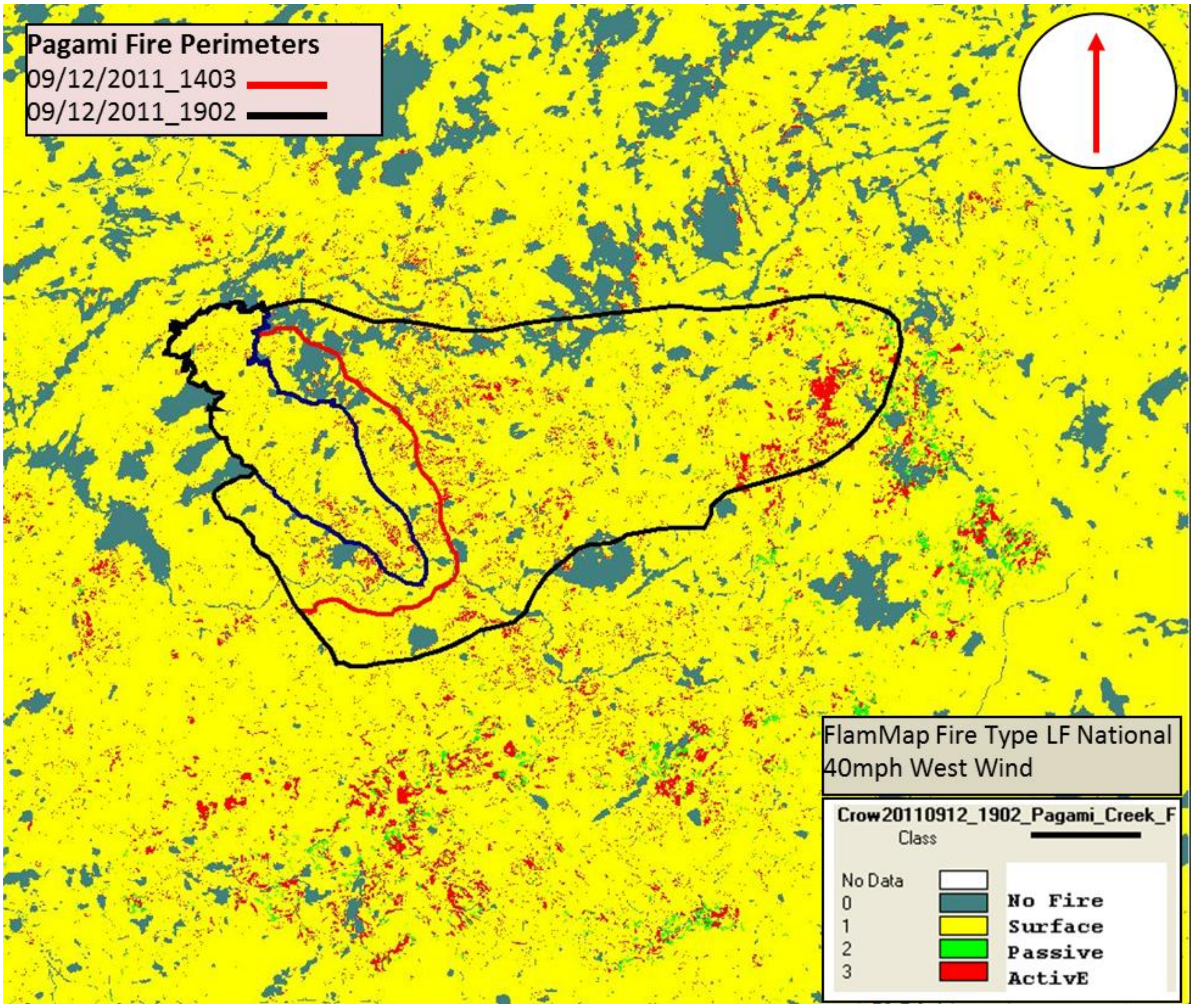

Figure 23 – FlamMap Fire Types at the Pagami Creek Fire Site using the LF National Landscape. The fire spread polygon from September 11th extended more than 9 miles in length southeast to northwest.

LF 2008 (Figure 24) depicts predominantly active crown fire activity across the landscape in general and throughout the fire area. With this type of fire activity, spotting would be prolific and have longer range than with surface fire type. If the FARSITE simulations were set to a higher spotting ignition frequency the final extent of the simulated fire would have been closer to the actual perimeter for September 12th at 2000 hrs.

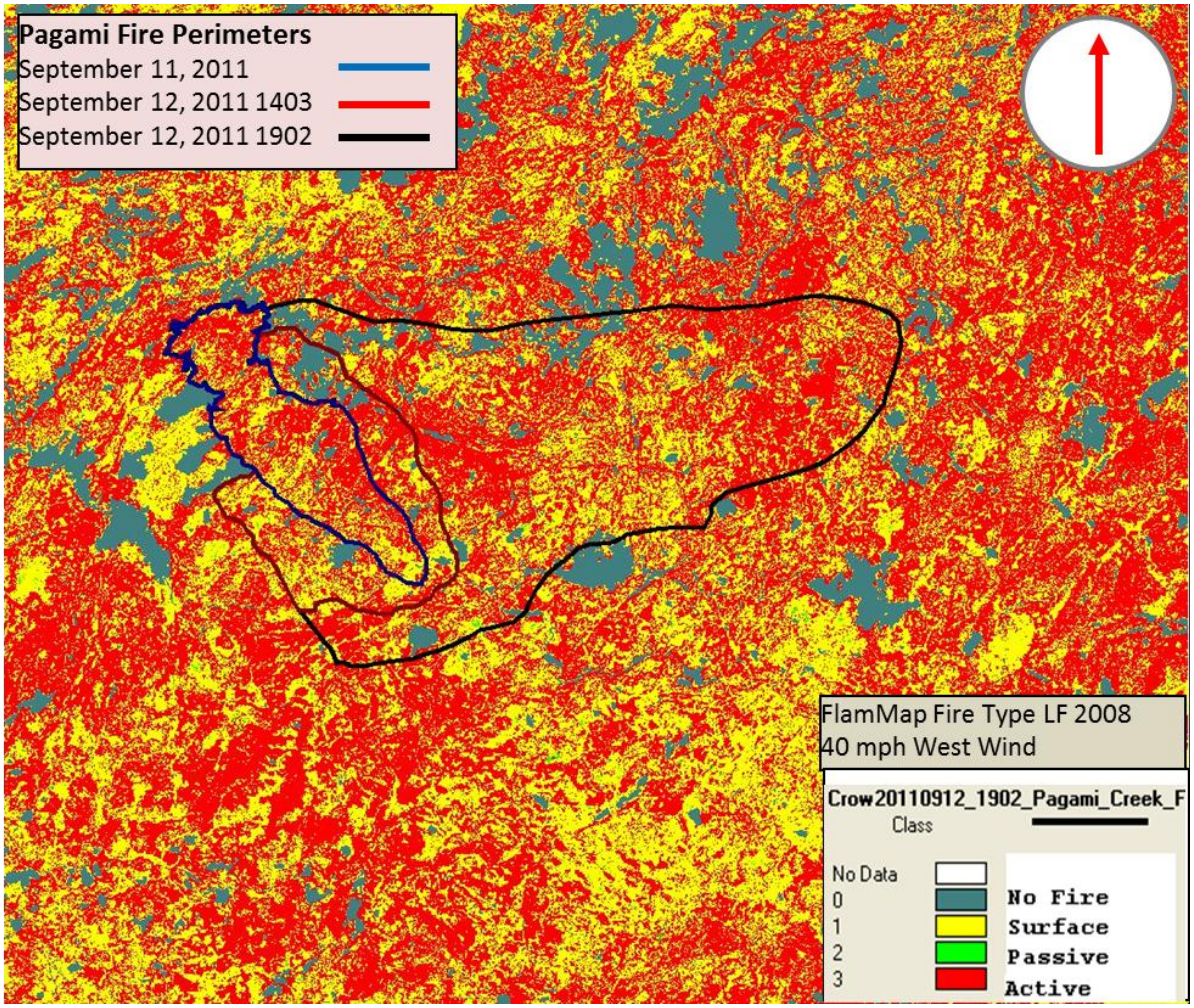

Figure 24 – FlamMap Fire Types at the Pagami Creek Fire Site using the LF 2008 Landscape. The fire spread polygon from September 11th extended more than 9 miles in length southeast to northwest.

3.2 Ferris Mountain Fire, 2011

The Ferris Mountain Fire occurred in South Central Wyoming approximately 30 miles north of Rawlins, WY (map zone 22) on October 3, 2011. The fire burned to nearly its final size by October 5th. Suppression actions on this fire are unknown, but ridgeline and fuel type changes are prominent boundaries of the final fire size. This would tend to indicate that burning to those boundaries was the likely cause of the final fire extent. NFDRS ERC figures indicated that the area was over the 90th percentile in fuel dryness over a ten year average and extreme values (97th percentile) for the first few days of October. It is suspected that torching and short runs of active crowning occurred within the fire.

The vegetation of the site was characterized by LF as predominately Poor Site Lodgepole Pine (approximately 80% of the area is EVT 2167), Subalpine Dry Mesic Spruce (10% of the area is EVT 2055), Sagebrush Steppe and Grasslands (5%of area are EVTs 2126 and 2146), and Rocky Mountain Aspen (5% of the area is EVT 2011). The IR fire perimeter map from October 4th at 0306 hrs is the first available observation of the fire and the remapped IR at 2156 hrs (night time) is the final extent used for this report.

3.2.1 Inputs

Weather, wind, and fuel moisture data used in the fire simulation were derived from a compilation of two RAWS located to the northwest and south of the fire area. Fales Rock RAWS is 15 miles south and Camp Creek 40 miles to the northwest. Median values from the two RAWS were used for fuel moisture, temperature, and relative humidity. The median value for 10 minute average and maximum gust wind speed was determined for each hour for October 4th for each station. Then the vales for the two stations were averaged as input into the model for the projection across all 3 versions of LF fuel data. The wind speeds at Fales Rock were much higher than those at Camp Creek, so minor adjustments were made to the median point of Camp Creek for the final 20 ft. wind speed that was input into the model. Minor adjustments were made in wind direction to ensure fire spread was in the direction of the final perimeter.

Surface fuel models (FBFM40) in LF National were predominantly 183 (TL3) 65%, 165 (TU5) 15% and 185 (TL5) 15% in the forest of the area. Generally 101 (GR1) and 121/122 (GS2 and GS1) prevail in the shrubs and grasslands, which was 5% of the area. Canopy base heights (CBH) were generally above 4.0 meters with some of the 165 (TU5) areas having CBHs of 2.0 to 3.0 meters.

Surface fuel models (FBFM40) in LF 2001 were mostly 183 (TL3) at 75%, 161 (TU1) at 10%, 165 (TU5) and 185 (TL5) (10% each). Shrubs and grass comprise the rest. CBH values are much lower and mainly range from 0.1 to 2.0 meters with some 2.0 to 3.0 values in 161 (TU1).

Surface fuel models (FBFM40) and CBH values in LF 2008 are very similar to LF 2001 with a few FBFM40 pixels changing between the two.

A 24 hour window (October 4, 2011) with a 5 hour maximum burn period was used to simulate the fire spread for all three versions of the fuels data. The ignition point was set to the intense heat polygons on the southeastern edge of the IR perimeter for October 4th at 0306 hrs and is compared to the IR perimeter of 2156 hrs of October 4th. The southeastern fire spread was the only part of the fire perimeter simulated. Crown fire activity was set to the Scott and Reinhardt method and spotting was enabled at 0.4%.

Displayed below (**Figure 25**) is the site for the Ferris Mountain Fire with the perimeter for the morning of October 4th 0306 hrs (orange), the intense heat polygon upon which this evaluation was based (red), and the final fire spread at 2156 hrs the night of the October 4th (blue).

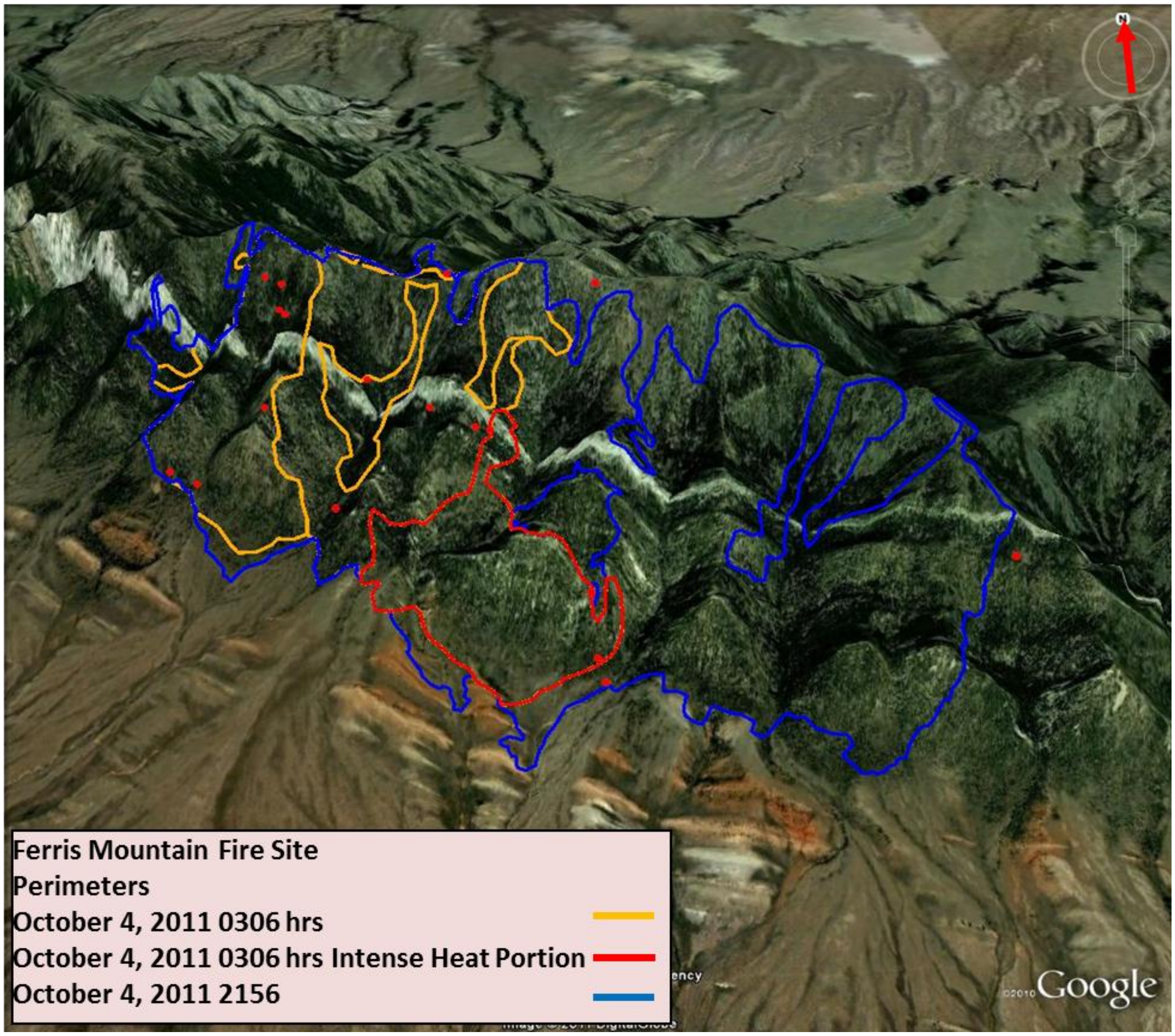

Figure 25 – Ferris Mountain Fire Wyoming with October 4, 2011 perimeters for the morning of October 4th 0306 hrs (orange), the intense heat polygon upon which this evaluation was based (red), and the final fire spread at 2156 hrs that night (blue).

3.2.2 Results

As displayed below LF National underestimates the fire spread (**Figure 26**) even though it is typified by hotter burning fuel models than the other versions of the LF data (LF2001 and LF2008). The simulation indicates that the fire is spread as a surface fire with little spotting and no crowning.

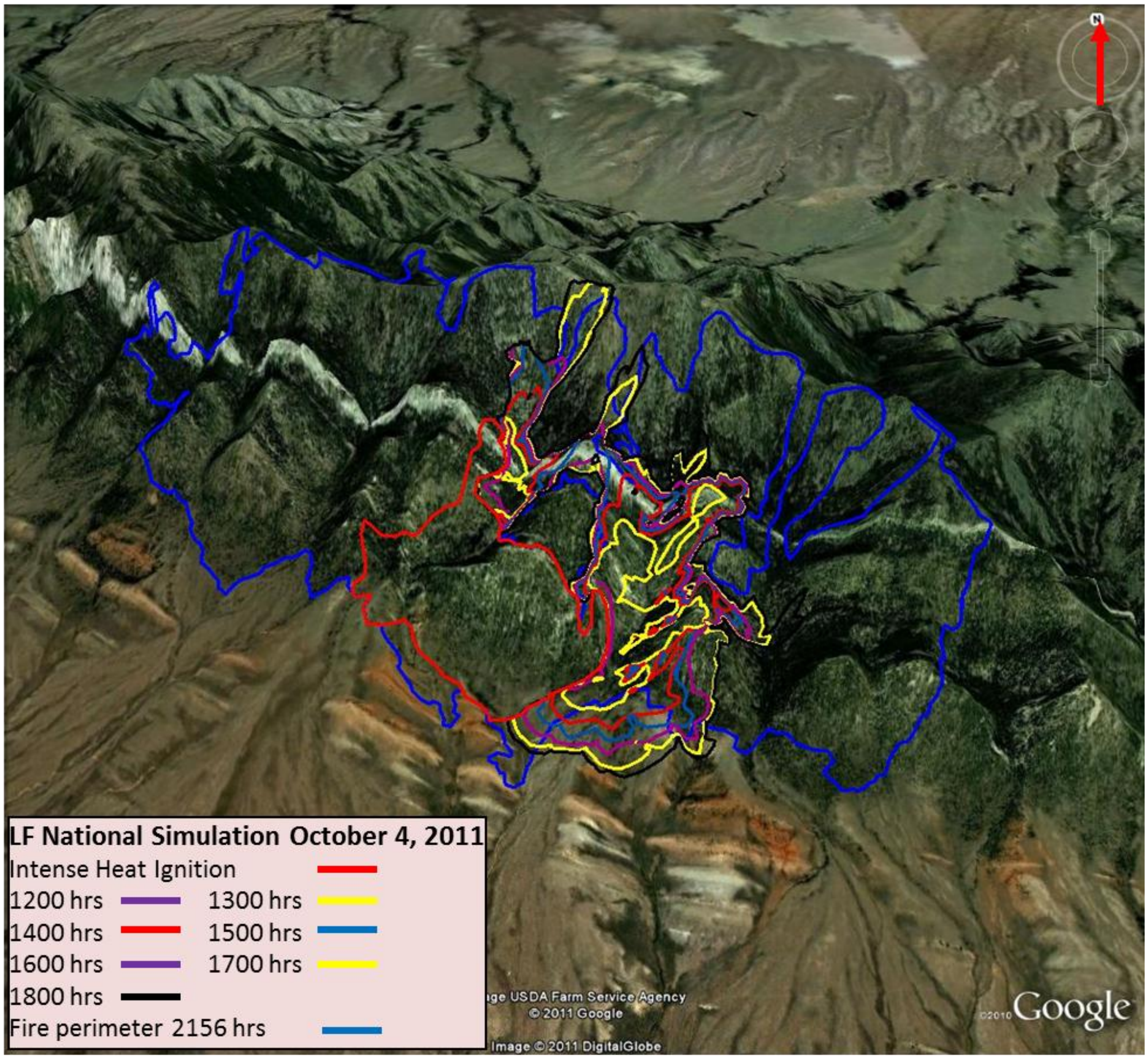

Figure 26 – LF National Fire Simulation of the Ferris Mountain Fire for October 4, 2011 from 1200 hours to 1800 hours and the actual fire perimeter at 2156 hours in blue. The fire extended nearly 3 miles from west to east.

LF 2001 fuels layers provided a much closer fit fire spread (Figure 27) for the same time window and burn period input than LF National. The lower CBH provided for torching and spotting to occur for the surface fuel model in the wind speed values from the RAWS. No attempt was made in the simulations to create barriers at the flanks of the fire or to use attack resources.

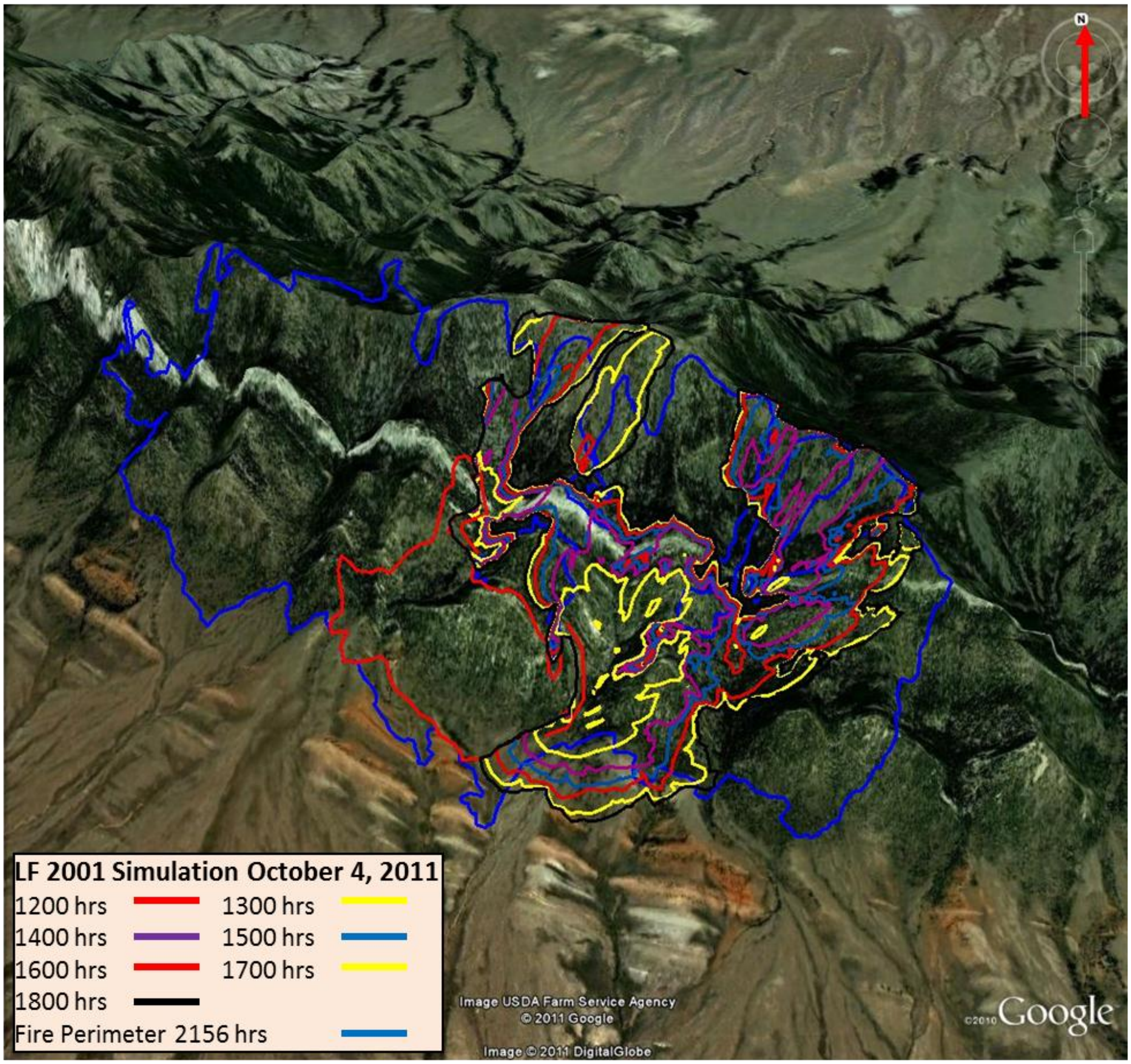

Figure 27 – LF 2001 Ferris Mountain simulated fire spread compared to final extent. The fire extended nearly 3 miles from west to east.

LF 2008 (**Figure 28**) is very similar to LF 2001 in simulated spread dynamics, which is to be expected since they have similar FBFM40 layers and CBH values. There are some discrepancies, however, due to some pixels changing in EVT from LF 2001 to LF 2008. This change would affect the surface fuel model and canopy characteristics assignment. No disturbances were found in the LF 2008 data to affect the spread. In both versions the ridge provides a spread barrier as it does in the actual fire perimeters. Areas of unburned are left inside the fire perimeter in both versions much like the actual fire foot print albeit not in the same locations. The band of open area in the center of the fire area is picked up and displayed as mainly sage and grass in all three versions.

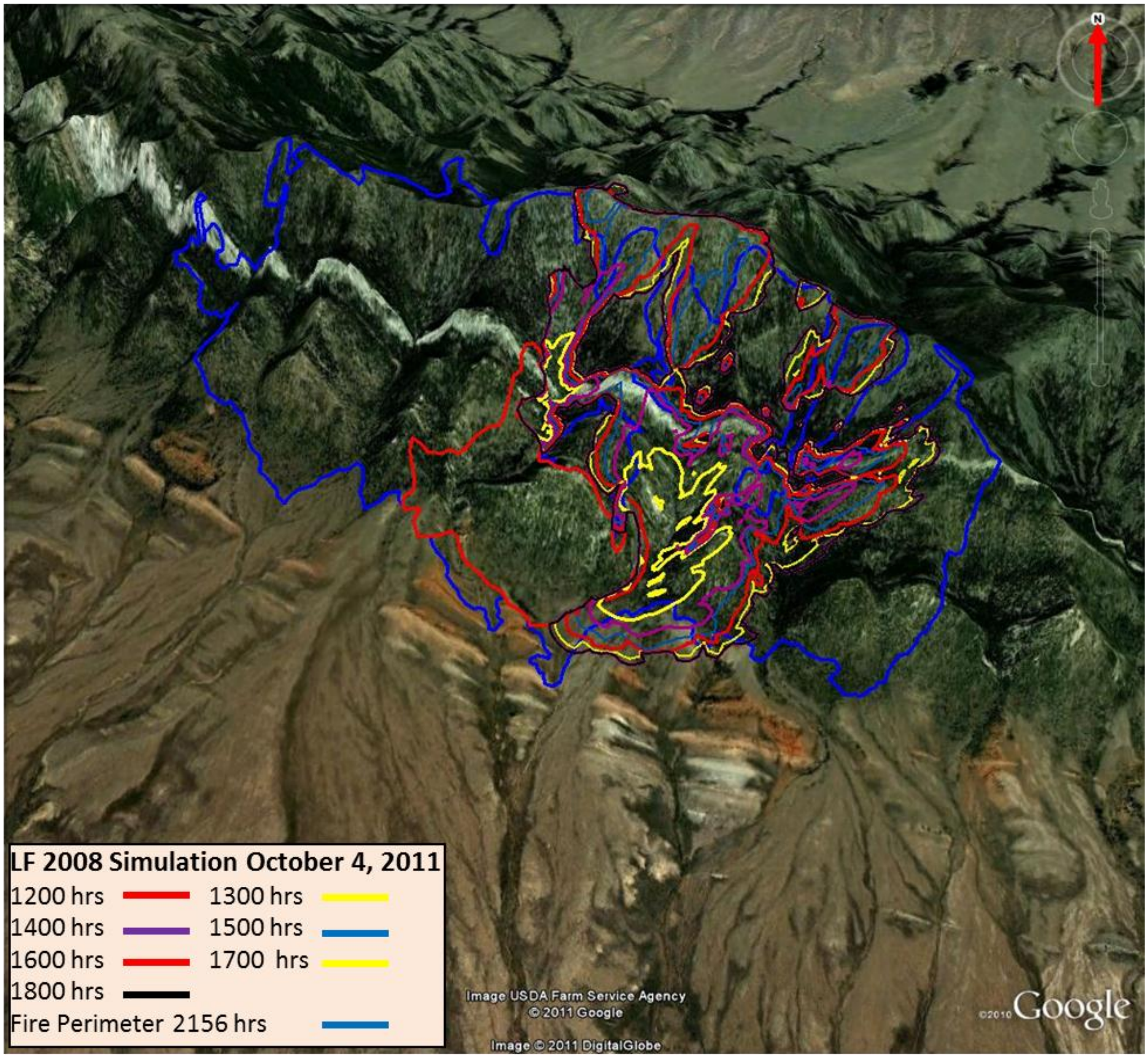

Figure 28 – LF 2008 Ferris Mountain simulated fire spread compared to final extent. The fire extended nearly 3 miles from west to east.

4.0 LF 2001/2008 Organization

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5.0 Disclaimers

This report and associated LF data are provided "as-is" and without express or implied warranties as to their completeness, accuracy, suitability, or current state thereof for any specific purpose. The LF Program is in no way condoning or endorsing the application of these data for any given purpose. The DOI and USFS manage multiple sets of information and derived data as a service to users of digital geographic data and various databases. No agent of LF shall have liability or responsibility to data users or any other person or entity with respect to any loss or damage caused or alleged to be caused directly or indirectly by the data set. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. government.

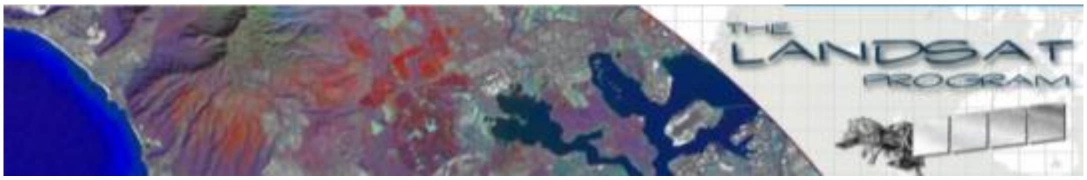
These data and related graphics (such as ".gif" or ".jpg" file formats) are not legal documents and are not intended to be used as such. Users take full responsibility for their applications of these data. It is the sole responsibility and obligation of the user to determine whether the data are suitable for the intended purpose and apply those data in an appropriate and conscientious manner.

LF is not obligated to provide updates to the data herein, as they are and shall remain consistent with those used to develop the LF Program products. However, the LF Program will, at its discretion, continue using these and previously supplied and sampled data to update and improve future versions of LF products. Users of these data are requested to inform the LF Program of significant errors to assist with product maintenance activities. Please send your feedback to helpdesk@landfire.gov.

6.0 Additional Information

This section lists some, but of course not all, partners that the LF Program works with and relies on for information and data.

6.1 Landsat



The Landsat program within USGS is a critical partner in the development of LF data products. The 30-meter Landsat imagery constitutes the foundation upon which all data layers were mapped as well as updated. When LF began in 2004, the cost of Landsat data greatly increased costs associated with the development of LF data products. Now that these data are free, costs have decreased and data improvement opportunities similar to the LF 2008 update process are expanding.

6.2 Forest Inventory Analysis

The FIA Program of the USFS provides key information to LF about America's forests. FIA provides a continuous forest census and reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. Given the confidentiality of the FIA data, LF has a memorandum of understanding and supports an FIA employee who works with the FIA data, enabling LF to use this key resource. FIA has changed processes and procedures from a periodic survey to an annual survey and by expanding the scope of data collection to include soil, under story vegetation, tree crown conditions, CWD, and lichen community composition on a subsample of plots. LF will evaluate these data sets in the continual process to improve and update the LF data products.

6.3 National Agricultural Statistics Service

NASS provides valuable agriculture data for the entire United States. These data were extremely useful in assisting to delineate burnable and non-burnable agricultural lands. LF 2001/2008 used NASS data to refine the burnable/non-burnable lands data. LF and NASS will continue to work together in the future on additional LF data product improvements.

6.4 Multi-Resolution Land Characteristics Consortium National Land Cover Database

The Multi-Resolution Land Characteristics Consortium (MRLC) is a group of Federal agencies that coordinates and generates consistent and relevant land cover information at the national scale for a wide variety of environmental, land management, and modeling applications. The creation of this consortium (the LF program is a member) has resulted in the mapping of a comprehensive land cover product, termed the NLCD, which is based upon a decadal composite of Landsat satellite imagery and other supplementary data sets.

LF has leveraged the MRLC NLCD2001 land cover product with the development of LF National (circa 2001) data and works to promote nationally complete, current, and consistent data across the nation.

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7.0 Glossary

FARSITE—Fire Area Simulator, a fire behavior and growth simulator

Fire Effects—The physical, biological, and ecological impacts of fire on the environment (NWCG 2005).

Fire Occurrence Database—A collection of information about fires including elements such as, date, location, acres, cause, etc.

Landsat Imagery—Thematic Mapper and Enhanced Thematic Mapper Plus image data from the Landsat 5 and Landsat 7 satellites, respectively. Image scenes have a footprint area of approximately 34,000 square kilometers and a pixel resolution of 30 meters.

Monitoring Trends in Burn Severity—Relevant spatial and non-spatial fire data are mapped by the MTBS project. Data elements include the latitude/longitude of the centroid of the MTBS burn scar perimeter.

Normalized Burn Ratio—a index similar to the Normalized Difference Vegetation Index. The primary difference is that NBR integrates the two Landsat bands that respond most, but in opposite ways to burning. The Landsat Thematic Mapper/Enhanced Thematic Mapper Plus bands used to calculate NBR are Band 4 and Band 7. The NBR is calculated as follows: NBR = (4 - 7) / (4 + 7).

Prescribed Fire—Any fire ignited by management actions to meet specific objectives (NWCG 2005).

Remote Sensing Landscape Change— A process composed of four main elements. These are: 1) acquisition and compilation of field data; 2) wildfire burn mapping, as being conducted by the MTBS project; 3) updating and analysis using the VCT; and 4) mapping and incorporation of subtle intra-state changes, such as those related to insects and disease.

Spatial Resolution—The areal extent of the smallest unit, pixel, or feature that can be resolved on an image, map, or surface. Typically expressed as a measure of distance – for example, a 30-meter pixel – but can also be expressed as a unit of area.

Vegetation Change Tracker— The VCT is an automated and highly efficient algorithm for mapping changes in forest cover. The algorithm uses Landsat time series stacks, which are defined as sequences of Landsat images with a nominal temporal interval (for example, one image every year or every two years) for a particular location.

Wildfire—An unplanned, unwanted wildland fire, including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out (NWCG 2005).

Wildland Fire—Any non-structure fire that occurs in the wildland. Three distinct types of wildland fire have been defined and include wildfire, wildland fire use, and prescribed fire (NWCG 2005).

8.0 Acronyms

8.1 Acronyms for Agencies and Organizations

Agencies and Organizations	
BIA – Bureau of Indian Affairs	BLM – Bureau of Land Management
DOI – Department of the Interior	FWS – U. S. Fish and Wildlife Service
NASS – National Agricultural Statistics Service	NPS – National Park Service
NS – NatureServe	TNC – The Nature Conservancy
USDA – United States Department of Agriculture	USFS – U. S. Forest Service
USGS – United States Geological Survey	

8.2 Acronyms for Terms, Information, and Systems

Terms, Information, and Systems	
AK – Alaska	BARC – Burned Area Reflectance Classification
BpS – Biophysical Settings	CBD – Canopy Bulk Density
CBH – Canopy Base Height	CC – Canopy Cover
CFA – Crown Fire Activity	CFFDRS – Canadian Forest Fire Danger Rating System
CH – Canopy Height	CONUS – Conterminous United States
CWD – Coarse Woody Debris	DDS – LANDFIRE Data Distribution Site
DWM – Downed Woody Material	EDNA – Elevation Derivatives for National Applications
ERC – Energy Release Component	ESP – Environmental Site Potential
EVC – Existing Vegetation Cover	EVH – Existing Vegetation Height

Acronyms

EVT – Existing Vegetation Type	FBFM13 – Fire Behavior Fuel Model 13, Anderson
FBFM40 – Fire Behavior Fuel Models 40, Scott and Burgan	FCCS – Fuel Characteristic Classification System
FERA – Fire and Environmental Research Applications Team – USFS	FFE – Fire and Fuels Extension
FIA – Forest Inventory and Analysis – USFS	FLM – Fuel Loading Models
FOFEM – First Order Fire Effects Model	FRCC – Fire Regime Condition Class (also known as LF Vegetation Condition Classes [VCC])
FRCCMT – FRCC Mapping Tool	FRG – Fire Regime Group
FVS – Forest Vegetation Simulator	GAP – Gap Analysis Program
GAP – Gap Analysis Program – USGS	GLM – General Linear Model
GR – Grass	GS – Grass-shrub
HI – Hawaii	hrs – hours
HUC – Hydrologic Unit Code	IR – Infrared
LCP – FARSITE landscape file	LF – LANDFIRE
LFRDB – LANDFIRE Reference Database	LTSS – Landsat Time Series Stacks
MFRI – Mean Fire Return Interval	MRLC – Multi-Resolution Land Characteristics Consortium
MTBS – Monitoring Trends in Burn Severity	MTBS – Monitoring Trends in Burn Severity
MTDB – Model Tracker Database	NBR – Normalized Burn Ratio
NC – North Central	NE – Northeast
NFDRS – National Fire Danger Rating System	NLCD – National Land Cover Database
PAD-US – Protected Area Database of the United States	PLS – Percent of Low-Severity fire
PM2.5 – total fine particulate matter emissions less than 2.5 micrometers in diameter	PMS – Percent of Mixed-Severity fire

Acronyms

PNW – Pacific Northwest	PRS – Percent Replacement-Severity fire
PSW – Pacific Southwest	QA/QC – Quality Assurance / Quality Control
RAVG – Rapid Assessment of Vegetation Condition after Wildfire	RAWS – Remote Automated Weather Station
RMT – Refresh Model Tracker (LF 2001/2008)	RSLC – Remote Sensing of Landscape Change
SC – South Central	SCLASS – Succession Class
SE – Southeast	SH – Shrub
SOW – Statement of Work	SSURGO – Soil Survey Geographic Database
SW – Southwest	TL – Timber litter
TU – Timber-understory	VCC – Vegetation Condition Class formerly known as LF FRCC
VCT – Vegetation Change Tracker	VDDT – Vegetation Dynamics Development Tool
VDEP – Vegetation Departure Index formerly known as LF FRCC Departure Index	VTDB – Vegetation Transition Data Base
WBS – Work Breakdown Structure	WFAT – Wildland Fire Assessment Tool

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