LANDFIRE 2001 and 2008 Refresh

Geographic Area Report

Southwest

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.

Table of Contents

Executive Summary ii

Table of Contents iii

1.0 Introduction 1

1.1 LANDFIRE Program 1

1.2 LANDFIRE Versions 1

1.2.1 LANDFIRE National (LF_1.0.0) circa 2001 2

1.2.2 LANDFIRE 2001 (LF_1.0.5) and 2008 (LF_1.1.0) Refresh 2

1.3 LANDFIRE 2001/2008 3

1.4 LANDFIRE 2001/2008 Statement of Work and Work Breakdown Structure 4

1.5 LANDFIRE 2001/2008 Spatial Products 6

2.0 LANDFIRE 2001 and 2008 Methods and Results 8

2.1 Geographic Area Description 8

2.2 LANDFIRE Reference Database 9

2.2.1 Product Description 9

2.2.2 LANDFIRE Reference Database Update Process 9

2.2.3 LANDFIRE Reference Database Update Results 10

2.3 Biophysical Settings 12

2.3.1 Product Description 12

2.3.2 Biophysical Settings Layer Enhancements 12

2.3.3 Fire Regime Products 13

2.4 Disturbance Mapping 15

2.4.1 Product Description 15

2.4.2 Disturbance Mapping Objectives 15

2.4.3 Disturbance Mapping Process 15

2.4.4 Disturbance Mapping Results 16

2.5 Existing Vegetation 20

2.5.1 Product Description 20

2.5.2 LF 2001: Enhancements to Existing Vegetation Products 20

2.5.3 LANDFIRE 2008: Updates to Existing Vegetation Products 28

2.6 Fire Behavior 35

2.6.1 Product Description 35

2.6.2 LF 2001 Enhancements to Fire Behavior Products 35

2.6.3 LF 2008 Updates to Fire Behavior Products 38

2.7 Fire Effects 40

2.7.1 Product Description 40

2.7.2 LF 2001 Enhancements to Fire Effects Products 41

2.7.3 LF 2008 Updates to Fire Effects Products 44
2.8 Fire Regime Products 46
2.8.1 Product Description 46
2.8.2 LF 2001 Enhancements to Fire Regime Products 47
2.8.3 LF 2008 Updates to Fire Regime Products 49
3.0 FARSITE Comparison of LANDFIRE Fuel Characteristics Versions 52
3.1 Wallow Fire, 2011 52
3.1.1 Inputs 53
3.1.2 Results 54
3.2 Thomas Fire, 2007 67
3.2.1 Inputs 68
3.2.2 Results 69
4.0 LF 2001/2008 Organization 73
5.0 Disclaimers 74
6.0 Additional Information 75
6.1 Landsat 75
6.2 Forest Inventory Analysis 75
6.3 National Agricultural Statistics Service 76
6.4 Multi-Resolution Land Characteristics Consortium National Land Cover Database 76
6.5 Writers, Contributors and Technical Editors 77
7.0 Glossary 78
8.0 Acronyms 79
8.1 Acronyms for Agencies and Organizations 79
8.2 Acronyms for Terms, Information, and Systems 79
9.0 References 82

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.

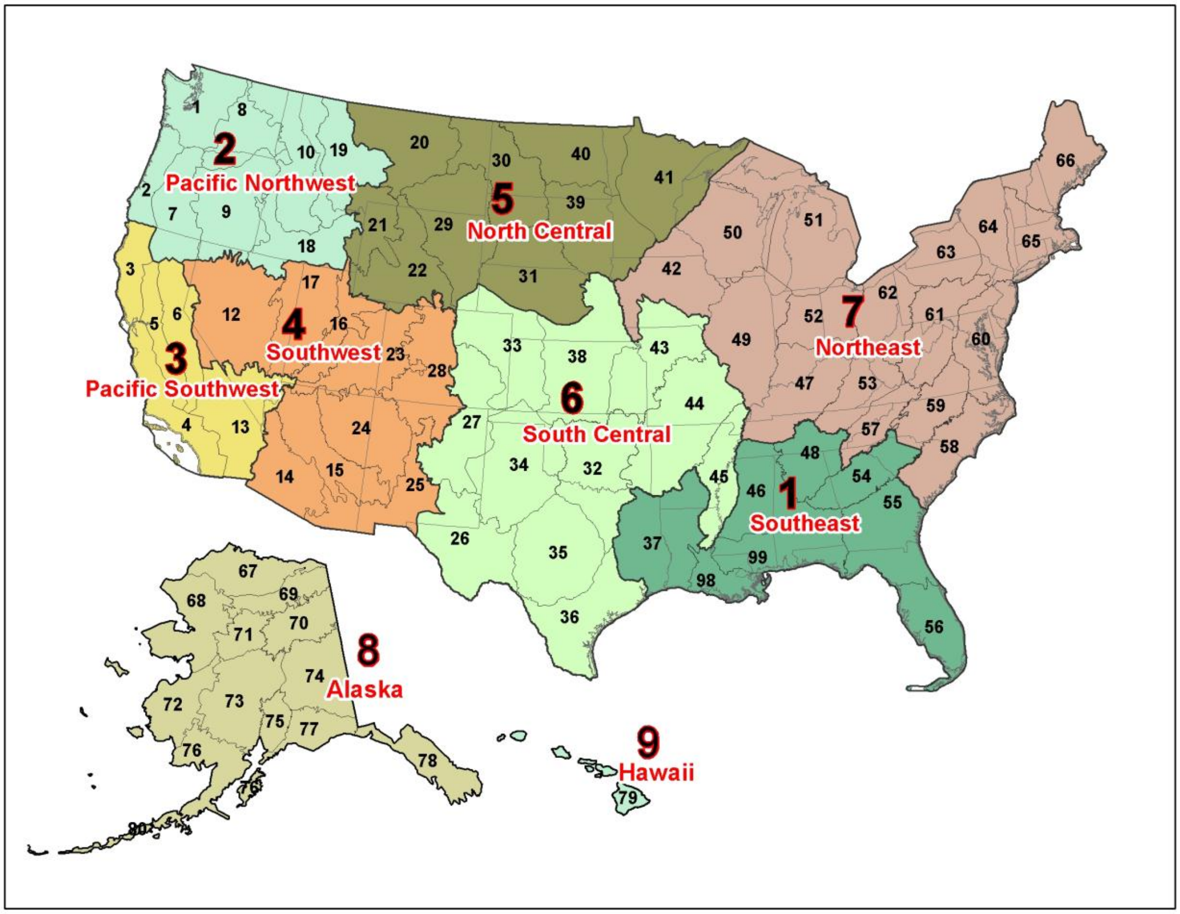


Figure 1 – Map of LF 2001/2008 GeoAreas according to the schedule. This image shows the nine GeoArea boundaries, which are comprised of National Land Cover Database 2001 mapping zones (numbered units), State boundaries are included for reference. GeoArea numbers and corresponding colors relate to the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

Introduction

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.

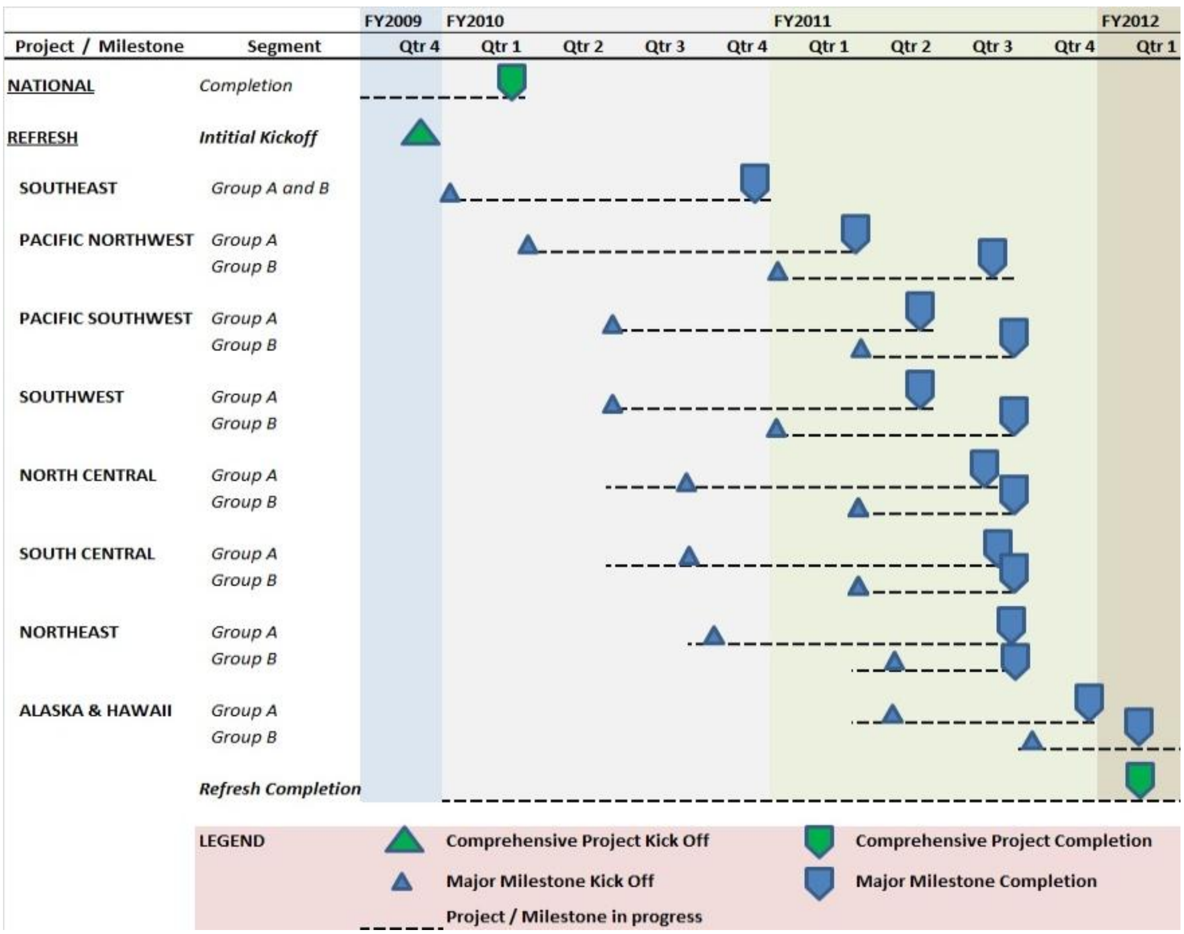


Figure 2 – LF 2001/2008 Gantt chart. This is a summary display of the actual results of the start and finish dates of the milestones and segments [such as GeoArea and Group A and Group B products]. These milestones and segments comprise the WBS discussed in Section 1.4.

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 Figure 1 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)	Biophysical Settings (BpS)
Fire Behavior Fuel Model 40 (FBFM 40)	Vegetation Condition Class (VCC)
Canadian Forest Fire Danger Rating System (CFFDRS) (Alaska Only)	Vegetation Departure Index (VDEP)
Forest Canopy Bulk Density (CBD)	Fire Regime Groups (FRG)
Forest Canopy Base Height (CBH)	Mean Fire Return Interval (MFRI)
Forest Canopy Cover (CC)	Percent Low Severity Fire (PLS)
Forest Canopy Height (CH)	Percent Mixed Severity Fire (PMS)
Fuel Characteristic Classification System Fuelbeds (FCCS)	Percent Replacement Severity Fire (PRS)
Existing Vegetation Type (EVT)	Fuel Loading Models (FLM)
Existing Vegetation Cover (EVC)	Succession Classes (SCLASS)
Existing Vegetation Height (EVH)	

2.0 LANDFIRE 2001 and 2008 Methods and Results

2.1 Geographic Area Description

The Southwest (SW) GeoArea consists of 9 mapping zones encompassing large portions of Arizona, Nevada, Utah, Colorado and New Mexico as well as small portions of California, Idaho, Texas and Wyoming, approximately 260 million acres. The mapping zones within the SW GeoArea are listed in Table 3.

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

Table 3. Southwest GeoArea Mapping Zones	
Mapping Zone	**Mapping Zone Name**
12	Western Great Basin
14	Sonoran Desert
15	Mogollon Rim
16	Utah High Plateaus
17	Eastern Great Basin
23	Colorado Plateau
24	Navajo Plateau
25	Rio Grande Basin
28	Southern Rocky Mountains

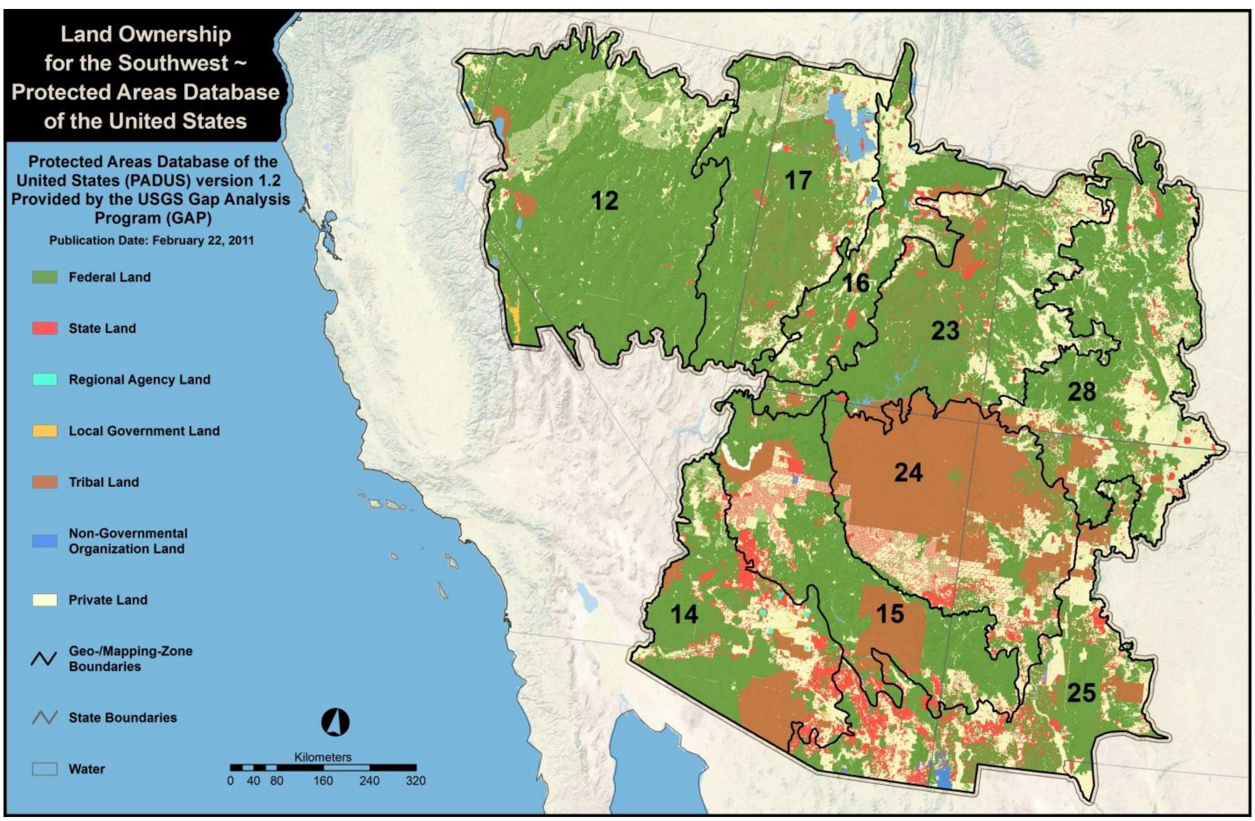


Figure 3 – Land ownership categories for the SW GeoArea.

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 SW 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 SW GeoArea.

Table 4. Acreage of Land Ownership Categories for the SW GeoArea.		
Land Ownership	**Acres**	**Percent of GeoArea**
Federal Government	155,283,086	58.4
Government and/or Private	1,187,796	0.4
Local Government	491,308	0.2
Private	56,253,045	21.1
State Government	18,895,316	7.1
Tribal	32,010,899	12.0
Water	2,099,325	0.8
Total	266,220,775	100.0

2.2 LANDFIRE Reference Database

2.2.1 Product Description

LF 2008 mapping was supported by a large database of field-referenced 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 has 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 SW GeoArea consisted of a catalog (spreadsheet) and archive (file system) of all acquired data, an AutoKey Database (Microsoft Access© database) was developed to quickly and accurately assign EVT to plots that has species composition (species and cover) attributes for the SW GeoArea, a LFRDB (Microsoft Access© database) for the SW GeoArea, and documentation of data conversion processes and QC measures taken during the data-loading stages.

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

- 138,281 geo-referenced sampling events were contained within the SW LFRDB.
- 90 different sources of data were contributed by Federal, State, and private entities.
- 44% of data were submitted in response to the LF data call (http://www.landfire.gov/participate_refdata.php) 56% 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)

- 7,333 FIA sampling events were added to the LFRDB for LF 2001/2008.

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 over half the data archived in the SW LFRDB from data sharing agreements, websites, and/or agency databases. Data contributions submitted in response to the data call were also important, accounting for 44% of the sampling events. Major data contributions can be accredited to the USFS, BLM and the USGS and the rest of the data came from multiple of sources. Table 5 shows a breakdown of the data contribution profile for the SW LFRDB.

Table 5 – Data contribution profile for the SW LFRDB.

Table 5 SW LANDFIRE Reference Database Data Contributions	
Data Contribution Profile	**Percent**
Multi Agency	38.1
USFS	24.3
BLM	22.5
State	6.5
USGS	5.4
NPS	1.7
Municipal	0.6
Department of Defense	0.4
FWS	0.3
Non-Governmental Organization /Private	0.2
BIA	0.0
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 1,820 new FIA sampling events added to the SW LFRDB for LF 2001/2008. The SW 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 SW 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 SW LFRDB.

Table 6. SW LANDFIRE Reference Database Plot Summary	
Data Type	**Percent***
Community Occurrence Records	3
Species Composition	56
Structure	33
Exotics	40
Fuels	11

**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 4,714 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		
Group	**Frequency (years)**	**Severity**
I	0-35	PRS < 75
II	0-35	PRS >= 75
III	35-200	PRS < 75
IV	35-200	PRS >= 75
V	200+	all

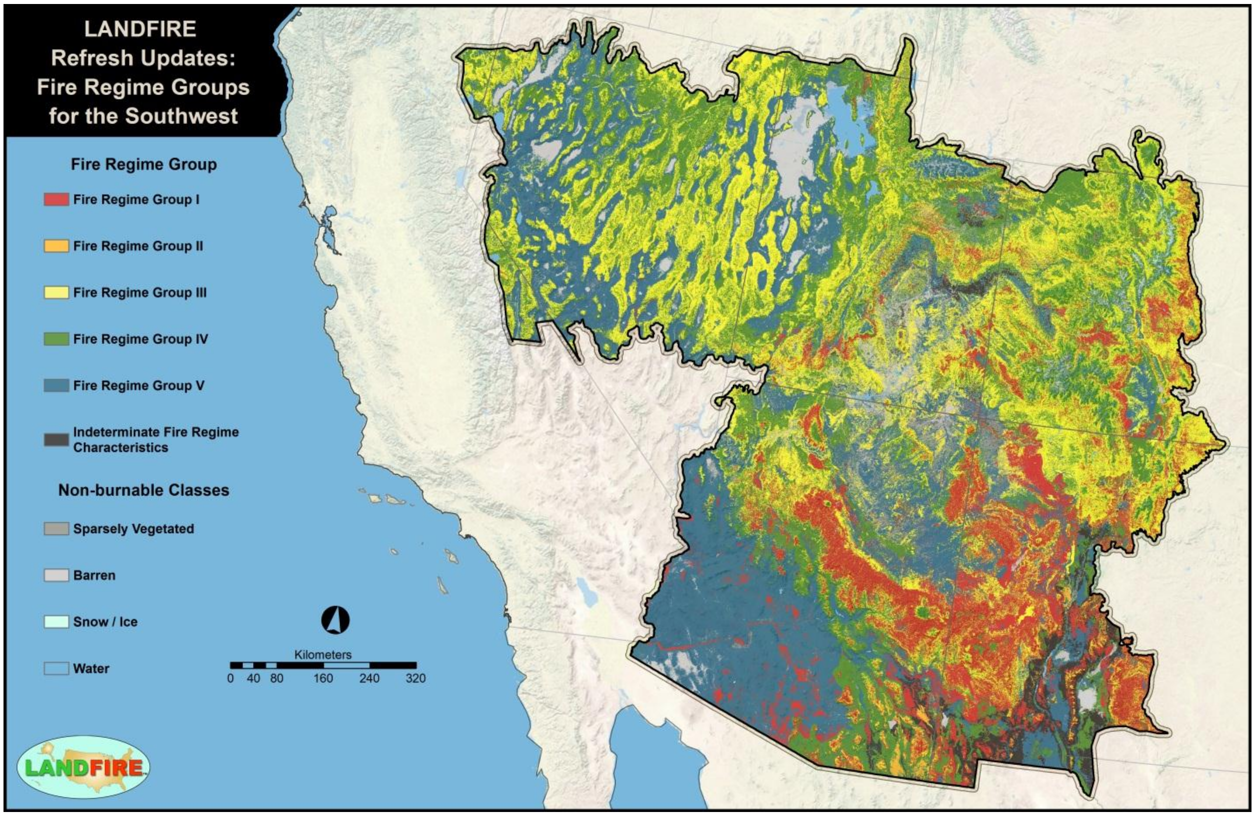


Figure 4 – Map of the SW GeoArea depicting LF Fire Regime Groups in the absence of modern human intervention with possible aboriginal fire use.

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 Groups Comparison

Fire Regime Groups Name	LF National (acres)	LF 2001 (acres)	Percent Change
FRG I	20,403,088	35,003,925	71.6
FRG II	5,885,306	856,564	-85.5
FRG III	88,146,193	73,328,243	-16.8
FRG IV	57,707,745	59,273,141	2.7
FRG V	70,839,466	73,199,271	3.3
Water	2,344,478	2,269,482	-3.2
Snow / Ice	173,574	162,486	-6.4
Barren	10,911,261	10,929,764	0.2
Sparsely Vegetated	4,466,020	4,150,694	-7.1
Indeterminate Fire Regime	5,649,070	7,352,748	30.2

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.

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 SW GeoArea (Table 9). Across all lands, 5 percent of the GeoArea was mapped as disturbed from 1999 to 2008, leaving 95 percent undisturbed. On Federal lands, 6 percent of the GeoArea was mapped as disturbed, leaving 94 percent undisturbed. We recognize that certain types are disturbances that 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 – Categories of land ownership divided between areas with and without disturbance with associated percentages of ownership for the PSW GeoArea and acres.

Table 9. Disturbance Acreage by Land Ownership			
Land Ownership	**Category**	**Acres**	**Percent of Ownership**
All Lands	No Disturbance	253,527,750	95
All Lands	All Disturbances	12,998,572	5
Federal Lands	No Disturbance	145,386,360	94
Federal Lands	All Disturbances	9,896,726	6

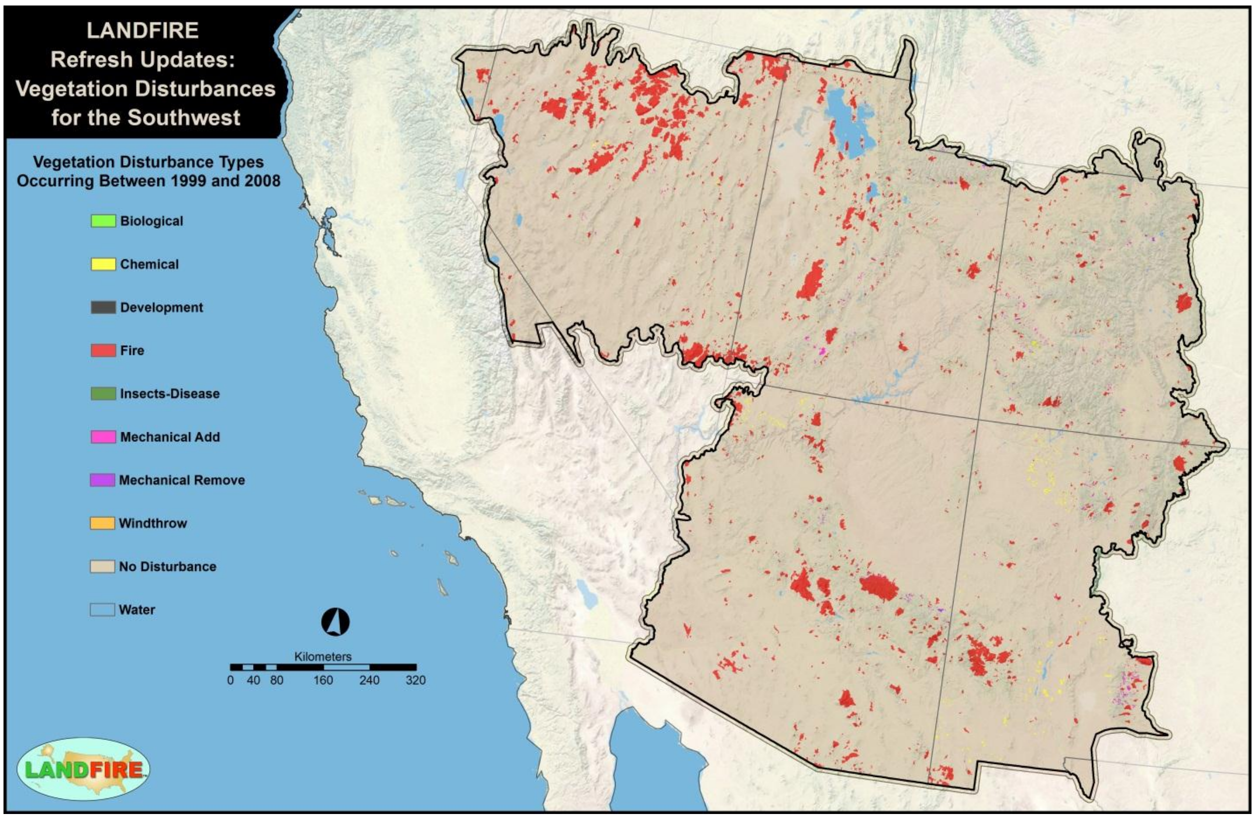


Figure 5 – Map of vegetation disturbance types (fire, mechanical, etc.) for the SW GeoArea from 1999 to 2008.

Table 10 – Number of acres 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 SW GeoArea.

Table 10. Area Affected by Fire Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Fire	Low	One Year	256,450
All Lands	Fire	Low	Two to Five Years	3,859,089
All Lands	Fire	Low	Six to Ten Years	3,726,022
All Lands	Fire	Moderate	One Year	78,032
All Lands	Fire	Moderate	Two to Five Years	1,401,015
All Lands	Fire	Moderate	Six to Ten Years	1,449,054
All Lands	Fire	High	One Year	19,455
All Lands	Fire	High	Two to Five Years	408,822
All Lands	Fire	High	Six to Ten Years	731,086
Federal Lands	Fire	Low	One Year	193,021
Federal Lands	Fire	Low	Two to Five Years	3,103,749
Federal Lands	Fire	Low	Six to Ten Years	2,720,061
Federal Lands	Fire	Moderate	One Year	53,054
Federal Lands	Fire	Moderate	Two to Five Years	1,097,944
Federal Lands	Fire	Moderate	Six to Ten Years	1,010,586
Federal Lands	Fire	High	One Year	15,411
Federal Lands	Fire	High	Two to Five Years	333,924
Federal Lands	Fire	High	Six to Ten Years	477,145

Table 11 – Number of acres 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 SW GeoArea.

Table 11. Area Affected by Mechanical Add Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Mechanical Add	Low	One Year	29,050
All Lands	Mechanical Add	Low	Two to Five Years	136,203
All Lands	Mechanical Add	Low	Six to Ten Years	116,326
All Lands	Mechanical Add	Moderate	One Year	11,567
All Lands	Mechanical Add	Moderate	Two to Five Years	28,456
All Lands	Mechanical Add	Moderate	Six to Ten Years	17,414
All Lands	Mechanical Add	High	One Year	3,652
All Lands	Mechanical Add	High	Two to Five Years	12,418
All Lands	Mechanical Add	High	Six to Ten Years	9,520
Federal Lands	Mechanical Add	Low	One Year	20,351
Federal Lands	Mechanical Add	Low	Two to Five Years	118,709
Federal Lands	Mechanical Add	Low	Six to Ten Years	108,751
Federal Lands	Mechanical Add	Moderate	One Year	5,311
Federal Lands	Mechanical Add	Moderate	Two to Five Years	22,324
Federal Lands	Mechanical Add	Moderate	Six to Ten Years	14,579
Federal Lands	Mechanical Add	High	One Year	888
Federal Lands	Mechanical Add	High	Two to Five Years	10,807
Federal Lands	Mechanical Add	High	Six to Ten Years	8,347

Table 12 – Number of acres affected by the Mechanical Remove 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 SW GeoArea.

Table 12. Area Affected by Mechanical Remove Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Mechanical Remove	Low	One Year	23,167
All Lands	Mechanical Remove	Low	Two to Five Years	81,082
All Lands	Mechanical Remove	Low	Six to Ten Years	85,392
All Lands	Mechanical Remove	Moderate	One Year	5,656
All Lands	Mechanical Remove	Moderate	Two to Five Years	30,043
All Lands	Mechanical Remove	Moderate	Six to Ten Years	32,212
All Lands	Mechanical Remove	High	One Year	1,277
All Lands	Mechanical Remove	High	Two to Five Years	11,392
All Lands	Mechanical Remove	High	Six to Ten Years	14,678
Federal Lands	Mechanical Remove	Low	One Year	18,726
Federal Lands	Mechanical Remove	Low	Two to Five Years	63,479
Federal Lands	Mechanical Remove	Low	Six to Ten Years	56,914
Federal Lands	Mechanical Remove	Moderate	One Year	3,755
Federal Lands	Mechanical Remove	Moderate	Two to Five Years	21,067
Federal Lands	Mechanical Remove	Moderate	Six to Ten Years	18,553
Federal Lands	Mechanical Remove	High	One Year	945
Federal Lands	Mechanical Remove	High	Two to Five Years	8,955
Federal Lands	Mechanical Remove	High	Six to Ten Years	10,509

Table 13 – Number of acres mapped as affected by Windthrow and Insects and Disease 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 SW 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	350
All Lands	Insects-Disease	Low	Two to Five Years	409
All Lands	Windthrow	Low	Two to Five Years	1,433
All Lands	Insects-Disease	Low	Six to Ten Years	217
All Lands	Windthrow	Low	Six to Ten Years	2,453
Federal Lands	Insects-Disease	Low	One Year	350
Federal Lands	Insects-Disease	Low	Two to Five Years	409
Federal Lands	Windthrow	Low	Two to Five Years	1,432
Federal Lands	Insects-Disease	Low	Six to Ten Years	217
Federal Lands	Windthrow	Low	Six to Ten Years	2,453

Table 14 – Number of acres 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 SW 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	63,751
All Lands	Chemical	Low	Two to Five Years	110,775
All Lands	Chemical	Low	Six to Ten Years	239,903
All Lands	Development	Low	Six to Ten Years	651
All Lands	Development	Moderate	Six to Ten Years	72
All Lands	Development	High	Six to Ten Years	1
Federal Lands	Chemical	Low	One Year	53,137
Federal Lands	Chemical	Low	Two to Five Years	103,080
Federal Lands	Chemical	Low	Six to Ten Years	217,040
Federal Lands	Development	Low	Six to Ten Years	648
Federal Lands	Development	Moderate	Six to Ten Years	67
Federal Lands	Development	High	Six to Ten Years	1

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-referenced 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 30 and Table 33 and Table 34 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.

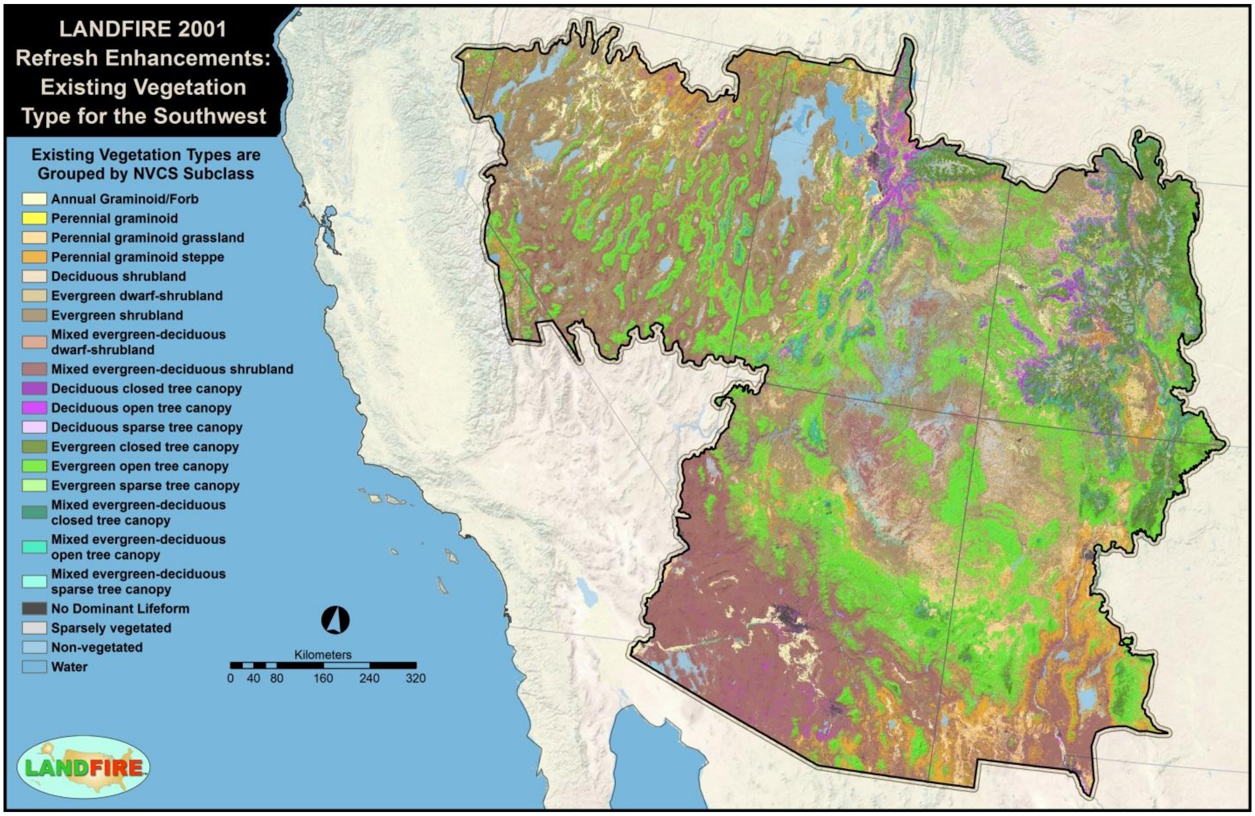


Figure 6 – Map of Existing Vegetation Type layer that was enhanced as part of the LF 2001 updates by incorporating user feedback and additional data.

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

Table 15. Agricultural Type Comparisons across All Lands			
Existing Vegetation Type Groups	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Agriculture-Cultivated Crops and Irrigated Agriculture	2,049,405	621,754	-69.7
Agriculture-General	40,639	0	-100.0
Agriculture-Pasture and Hay*	4,327,362	3,603,658	-16.7
NASS-Close Grown Crop	0	884,069	100.0
NASS-Fallow/Idle Cropland*	0	308,853	100.0
NASS-Orchard*	0	50,508	100.0
NASS-Pasture and Hayland*	0	6,064	100.0
NASS-Row Crop	0	380,856	100.0
NASS-Row Crop-Close Grown Crop	0	135,246	100.0
NLCD-Herbaceous Semi-dry*	0	163,573	100.0
NLCD-Herbaceous Semi-wet*	0	54,239	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 SW GeoArea between LF National and LF 2001

Table 16. Agricultural Type Comparisons across Federal Lands			
Existing Vegetation Type Groups	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Agriculture-Cultivated Crops and Irrigated Agriculture	128,567	9,465	-92.6
Agriculture-General	1,558	0	-100.0
Agriculture-Pasture and Hay*	146,352	31,943	-78.2
NASS-Close Grown Crop	0	1,929	100.0
NASS-Fallow/Idle Cropland*	0	216	100.0
NASS-Orchard*	0	26	100.0
NASS-Pasture and Hayland*	0	31	100.0
NASS-Row Crop	0	448	100.0
NASS-Row Crop-Close Grown Crop	0	84	100.0
NLCD-Herbaceous Semi-dry*	0	162,390	100.0
NLCD-Herbaceous Semi-wet*	0	53,675	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 SW GeoArea between LF National and LF 2001.

Table 17. Developed Lands Comparisons across All Lands			
Existing Vegetation Type Groups	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Developed-General	104,765	0	-100.0
Developed-High Intensity	54,207	73,474	35.5
Developed-Low Intensity	734,796	0	-100.0
Developed-Medium Intensity	269,996	289,289	7.2
Developed-Open Space	1,809,749	0	-100.0
Developed-Roads	0	1,674,142	100.0
Developed-Upland Deciduous Forest	0	150,162	100.0
Developed-Upland Evergreen Forest	0	139,255	100.0
Developed-Upland Herbaceous	0	533,748	100.0
Developed-Upland Mixed Forest	0	80,461	100.0
Developed-Upland Shrubland	0	615,727	100.0

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

Table 18. Developed Lands Comparisons across Federal Lands			
Existing Vegetation Type Groups	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Developed-General	11,095	0	-100.0
Developed-High Intensity	2,953	3,365	14.0
Developed-Low Intensity	142,927	0	-100.0
Developed-Medium Intensity	38,813	9,951	-74.4
Developed-Open Space	342,082	0	-100.0
Developed-Roads	0	318,490	100.0
Developed-Upland Deciduous Forest	0	10,947	100.0
Developed-Upland Evergreen Forest	0	43,653	100.0
Developed-Upland Herbaceous	0	70,289	100.0
Developed-Upland Mixed Forest	0	15,537	100.0
Developed-Upland Shrubland	0	130,145	100.0

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

Table 19. Riparian/Wetland Comparisons				
Land Ownership	**Existing Vegetation Type Groups**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Depressional Wetland	93,642	93,312	-0.4
All Lands	NLCD-Herbaceous Wetlands	0	505,995	100.0
All Lands	Western Riparian Woodland and Shrubland	5,020,087	3,241,279	-35.4
Federal Lands	Depressional Wetland	52,171	52,148	0.0
Federal Lands	NLCD-Herbaceous Wetlands	0	118,112	100.0
Federal Lands	Western Riparian Woodland and Shrubland	2,806,664	1,725,500	-38.5

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

Table 20. Barren Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Barren	10,902,028	10,929,764	0.3
Federal Lands	Barren	8,263,636	8,400,093	1.7

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

Table 21. Water Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Open Water	2,344,396	2,269,482	-3.2
Federal Lands	Open Water	214,464	185,613	-13.5

2.5.2b Enhancements to Existing Vegetation Cover

LANDFIRE 2001 and 2008 Methods and Results

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.

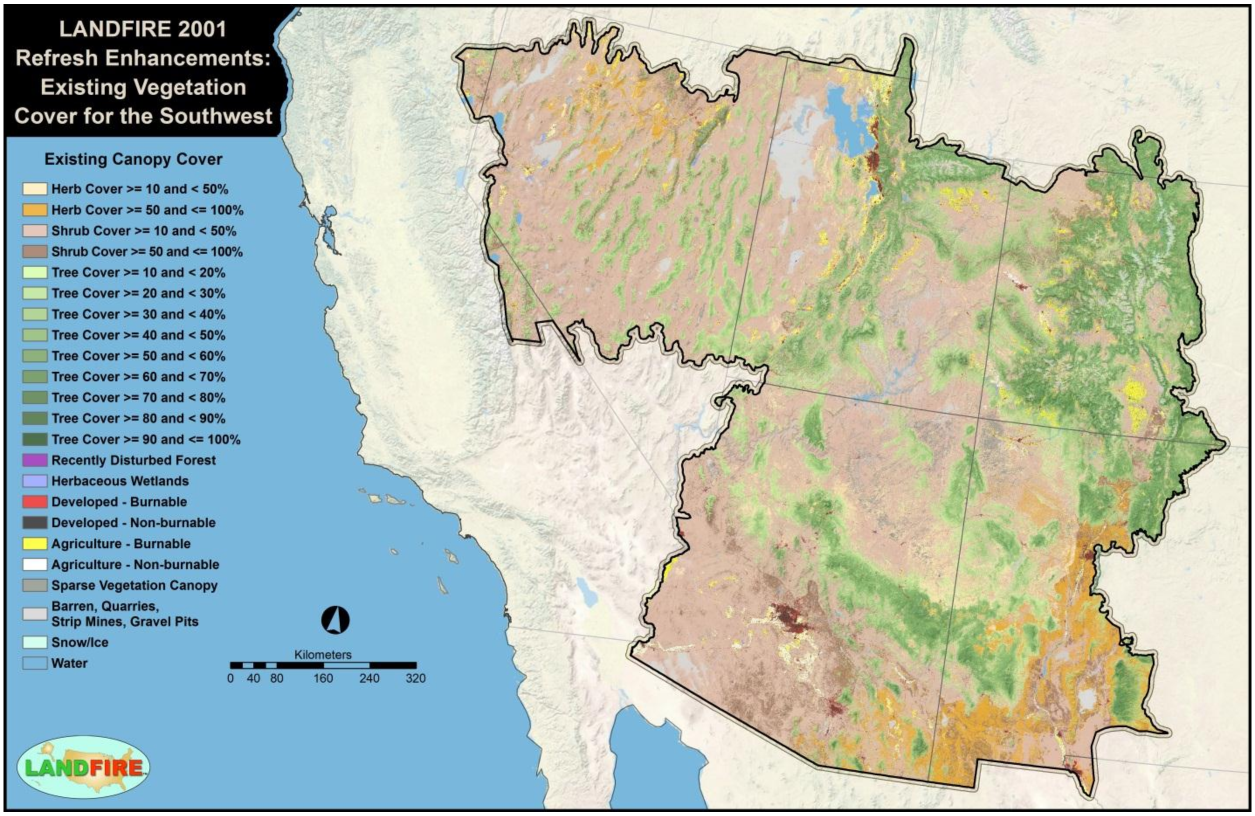


Figure 7 – Map of Existing Vegetation Cover layer that was enhanced as part of the LF 2001 update by incorporating user feedback and additional data.

Table 22 – Existing Vegetation Cover: Forest Canopy Cover – Comparison between LF National and Refresh 2001.

Table 22. Tree Cover Comparison

Land Ownership	Percent Tree Cover	National (acres)	LF 2001 (acres)	Percent Change
All Lands	>= 10 and < 20	13,539,686	10,560,006	-22.0
All Lands	>= 20 and < 30	10,210,290	21,526,858	110.8
All Lands	>= 30 and < 40	9,157,763	16,841,663	83.9
All Lands	>= 40 and < 50	8,733,206	13,875,912	58.9
All Lands	>= 50 and < 60	8,759,435	11,613,394	32.6
All Lands	>= 60 and < 70	9,535,325	3,299,059	-65.4
All Lands	>= 70 and < 80	10,039,190	722,093	-92.8
All Lands	>= 80 and < 90	6,601,982	84,974	-98.7
All Lands	>= 90 and <= 100	1,699,308	17,680	-99.0
Federal Lands	>= 10 and < 20	8,801,665	6,766,460	-23.1
Federal Lands	>= 20 and < 30	6,609,557	14,001,727	111.8
Federal Lands	>= 30 and < 40	5,995,080	11,864,704	97.9
Federal Lands	>= 40 and < 50	5,841,718	9,760,325	67.1
Federal Lands	>= 50 and < 60	6,024,533	8,353,816	38.7
Federal Lands	>= 60 and < 70	6,748,467	2,382,368	-64.7
Federal Lands	>= 70 and < 80	7,322,956	553,951	-92.4
Federal Lands	>= 80 and < 90	4,956,840	65,067	-98.7
Federal Lands	>= 90 and <= 100	1,326,254	14,084	-98.9

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.

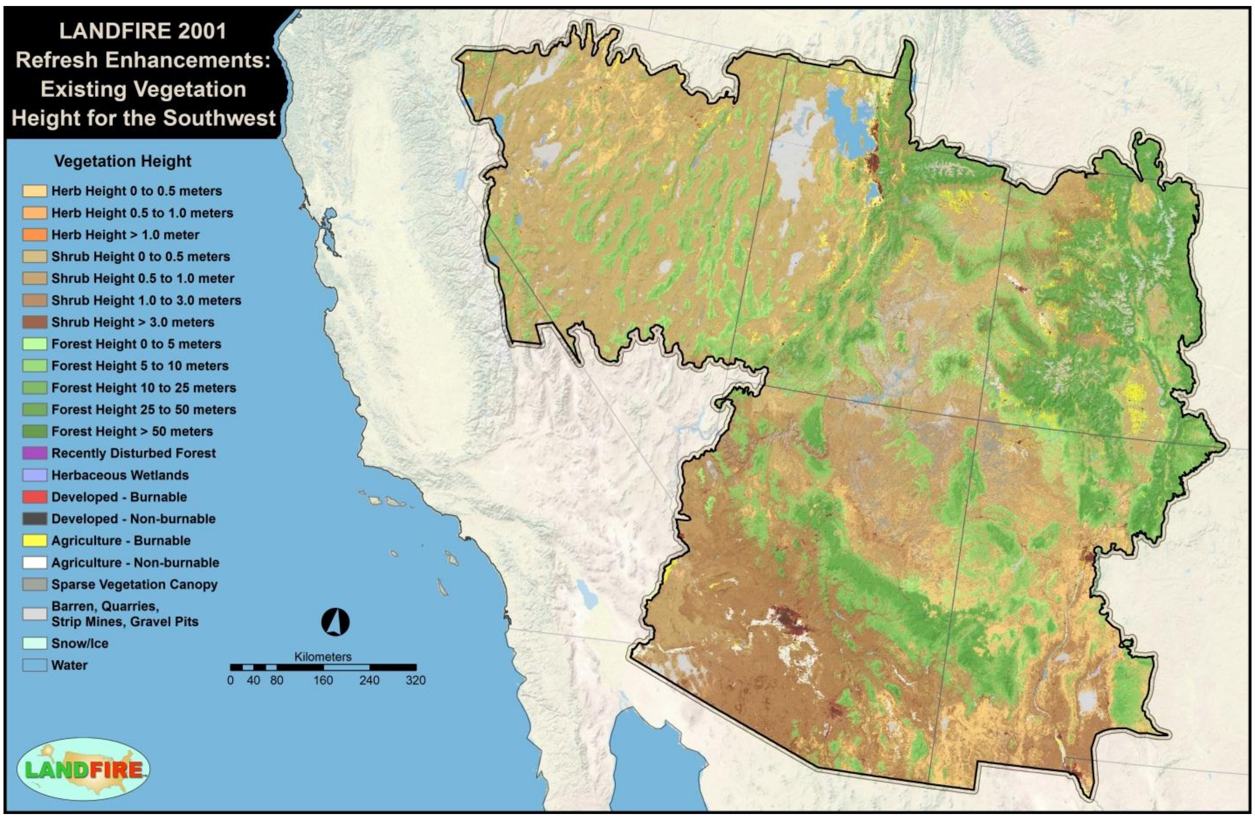


Figure 8 – Map of Existing Vegetation Height layer that was enhanced as part of the LF 2001 update by incorporating user feedback and additional data.

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

Table 23. Tree Height Comparison				
Land Ownership	**Height (m)**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	0 to 5	39,205,742	11,870,888	-69.7
All Lands	5 to 10	14,645,562	36,426,948	148.7
All Lands	10 to 25	24,379,069	30,114,059	23.5
All Lands	25 to 50	45,812	129,744	183.2
Federal Lands	0 to 5	26,755,128	7,603,955	-71.6
Federal Lands	5 to 10	8,728,858	23,593,304	170.3
Federal Lands	10 to 25	18,108,699	22,453,739	24.0
Federal Lands	25 to 50	34,383	111,504	224.3

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 the FVS and FFE. 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.

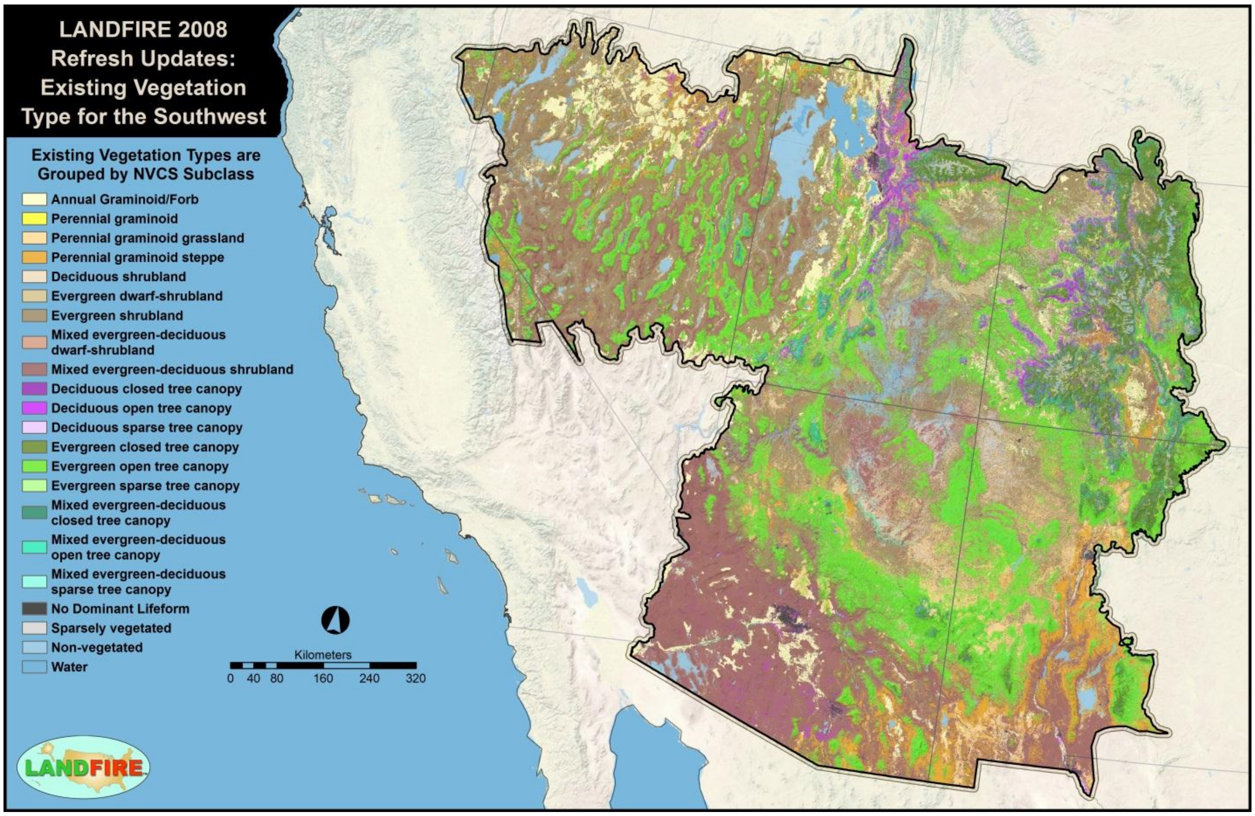


Figure 9 – Map of Existing Vegetation Type layer for the SW GeoArea depicting vegetation changes with disturbances for 1999 - 2008.

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

Table 24. Forested Existing Vegetation Type Groups Comparison: All Lands				
Ownership	Existing Vegetation Type Groups	LF 2001 (acres)	LF 2008 (acres)	Percent Change
All Lands	Aspen Forest, Woodland, and Parkland	5,308,166	5,348,532	0.8
All Lands	Aspen-Mixed Conifer Forest and Woodland	4,255,410	4,244,821	-0.3
All Lands	Bigtooth Maple Woodland	536,804	527,178	-1.8
All Lands	Conifer-Oak Forest and Woodland	915,915	910,172	-0.6
All Lands	Douglas-fir-Grand Fir-White Fir Forest and Woodland	2,597,785	2,589,761	-0.3
All Lands	Douglas-fir-Ponderosa Pine-Lodgepole Pine Forest and Woodland	3,318,368	3,307,649	-0.3
All Lands	Juniper Woodland and Savanna	574,542	572,009	-0.4
All Lands	Juniper-Oak	956,368	957,303	0.1
All Lands	Limber Pine Woodland	226,257	226,135	-0.1
All Lands	Lodgepole Pine Forest and Woodland	2,517,309	2,514,047	-0.1
All Lands	Mountain Mahogany Woodland and Shrubland	1,191,569	1,185,073	-0.6
All Lands	Pinyon-Juniper Woodland	38,719,318	38,942,449	0.6
All Lands	Ponderosa Pine Forest, Woodland and Savanna	8,914,461	8,953,042	0.4
All Lands	Spruce-Fir Forest and Woodland	6,360,548	6,378,941	0.3
All Lands	Subalpine Woodland and Parkland	14,858	14,858	0.0
All Lands	Western Riparian Woodland and Shrubland	2,899,124	2,876,594	-0.8
Federal Lands	Aspen Forest, Woodland, and Parkland	3,479,712	3,501,574	0.6
Federal Lands	Aspen-Mixed Conifer Forest and Woodland	3,195,599	3,187,336	-0.3
Federal Lands	Bigtooth Maple Woodland	224,080	222,819	-0.6
Federal Lands	Conifer-Oak Forest and Woodland	675,469	670,275	-0.8
Federal Lands	Douglas-fir-Grand Fir-White Fir Forest and Woodland	1,823,761	1,814,954	-0.5
Federal Lands	Douglas-fir-Ponderosa Pine-Lodgepole Pine Forest and Woodland	1,988,423	1,980,785	-0.4
Federal Lands	Juniper Woodland and Savanna	257,183	256,402	-0.3
Federal Lands	Juniper-Oak	644,836	642,813	-0.3
Federal Lands	Limber Pine Woodland	195,695	195,604	-0.1
Federal Lands	Lodgepole Pine Forest and Woodland	2,178,193	2,175,004	-0.2
Federal Lands	Mountain Mahogany Woodland and Shrubland	1,027,057	1,022,503	-0.4
Federal Lands	Pinyon-Juniper Woodland	25,570,324	25,692,015	0.5
Federal Lands	Ponderosa Pine Forest, Woodland and Savanna	5,507,461	5,539,385	0.6
Federal Lands	Spruce-Fir Forest and Woodland	5,793,724	5,808,750	0.3
Federal Lands	Subalpine Woodland and Parkland	14,297	14,297	0.0
Federal Lands	Western Riparian Woodland and Shrubland	1,535,338	1,539,870	0.3

Table 25 – Comparison of acreage of shrubland Existing Vegetation Type Groups between LF 2001 and LF 2008 across land ownerships in the SW GeoArea.

Table 25. 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	23,904	23,414	-2.1
All Lands	Big Sagebrush Shrubland and Steppe	36,124,157	33,204,636	-8.1
All Lands	Blackbrush Shrubland	5,272,506	5,060,924	-4.0
All Lands	Chaparral	5,350,459	4,741,785	-11.4
All Lands	Creosotebush Desert Scrub	8,571,504	8,340,776	-2.7
All Lands	Deciduous Shrubland	5,274,952	4,735,086	-10.2
All Lands	Desert Scrub	22,715,984	21,886,418	-3.7
All Lands	Grassland and Steppe	7,693,179	7,850,229	2.0
All Lands	Greasewood Shrubland	11,104,526	10,935,951	-1.5
All Lands	Introduced Riparian Vegetation	574,916	564,126	-1.9
All Lands	Low Sagebrush Shrubland and Steppe	10,526,077	9,750,370	-7.4
All Lands	Mesquite Woodland and Scrub	5,212,143	5,009,218	-3.9
All Lands	Salt Desert Scrub	20,333,940	19,817,225	-2.5
All Lands	Sand Shrubland	3,791,014	3,783,643	-0.2
All Lands	Succulent Desert Scrub	86,128	84,508	-1.9
All Lands	Western Riparian Woodland and Shrubland	342,155	318,583	-6.9
Federal Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	21,718	21,257	-2.1
Federal Lands	Big Sagebrush Shrubland and Steppe	21,856,711	19,969,054	-8.6
Federal Lands	Blackbrush Shrubland	3,745,980	3,552,402	-5.2
Federal Lands	Chaparral	3,175,598	2,663,254	-16.1
Federal Lands	Creosotebush Desert Scrub	5,434,390	5,352,305	-1.5
Federal Lands	Deciduous Shrubland	2,417,141	2,095,192	-13.3
Federal Lands	Desert Scrub	12,614,035	12,075,243	-4.3
Federal Lands	Grassland and Steppe	2,877,449	3,029,345	5.3
Federal Lands	Greasewood Shrubland	6,378,471	6,300,009	-1.2
Federal Lands	Introduced Riparian Vegetation	191,493	190,438	-0.6
Federal Lands	Low Sagebrush Shrubland and Steppe	8,928,908	8,382,083	-6.1
Federal Lands	Mesquite Woodland and Scrub	2,243,507	2,181,044	-2.8
Federal Lands	Salt Desert Scrub	12,705,088	12,385,298	-2.5
Federal Lands	Sand Shrubland	728,192	726,545	-0.2
Federal Lands	Succulent Desert Scrub	54,342	53,484	-1.6
Federal Lands	Western Riparian Woodland and Shrubland	190,162	176,193	-7.4

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

Table 26. 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	427,178	781,767	83.0
All Lands	Depressional Wetland	93,312	92,754	-0.6
All Lands	Dry Tundra	603,082	603,251	0.0
All Lands	Grassland	10,601,155	11,385,727	7.4
All Lands	Introduced Annual and Biennial Forbland	1,780,404	1,735,662	-2.5
All Lands	Introduced Annual Grassland	2,225,248	6,508,118	192.5
All Lands	Introduced Perennial Grassland and Forbland	506,671	483,096	-4.7
All Lands	NLCD-Herbaceous Semi-dry	163,573	157,118	-4.0
All Lands	NLCD-Herbaceous Semi-wet	54,239	52,717	-2.8
All Lands	NLCD-Herbaceous Wetlands	505,995	428,277	-15.4
All Lands	NLCD-Recently Disturbed Forest	30,603	86	-99.7
All Lands	Shortgrass Prairie	33,304	33,266	-0.1
All Lands	Transitional Herbaceous Vegetation	0	7,977	100.0
Federal Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	314,703	579,740	84.2
Federal Lands	Depressional Wetland	52,148	52,119	-0.1
Federal Lands	Dry Tundra	565,283	565,438	0.0
Federal Lands	Grassland	2,958,697	3,731,435	26.1
Federal Lands	Introduced Annual and Biennial Forbland	1,091,935	1,088,705	-0.3
Federal Lands	Introduced Annual Grassland	1,390,525	4,633,829	233.2
Federal Lands	Introduced Perennial Grassland and Forbland	161,155	156,715	-2.8
Federal Lands	NLCD-Herbaceous Semi-dry	162,390	155,944	-4.0
Federal Lands	NLCD-Herbaceous Semi-wet	53,675	52,154	-2.8
Federal Lands	NLCD-Herbaceous Wetlands	118,112	111,498	-5.6
Federal Lands	NLCD-Recently Disturbed Forest	26,391	11	-100.0
Federal Lands	Shortgrass Prairie	11,831	11,831	0.0
Federal Lands	Transitional Herbaceous Vegetation	0	7,967	100.0

2.5.3b Updates to Existing Vegetation Cover

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

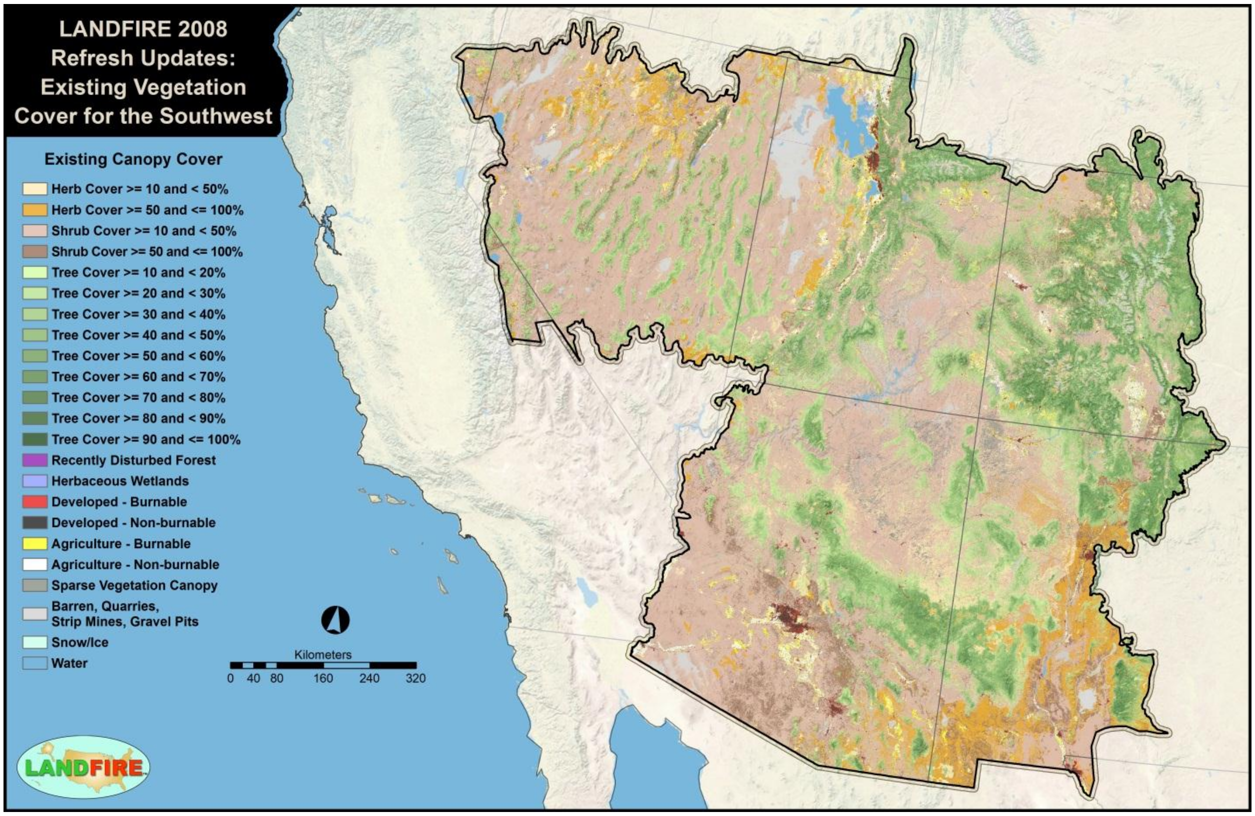


Figure 10 – Map of Existing Vegetation Cover for the SW accounting for vegetation changes with disturbances for 1999 - 2008.

Table 27 – Existing Vegetation Cover: Tree Cover – Comparison between LF 2001 and 2008 Refresh.

Table 27. Tree Cover Comparison				
Land Ownership	**Percent Tree Cover**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	>= 10 and < 20	10,560,006	11,185,287	5.9
All Lands	>= 20 and < 30	21,526,858	21,827,341	1.4
All Lands	>= 30 and < 40	16,841,663	17,110,512	1.6
All Lands	>= 40 and < 50	13,875,912	13,768,098	-0.8
All Lands	>= 50 and < 60	11,613,394	11,005,671	-5.2
All Lands	>= 60 and < 70	3,299,059	3,068,382	-7.0
All Lands	>= 70 and < 80	722,093	702,160	-2.8
All Lands	>= 80 and < 90	84,974	86,777	2.1
All Lands	>= 90 and <= 100	17,680	17,084	-3.4
Federal Lands	>= 10 and < 20	6,766,460	7,164,201	5.9
Federal Lands	>= 20 and < 30	14,001,727	14,239,498	1.7
Federal Lands	>= 30 and < 40	11,864,704	12,029,836	1.4
Federal Lands	>= 40 and < 50	9,760,325	9,749,392	-0.1
Federal Lands	>= 50 and < 60	8,353,816	7,893,187	-5.5
Federal Lands	>= 60 and < 70	2,382,368	2,201,404	-7.6
Federal Lands	>= 70 and < 80	553,951	537,102	-3.0
Federal Lands	>= 80 and < 90	65,067	65,280	0.3
Federal Lands	>= 90 and <= 100	14,084	13,832	-1.8

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.

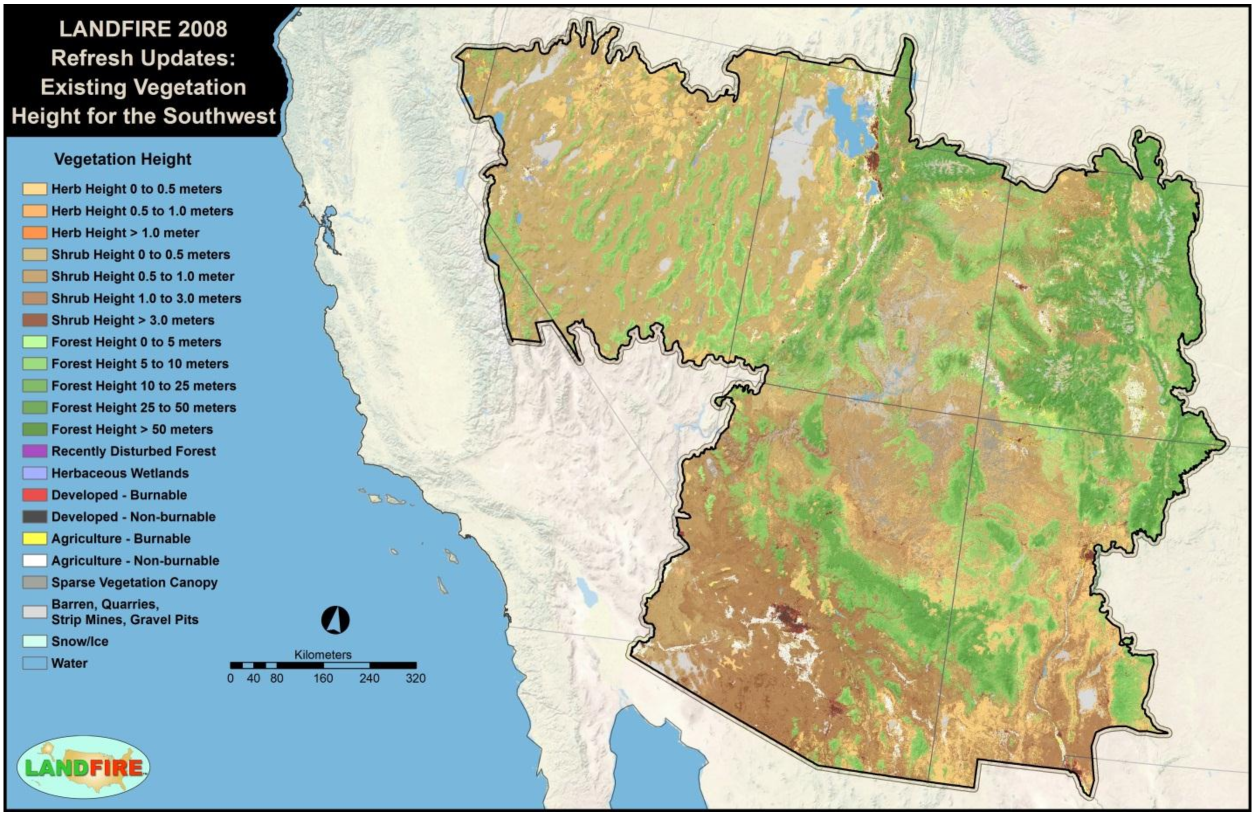


Figure 11 – Map of Existing Vegetation Height for the SW GeoArea accounting for vegetation changes from disturbances for 1999 - 2008.

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

Table 28. Tree Height Comparison				
Land Ownership	**Height (m)**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	0 to 5	11,870,888	12,474,719	5.1
All Lands	5 to 10	36,426,948	36,153,027	-0.8
All Lands	10 to 25	30,114,059	30,014,778	-0.3
All Lands	25 to 50	129,744	128,789	-0.7
Federal Lands	0 to 5	7,603,955	7,962,320	4.7
Federal Lands	5 to 10	23,593,304	23,443,421	-0.6
Federal Lands	10 to 25	22,453,739	22,377,472	-0.3
Federal Lands	25 to 50	111,504	110,518	-0.9

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.

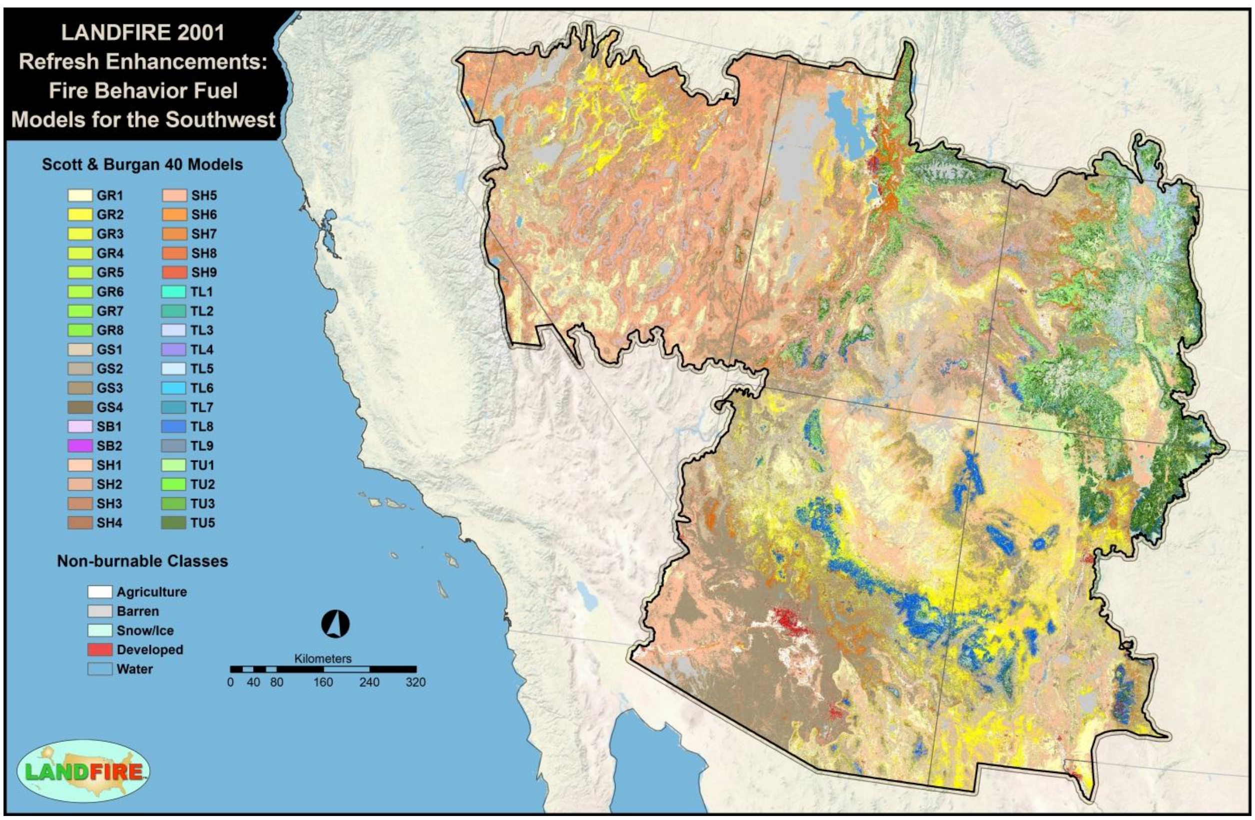


Figure 12 – LF 2001 Fire Behavior Fuel Model 40 for the SW GeoArea.

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 29). 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 29 – Comparison of fire behavior characteristics derived from LF National and LF 2001 for Federal Lands in the SW GeoArea.

Table 29. Fire Behavior Comparison – LF National and LF 2001			
Fire Behavior Characteristic	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Flame Length (feet)			
No Fire	11,869,482	9,617,124	-19.0
Low(>0 and <=4)	49,244,789	45,730,702	-7.1
Moderate (>4 and <=11)	54,436,899	51,833,855	-4.8
High (> 11)	40,037,340	48,406,829	20.9
Spread Rate (chains/hour)			
No Fire	11,869,482	9,617,124	-19.0
Low (>0 and <=5)	27,240,239	25,366,437	-6.9
Moderate (>5 and <=50)	47,174,535	44,207,753	-6.3
High (>50)	69,304,254	76,397,196	10.2
Crown Fire			
No Fire	11,869,482	9,617,124	-19.0
Surface Fire	115,496,069	109,692,240	-5.0
Passive Crown Fire	10,626,958	12,033,731	13.2
Active Crown Fire	17,596,000	24,245,414	37.8

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 was 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.

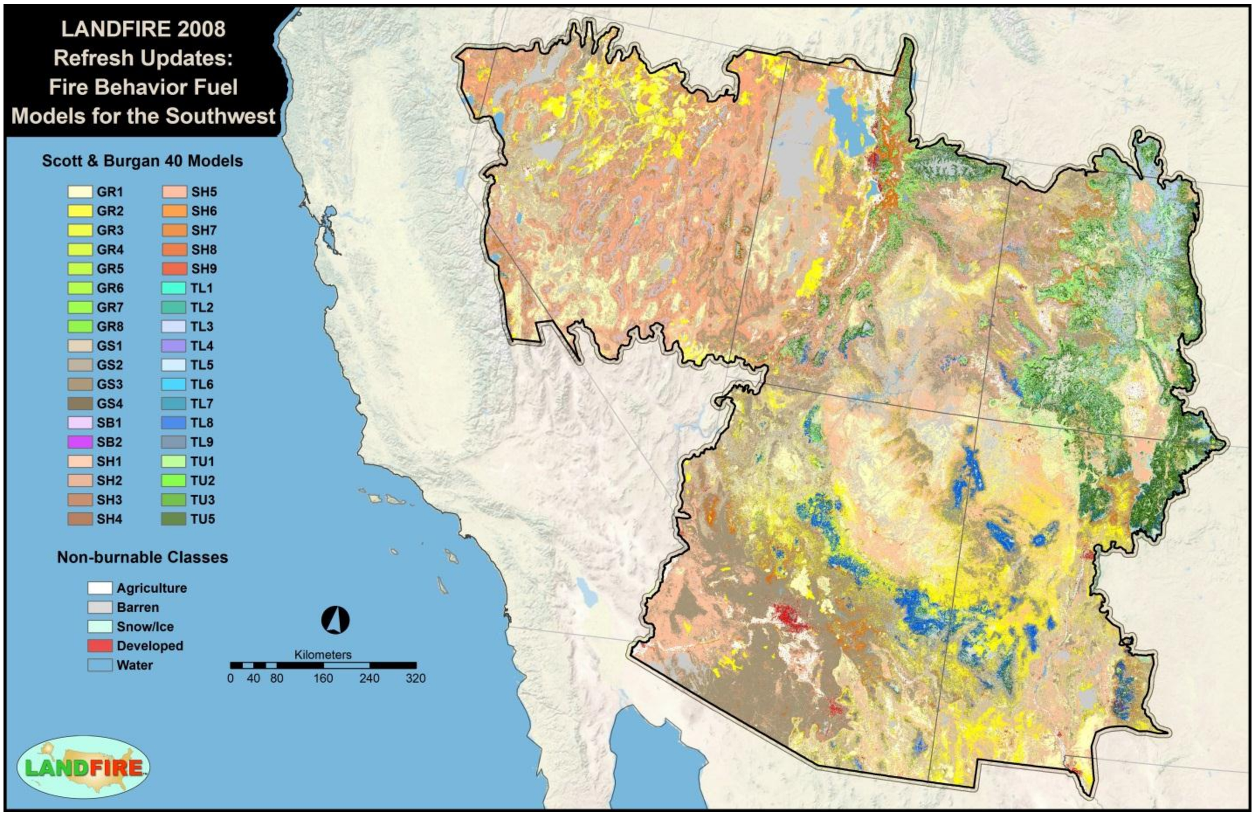


Figure 13 – LF 2008 Fire Behavior Fuel Model 40 for the SW GeoArea.

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 30). 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 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.

Table 30 – Comparison of fire behavior characteristics derived from LF 2001 and LF 2008 for Federal Lands in the SW GeoArea.

Table 30. Fire Behavior Comparison – LF 2001 and LF 2008			
Fire Behavior Characteristic	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Flame Length (feet)			
No Fire	9,617,124	9,693,217	0.8
Low(>0 and <=4)	45,730,702	46,050,173	0.7
Moderate (>4 and <=11)	51,833,855	53,237,415	2.7
High (> 11)	48,406,829	46,607,705	-3.7
Spread Rate (chains/hour)			
No Fire	9,617,124	9,693,217	0.8
Low (>0 and <=5)	25,366,437	24,857,480	-2.0
Moderate (>5 and <=50)	44,207,753	44,927,150	1.6
High (>50)	76,397,196	76,110,662	-0.4
Crown Fire			
No Fire	9,617,124	9,693,217	0.8
Surface Fire	109,692,240	109,890,636	0.2
Passive Crown Fire	12,033,731	12,013,503	-0.2
Active Crown Fire	24,245,414	23,991,154	-1.1

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 was 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 fuelbeds 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.

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 31 and Table 32 display the FCCS rule sets developed for EVT 2027 and 2028 in mapping zone 7. LF National and LF 2001 and depict the change in acreage between data versions. For example, Table 31 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.

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 31 – 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 31. LF National Fuel Rule Sets					
Existing Vegetation Type	**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 32 – 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 32. LF 2001 Fuel Rule Sets					
Existing Vegetation Type	**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 with loading attributes were developed for grasslands using the loading data from FCCS. For some FLM, 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 SW 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.

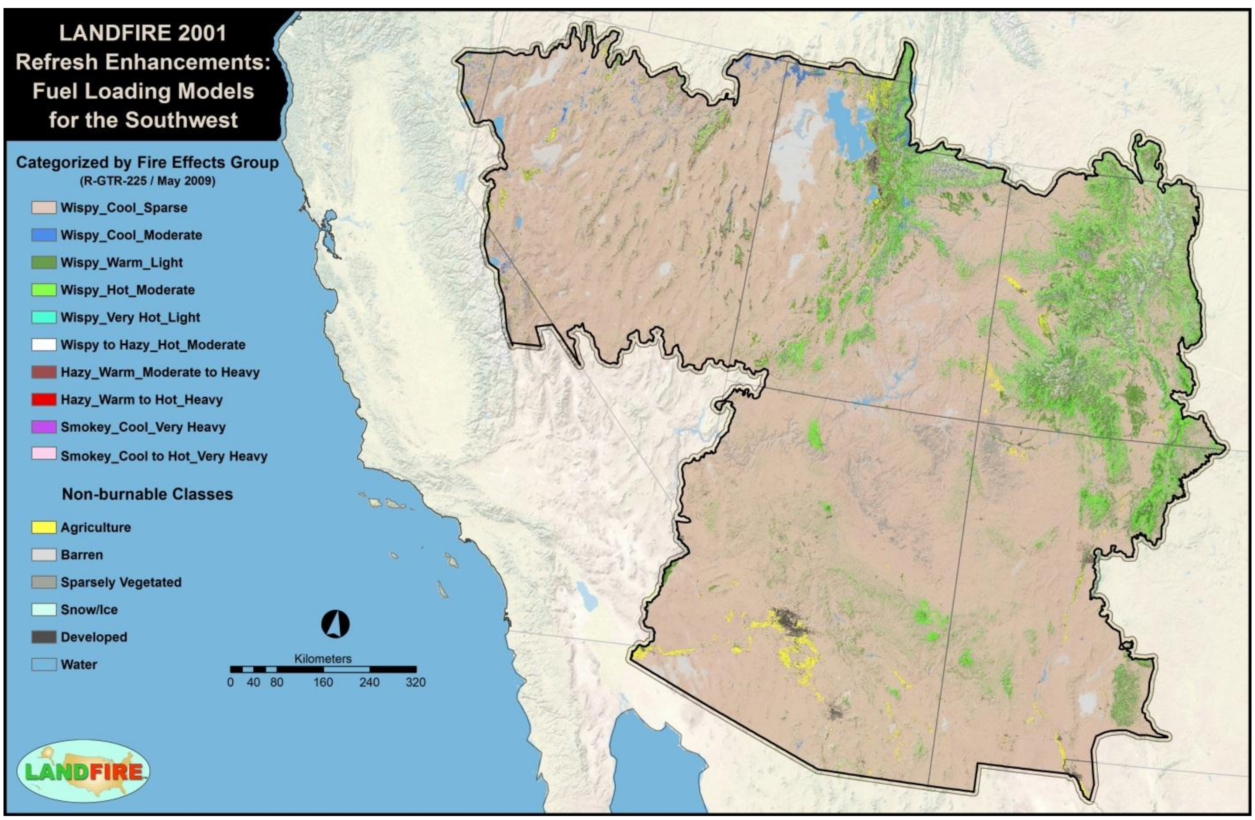


Figure 14 – LF 2001 Fuel Loading Models for the SW GeoArea. FLM categories are from Rocky Mountain Research Station General Technical Report 225.

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 33). 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 33 –Comparison of fire effect characteristics derived from LF National and LF 2001 for Federal Lands in the SW GeoArea.

Table 33. Fire Effect Characteristics Comparison – LF National to 2001				
Ownership	**Fire Effect Characteristics**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Particulate Production:				
Federal Lands	No Burnable Fuels	11,728,301	9,595,185	-18.2
Federal Lands	No Burn In Fuels	4,419	20,028	353.2
Federal Lands	No Effect	165,736	0	-100.0
Federal Lands	Low (>0 and <=250 lb/ac)	21,555,576	135,541,807	528.8
Federal Lands	Moderate (>250 and <=1000 lb/ac)	43,154,877	9,199,191	-78.7
Federal Lands	High(>1000 lb/ac)	78,674,177	926,874	-98.8
Soil Heating:				
Federal Lands	No Burnable Fuels	11,728,301	9,595,185	-18.2
Federal Lands	No Burn in Fuels	4,419	20,028	353.2
Federal Lands	No Effect	108,575,060	127,783,501	17.7
Federal Lands	Low (>0 and <=3 cm)	25,049,975	146,584	-99.4
Federal Lands	Moderate (>3 and <=8 cm)	4,627,944	15,632,217	237.8
Federal Lands	High(>8 cm)	5,297,385	2,105,569	-60.3
Fuel Consumption:				
Federal Lands	No Burnable Fuels	11,728,301	9,595,185	-18.2
Federal Lands	No Burn in Fuels	4,419	20,028	353.2
Federal Lands	No Effect	165,736	0	-100.0
Federal Lands	Low (>0 and <=33 %)	522,309	7,496,601	1335.3
Federal Lands	Moderate (>33 and <= 66 %)	2,972,745	39,829,652	1239.8
Federal Lands	High (>66 %)	139,889,574	98,341,619	-29.7

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.

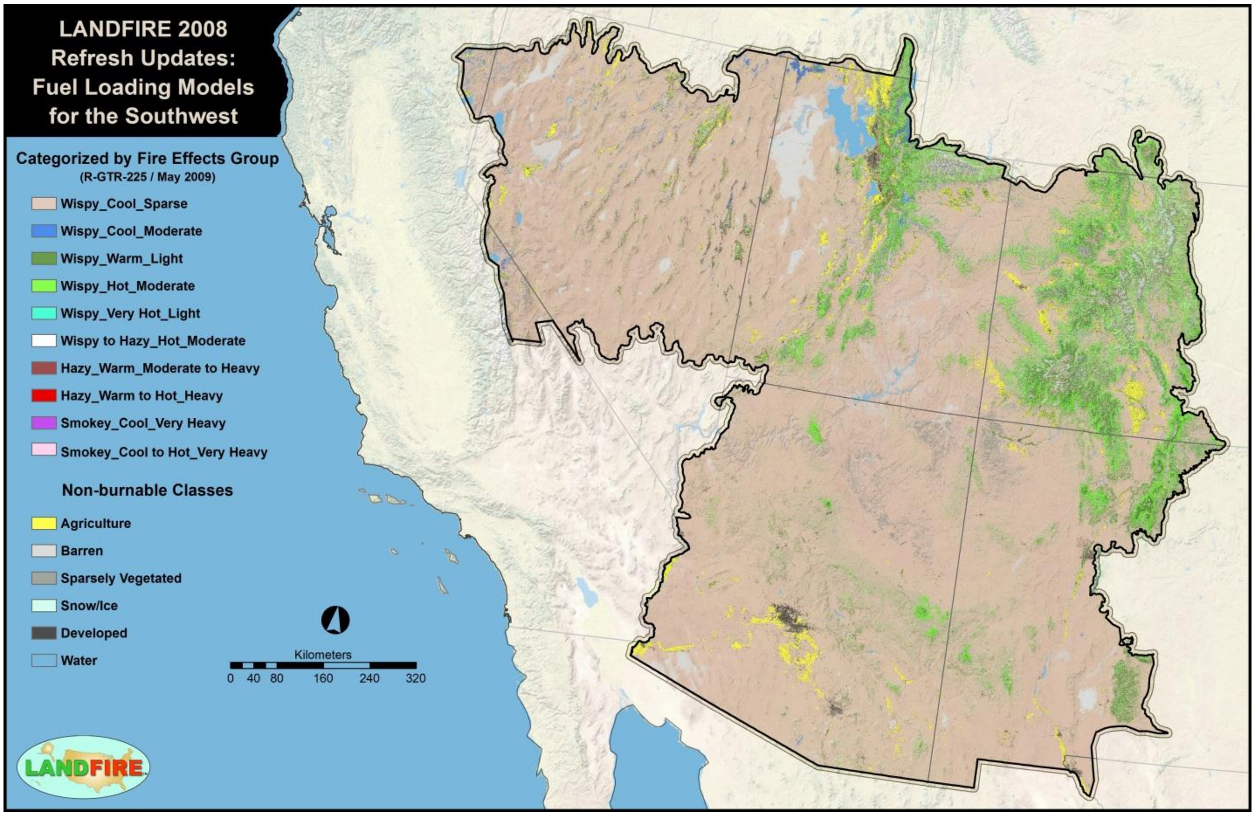


Figure 15 – LF 2008 Fuel Loading Models for the SW GeoArea. Categories are from the Rocky Mountain Research Station General Technical Report 225.

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 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 98^{th} 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 2001 and LF 2008 for Federal Lands in the SW GeoArea.

Table 34. Fire Effect Characteristics Comparison– LF 2001 to LF 2008				
Ownership	**Fire Effect Characteristics**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Particulate Production:				
Federal Lands	No Burnable Fuels	9,595,185	9,609,277	0.2
Federal Lands	No Burn In Fuels	20,028	82,029	309.6
Federal Lands	No Effect	0	0	0.0
Federal Lands	Low (>0 and <=250 lb/ac)	135,541,807	135,613,776	0.1
Federal Lands	Moderate (>250 and <=1000 lb/ac)	9,199,191	9,059,005	-1.5
Federal Lands	High(>1000 lb/ac)	926,874	918,998	-0.9
Soil Heating:				
Federal Lands	No Burnable Fuels	9,595,185	9,609,277	0.2
Federal Lands	No Burn in Fuels	20,028	82,029	309.6
Federal Lands	No Effect	127,783,501	128,032,909	0.2
Federal Lands	Low (>0 and <=3 cm)	146,584	61,051	-58.4
Federal Lands	Moderate (>3 and <=8 cm)	15,632,217	14,876,412	-4.8
Federal Lands	High(>8 cm)	2,105,569	2,621,407	24.5
Fuel Consumption:				
Federal Lands	No Burnable Fuels	9,595,185	9,609,277	0.2
Federal Lands	No Burn in Fuels	20,028	82,029	309.6
Federal Lands	No Effect	0	0	0.0
Federal Lands	Low (>0 and <=33 %)	7,496,601	7,452,015	-0.6
Federal Lands	Moderate (>33 and <= 66 %)	39,829,652	37,553,087	-5.7
Federal Lands	High (>66 %)	98,341,619	100,586,677	2.3

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.

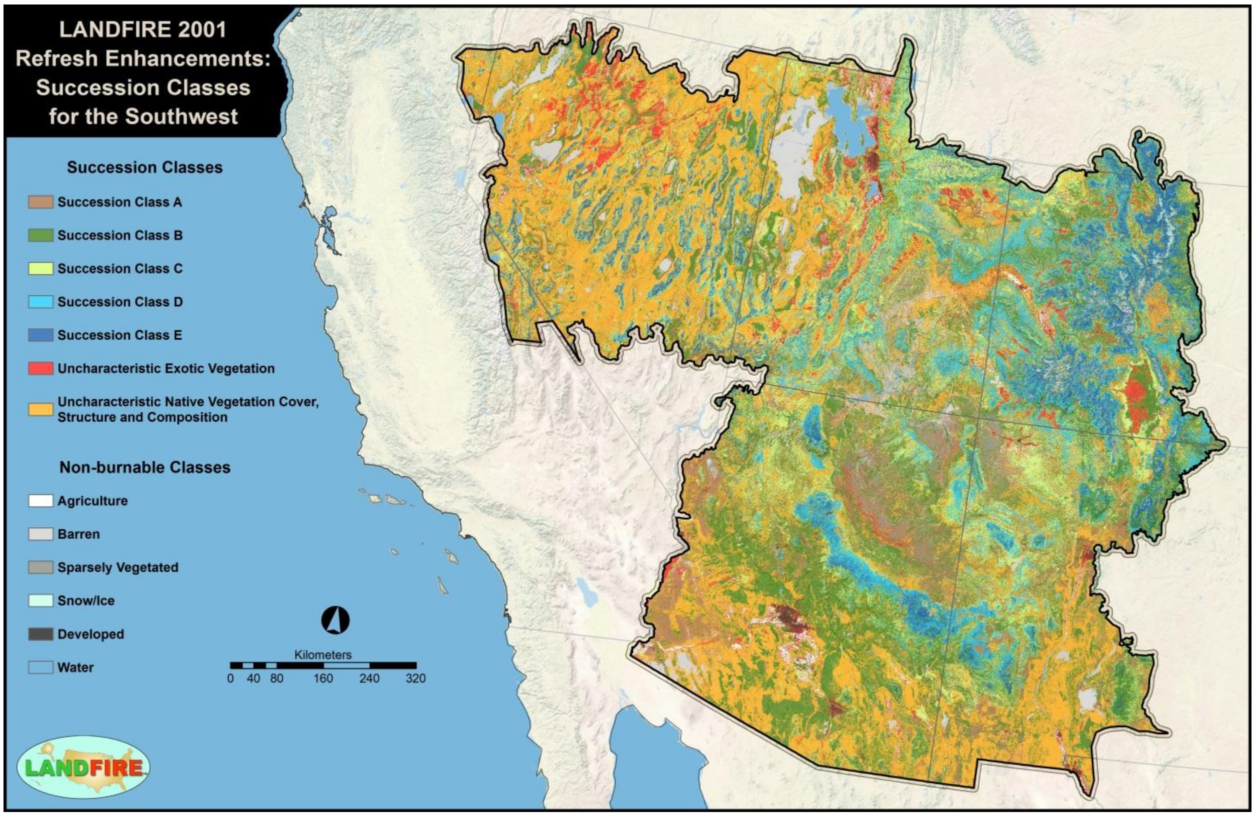


Figure 16 – Map of LF 2001 enhancements of the Succession Classes layer for the SW GeoArea.

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

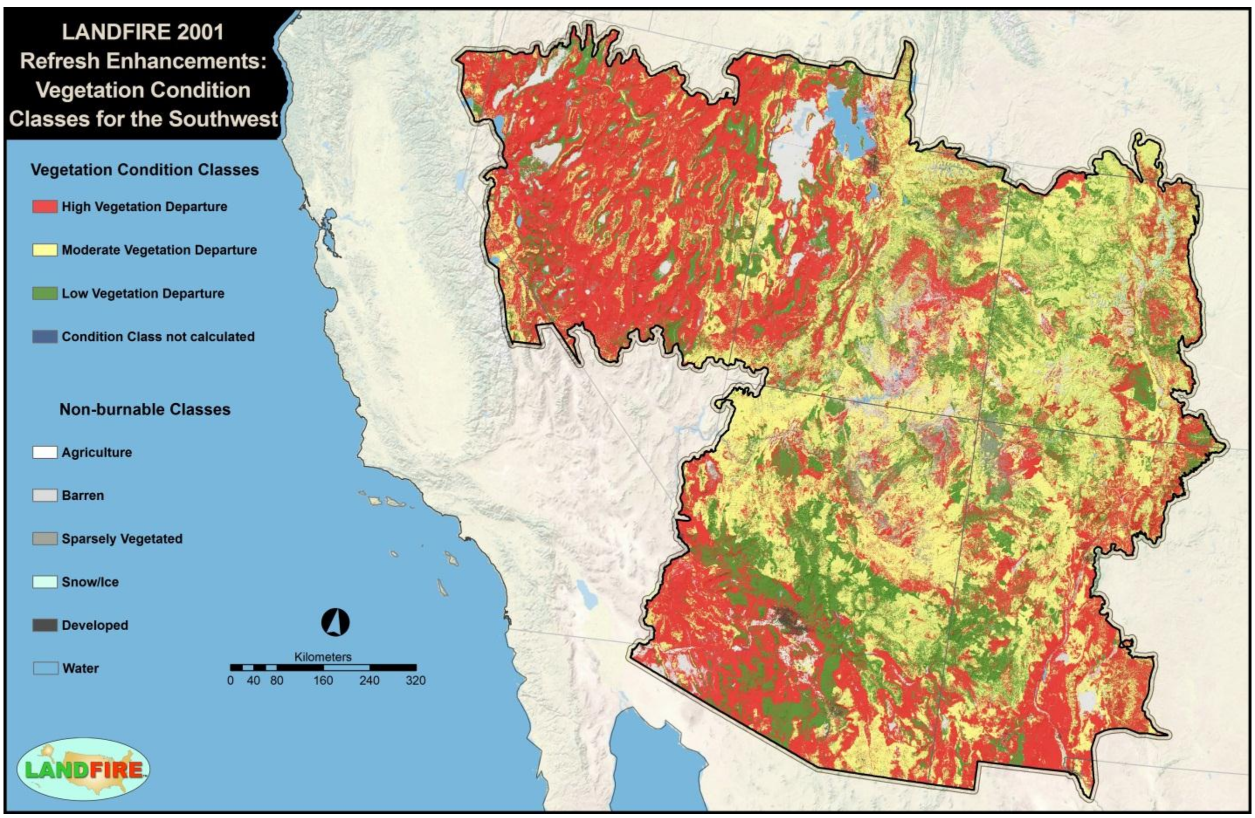


Figure 17 – Map of Vegetation Condition Class for the SW GeoArea from LF 2001 enhancements.

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.

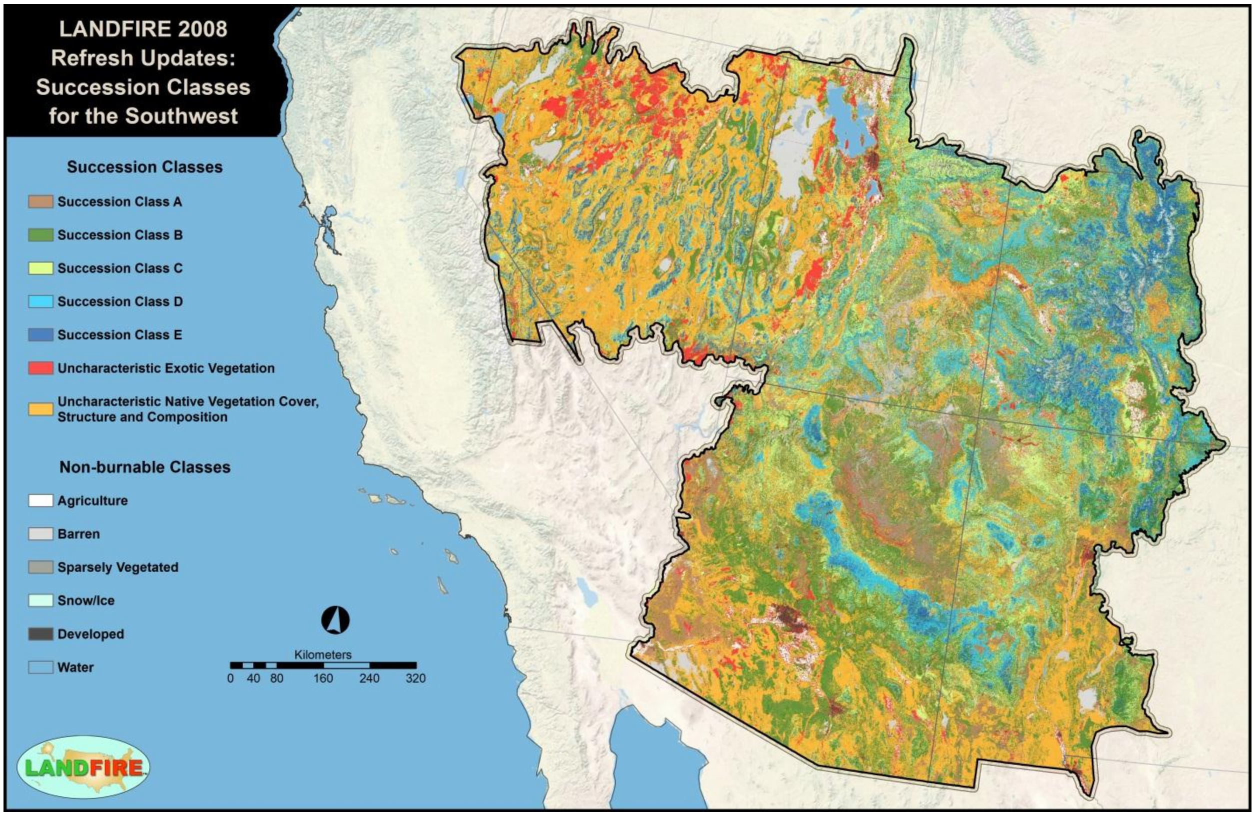


Figure 18 – Map of LF 2008 updates of the Succession Classes layer for the SW GeoArea.

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.

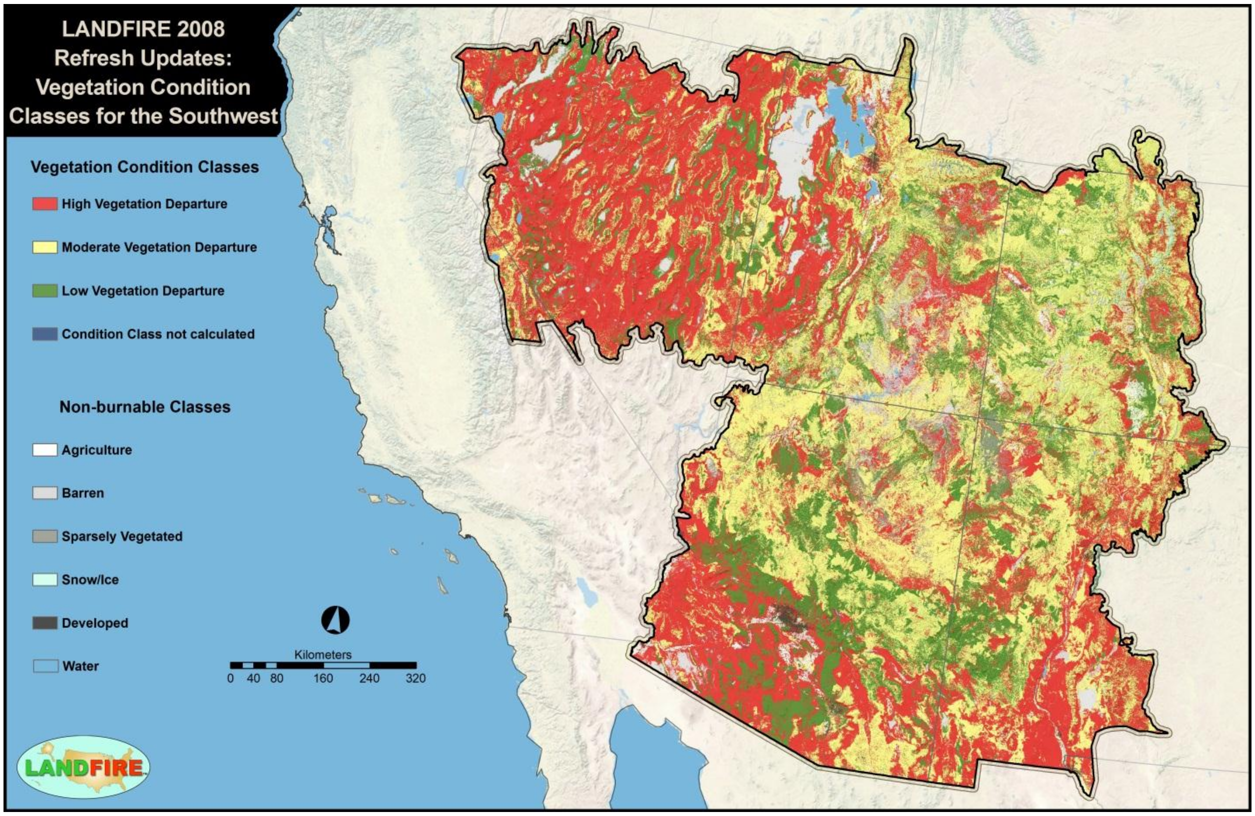


Figure 19 – Map of Vegetation Condition Class for the SW GeoArea from LF 2008 updates.

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. This is a comparison between LF data sets with the final perimeters of an actual wildland fire. Fires were selected from one of several sources, either the MTBS Fire Occurrence Database 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.

3.1 Wallow Fire, 2011

The Wallow Fire occurred in East Central Arizona (map zone 15) and was most active from May 29, 2011 through June 12, 2011. During this period, extensive fire spreads were recorded June 1st through 3rd due to "Red Flag Conditions" of low fuel moistures and high wind speeds. These conditions were compounded by the reality of the area experiencing several years of drought and fuel conditions well past the 90th percentile dryness according to the National Fire Danger Rating System (NFDRS) Energy Release Component (ERC) index. The vegetation within the area was older aged mixed conifer stands dominated by Douglas fir (*Pseudotsuga menziesii*) and Ponderosa Pine (*Pinus ponderosa*) forests. The fire activity in early June, that this report focuses on, occurred mainly in two LF EVT classes: Southern Rocky Mountain Ponderosa Pine Woodland (2054- 65% of area) and Southern Rocky Mountain Mesic Montane Mixed Conifer (2052- 25% of area). The rest of the area had riparian, grassland, and other assorted EVT classes represented across the landscape.

Infrared (IR) perimeters of the wildland fire for June 1, 2011 and June 2, 2011 indicated fire movement of approximately 12 miles from the Southwest to Northeast (see **Error! Reference source not found.**). This extensive fire spread threatened the valley that comprises the town of Alpine, AZ and its outlying residences. Two fuels treatment areas had previously been completed on the Northeast and Southeast edges of the valley. A report issued by the USFS (Bostwick et al., 2011) states that fire activity during this period had been crowning, torching, and spotting and on the morning of June 3, 2011 suppression activities were implemented within these fuels treatment areas to restrict the crown fire movement into the valley where the residences and community of Alpine are located.

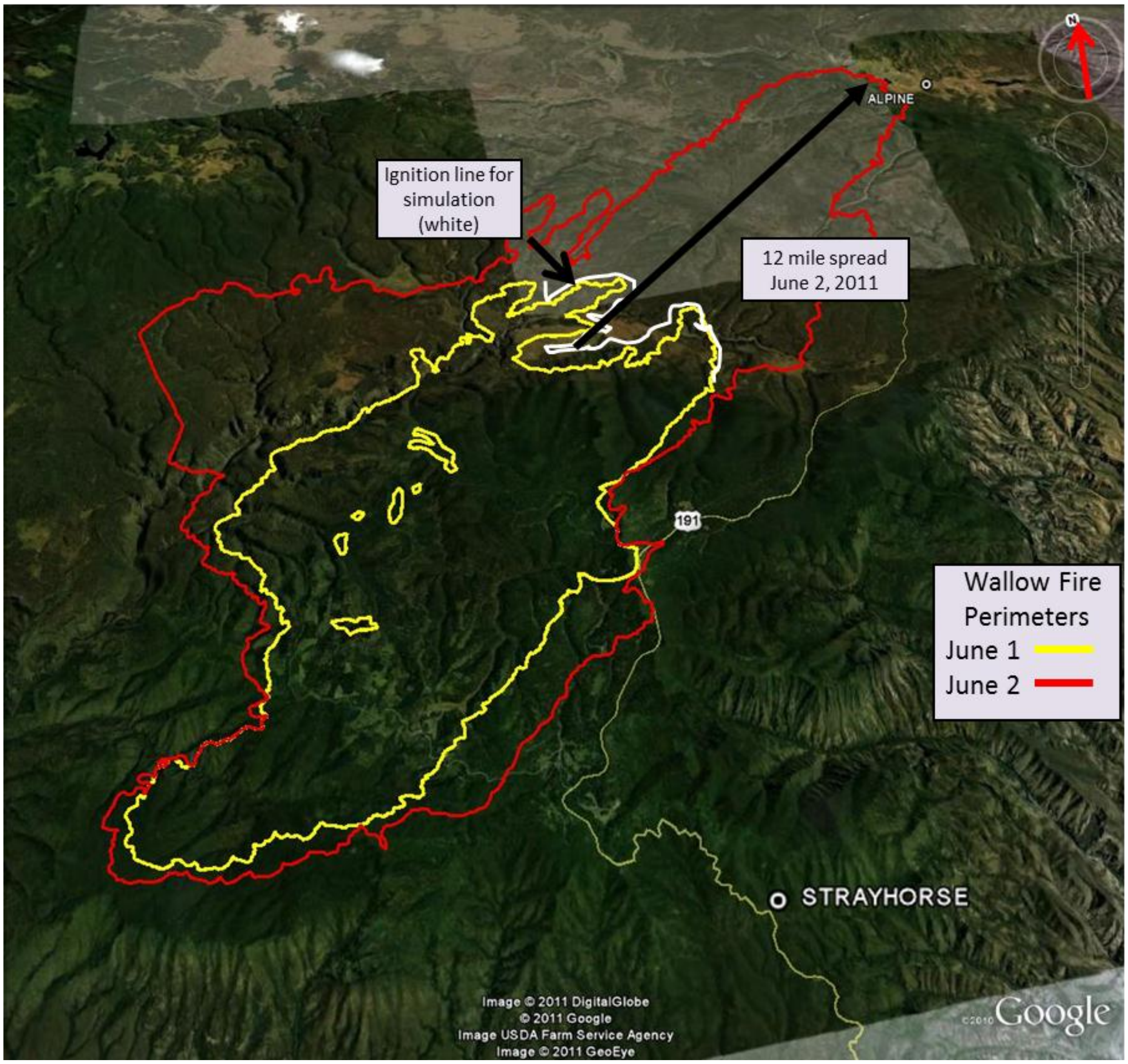


Figure 20 – Wallow Fire actual fire perimeters from June 1 to June 2, 2011 showing the Southwest to Northeast spread of the fire over a 12 mile distance toward the community of Alpine, AZ. The Strayhorse Remote Automated Weather Station as shown in the image was used for weather data in this comparative analysis. The ignition line was selected as the starting point for this modeling comparison based on an infrared flight where intense heat areas were detected on June 2, 2011 at 0013 hours. The June 2, 2011 perimeter extends approximately 26 miles southwest to northeast.

3.1.1 Inputs

Weather, wind, and fuel moisture data used in the fire simulations were from two Remote Automated Weather Station (RAWS). The Strayhorse RAWS is located approximately 8 miles SE and Mountain Lion RAWS is 17 miles NW of the fire origin. Fuel moistures provided by both RAWS were extremely low during the burn period on June 2, 2011. For this analysis, fuel moisture conditions for the dead fuel size classes were selected as follows: 1 hr 2%, 10 hr 2%, 100 hr 4%. The information for conditioning the weather for the model was taken directly from Strayhorse RAWS. Median point wind speeds for some of the simulations were used between the 10-minute average 20-ft. winds and maximum wind gusts, however these wind speeds resulted in a poor emulation of fire spread. Use of the maximum wind gusts, with some hours of the burn period listed a few mph higher, provided the best results in the simulations. Some wind directions were altered to post fire known directions.

As previously mentioned, this area was predominately two vegetation types, the Ponderosa Pine type (2054) being almost completely Timber Litter (TL) TL8 (188) within all three versions of the LF surface fuel model layers (FBFM40). The Mixed Conifer type (2052) was a mixture of TL 5 (185), Timber Understory (TU) TU1 (161), TL3 (183), and TL8 (188) within LF National; whereas in LF 2001 and LF 2008 these Mixed Conifer areas were predominately TL3 (183). This is probably due to the shifting of pixels with the new CC and CH as discussed in sections 2.5.2b and 2.5.2c of this report. The only other differences for the surface fuel model changes were a few previously disturbed areas within the Wallow fire perimeter where some pixels changed to a grass model. CBH is an important fuel characteristic to address crown fire activity since it is associated with spotting. This type of fire behavior was reported to be the most prevalent type for the movement of this fire. In LF National, the CBH in the Mixed Conifer type was generally 1 to 2 meters and in the Ponderosa Pine type CBH was generally 2 to 3 meters in height with some areas 3 to 4 meters. In LF 2001 and LF 2008 the Ponderosa Pine type was 1 to 2 meters and the Mixed Conifer was 0.1 to 1 meter. In LF 2008, the previously disturbed fire and fuels treatment areas had a CBH of 2 to 3 meters.

A 22-hour window with various hours of maximum burn periods was used to simulate the fire spread in all three versions of the LF fuels data. For this comparison analysis the idea was to emulate the actual fire spread of June 2, 2011 in the LF 2008 landscape and review the result as the fire advanced to the fuels treatment areas.

The ignition points or ignition line was set as the starting point for this modeling comparison at the location where intense heat areas were detected by an IR flight on June 2, 2011 at 0013 hours within all three simulations as represented with the white line in Figure 20. Crown fire activity was set to the Scott and Reinhardt method (Scott and Reinhardt 2001) and spotting was enabled at 0.9%. A fuel moisture and environmental conditioning period for the model was used from May 31, 2011 through June 1, 2011 and the weather values were from the Strayhorse RAWS. Winds were input values at the highest gust for the hour reported at either of the two RAWS. The yellow line in **Error! Reference source not found.** represents the fire perimeter from June 1 and the red line represents the fire perimeter from June 2, 2011.

3.1.2 Results

None of the modeled simulations that were produced using the 10-minute wind average or a median point 10-minute average with maximum gust wind speeds resulted in fire spread or perimeter growth of the fire as compared to the spread of the actual fire perimeter for June 2, 2011. This is also true for simulations completed with less than a 10-hour burn period. The following images depict the simulations with a burn period from 0900 hrs through 1900 hrs and weather and fuel moistures as collected on June 2, 2011 along with the maximum gust wind speed from the two RAWS. Values used in this simulation were from the RAWS with the highest maximum gust wind speed for the hourly value and if an hourly max gust was below 25 mph the wind speed was increased to 25 mph to allow for and produce crown fire activity for the fuels as described by folks on the fire based upon the characteristics on site. Results can be viewed in Figure 21 where LF National fuel characteristics are depicted with the max gust wind speed values. In Figure 21 the spread of the fire is limited because crowning of the fire does not occur due to high CBH values within LF National.

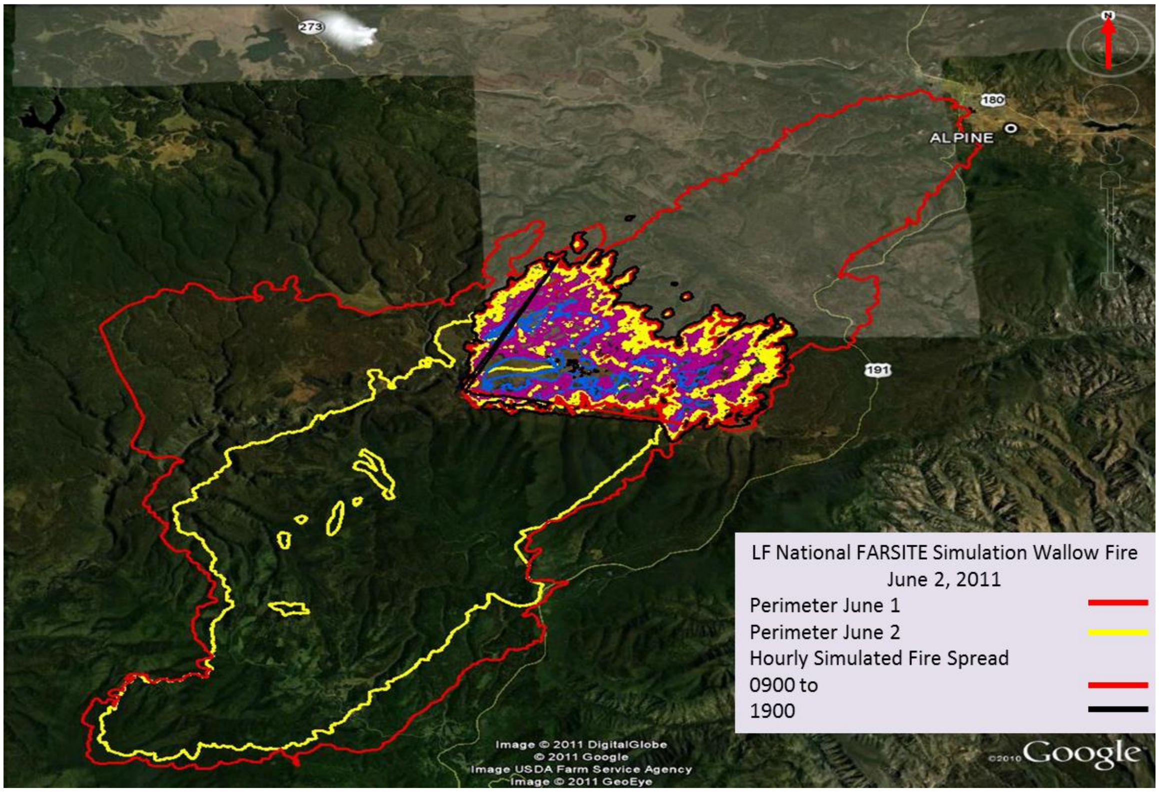


Figure 21 – LF National Fire Spread Simulation based on June 2, 2011 information for a 10-hr Burn Period and Maximum Gust Wind speeds. Fire spread is limited due to high Canopy Base Height values which constrains crowning of the wildland fire. The June 2, 2011 perimeter extends approximately 26 miles southwest to northeast.

The only way a fire behavior simulation for June 2, 2011 on the Wallow Fire can replicate the spread on that day is to provide crowning and spotting across the landscape. LF National provides spotting behavior but provides little in the way of crowning, whereas LF 2001 & LF 2008, with lower CBH values, provides for additional fire spread through torching, spotting and increased active crown fire activity particularly in the Ponderosa Pine EVT TL8 (188) fuel model. The FlamMap projections (Figure 22 and Figure 23) depict changes in fire type (surface fire or passive or active crowning) between LF National and LF 2001 (LF 2008 and LF 2001 are essentially the same) with a 25mph wind and the same dry fuel moistures.

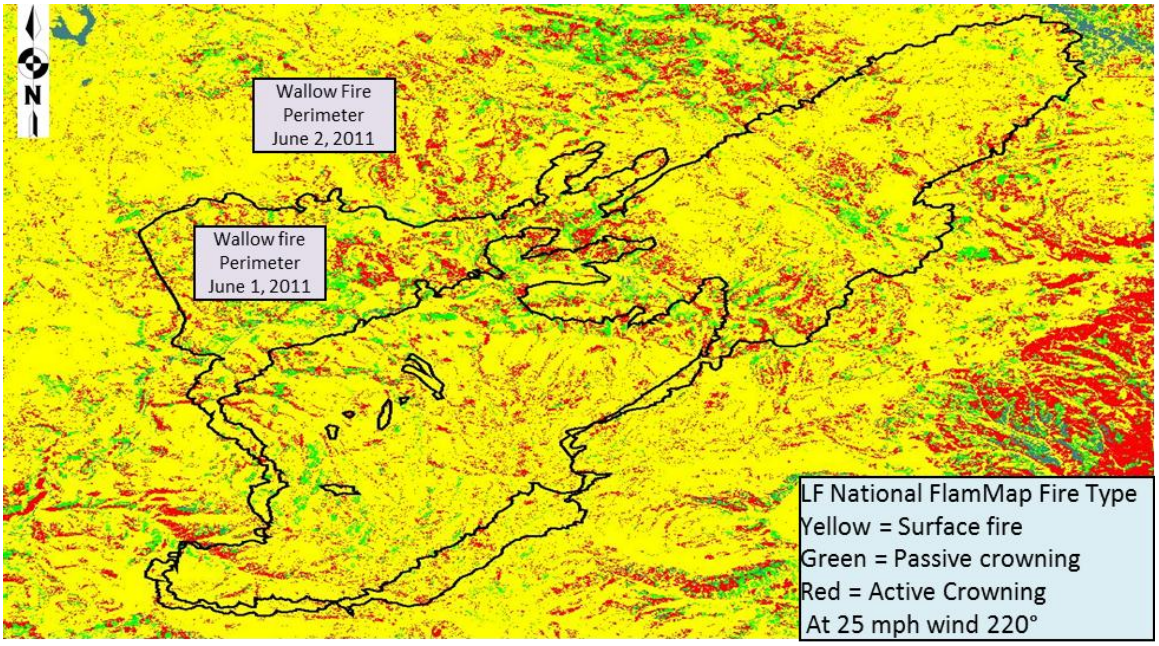


Figure 22 - FlamMap analysis of the Wallow fire area using LF National data. This analysis shows that the majority of the landscape is characterized with surface fire conditions with a 25 mph wind speed. A small portion of the landscape has the potential for either passive or active crown fire. The June 2, 2011 perimeter extends approximately 26 miles southwest to northeast.

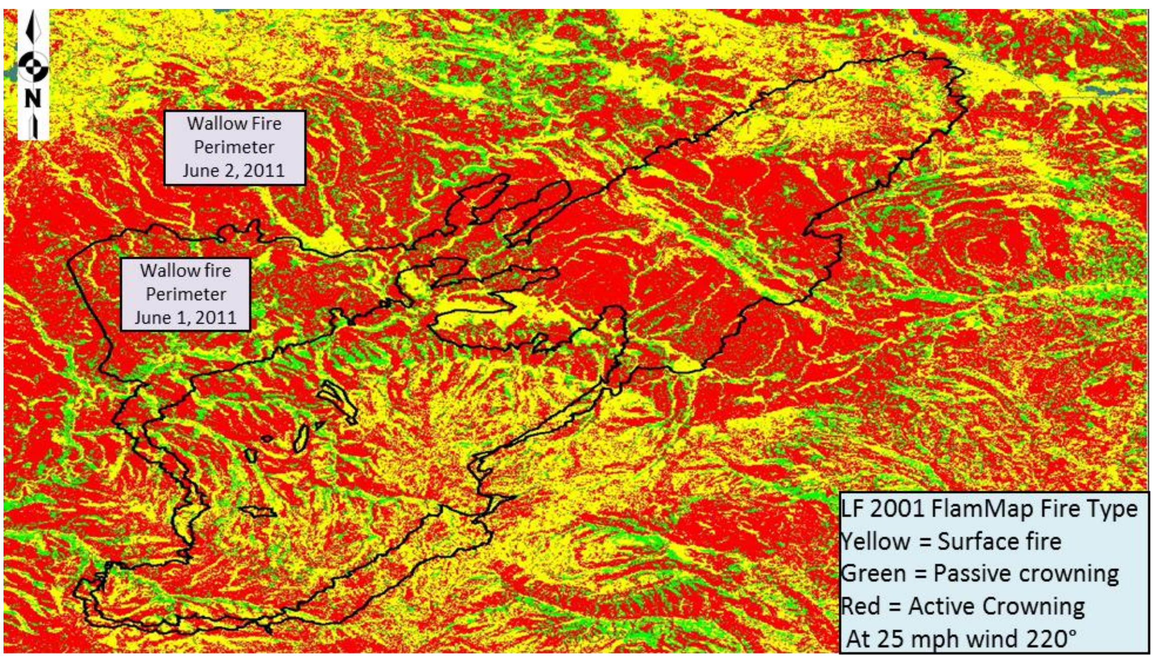


Figure 23 – FlamMap analysis of the Wallow fire area using LF 2001 and LF 2008 data. This analysis shows a mix of fire types across the landscape with increased potential for passive and active crown fire. The June 2, 2011 perimeter extends approximately 26 miles southwest to northeast.

The FARSITE simulation for LF 2001 which captured the additional fire movement from the increase in crowning activity and the additional spotting from that activity is depicted in Figure 24. The simulation reaches the extent of the actual fire spread on the Southeast side, but does not in the area where one of the fuel treatments was previously completed and used for suppression activities in the Wallow fire due to reduced fuel density and loading on the site. Similar results occur with the LF 2008 landscape under the same conditions in Figure 25. This fuels treatment area did not burn in the simulation in the areas in which the EVT changed from Ponderosa Pine (2054) with a fuel model of TL8 (188) to a Mesic Montane Mixed Conifer (2052) vegetation type with a fuel model of TL3 (183). Within the Mesic Montane Mixed Conifer EVT this area changed significantly due to a canopy cover range which has a TL3 (183) associated with it from version LF National to LF 2001. Fuel model TL3 (183) would require significantly exaggerated wind speeds and/or spotting percentages in order for the fire to carry through it. An increase in burn period would allow the fire to spread considerably past Alpine before burning or through this fuel treatment area.

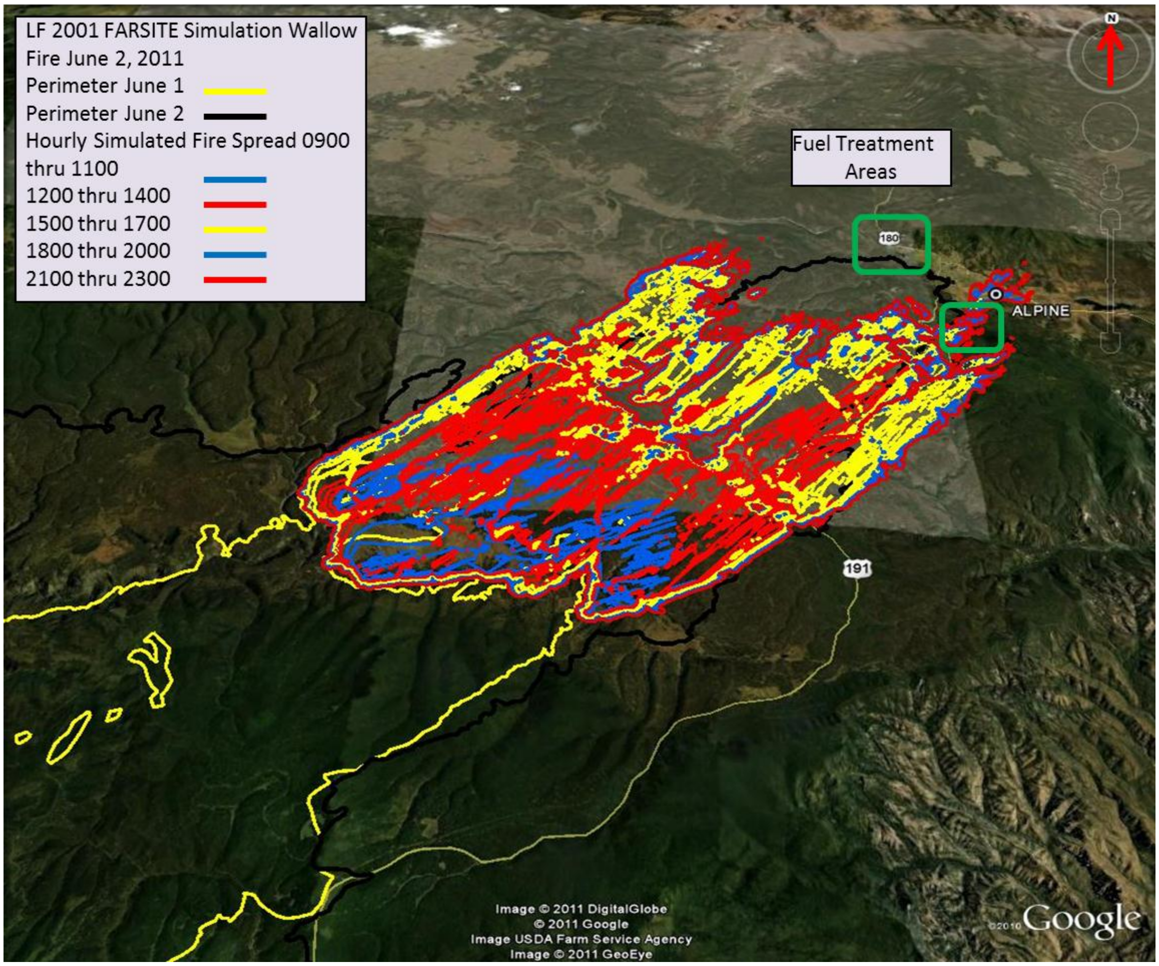


Figure 24 – Fire Spread Simulation using LF 2001 data for June 2, 2011 with 10-hr Burn Period and Maximum Gust Wind speeds. This simulation is more representative of the actual fire spread which factors in the increase in wildland fire crowning activity and spotting as compared to Figure 21 which used LF National data. The path of the fire was nearly 4 miles wide as it approached Alpine, AZ.

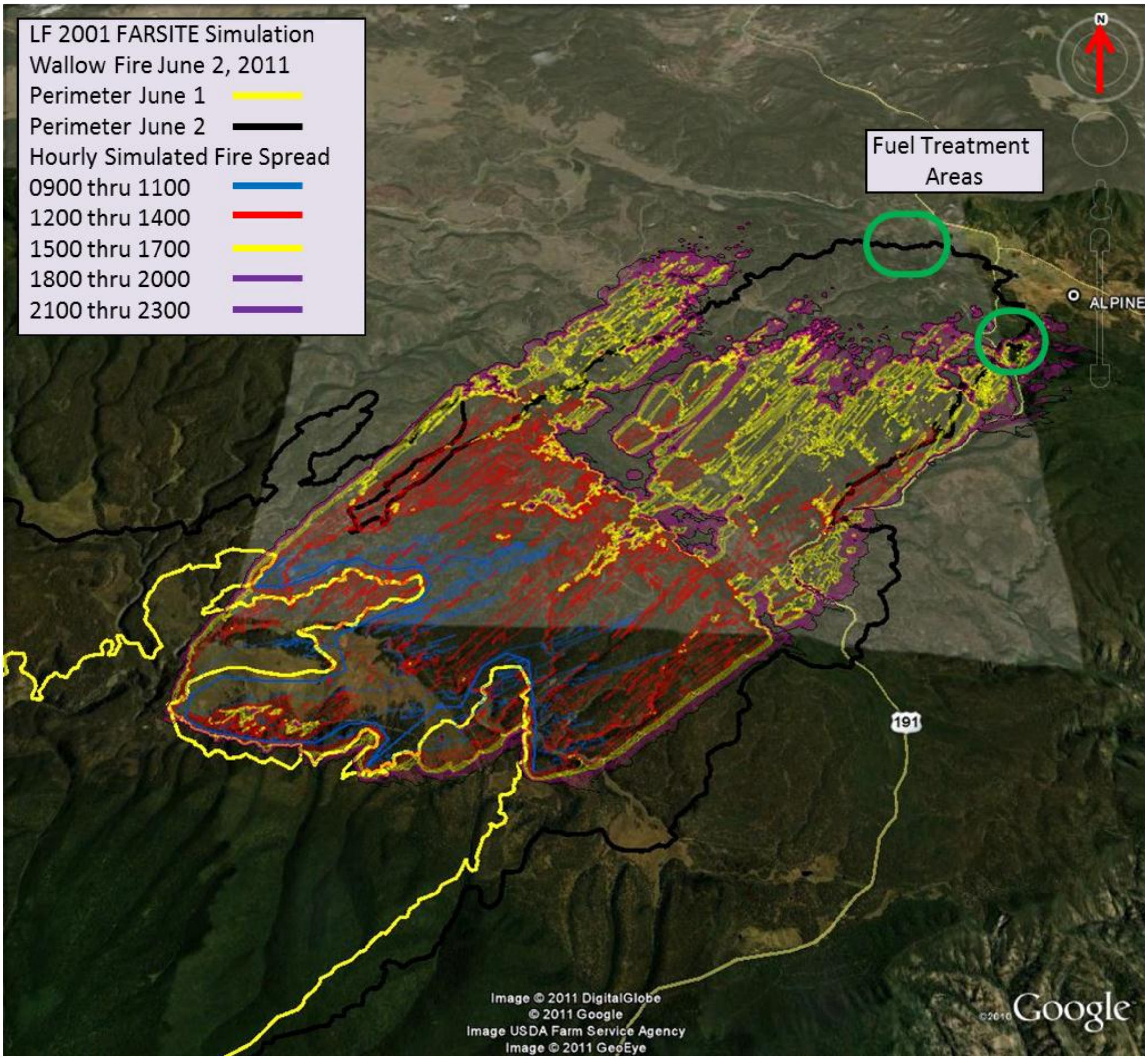


Figure 25 – Fire Spread Simulation using LF 2008 data for June 2, 2011 with 10-hr Burn Period and Maximum Gust Wind speeds. Similar to Figure 24, this simulation is more representative of the actual fire spread due to increases in wildland fire crowning activity and spotting. The path of the fire was nearly 4 miles wide as it approached Alpine, AZ.

As illustrated in Figure 25 the same TL3 (183) condition occurs on the Northeast corner of the June 2, 2011 perimeter and note the drainage in the middle of the fire spread is also the Mixed Conifer TL3 (183). This area did not burn until the end of the burn period and generally held up spread until spotting crossed it in the simulation. Two treatment areas exist that affected the final extent and the suppression activities of the fire at the end of the June 2, 2011 fire run. One affected the previous simulation the second was outside the simulated fire spread due to the fuel models discussed above.

Since the simulated fire spread never entered the area of the Northeast fuel treatment (Figure 26) in the LF 2008 data, a new ignition source was ignited on the other side of the TL3 (183) area but in front of the treatment area in order to judge the change in fuels and fire activity between the treated and untreated landscapes. Note that in Figure 24 the simulation burns up through Alpine whereas, in Figure 25 (LF 2008) the Southeast perimeter fuels treatment area restricts the fires spread.

Figure 26 displays the treatment areas on the Northeast and Southeast perimeter of the Wallow Fire of June 2, 2011 where suppression activities began in the protection of Alpine and the outlying residences.

These two areas and roads between them provided safe effective tactics that affected the final footprint of the Wallow Fire.

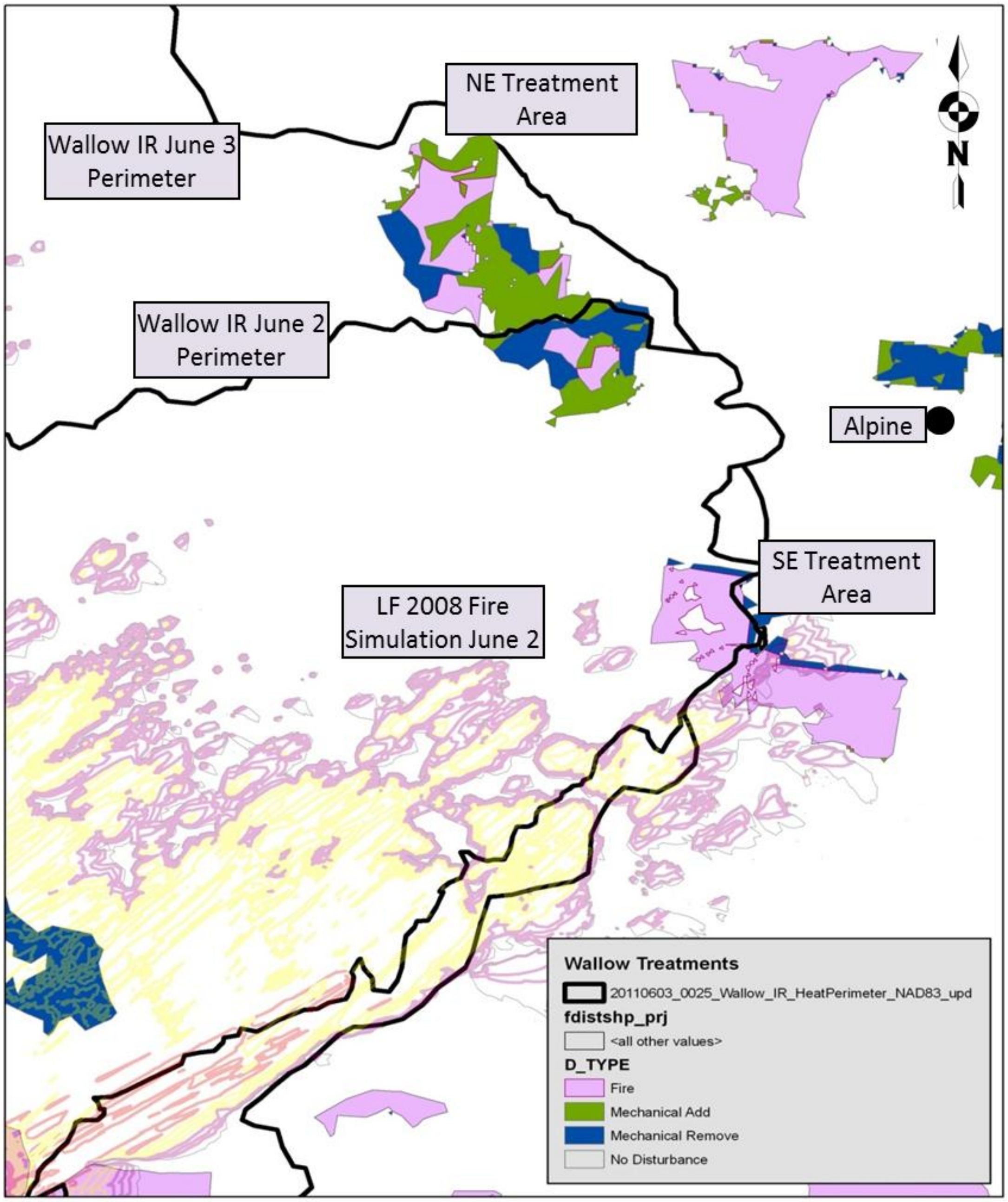
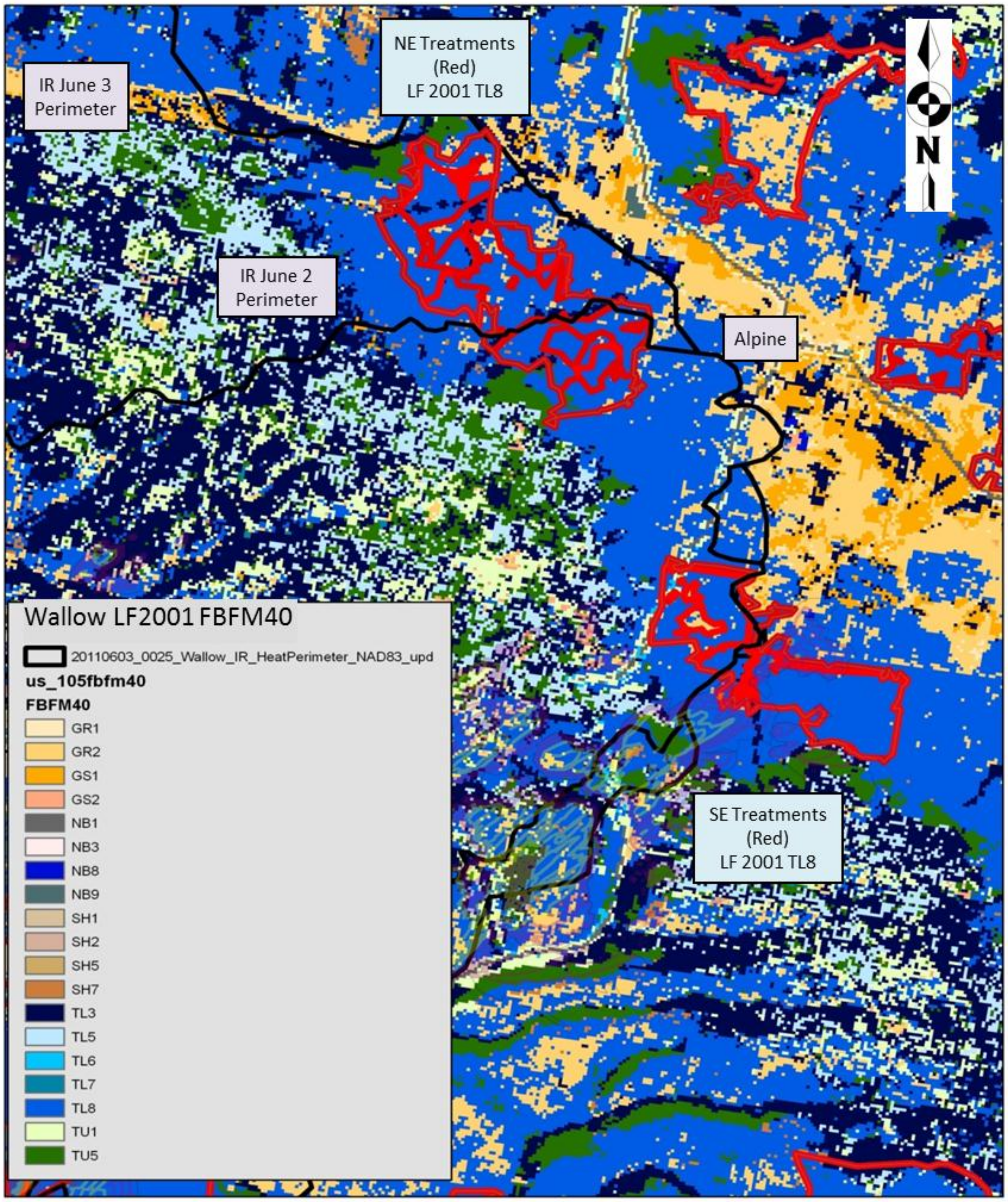


Figure 26 - Treatments (prescribed fire, mechanical, etc.) that had been implemented prior to the Wallow Fire in relation to the fire perimeters and the community of Alpine, AZ. The path of the fire was nearly 4 miles wide as it approached Alpine, AZ.

The combination of surface fuel model and CBH change from LF 2001 to LF 2008 would have had dramatic effects on crown fire activity in both fuel treatment units.


IR June 3
Perimeter
NE Treatments
(Red)
LF 2001 TL8
IR June 2
Perimeter
Alpine
SE Treatments
(Red)
LF 2001 TL8
N
Wallow LF2001 FBFM40
20110603_0025_Wallow_IR_HeatPerimeter_NAD83_upd
us_105fbfm40
FBFM40
GR1
GR2
GS1
GS2
NB1
NB3
NB8
NB9
SH1
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SH7
TL3
TL5
TL6
TL7
TL8
TU1
TU5

Figure 27 and

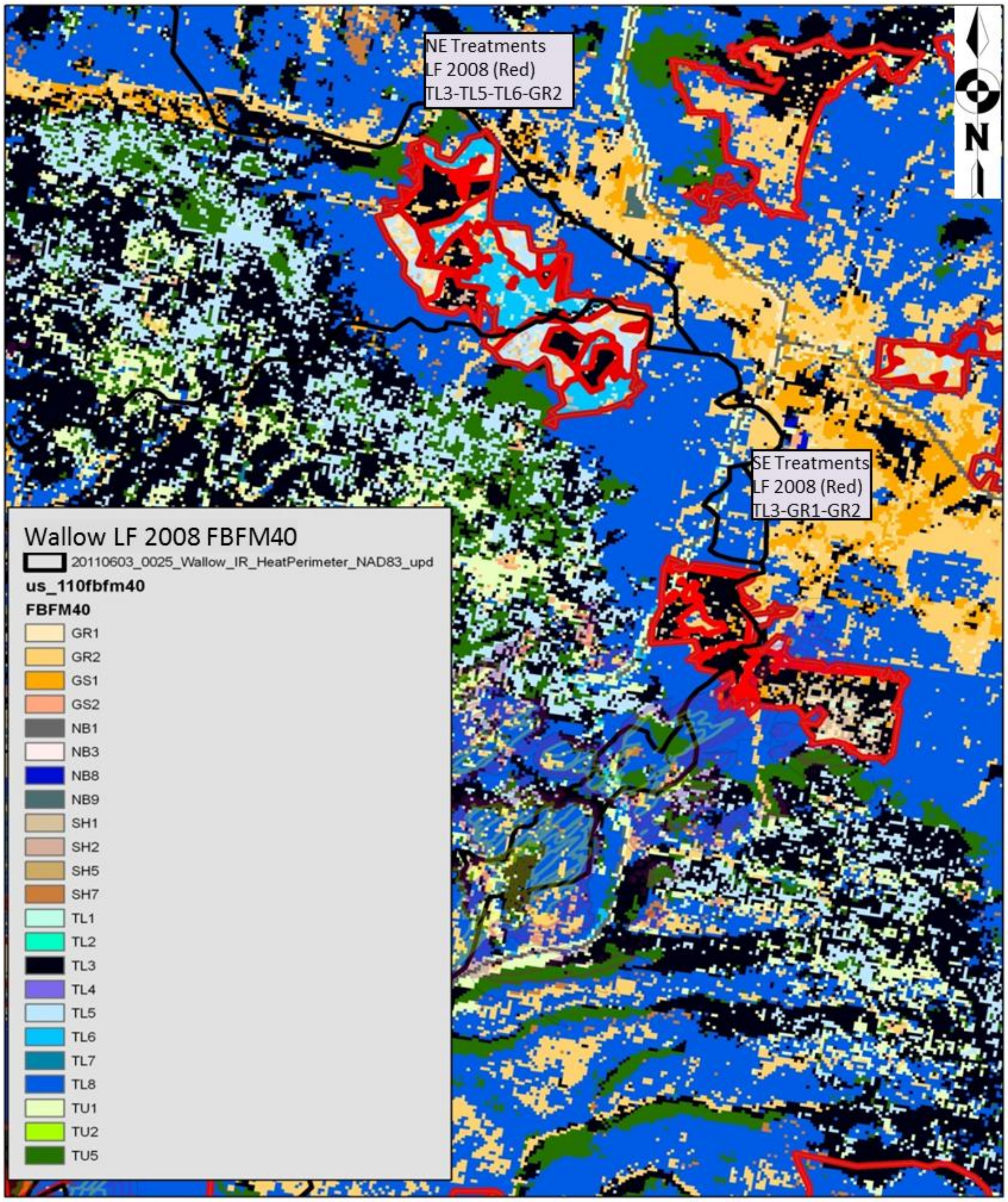

Figure 28 contrast the surface fuel model differences in the two versions of LF data particularly within the treatment areas. In

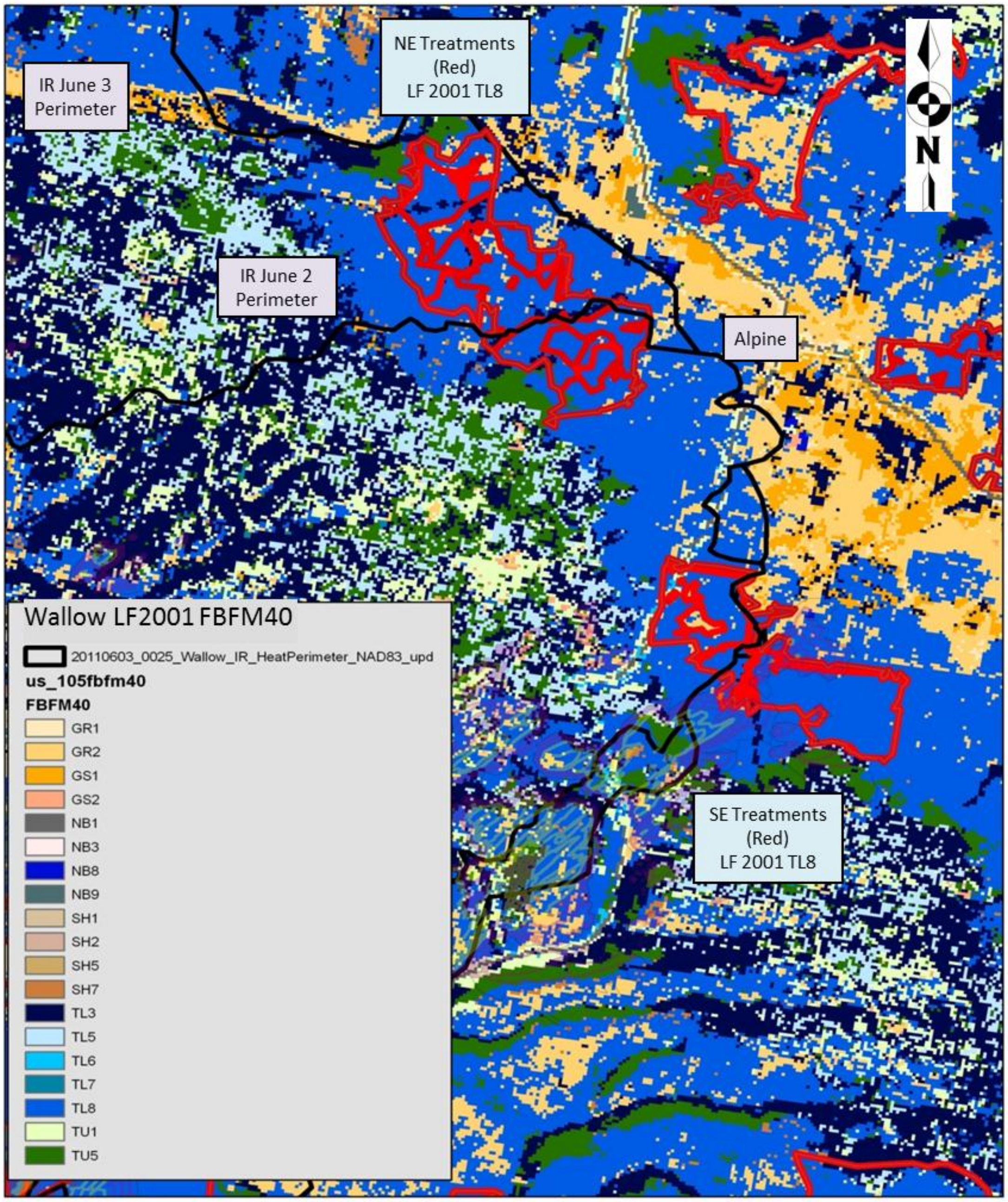

Figure 27, note the surface fuel model for both treatment areas is TL8 (188) which, with low CBH accounted for the crown fire activity in the previous simulations.

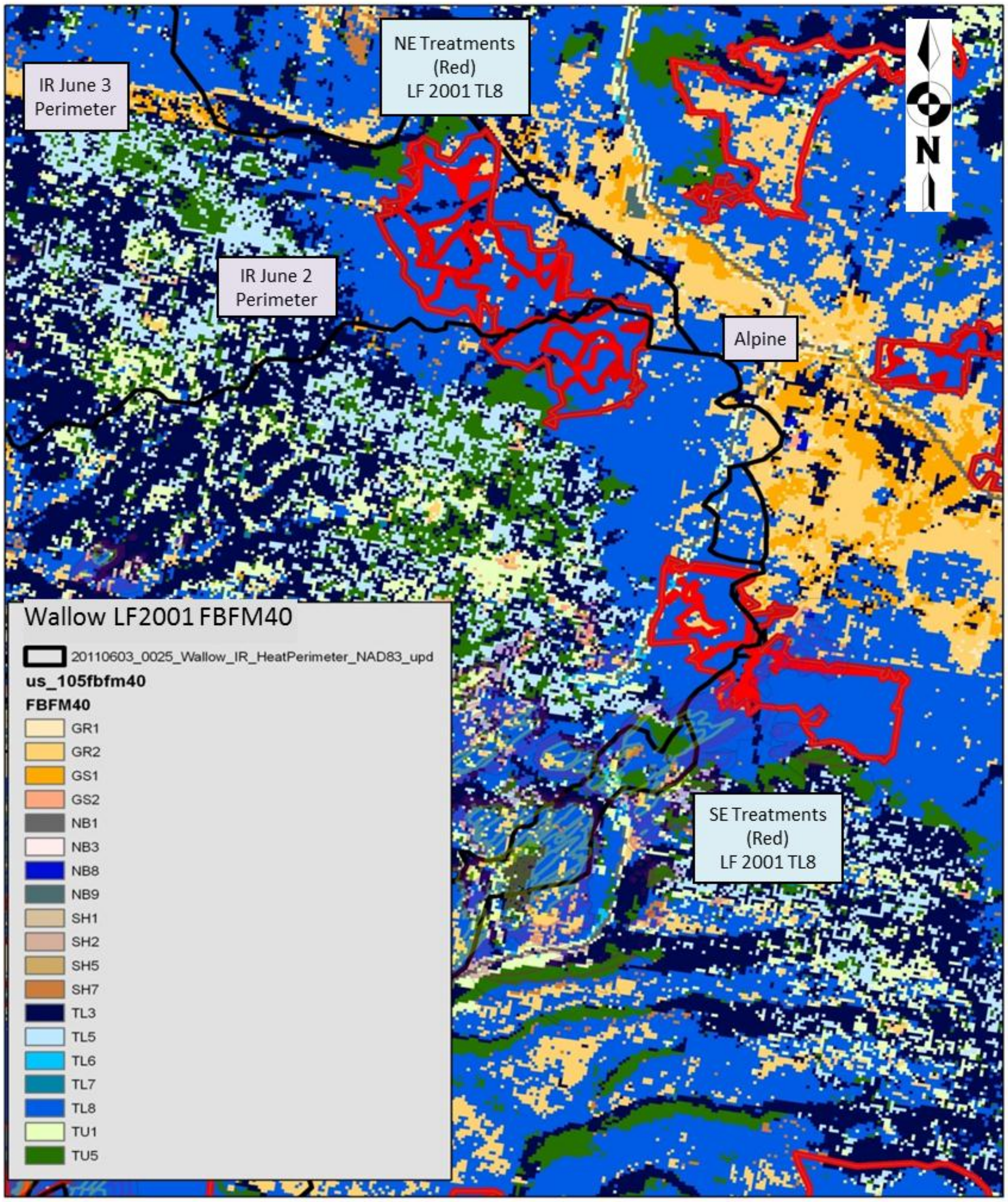

Figure 27 -LF 2001 Fire Behavior Fuel Model 40 types around the community of Alpine, AZ and as represented in the treatment areas (outlined in red). Each treatment area is classified as a TL8 (188) which have lower CBH values and accounts for the increase in crown fire activity. The path of the fire was nearly 4 miles wide as it approached Alpine, AZ.

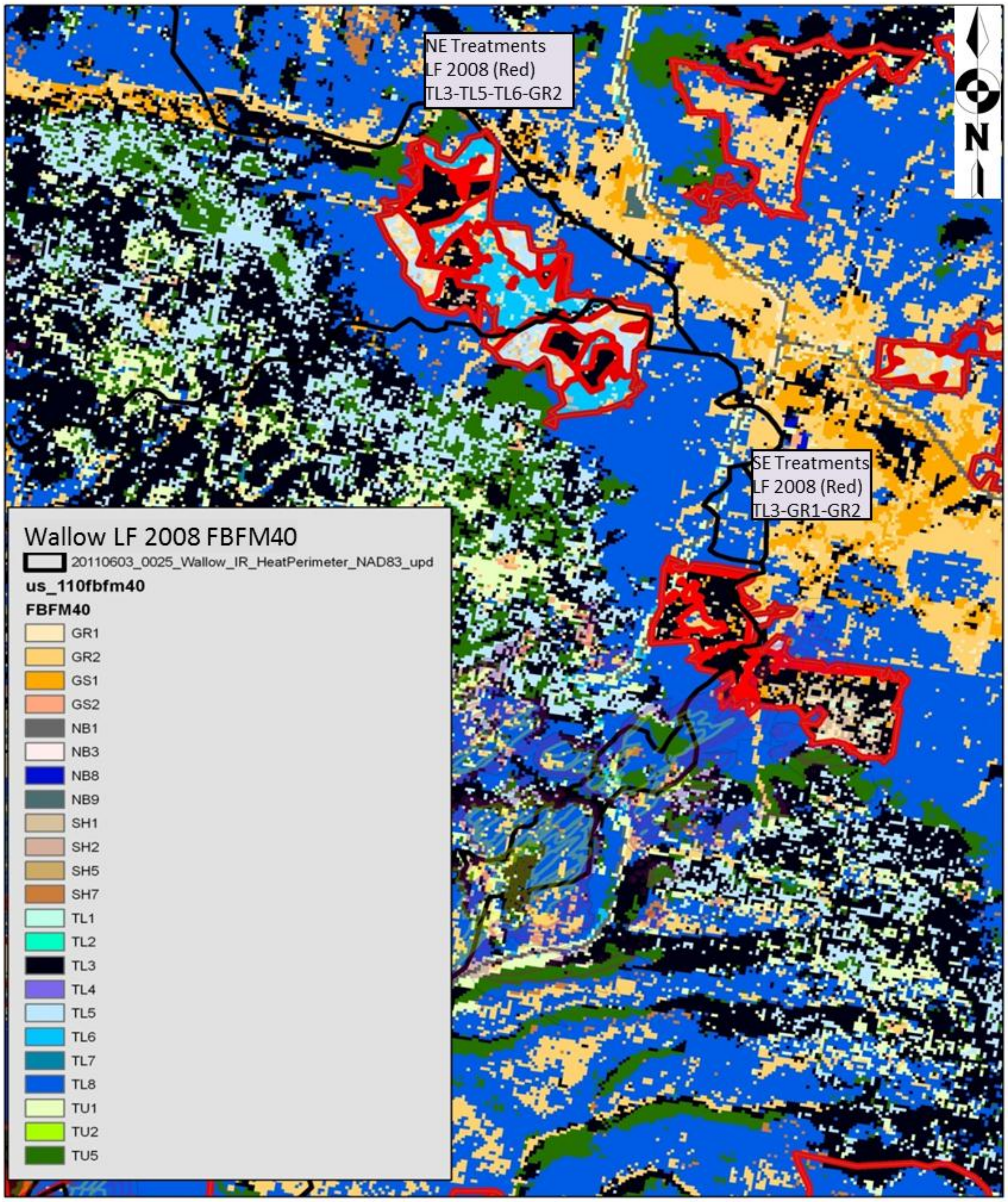

Figure 28- LF 2008 Fire Behavior Fuel Model 40 types around the community of Alpine, AZ and as represented in the treatment areas (outlined in red). In LF 2008 treatment areas were updated as result of the work completed in the LANDFIRE "Refresh" project. The path of the fire was nearly 4 miles wide as it approached Alpine, AZ.

Note the change in the surface fuel model from TL8 in LF 2001 to less intense fuel models TL3, TL5, and TL6. The canopy structure also changes between the two versions providing for a higher CBH in LF 2008 further reducing the possibility that less intense fuel models will initiate crown fire.

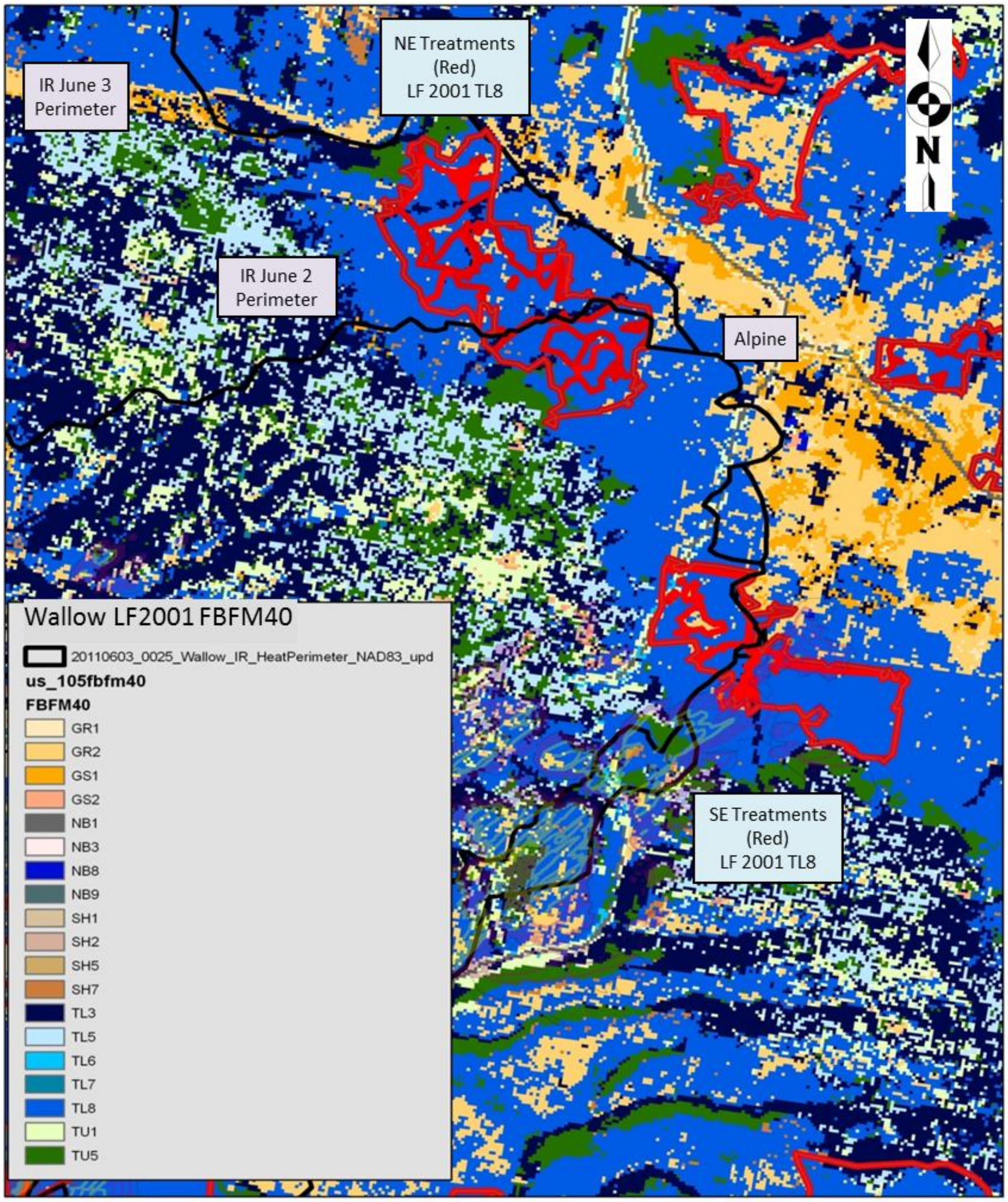

Figure 27 displays the TL8 (188) fuel model with a CBH between 1 and 2 meters in the LF 2001 version. This combination is what carried the simulated fire spread to the outskirts of Alpine, AZ. in the burn period conditions of June 2, 2011.

The ranges used for CBH for this comparison do not necessarily show the magnitude of the possibility of torching and crowning in the LF 2001 landscape. Within that landscape almost all pixels in the treated areas are surface fuel model TL8 (188) with a CBH of 1.3 meters (just over 4 feet). With the wind speeds and fuel dryness in this fire environment the probability for torching and crowning would be very strong. In the LF 2008 landscape the pixels within the treatment areas range in CBH from 2.2 to 2.9 meters (7 to 10 feet) with less intense surface fuel models. Within this fire environment there is a low probability of torching and crowning.

FARSITE Comparison of LANDFIRE Fuel Characteristics Versions

LF 2001 and LF 2008 data sets were able to emulate a large portion of the Wallow Fire spread of June 2, 2011, whereas LF National was deficient. As has been the case in other analyses, the surface fuel models are comparable, but the CBH in LF National does not allow for sufficient torching and crown fire spread in these conditions.

The fire spread simulations for LF 2001 and LF 2008 show that these .LCP files within FARSITE can produce suitable results in extreme fire conditions, such as those at the Wallow Fire, provided the analyst knows the limitations of the model and adjusts the model inputs accordingly. Some editing of fuel characteristics could be required for areas that have anomalous fuel characteristics that require the model inputs to be exaggerated (i.e. TL3 in the Northeast section of the simulation). In this particular case the occurrence of TL3 in LF 2001 and LF 2008 appear to be anomalous, which has to do with a ruleset within the LF mapping procedures where medium cover range provides less fire behavior than either the open or closed condition. In EVT 2052, when LF 2001 was instituted with new CC and CH, many of the pixels that had been in either open cover (10 to 39% FBFM TL8) or closed cover (60 to 90% FBFM TL5) shifted to a more medium cover (40 to 59% FBFM TL3).

Fuel treatments are shown in the simulation to have an effect on final fire extent. The Southeast perimeter fuel treatments in the LF 2008 simulation for June 2, 2011 decreases the simulated fire spread considerably from the LF 2001 simulation. The LF 2001 simulation shows the fire spreading to the community of Alpine, AZ and beyond, whereas the fire spread barely makes it through the treated area in LF 2008 (with the same inputs).

A separate simulation ignited past the TL3 (183) fuel model area for the Northeast perimeter treatment area is displayed in Figure 29. This projection takes into account the winds on the morning of June 3, 2011 (lighter wind speeds than those of the run of June 2) and is within the time frame stated in the USFS report when the crown fire encroached on the fuels treatment area on the NE perimeter. The simulation burn period ran from 1200 to 1700 hrs, and the winds ranged from 15 to 20 mph. The depiction shows the fire reaching the fuels treated area by 1300 and burns irregularly within the treatment area but does not burn to the other side by the end of the burn period at 1700 hrs. Ignition frequency in spotting activity was at 0.8% rather than 0.9% in the previous simulations due to a considerable lessening in the wind speeds.

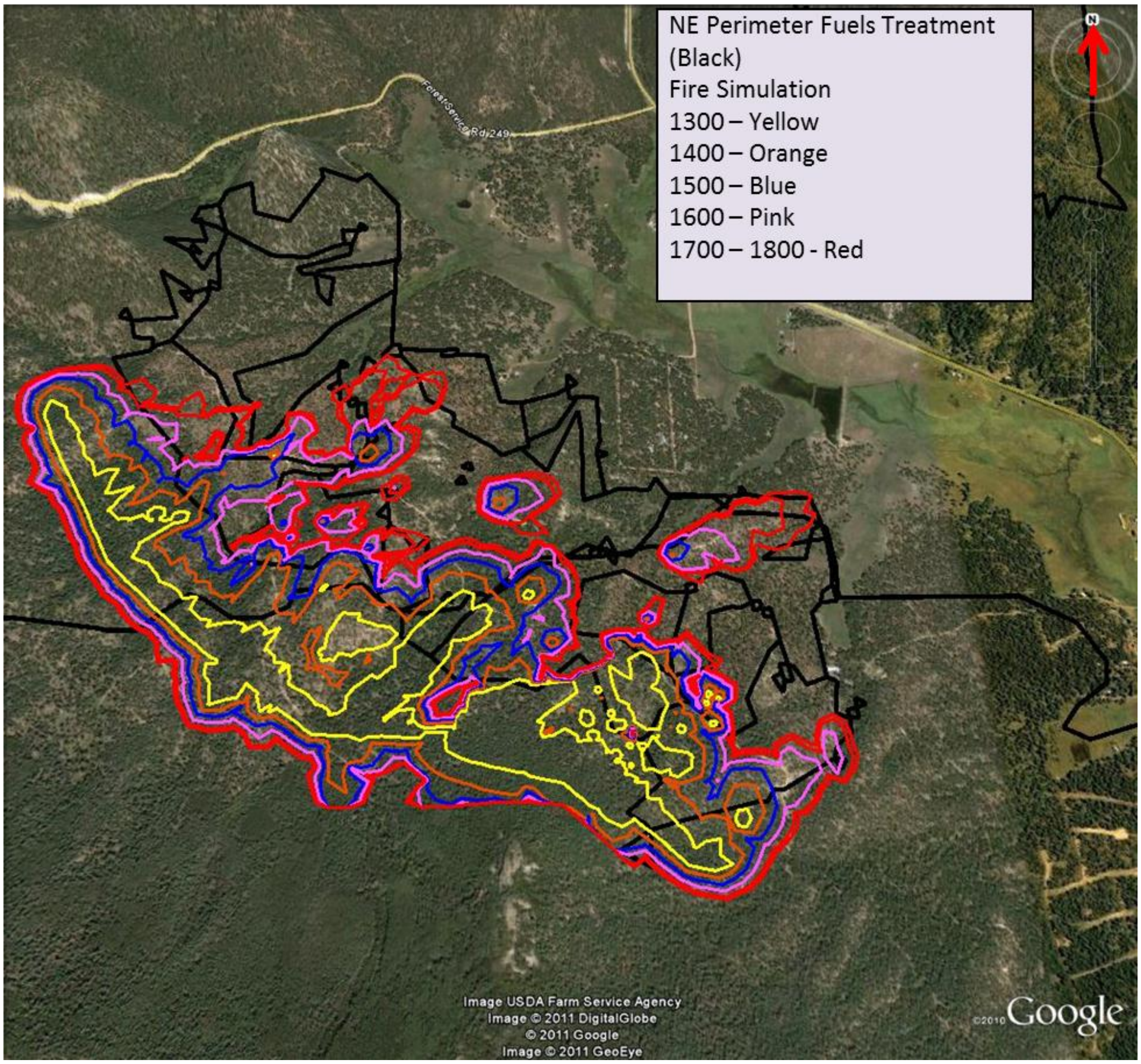

Figure 29 – LF 2008 fire simulation of northeast perimeter fuels treatment area near Alpine, AZ. This simulation shows a decrease in fire spread on June 3, 2011 due to the reduction in the fuel characteristics as a result of the fuels treatment. The simulation is nearly two miles measured northwest to southeast.

3.2 Thomas Fire, 2007

The Thomas Fire occurred within map zone 12 in North Central Nevada, southeast of Winnemucca on July 6, 2007. The fire burned to its final extent by July 11, 2007. Suppression actions on this fire are unknown, but wildland urban interface areas, ridgelines, and fuel type changes are prominent features of the landscape serving as boundaries of the final fire size. These patterns indicate that suppression actions and/or burning to those boundaries was the likely cause of the final fire extent particularly on the west and north sides. NFDRS ERC figures show the area at the 90th percentile in fuel dryness over a ten year average. Rapid surface fire spread with spotting was the suspected fire activity for the Thomas Fire. Some torching may have occurred where Juniper trees existed.

The vegetation for this site is characterized by LANDFIRE as predominately:

- Mountain Basin Big Sage (EVT 2080) and Introduced Upland Vegetation – Annual Grassland (2181), on the west aspect of the fire area and the assumed origin area. They comprise approximately 65% of the fire and surrounding area.
- Great Basin Xeric Mixed Sagebrush Shrubland (2079), Inter- Mountain Basin Big Sagebrush Steppe (2125), and Great Basin Pinyon- Juniper Woodland (2019) were found along the ridge and on the east aspect, of the fire area. They comprise most of the rest of the fire area (35%).

The IR map taken on July 10, 2007 at 2305 hrs is the first available observation of the fire spread from the evening of July 6, 2007 through July 8, 2007 (see progression map below). This evaluation will focus on the fire spread on July 6, 2007 through July 8, 2007.

3.2.1 Inputs

Weather, wind, and fuel moisture data used in the fire simulation was primarily from the Saird RAWS, just to the north of the fire site. Data from the Morey Creek RAWS was used to check or verify the weather data for the area for the days of the fire, but was not used for analysis due to its short weather history. The Saird RAWS values from July 3, 2007 through July 8, 2007 were used for fuel moisture, temperature, and relative humidity. The 20 foot, 10-minute average wind speed and direction were used directly from Saird RAWS by the model for the projection across all 3 versions of LF fuel data.

Surface fuel models (FBFM40) in LF National were predominantly:

- Shrub (SH) SH5 (145) in EVT 2080 and Grass (GR) GR2 (102) in EVT 2181 which reside on the west and north aspects of the fire and origin area accounting for 65% of the vicinity.
- Grass-shrub (GS) GS2 (122) in EVT 2019 and SH2 (142) in EVT 2079 were on the ridges and east side of the fire area represent most of the remaining area.
- There were insignificant areas of GS 1 (121) and TL3 (183) within the same EVT's within the fire perimeter and the surrounding area.

Although CBH is not a dominate feature in terms of fire behavior characteristics within these vegetation types, there are a few recorded in EVT 2019, but they are very low (0.2m). Surface fuel models (FBFM40) and CBH in LF 2001 are very similar to LF National.

A simulation window from July 6, 2007 at 1700 hrs through the burn period of July 8, 2007 was used to compare with the perimeter in the fire progression map. A fuel moisture conditioning period from July 3, 2007 to time of ignition was used with a maximum burn period from 1100 to 1800. The spotting frequency of 0.3%, and Scott and Reinhardt crown fire method were used as simulation inputs. A barrier file was created for the west and northern portions of the fire perimeter to emulate probable suppression activities along the urban interface boundary. The dark green area in Figure 30 is the fire spread from July 6, 2007 through July 8, 2007 that will be compared to the simulation in the versions of the LF fuels data.

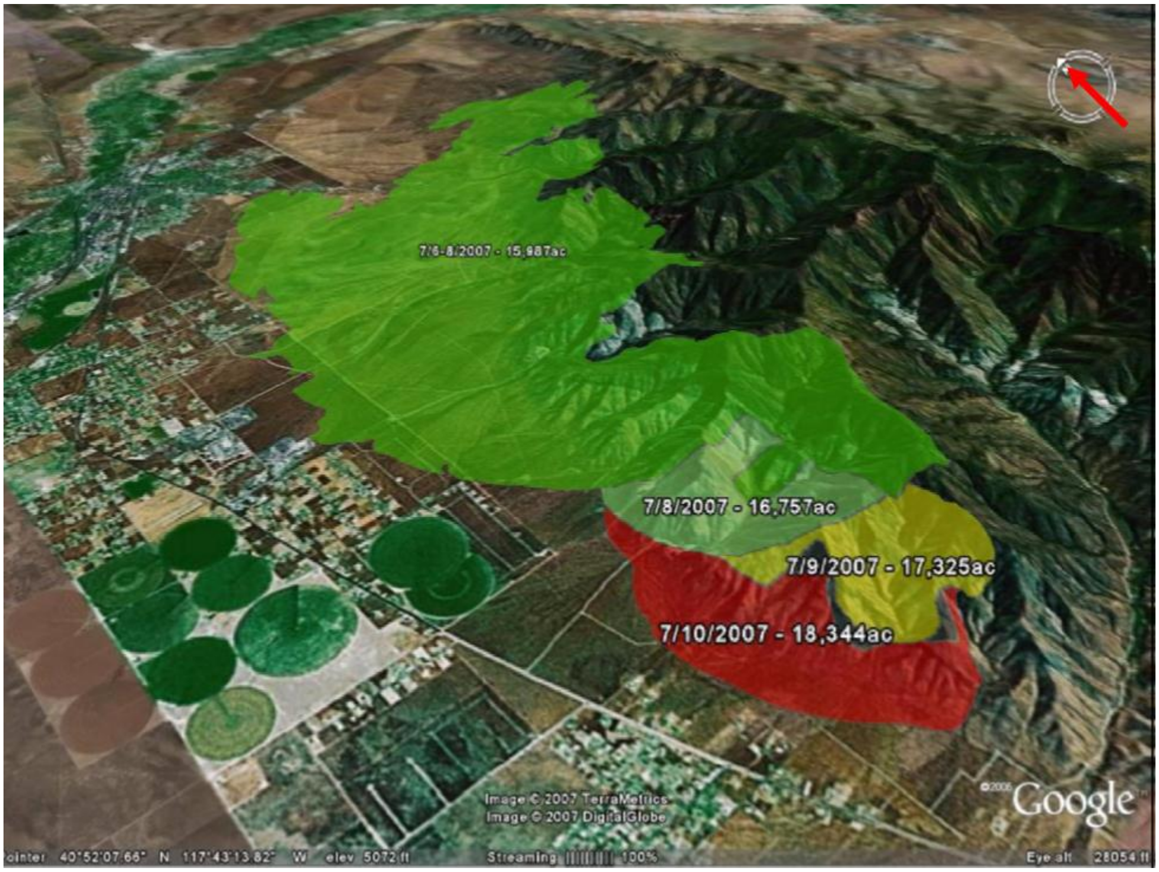

Figure 30 – Thomas Fire Progression from July 6, 2007-July 8, 2007 in green, with July, 9, 2007 fire spread in yellow, and July 10, 2007 in red. The Thomas Fire occurred southeast of Winnemucca, NV. The fire extended nearly 11 miles from northeast to southwest.

3.2.2 Results

As displayed in Figure 31, LF National data overestimated the fire spread compared to the actual perimeter, without the barrier file in place, the simulation would have been approximately twice the size of the actual fire. Even with the barrier on the north side of the perimeter the simulated fire wraps around it and spreads north. The simulation also spreads past the fire extent for July 9, 2007, and July 10, 2007 in the south.

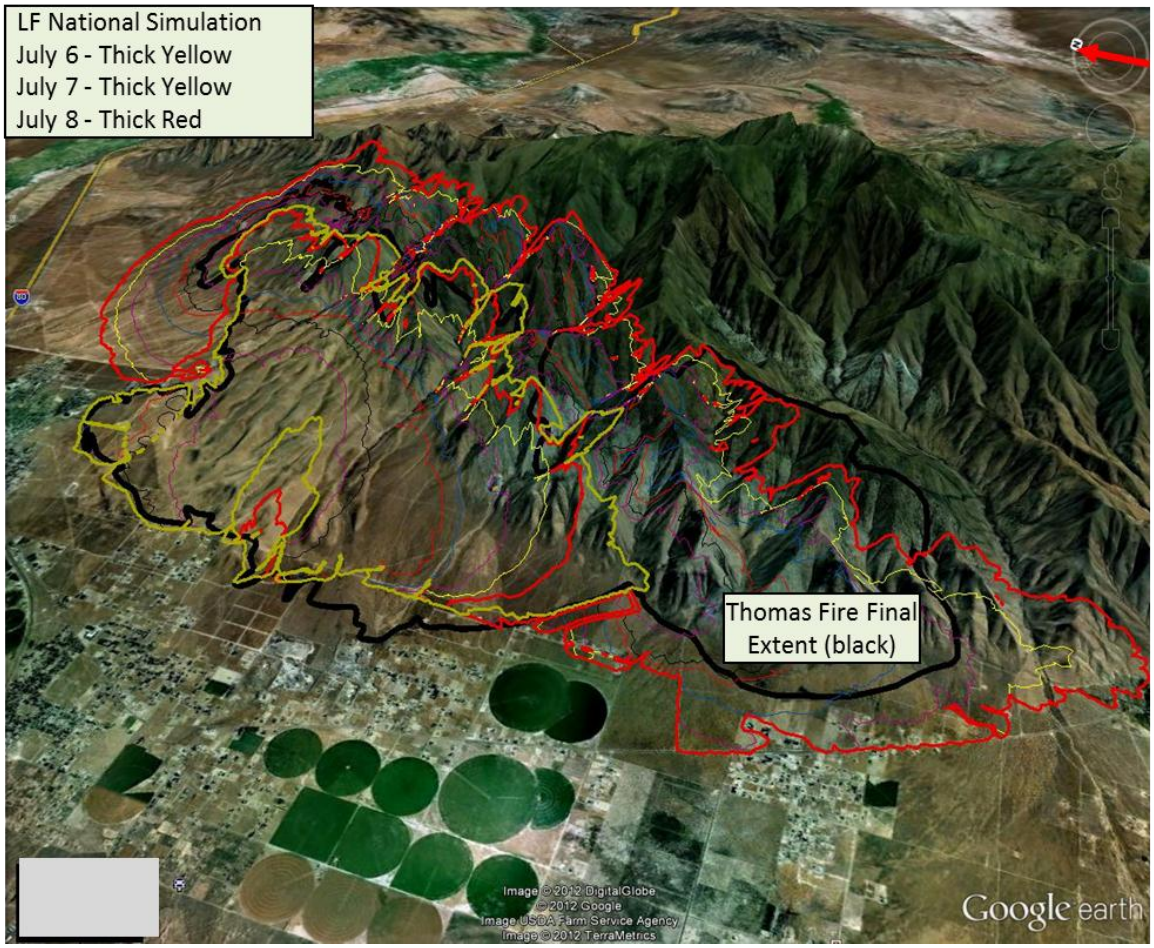

Figure 31 – LF National data Fire Simulation of the Thomas Fire outlined in black. The simulation (lines of yellow and red) was approximately twice the size of the actual fire even with a modeled barrier included on the north side of the perimeter. The fire extended nearly 11 miles from northeast to southwest.

LF 2001 fuels layers provided much the same fire spread (Figure 32) for the same time window and burn period input as LF National. The depiction in Figure 32 below shows the final extent of the simulation for both LF National and LF 2001 with the fire's final extent imposed over the simulated fire spread. The barriers, which were used in the simulation, were emphasized in the depiction.

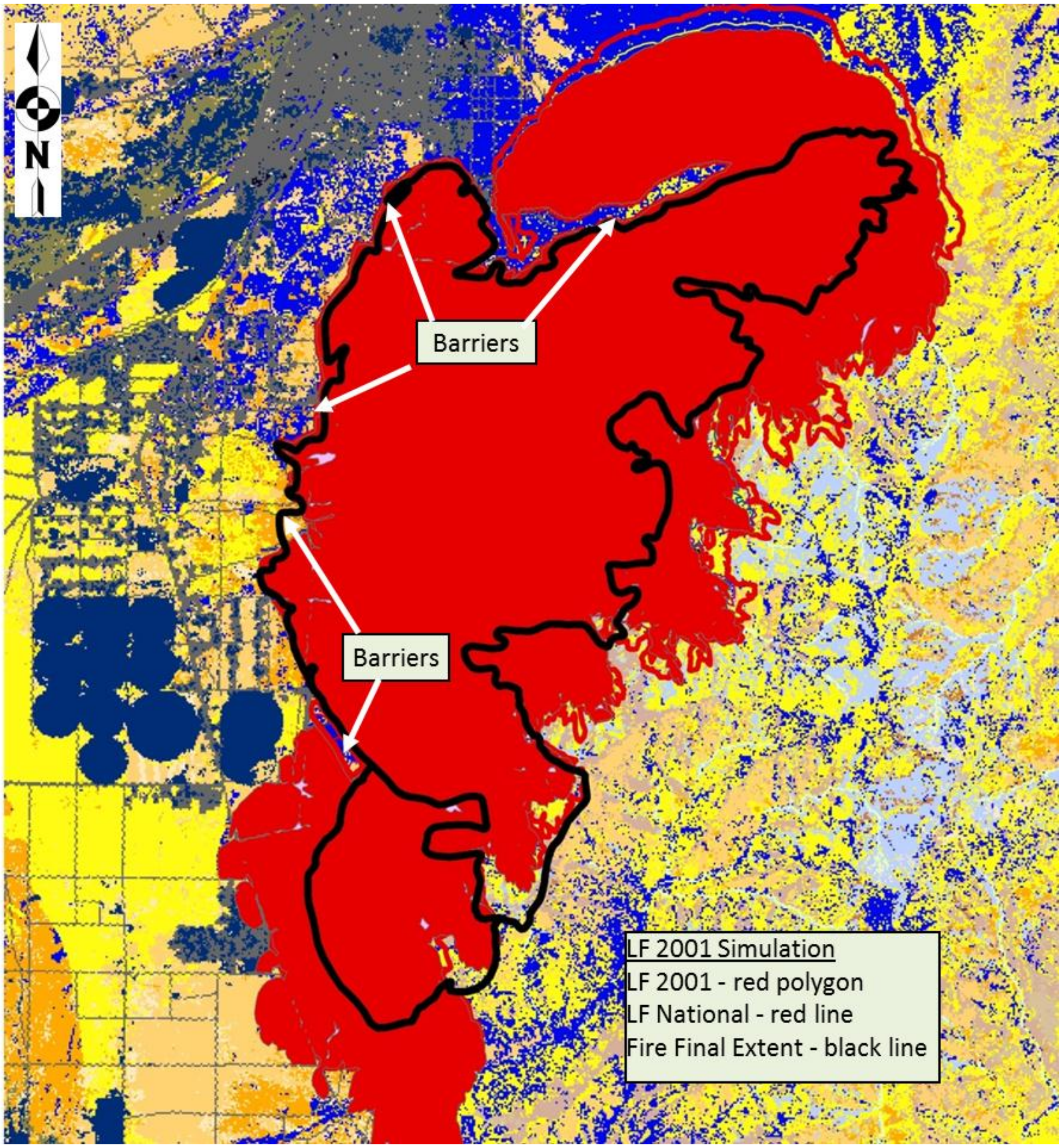

Figure 32 – LF 2001 data depicting the Thomas Fire spread on July 6, 2007 through July 8, 2007 compared to final extent. Modeled barriers were included within the simulation on the north side of the perimeter of the fire but even with the barrier on the north side of the perimeter the simulated fire wraps around it and spreads north. Both LF National and LF 2001 data sets produced similar extents as noted with the red lines and red polygon. The fire extended nearly 11 miles from northeast to southwest.

LF 2008 (Figure 33) is a simulation of the site after the Thomas Fire event. The FBFM40 transitioned from shrub, in many instances, to herbaceous for the first time step post disturbance (1 to 5 years). Some areas transitioned to a sparse grass model GR1 (101) and much of the Mountain Basin Big Sage that had been an SH5 (145) prior to the fire transitioned to a moderate load herbaceous GR2 (102). All environmental conditions and model settings remain the same as the LF National and LF 2001 simulations.

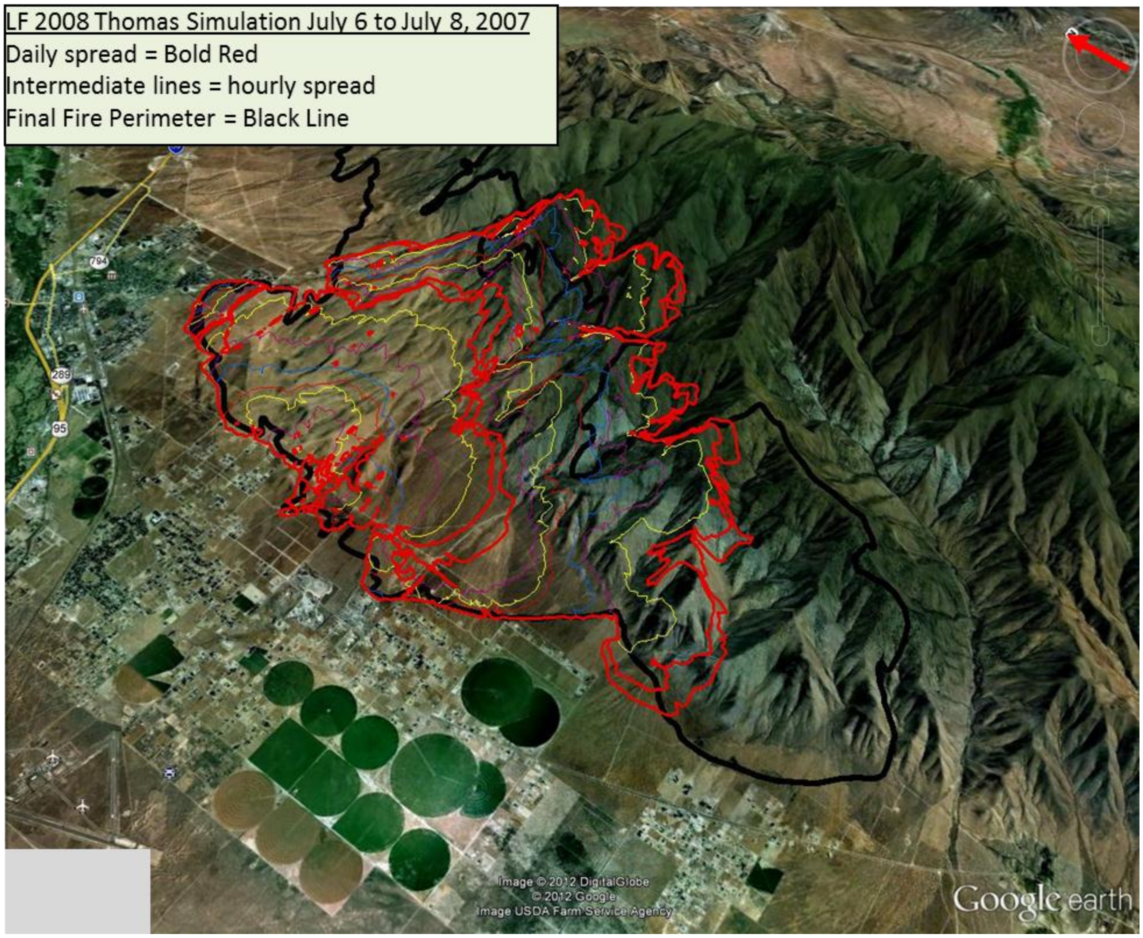

Figure 33 - LF 2008 fire simulation of the landscape after the occurrence of the Thomas Fire near Winnemucca, NV. Vegetation for this site was transitioned from shrub to herbaceous in many cases. This example provides a reasonable representation of a site that has experienced a recent fire in Great Basin fuels and how a fire may react given the disturbance and new growth in the area. The fire extended nearly 11 miles from northeast to southwest.

The FBFM40 SH5 (145) model over predicts fire spread in dry conditions with light winds for the Mountain Basin Big Sage (EVT 2080). The aggressive start that the simulated fire gets with this fuel model causes the fire to far surpass the actual boundary in LF National and LF 2001 as depicted in Figure 31 and Figure 32. The final extent of the simulated fire progression wraps completely around the barriers and burns back through into the urban areas in the SH5 (145) fuel model on the northern and southern portions of the perimeter. Of the fuel models in the fire site, GS2 (122) seems to react, in terms of rate of spread, closest to the actual fire progression. LF 2008 fuels seem to be reasonable for a site with a recent fire in Great Basin fuels as shown in Figure 33.

4.0 LF 2001/2008 Organization

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5.0 Disclaimers

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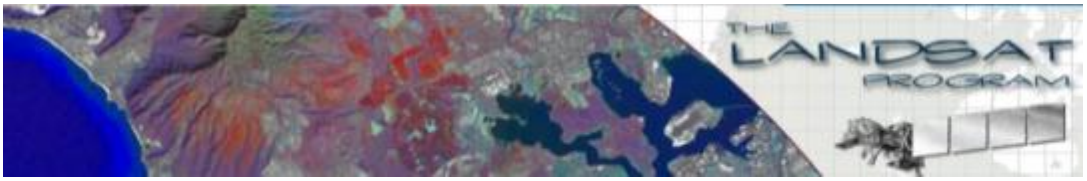
These data and related graphics (such as ".gif" or ".jpg" file formats) are not legal documents and are not intended to be used as such. Users take full responsibility for their applications of these data. It is the sole responsibility and obligation of the user to determine whether the data are suitable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

6.5 Writers, Contributors and Technical Editors

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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—An 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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