LANDFIRE 2001 and 2008 Refresh

Geographic Area Report

Pacific Northwest

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 (or) management. In addition, changes caused by insects and disease, storms, invasive plants, and other natural or anthropogenic events were incorporated when data were available. This report describes the LANDFIRE 2001/2008 Refresh effort to update existing map layers to reflect more current conditions, focusing primarily on vegetation changes. The effort incorporated user feedback and new data, producing two comprehensive Refresh data product sets:

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

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

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

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1.0 Introduction

1.1 LANDFIRE Program

LANDFIRE (LF), also known as Landscape Fire and Resource Management Planning Tools, is a joint program between the wildland fire management programs of the United States Department of Agriculture (USDA) Forest Service (USFS) and the United States Department of the Interior (DOI), including the following bureaus: the United States Geological Survey (USGS), the Bureau of Indian Affairs, 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 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. 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 at the landscape scale 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 data 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 data were available. LF 2008 used Landsat imagery, an events database, a collection of recent natural disturbance and land management activities used to update existing vegetation and fuel layers, which were then used to update other LF data products. LF 2008 focused on the years from 1999 to 2008, incorporated new vegetation and disturbance imagery from 1999 - 2008. LF 2008 did not use new imagery across the entire landscape but focused rather on areas that experienced a 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.

Eight 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 geographic areas were not intended to represent standardized analysis units or reporting extents. The primary purpose of the geographic areas and mapping zones was to define ecologically relevant divisions for data acquisition and production planning.

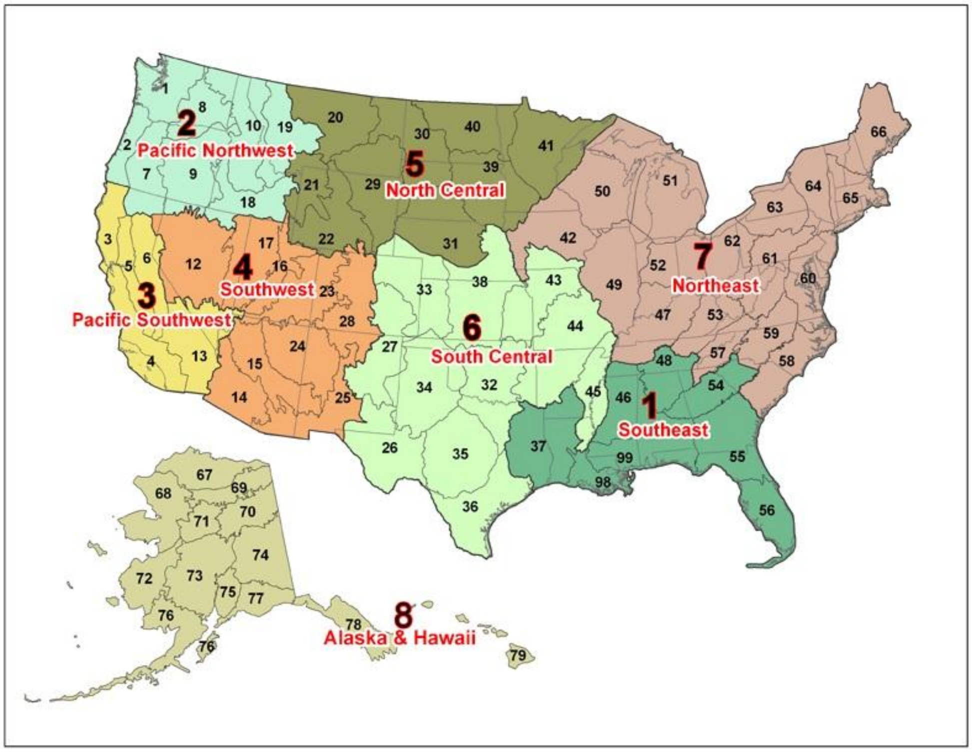

Figure 1 – Map of LF 2001/2008 GeoAreas. This image shows the eight GeoArea boundaries, which are comprised of NLCD2001 mapping zones (numbered units), and state boundaries. GeoArea numbers and corresponding colors relate to the schedule in Table 1 below.

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

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

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

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

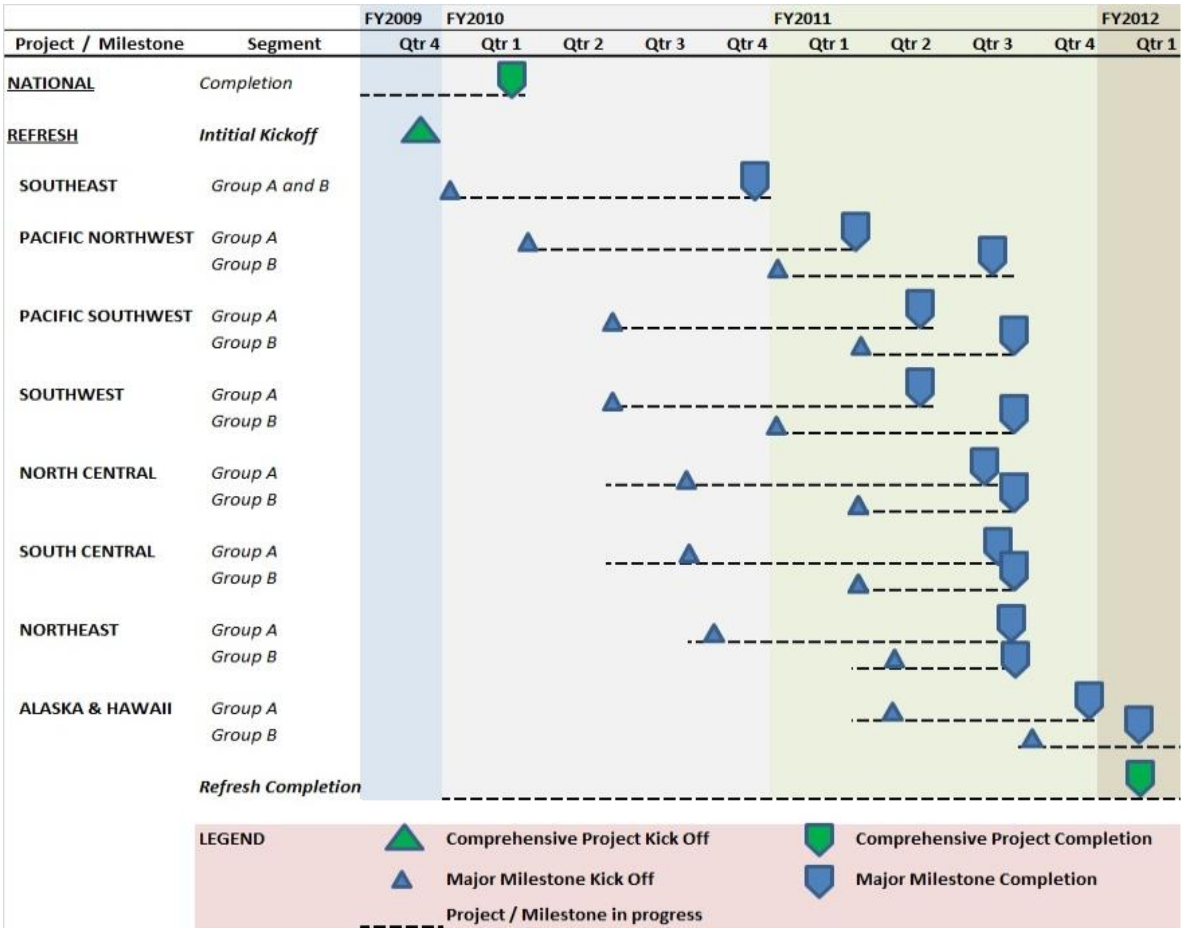

Figure 2 – LF 2001/2008 Gantt chart. This is a summary display of the actual results of the start and finish dates of the milestones and segments [such as GeoAreas and Group A and Group B products]. These milestones and segments comprise the WBS discussed in Section 1.4.

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 eight GeoAreas as represented above 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 & Hawaii	3rd Qtr 2011	4th Qtr 2011

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

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

2.0 LANDFIRE 2001 and 2008 Methods and Results

2.1 Geographic Area Description

The Pacific Northwest (PNW) GeoArea consists of eight mapping zones encompassing Oregon, Washington, Idaho, and parts of Montana, California, Utah and Nevada and covers 201,089,594 acres. The mapping zones within the PNW GeoArea are listed in Table 3.

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

Table 3. Pacific Northwest GeoArea Mapping Zones	
Mapping Zone	**Mapping Zone Name**
1	Northern Cascades
2	Oregon Coastal Range
7	Cascade Mountain Range
8	Grand Coulee Basin of the Columbia Plateau
9	Blue Mountain Region
10	Northwestern Rocky Mountains
18	Snake River Plain
19	Northern Rocky Mountains

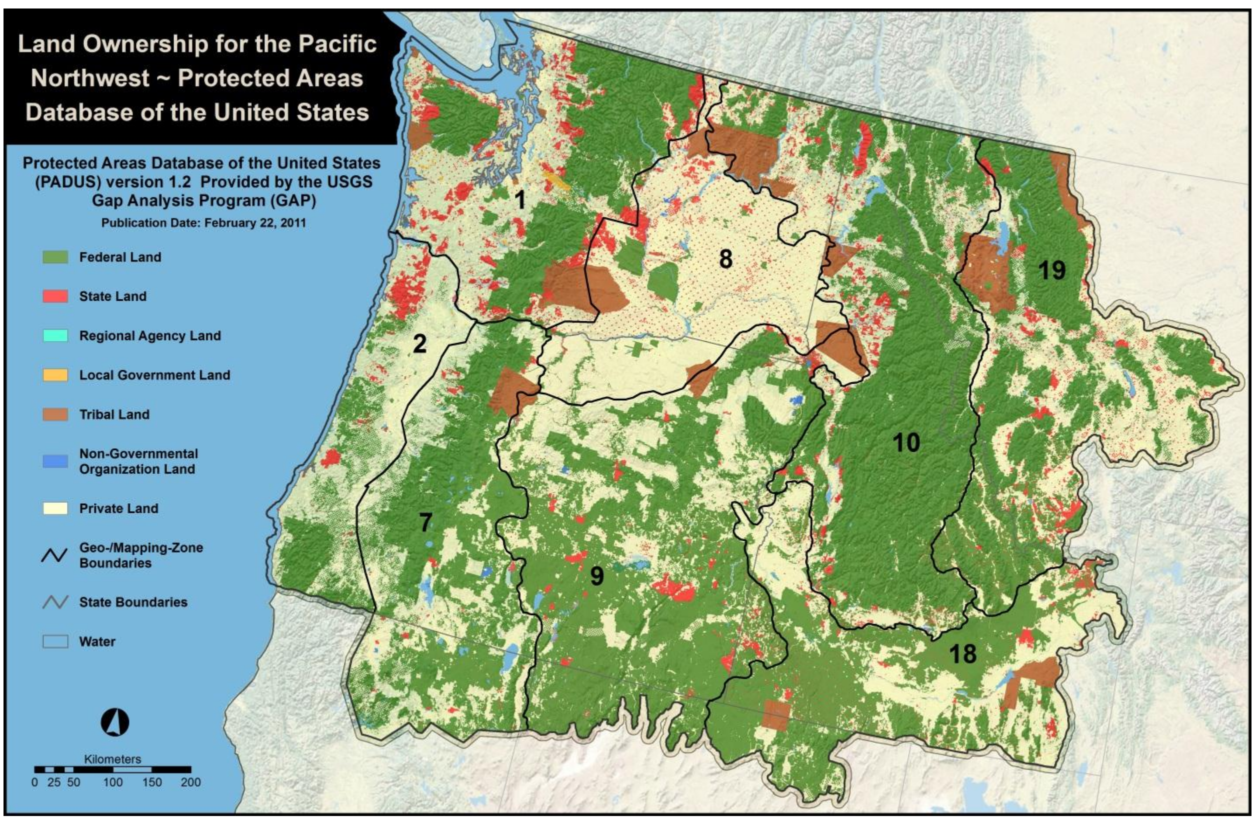

Figure 3– Land ownership categories for the PNW GeoArea.

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 PNW 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 PNW GeoArea.

Table 4. Acreage of Land Ownership Categories for the PNW GeoArea.		
Land Ownership	**Acres**	**% of total GeoArea**
Federal Land	101,379,836	50
State Land	8,609,665	4
Regional Agency Land	371,781	1
Local Government Land	20,650	1
Tribal Land	6,769,373	3
Non-governmental	3,521,469	2
Private Land	79,094,119	38
Water	1,322,701	1
Total	201,089,594	100

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 (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 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 PNW 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 PNW GeoArea, a LFRDB (Microsoft Access© database) for the PNW GeoArea, and documentation of data conversion processes and QC measures taken during the data-loading stages.

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

- 142,940 geo-referenced sampling events were contained within the PNW LFRDB.
- 133 different sources of data were contributed by federal, state, and private entities.
- 40% of data were submitted in response to the LF data call (http://www.landfire.gov/participate_refdata.php) and 60% 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

- 6,438 Forest Inventory and Analysis (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 PNW LFRDB from data sharing agreements, websites, and/or agency databases. Data contributions submitted in response to the data call were also important, accounting for 40% of the sampling events. Major data contributions can be accredited to the USFS, multi-agency data sources, and the USGS. Table 5 shows a breakdown of the data contribution profile for the PNW LFRDB.

Table 5– Data contribution profile for the PNW LFRDB.

Table 5. PNW LANDFIRE Reference Database Data Contributions	
Data Contribution Profile	**Percent**
USFS	58.5
Multi-agency	12.6
BLM	12.3
State	9.4
USGS	3.5
Non-Government Organization / Private	2.0
Tribal	0.7
USFWS	0.6
Department of Defense	0.2
Department of Energy	0.1
NPS	0.1
Total	100.0

For LF 2001/2008, the LFRDB team acquired and incorporated additional data to the existing LFRDB to facilitate the improvement and update of several LF data products. Data provided by FIA contain a complete set of attributes necessary for updating LF products, so efforts were focused on converting and adding these data. During LF 2001/2008, several improvements were made to FIA data processing procedures, including updates to the way forest canopy cover and height metrics were derived and improvements to the LFRDB database schema that allowed for the archiving of repeat measures. There were 4,714 new FIA sampling events added to the PNW LFRDB for LF 2001/2008. The PNW 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 PNW 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 PNW LFRDB.

Table 6. PNW LANDFIRE Reference Database Plot Summary	
Data Type	**Percent***
Community Occurrence Records	3
Species Composition	75
Structure	35
Exotics	17
Fuel	24

**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 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 Databases (MTDBs) for each mapping zone. Model Tracker Data Base (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 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 [MFRI, PLS, PMS, PRS, and 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 Class (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 (Barrett et. al 2010), as displayed in Table 7 and Table 8 showing the comparisons between LF National and LF 2001.

Table 7– The FRG 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**
1	0-35	PRS < 75
2	0-35	PRS >= 75
3	35-200	PRS < 75
4	35-200	PRS >= 75
5	200+	all

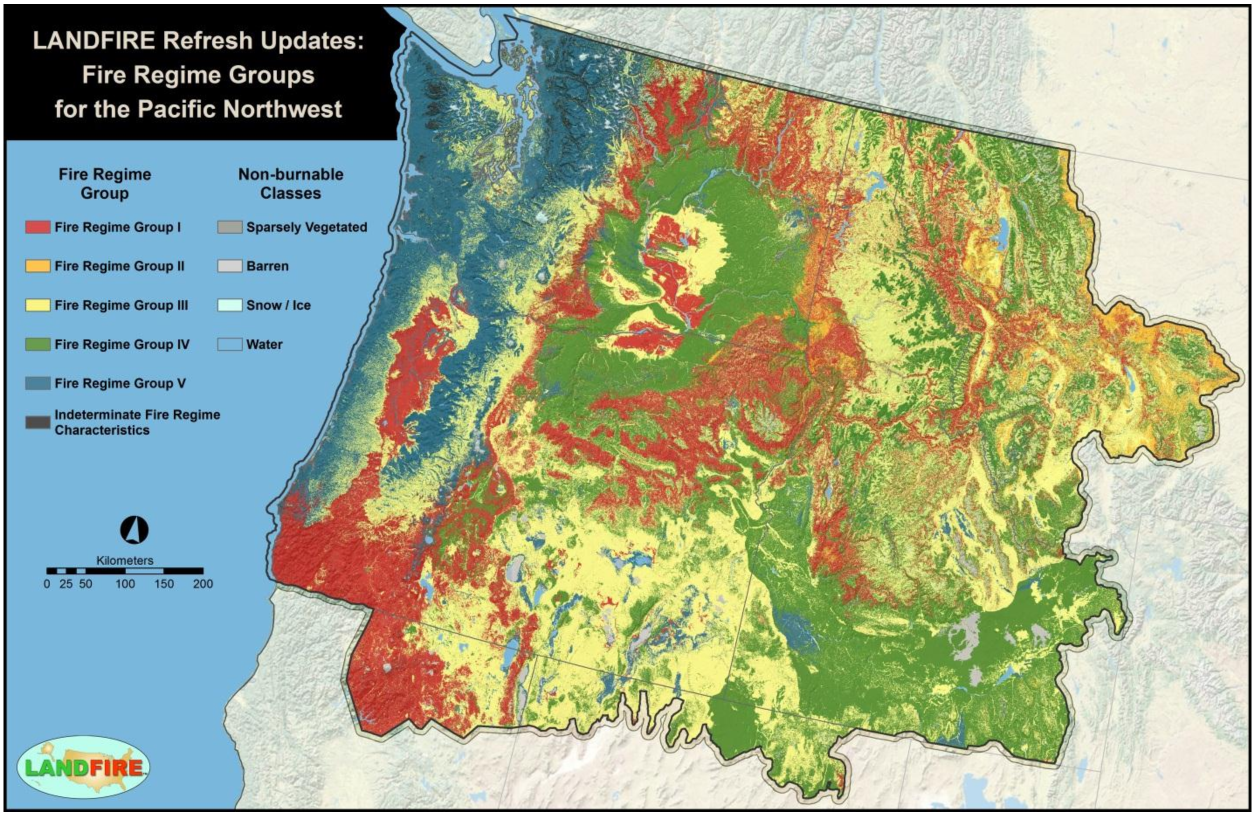

Figure 4 – Map of the PNW landscape depicting LF FRG in the absence of modern human intervention with possible aboriginal fire use.

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

Table 8. Fire Regime Group Comparison			
Fire Regime Group Name	LF National (acres)	LF 2001 (acres)	Percent Change
FRG I	21,382,026	37,624,226	76.0
FRG II	4,527,850	4,397,052	-2.9
FRG III	90,602,603	70,584,567	-22.1
FRG IV	46,154,850	54,421,911	17.9
FRG V	25,095,041	23,842,258	-5.0
Water	5,437,090	5,267,366	-3.1
Snow / Ice	181,576	190,343	4.8
Barren	3,010,403	2,626,577	-12.7
Sparsely Vegetated	343,256	279,256	-18.6
Indeterminate Fire Regime	4,352,327	1,856,042	-57.4

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). This process includes multiple data sources and processes, including remotely sensed imagery, 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 image pairs. 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 time series of Landsat data in order to identify landscape changes. VCT data were developed for each year identifying disturbed areas as well as disturbance severity. Severity was determined from the Landsat image pair by using the differenced Normalized Burn Ratio (dNBR) data 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 Area Database (PAD; http://www.protectedlands.net/padus/). PAD 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. PADUS 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.

LANDFIRE 2001 and 2008 Methods and Results

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 (VDist2008) 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

As mentioned earlier, severity was determined in the disturbance mapping process by using dNBR classified into high, medium, and low severity levels based on a statistical comparison with the MTBS, BARC, and RAVG fire data. 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 PNW GeoArea (Table 9). Across all lands, almost 12 percent of the GeoArea was disturbed from 1999 to 2008, leaving 88 percent undisturbed. On federal lands, almost 17 percent of the GeoArea was disturbed, leaving 83 percent undisturbed.

Table 9 – Categories of land ownership divided between areas with and without disturbance with associated percentages of ownership for the PNW GeoArea and acres.

Table 9. Disturbance Acreage by Land Ownership			
Land Ownership	**Category**	**Acres**	**Percent Ownership**
All Lands	No Disturbance	177,474,878	88.3
All Lands	All Disturbances	23,614,716	11.7
Federal Lands	No Disturbance	84,642,620	83.5
Federal Lands	All Disturbances	16,737,216	16.5

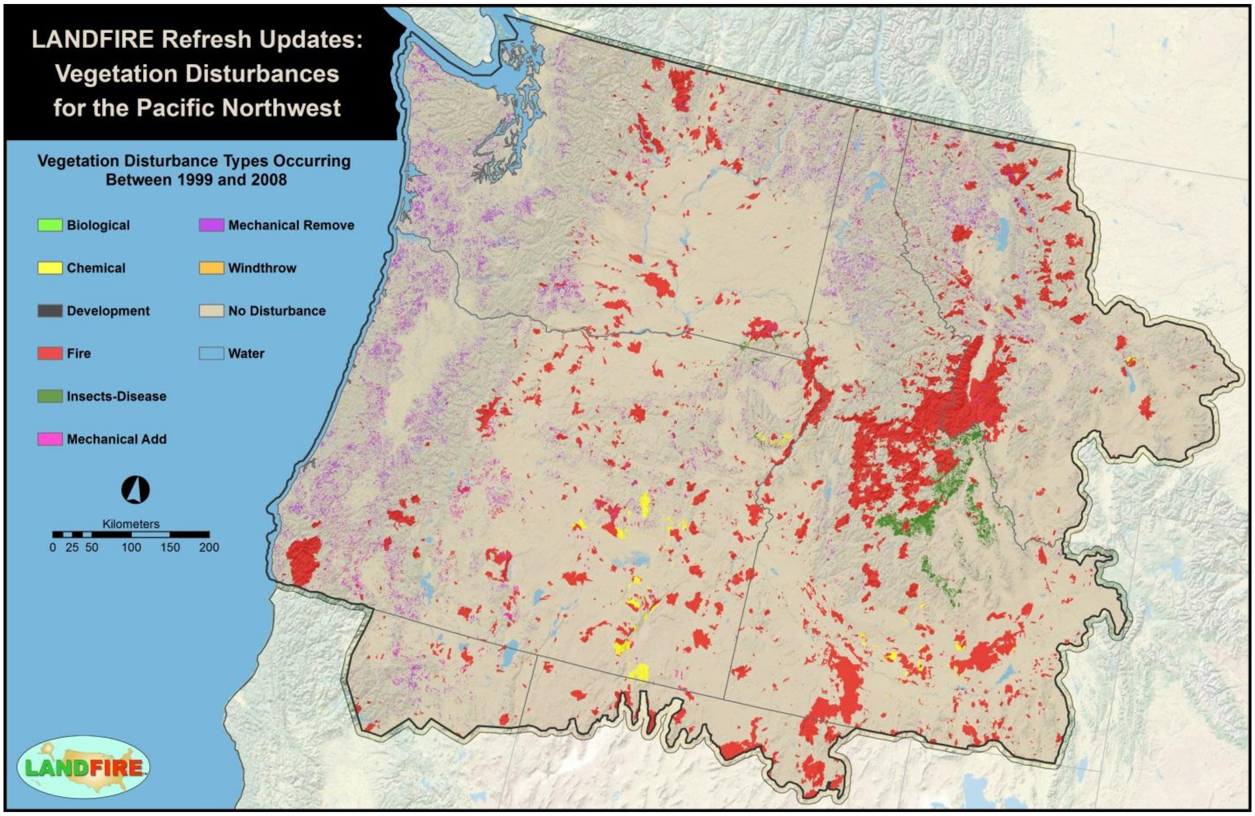

Figure 5 – Map of vegetation disturbance types (fire, mechanical, etc.) for the PNW GeoArea from 1999 to 2008.

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 PNW GeoArea.

Table 10. Area Affected by Fire Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Fire	Low	One Year	520,756
All Lands	Fire	Low	Two to Five Years	4,938,388
All Lands	Fire	Low	Six to Ten Years	5,690,095
All Lands	Fire	Moderate	One Year	146,173
All Lands	Fire	Moderate	Two to Five Years	1,813,920
All Lands	Fire	Moderate	Six to Ten Years	1,536,782
All Lands	Fire	High	One Year	64,113
All Lands	Fire	High	Two to Five Years	1,081,835
All Lands	Fire	High	Six to Ten Years	1,024,026
Federal Lands	Fire	Low	One Year	335,161
Federal Lands	Fire	Low	Two to Ten Years	315,186
Federal Lands	Fire	Low	One Year	9,034
Federal Lands	Fire	Moderate	One Year	86,391
Federal Lands	Fire	Moderate	Two to Ten Years	26,443
Federal Lands	Fire	High	One Year	4,538
Federal Lands	Fire	High	One Year	52,161
Federal Lands	Fire	High	Two to Ten Years	6,309
Federal Lands	Fire	Low	One Year	60,964

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

Table 11. Area Affected by Mechanical Add Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Mechanical Add	Low	One Year	65,673
All Lands	Mechanical Add	Low	Two to Five Years	426,818
All Lands	Mechanical Add	Low	Six to Ten Years	369,015
All Lands	Mechanical Add	Moderate	One Year	11,855
All Lands	Mechanical Add	Moderate	Two to Five Years	51,409
All Lands	Mechanical Add	Moderate	Six to Ten Years	42,487
All Lands	Mechanical Add	High	One Year	6,300
All Lands	Mechanical Add	High	Two to Five Years	25,716
All Lands	Mechanical Add	High	Six to Ten Years	22,138
Federal Lands	Mechanical Add	Low	One Year	54,184
Federal Lands	Mechanical Add	Low	Two to Five Years	369,275
Federal Lands	Mechanical Add	Low	Six to Ten Years	315,186
Federal Lands	Mechanical Add	Moderate	One Year	9,034
Federal Lands	Mechanical Add	Moderate	Two to Five Years	37,540
Federal Lands	Mechanical Add	Moderate	Six to Ten Years	26,443
Federal Lands	Mechanical Add	High	One Year	4,538
Federal Lands	Mechanical Add	High	Two to Five Years	14,830
Federal Lands	Mechanical Add	High	Six to Ten Years	6,309

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

Table 12. Area Affected by Mechanical Remove Disturbance				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Mechanical Remove	Low	One Year	219,078
All Lands	Mechanical Remove	Low	Two to Five Years	876,692
All Lands	Mechanical Remove	Low	Six to Ten Years	846,468
All Lands	Mechanical Remove	Moderate	One Year	123,187
All Lands	Mechanical Remove	Moderate	Two to Five Years	456,618
All Lands	Mechanical Remove	Moderate	Six to Ten Years	504,236
All Lands	Mechanical Remove	High	One Year	100,247
All Lands	Mechanical Remove	High	Two to Five Years	448,789
All Lands	Mechanical Remove	High	Six to Ten Years	499,690
Federal Lands	Mechanical Remove	Low	One Year	60,964
Federal Lands	Mechanical Remove	Low	Two to Five Years	263,008
Federal Lands	Mechanical Remove	Low	Six to Ten Years	257,096
Federal Lands	Mechanical Remove	Moderate	One Year	29,369
Federal Lands	Mechanical Remove	Moderate	Two to Five Years	106,698
Federal Lands	Mechanical Remove	Moderate	Six to Ten Years	111,308
Federal Lands	Mechanical Remove	High	One Year	17,361
Federal Lands	Mechanical Remove	High	Two to Five Years	57,676
Federal Lands	Mechanical Remove	High	Six to Ten Years	60,205

Table 13 – Number of acres affected by Windthrow and Insects and Disease disturbance by severity classes low, moderate, and high with the period of years since disturbance between All Lands and Federal Land ownership for the PNW GeoArea.

Table 13. Area Affected by Windthrow and Insect/Disease Disturbances				
Land Ownership	**Category**	**Severity**	**Time Since Disturbance**	**Acres**
All Lands	Windthrow	Low	Two to Five Years	4,525
Federal Lands	Windthrow	Low	Two to Five Years	3,321
All Lands	Insects-Disease	Low	One Year	344,940
All Lands	Insects-Disease	Low	Two to Five Years	460,633
All Lands	Insects-Disease	Low	Six to Ten Years	225,209
All Lands	Insects-Disease	Moderate	Two to Five Years	155
All Lands	Insects-Disease	High	Two to Five Years	31
Federal Lands	Insects-Disease	Low	One Year	344,044
Federal Lands	Insects-Disease	Low	Two to Five Years	457,823
Federal Lands	Insects-Disease	Low	Six to Ten Years	220,517
Federal Lands	Insects-Disease	Moderate	Two to Five Years	154
Federal Lands	Insects-Disease	High	Two to Five Years	31

Table 14 – Number of acres affected by Chemical, Biological, and Development disturbances by severity classes low, moderate, and high with the period of years since disturbance between All Lands and Federal Land ownership for the PNW 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	36,884
All Lands	Chemical	Low	Two to Five Years	532,175
All Lands	Chemical	Low	Six to Ten Years	96,636
Federal Lands	Chemical	Low	One Year	34,851
Federal Lands	Chemical	Low	Two to Five Years	407,695
Federal Lands	Chemical	Low	Six to Ten Years	93,947
All Lands	Biological	Low	Two to Five Years	171
All Lands	Biological	Low	Six to Ten Years	194
Federal Lands	Biological	Low	Two to Five Years	171
Federal Lands	Biological	Low	Six to Ten Years	161
All Lands	Development	Low	One Year	37
All Lands	Development	Low	Two to Five Years	339
All Lands	Development	Low	Six to Ten Years	85
All Lands	Development	Moderate	One Year	18
All Lands	Development	Moderate	Two to Five Years	78
All Lands	Development	Moderate	Six to Ten Years	38
All Lands	Development	High	One Year	2
All Lands	Development	High	Two to Five Years	50
All Lands	Development	High	Six to Ten Years	12
Federal Lands	Development	Low	One Year	37
Federal Lands	Development	Low	Two to Five Years	332
Federal Lands	Development	Low	Six to Ten Years	85
Federal Lands	Development	Moderate	One Year	18
Federal Lands	Development	Moderate	Two to Five Years	75
Federal Lands	Development	Moderate	Six to Ten Years	38
Federal Lands	Development	High	One Year	2
Federal Lands	Development	High	Two to Five Years	46
Federal Lands	Development	High	Six to Ten Years	12

2.5 Existing Vegetation

2.5.1 Product Description

The existing vegetation layers for each LF mapping zone include: EVT, EVC, and 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 31 and Table 34 and Table 35 of this report, comparisons are made between the LF National data product and the LF 2001 product and the LF 2001 and the LF 2008 updated products. It is important to note that in the majority of cases, the percent changes between the National and LF 2001 / 2008 are a result of classification and product differences and not actual changes on the ground. LF staff developed a series of steps to improve LF National vegetation data. In addition, problems with the LF National CC documented by Scott (2008) needed to be addressed. Generally, canopy cover 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.

2.5.2a Enhanced 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-use 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, non-land-use classes were reclassified to land-use classes based on the NLCD2001 land cover product. Where NLCD2001 was classified as non-land-use and LF layers were classed land-use, LF data were reclassified to the most dominant non-land-use 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 concerns with burnable agricultural classes, information from the National Agricultural Statistics Survey (NASS; http://www.nass.usda.gov/) and PADUS was incorporated into the LF 2001 EVT layer to improve agricultural mapping. 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. Most revised agricultural classes resulted in burnable fuel models. In order to address urban areas mapped as non-burnable, the NLCD2001 urban classes were remapped. NLCD2001 natural vegetation classes were incorporated by modeling the most commonly occurring NLCD2001 natural vegetation classes which were originally masked out due to proximity to urban areas. Only the urban classes were actually remapped by bringing natural vegetation stringers and pockets back into the map.

In this process, roads were reintroduced using the National Transportation Statistics (http://www.bts.gov/) layer and were classed as non-burnable. Most revised urban classes resulted in burnable fuel models.

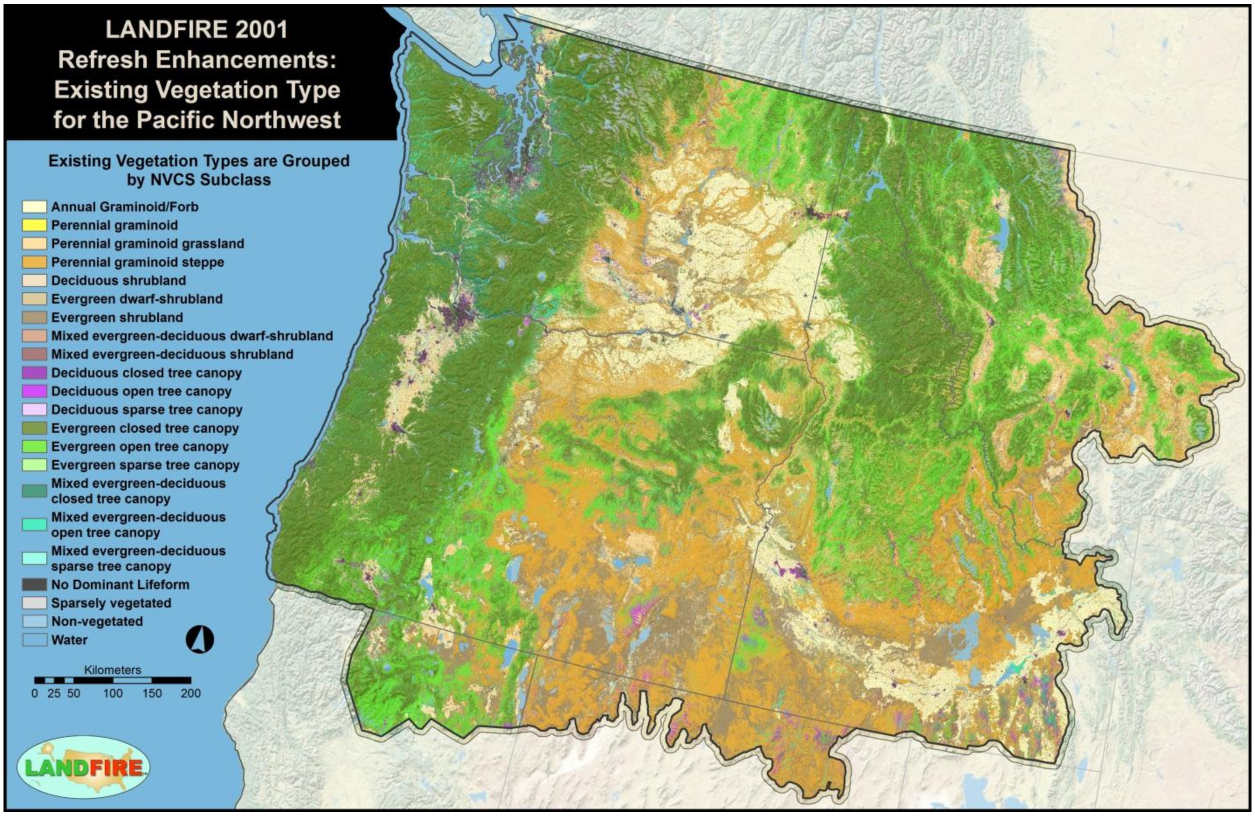

Figure 6 – Map of EVT layer that was enhanced as part of the LF 2001 updates by incorporating user feedback and additional data. This data provided a foundation upon which to update data to 2008.

Table 15 – Acreage of LF agricultural EVT Groups and percent change on All Land ownerships in the PNW 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	10,086,837	3,049,849	-69.8
Agriculture-Fallow	4,255	0	-100.0
Agriculture-General	6,202,463	0	-100.0
Agriculture-Pasture and Hay	4,988,396	4,749,636*	-4.8
Agriculture-Small Grains	20,459	0	-100.0
NASS -Bush Fruit and Berries	0	5,496	100.0
NASS-Close Grown Crop	0	6,328,843	100.0
NASS-Fallow/Idle Cropland	0	1,823,534	100.0
NASS-Orchard	0	138,985	100.0
NASS-Pasture and Hay land	0	910,984*	100.0
NASS-Row Crop	0	2,037,132	100.0
NASS-Row Crop-Close Grown Crop	0	607,446	100.0
NASS-Vineyard	0	69,502*	100.0
NLCD-Herbaceous Semi-dry	0	68,197*	100.0
NLCD-Herbaceous Semi-wet	0	84,106*	100.0

** Denotes burnable vegetation type*

Table 16 – Acreage of LF agricultural EVT Groups and percent change on Federal Land ownership in the PNW 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	96,517	34,809	-63.9
Agriculture-Fallow	62	0	-100.0
Agriculture-General	117,358	0	-100.0
Agriculture-Pasture and Hay	151,458	111,887*	-26.1
Agriculture-Small Grains	218	0	-100.0
NASS -Bush Fruit and Berries	0	34	100.0
NASS-Close Grown Crop	0	32,486	100.0
NASS-Fallow/Idle Cropland	0	3,384	100.0
NASS-Orchard	0	653	100.0
NASS-Pasture and Hayland	0	2,842*	100.0
NASS-Row Crop	0	12,878	100.0
NASS-Row Crop-Close Grown Crop	0	5,036	100.0
NASS-Vineyard	0	176*	100.0
NLCD-Herbaceous Semi-dry	0	41,520*	100.0
NLCD-Herbaceous Semi-wet	0	52,238*	100.0

** Denotes burnable vegetation type*

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

Table 17. Developed Lands Comparisons across All Lands				
Land Ownership	**Existing Vegetation Type Groups**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	Developed-General	567,121	0	-100.0
All Lands	Developed-High Intensity	162,530	116,819	-28.1
All Lands	Developed-Low Intensity	1,116,382	0	-100.0
All Lands	Developed-Medium Intensity	153,794	340,805	121.6
All Lands	Developed-Open Space	956,437	0	-100.0
All Lands	Developed-Roads	0	2,072,909	100.0
All Lands	Developed-Upland Deciduous Forest	0	188,664	100.0
All Lands	Developed-Upland Evergreen Forest	0	437,370	100.0
All Lands	Developed-Upland Herbaceous	0	938,847	100.0
All Lands	Developed-Upland Mixed Forest	0	241,374	100.0
All Lands	Developed-Upland Shrubland	0	511,824	100.0

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

Table 18. Developed Lands Comparisons across Federal Lands				
Land Ownership	**Existing Vegetation Type Groups**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
Federal Lands	Developed-General	24,012	0	-100.0
Federal Lands	Developed-High Intensity	4,971	3,802	-23.5
Federal Lands	Developed-Low Intensity	61,452	0	-100.0
Federal Lands	Developed-Medium Intensity	4,582	13,188	187.8
Federal Lands	Developed-Open Space	95,586	0	-100.0
Federal Lands	Developed-Roads	0	203,004	100.0
Federal Lands	Developed-Upland Deciduous Forest	0	8,171	100.0
Federal Lands	Developed-Upland Evergreen Forest	0	65,487	100.0
Federal Lands	Developed-Upland Herbaceous	0	39,996	100.0
Federal Lands	Developed-Upland Mixed Forest	0	16,410	100.0
Federal Lands	Developed-Upland Shrubland	0	52,230	100.0

Table 19 – Acreage of LF riparian and wetland EVT Groups and percent change in the PNW 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	NLCD-Herbaceous Wetlands	0	1,134,522	100.0
All Lands	Western Riparian Woodland and Shrubland	5,719,774	3,443,491	-39.8
Federal Lands	NLCD-Herbaceous Wetlands	0	218,961	100.0
Federal Lands	Western Riparian Woodland and Shrubland	2,470,967	1,424,912	-42.3

Table 20 – Acreage of LF barren EVT Groups and percent change in the PNW 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	3,010,403	2,626,464	-12.8
Federal Lands	Barren	2,525,451	2,046,764	-19.0

Table 21 – Acreage of LF water EVT Groups and percent change in the PNW 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	5,437,090	5,267,219	-3.1
Federal Lands	Open Water	347,736	332,567	-4.4

2.5.2b Enhancements to Existing Vegetation Cover

EVC was updated 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 (DEM) and derivatives (slope and aspect). EDNA is a multi-layered database derived from a version of the National Elevation Dataset (NED), 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 the 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.

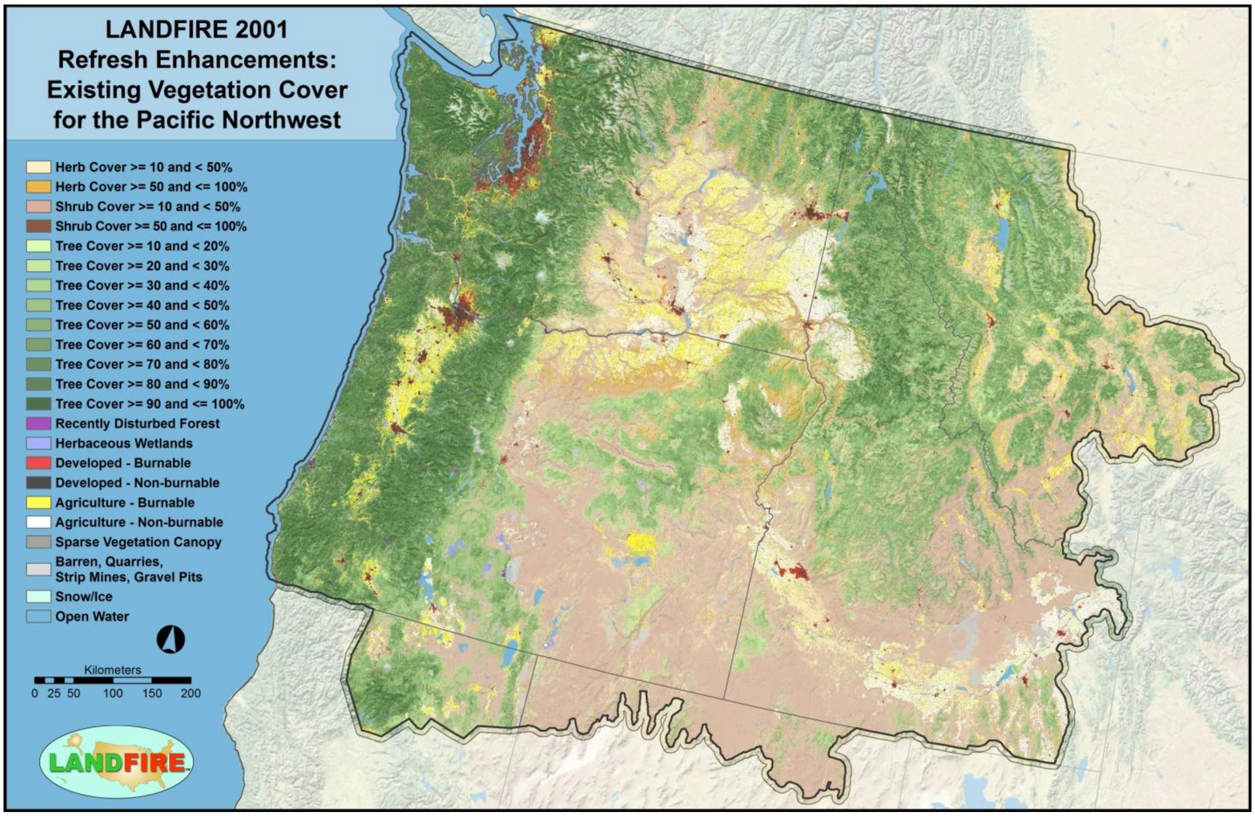

Figure 7 – Map of EVC layer that was enhanced as part of the LF 2001 update by incorporating user feedback and additional data. This data provided a foundation upon which to update data to 2008.

Table 22 – Acreage of LF CC classes and percent change in the PNW GeoArea by ownership categories.

Table 22. Tree Cover Comparison				
Land Ownership	**Percent Tree Cover**	**National (acres)**	**LF 2001 (acres)**	**Percent Change**
All Lands	>= 10 and < 20	6,168,565	7,304,491	18.4
All Lands	>= 20 and < 30	6,482,857	10,601,648	63.5
All Lands	>= 30 and < 40	7,174,173	15,106,615	110.6
All Lands	>= 40 and < 50	7,556,562	18,274,644	141.8
All Lands	>= 50 and < 60	7,869,952	12,631,431	60.5
All Lands	>= 60 and < 70	8,521,561	11,286,042	32.4
All Lands	>= 70 and < 80	10,468,237	13,500,664	29.0
All Lands	>= 80 and < 90	18,833,773	3,612,128	-80.8
All Lands	>= 90 and <= 100	20,612,881	184,086	-99.1
Federal Lands	>= 10 and < 20	2,915,818	4,145,917	42.2
Federal Lands	>= 20 and < 30	3,328,193	6,344,396	90.6
Federal Lands	>= 30 and < 40	3,825,990	9,083,898	137.4
Federal Lands	>= 40 and < 50	4,302,218	11,956,765	177.9
Federal Lands	>= 50 and < 60	4,809,296	8,999,597	87.1
Federal Lands	>= 60 and < 70	5,529,035	6,619,876	19.7
Federal Lands	>= 70 and < 80	6,981,767	7,517,099	7.7
Federal Lands	>= 80 and < 90	12,399,570	1,758,121	-85.8
Federal Lands	>= 90 and <= 100	12,629,152	111,777	-99.1

2.5.2c Enhanced Existing Vegetation Height

The EVH improvement and enhancement process focused on CH. The CH remapping relied on canopy height 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 (SRTM) 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 LF National to create the new LF 2001 EVH layer.

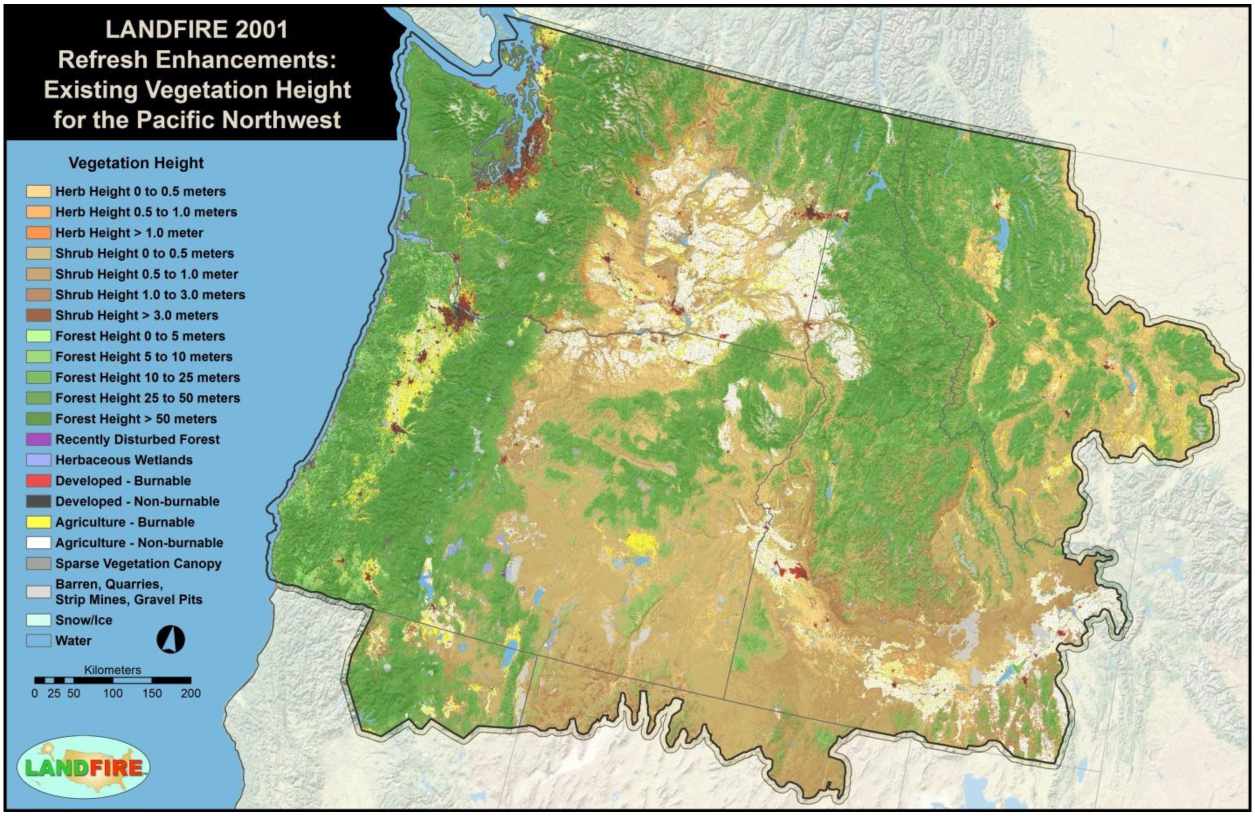

Figure 8 – Map of EVH layer that was enhanced as part of the LF 2001 update by incorporating user feedback and additional data. This data provided a foundation upon which to update data to 2008.

Table 23 – Acreage of LF CH categories and percent change in the PNW 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	5,149,015	3,940,888	-23.5
All Lands	5 to 10	5,197,298	4,496,125	-13.5
All Lands	10 to 25	71,243,948	53,282,502	-25.2
All Lands	25 to 50	12,092,795	30,128,705	149.2
All Lands	> 50	5,504	653,528	11,773.7
Federal Lands	0 to 5	2,761,380	1,833,158	-33.6
Federal Lands	5 to 10	2,988,812	2,573,936	-13.9
Federal Lands	10 to 25	45,303,099	32,844,315	-27.5
Federal Lands	25 to 50	5,664,659	18,757,912	231.1
Federal Lands	> 50	3,090	52,8126	16,991.5

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 and assigned a relatively low tree cover and height class. Relationships between ESP and these shrub and herbaceous communities were used to predict the new forested EVT at a particular site. In the eight-year interval, it was assumed that some herbaceous and shrub communities would begin to transition to forested communities. These sites were typically within forested communities where non-forested EVTs occurred in areas of older disturbance. In these situations, undisturbed shrub and herbaceous communities were transitioned to the lowest tree cover and height classes. 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 US 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.

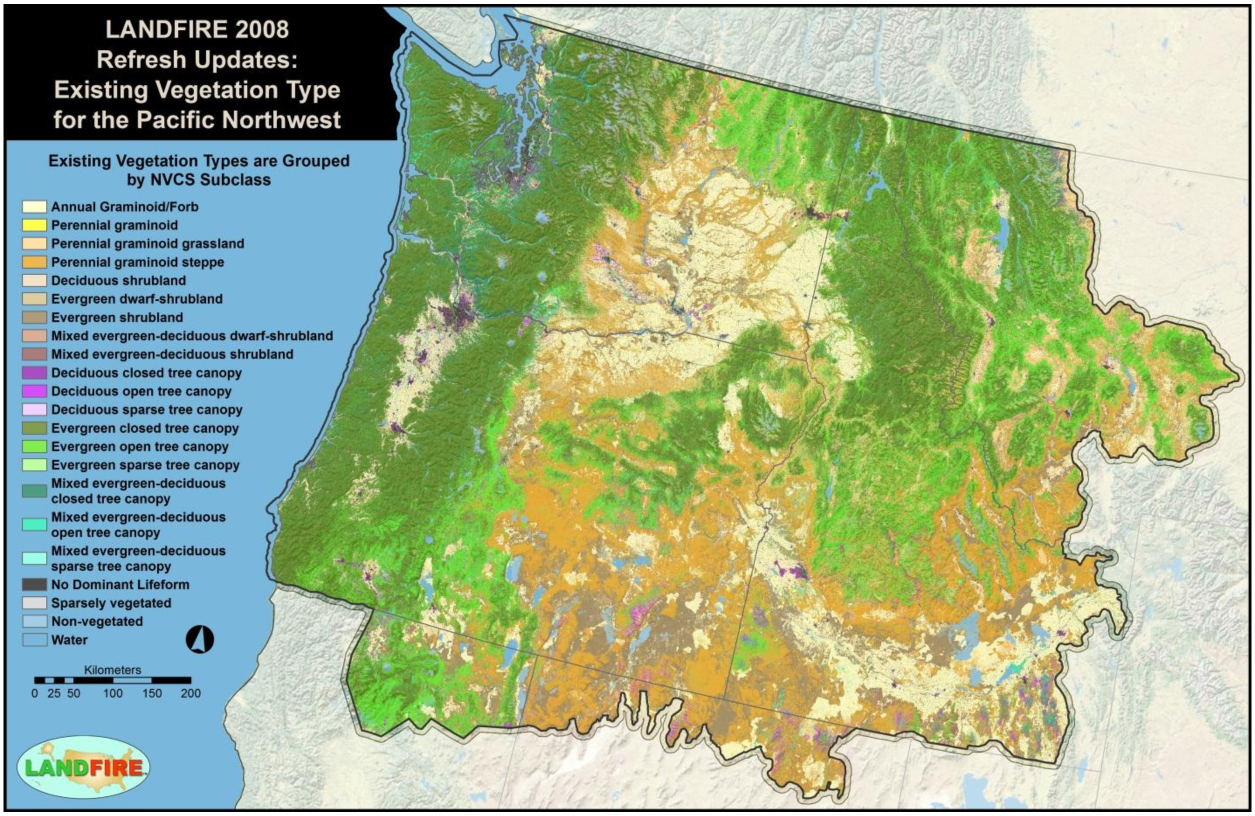

Figure 9 – Map of EVT layer for the PNW GeoArea depicting vegetation changes with disturbances for 1999 - 2008.

Table 24 – Comparison of acreage of forested EVT Groups between LF 2001 and LF 2008 on All Lands in the PNW 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	Douglas-fir Forest and Woodland	14,027,951	13,995,767	-0.2
All Lands	Douglas-fir-Western Hemlock Forest and Woodland	12,805,847	13,104,739	2.3
All Lands	Douglas-fir-Ponderosa Pine-Lodgepole Pine Forest and Woodland	12,519,544	12,878,560	2.9
All Lands	Douglas-fir-Grand Fir-White Fir Forest and Woodland	8,938,987	8,917,507	-0.2
All Lands	Spruce-Fir Forest and Woodland	8,499,032	8,366,737	-1.6
All Lands	Ponderosa Pine Forest, Woodland and Savanna	6,771,091	6,669,477	-1.5
All Lands	Western Hemlock-Silver Fir Forest	4,441,791	4,425,851	-0.4
All Lands	Lodgepole Pine Forest and Woodland	3,607,782	3,484,408	-3.4
All Lands	Western Riparian Woodland and Shrubland	3,130,348	3,036,703	-3.0
All Lands	Red Alder Forest and Woodland	2,517,326	2,500,560	-0.7
All Lands	Subalpine Woodland and Parkland	2,474,006	2,415,907	-2.4
All Lands	California Mixed Evergreen Forest and Woodland	1,976,150	1,956,341	-1.0
All Lands	Sitka Spruce Forest	1,767,201	1,756,756	-0.6
All Lands	Aspen Forest, Woodland, and Parkland	1,697,378	1,672,676	-1.5
All Lands	Juniper Woodland and Savanna	1,647,480	1,668,613	1.3
All Lands	Western Red-cedar-Western Hemlock Forest	1,523,815	1,504,483	-1.3
All Lands	Mountain Hemlock Forest and Woodland	1,374,905	1,447,835	5.3
All Lands	Conifer-Oak Forest and Woodland	787,759	763,734	-3.1
All Lands	Red Fir Forest and Woodland	494,701	491,318	-0.7
All Lands	Mountain Mahogany Woodland and Shrubland	351,841	347,827	-1.1
All Lands	Pinyon-Juniper Woodland	311,919	320,973	2.9
All Lands	Aspen-Mixed Conifer Forest and Woodland	302,278	298,461	-1.3
All Lands	Western Oak Woodland and Savanna	181,942	177,342	-2.5
All Lands	Limber Pine Woodland	150,279	148,947	-0.9
All Lands	Bigtooth Maple Woodland	58,001	57,441	-1.0
All Lands	Western Larch Forest and Woodland	38,374	37,705	-1.7
All Lands	Chaparral	7,594	7,579	-0.2
All Lands	Redwood Forest and Woodland	1,835	1,831	-0.2

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

Table 25. Forested Existing Vegetation Type Groups Comparison: Federal Lands				
Ownership	**Existing Vegetation Type Groups**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Federal Lands	Douglas-fir Forest and Woodland	9,048,663	8,989,046	-0.7
Federal Lands	Douglas-fir-Ponderosa Pine-Lodgepole Pine Forest and Woodland	7,596,357	7,782,594	2.5
Federal Lands	Spruce-Fir Forest and Woodland	7,690,472	7,572,791	-1.5
Federal Lands	Douglas-fir-Grand Fir-White Fir Forest and Woodland	5,890,636	5,926,411	0.6
Federal Lands	Douglas-fir-Western Hemlock Forest and Woodland	4,730,939	4,794,740	1.4
Federal Lands	Ponderosa Pine Forest, Woodland and Savanna	3,811,583	3,793,528	-0.5
Federal Lands	Western Hemlock-Silver Fir Forest	3,717,011	3,708,470	-0.2
Federal Lands	Lodgepole Pine Forest and Woodland	3,230,210	3,123,243	-3.3
Federal Lands	Subalpine Woodland and Parkland	2,378,899	2,318,165	-2.6
Federal Lands	Mountain Hemlock Forest and Woodland	1,285,432	1,327,672	3.3
Federal Lands	Western Riparian Woodland and Shrubland	1,248,845	1,242,718	-0.5
Federal Lands	California Mixed Evergreen Forest and Woodland	1,178,607	1,175,259	-0.3
Federal Lands	Aspen Forest, Woodland, and Parkland	1,138,442	1,131,776	-0.6
Federal Lands	Juniper Woodland and Savanna	977,651	999,619	2.3
Federal Lands	Western Red-cedar-Western Hemlock Forest	535,520	534,954	-0.1
Federal Lands	Red Fir Forest and Woodland	437,680	435,522	-0.5
Federal Lands	Conifer-Oak Forest and Woodland	290,532	288,929	-0.6
Federal Lands	Mountain Mahogany Woodland and Shrubland	252,031	250,837	-0.5
Federal Lands	Pinyon-Juniper Woodland	205,259	212,857	3.7
Federal Lands	Aspen-Mixed Conifer Forest and Woodland	214,261	212,398	-0.9
Federal Lands	Sitka Spruce Forest	205,423	204,961	-0.2
Federal Lands	Red Alder Forest and Woodland	189,414	188,909	-0.3
Federal Lands	Limber Pine Woodland	100,750	99,849	-0.9
Federal Lands	Western Oak Woodland and Savanna	64,129	63,906	-0.4
Federal Lands	Bigtooth Maple Woodland	28,695	28,544	-0.5
Federal Lands	Western Larch Forest and Woodland	24,640	24,364	-1.1
Federal Lands	Chaparral	5,371	5,367	-0.1
Federal Lands	Redwood Forest and Woodland	246	246	0.0

Table 26 – Comparison of acreage of shrubland EVT Groups between LF 2001 and LF 2008 across land ownerships in the PNW GeoArea.

Table 26. Shrubland Existing Vegetation Type Groups Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	489,683	438,216	-10.5
All Lands	Big Sagebrush Shrubland and Steppe	41,786,294	36,679,857	-12.2
All Lands	Chaparral	463,340	381,301	-17.7
All Lands	Deciduous Shrubland	2,787,599	2,084,596	-25.2
All Lands	Desert Scrub	1,424,117	1,175,438	-17.5
All Lands	Grassland and Steppe	4,289,215	4,675,097	9.0
All Lands	Greasewood Shrubland	270,308	226,057	-16.4
All Lands	Introduced Upland Vegetation-Shrub	21,782	13,437	-38.3
All Lands	Low Sagebrush Shrubland and Steppe	7,356,548	6,713,544	-8.7
All Lands	Pacific Coastal Scrub	6,317	2,856	-54.8
All Lands	Salt Desert Scrub	1,002,067	846,775	-15.5
All Lands	Western Riparian Woodland and Shrubland	313,143	271,181	-13.4
Federal Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	432,491	389,294	-10.0
Federal Lands	Big Sagebrush Shrubland and Steppe	25,423,366	22,110,418	-13.0
Federal Lands	Chaparral	148,336	112,733	-24.0
Federal Lands	Deciduous Shrubland	1,808,606	1,327,334	-26.6
Federal Lands	Desert Scrub	544,206	375,812	-30.9
Federal Lands	Grassland and Steppe	1,360,243	1,817,963	33.7
Federal Lands	Greasewood Shrubland	118,758	111,264	-6.3
Federal Lands	Introduced Upland Vegetation-Shrub	3,704	2,926	-21.0
Federal Lands	Low Sagebrush Shrubland and Steppe	5,330,390	4,866,529	-8.7
Federal Lands	Pacific Coastal Scrub	538	370	-31.2
Federal Lands	Salt Desert Scrub	628,154	531,758	-15.4
Federal Lands	Western Riparian Woodland and Shrubland	176,067	148,808	-15.5

Table 27 – Comparison of acreage of herbaceous EVT Groups between LF 2001 and LF 2008 across land ownerships in the PNW GeoArea.

Table 27. Herbaceous Existing Vegetation Type Group Comparison				
Land Ownership	**Existing Vegetation Type Groups**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	2,293,772	2,253,596	-1.8
All Lands	Dry Tundra	389	389	0.0
All Lands	Grassland	5,513,893	7,098,644	28.7
All Lands	Introduced Annual and Biennial Forbland	227,676	220,869	-3.0
All Lands	Introduced Annual Grassland	2,413,548	6,104,147	152.9
All Lands	Introduced Perennial Grassland and Forbland	3,427,109	3,096,226	-9.7
All Lands	NLCD-Herbaceous Semi-dry	68,197	62,962	-7.7
All Lands	NLCD-Herbaceous Semi-wet	84,106	80,427	-4.4
All Lands	NLCD-Herbaceous Wetlands	1,134,522	901,060	-20.6
All Lands	NLCD-Recently Disturbed Forest	272,493	0	-100.0
All Lands	Transitional Herbaceous Vegetation	0	8,915	
Federal Lands	Alpine Dwarf-Shrubland, Fell-field and Meadow	735,681	938,233	27.5
Federal Lands	Dry Tundra	385	385	0.0
Federal Lands	Grassland	2,050,807	3,382,229	64.9
Federal Lands	Introduced Annual and Biennial Forbland	158,914	158,057	-0.5
Federal Lands	Introduced Annual Grassland	1,141,167	3,891,017	241.0
Federal Lands	Introduced Perennial Grassland and Forbland	1,056,506	998,564	-5.5
Federal Lands	NLCD-Herbaceous Semi-dry	41,520	36,841	-11.3
Federal Lands	NLCD-Herbaceous Semi-wet	52,238	49,395	-5.4
Federal Lands	NLCD-Herbaceous Wetlands	218,961	187,075	-14.6
Federal Lands	NLCD-Recently Disturbed Forest	56,523	0	-100.0
Federal Lands	Transitional Herbaceous Vegetation	0	7,522	

2.5.3b Updated Existing Vegetation Cover

Transitions in CC 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. As mentioned earlier, severity was determined in the disturbance mapping process by using dNBR classified into high, medium, and low severity levels based on a statistical comparison with the MTBS, BARC, and RAVG fire data. 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 and assigned a relatively low tree cover and height class.

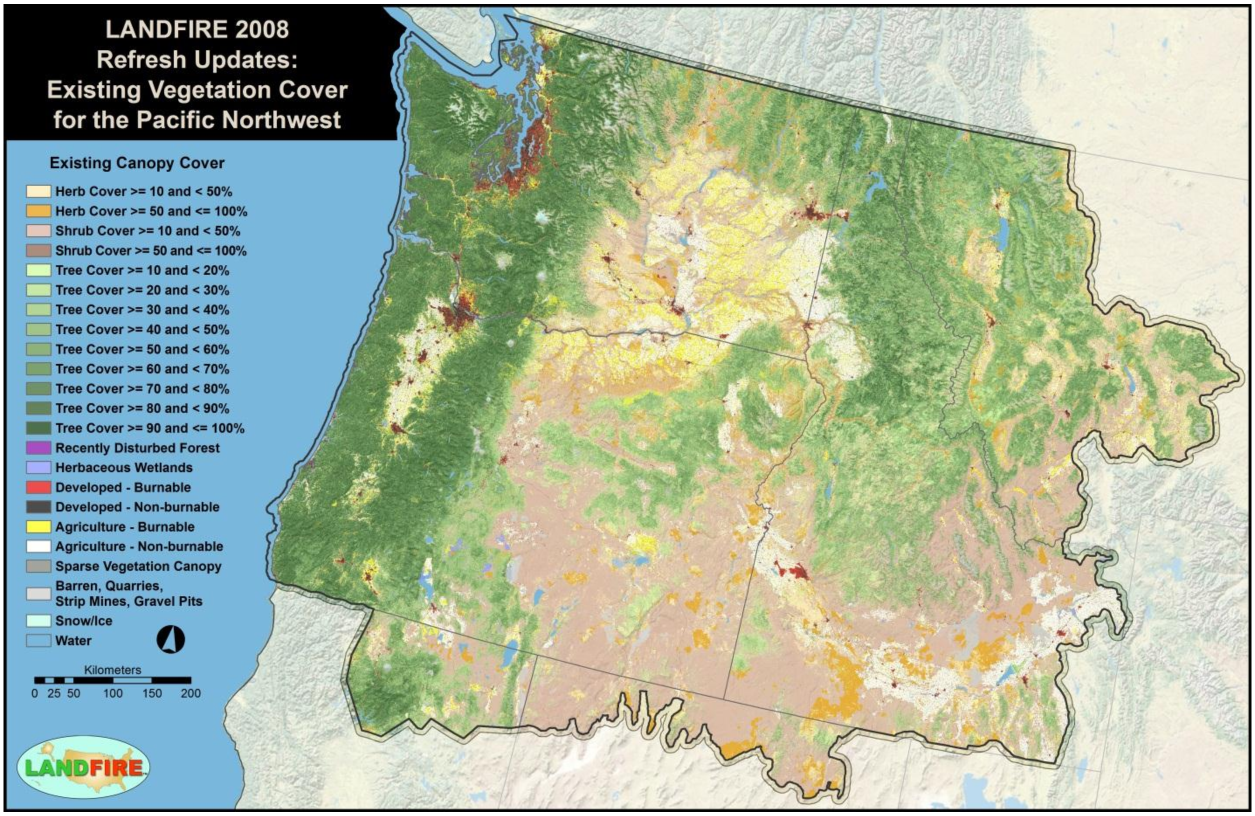

Figure 10 – Map of EVC for the PNW accounting for vegetation changes with disturbances for 1999 - 2008.

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

Table 28. Tree Cover Comparison				
Land Ownership	Percent Tree Cover	LF 2001 (acres)	LF 2008 (acres)	Percent Change
All Lands	>= 10 and < 20	7,304,491	8,012,680	9.7
All Lands	>= 20 and < 30	10,601,648	10,477,800	-1.2
All Lands	>= 30 and < 40	15,106,615	15,507,107	2.7
All Lands	>= 40 and < 50	18,274,644	16,446,444	-10.0
All Lands	>= 50 and < 60	12,631,431	12,573,679	-0.5
All Lands	>= 60 and < 70	11,286,042	11,333,283	0.4
All Lands	>= 70 and < 80	13,500,664	14,578,944	8.0
All Lands	>= 80 and < 90	3,612,128	3,410,135	-5.6
All Lands	>= 90 and <= 100	184,086	176,106	-4.3
Federal Lands	>= 10 and < 20	4,145,917	4,692,120	13.2
Federal Lands	>= 20 and < 30	6,344,396	6,554,491	3.3
Federal Lands	>= 30 and < 40	9,083,898	9,524,357	4.9
Federal Lands	>= 40 and < 50	11,956,765	10,989,230	-8.1
Federal Lands	>= 50 and < 60	8,999,597	8,654,567	-3.8
Federal Lands	>= 60 and < 70	6,619,876	6,642,863	0.4
Federal Lands	>= 70 and < 80	7,517,099	7,610,971	1.3
Federal Lands	>= 80 and < 90	1,758,121	1,696,031	-3.5
Federal Lands	>= 90 and <= 100	111,777	108,208	-3.2

2.5.3c Updated Existing Vegetation Height

Transitions in CH 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. 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 and assigned a relatively low tree cover and height class.

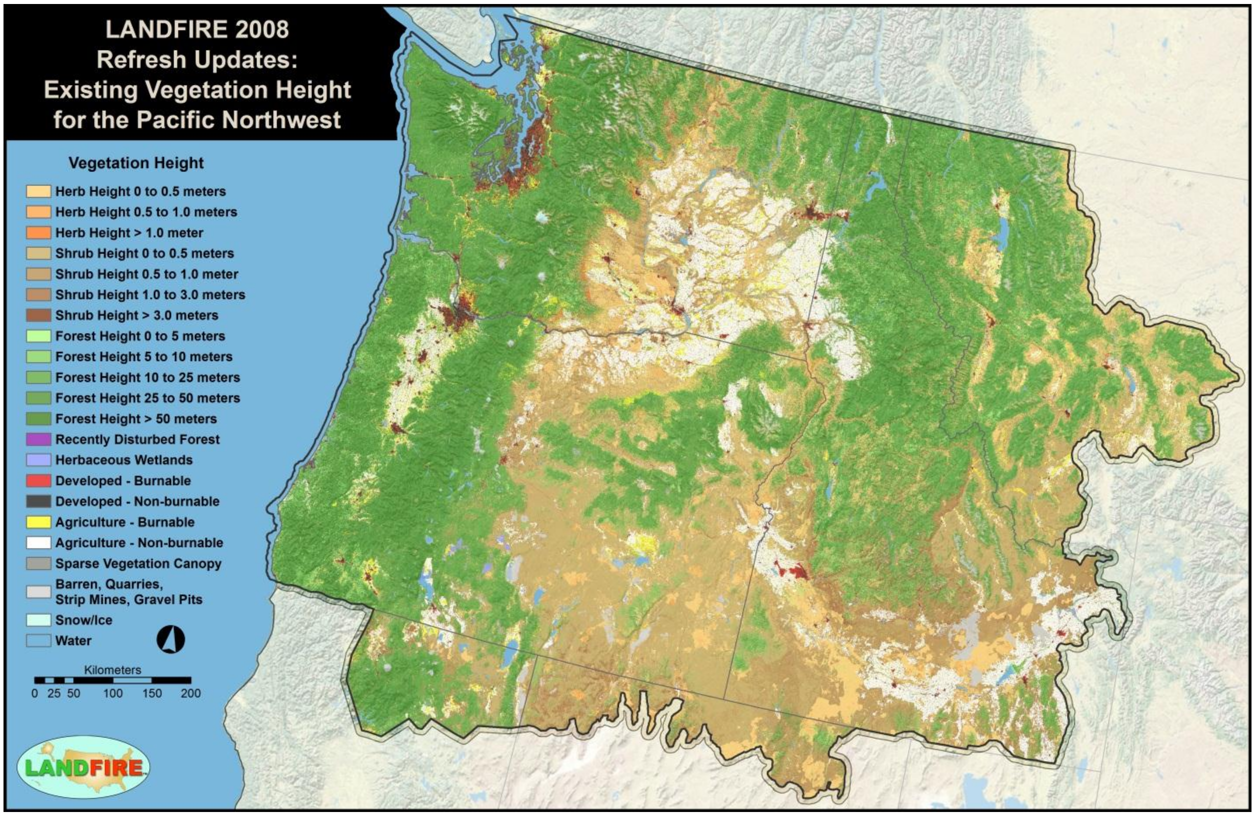

Figure 11 – Map of EVH for the PNW GeoArea accounting for vegetation changes from disturbances for 1999 - 2008.

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

Table 29. Tree Height Comparison				
Land Ownership	**Height (m)**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
All Lands	0 to 5	3,940,888	4,584,431	16.3
All Lands	5 to 10	4,496,125	5,514,336	22.7
All Lands	10 to 25	53,282,502	52,558,225	-1.4
All Lands	25 to 50	30,128,705	29,283,413	-2.8
All Lands	> 50	653,528	575,773	-11.9
Non-Federal Lands	0 to 5	2,107,730	2,411,183	14.4
Non-Federal Lands	5 to 10	1,922,190	2,558,078	33.1
Non-Federal Lands	10 to 25	20,438,188	20,227,719	-1.0
Non-Federal Lands	25 to 50	11,370,793	10,744,240	-5.5
Non-Federal Lands	> 50	125,401	102,120	-18.6

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 models (FBFM13 [Anderson, 1982], FBFM40 [Scott and Burgan, 2005], and the Canadian Forest Fire Danger Rating System (CFFDRS) [Stocks et al. 1989]), CBD, 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.

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 does not produce the expected fire behavior characteristics
- High CC causes high wind reduction factor

2.6.2a Enhanced 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 completion of the Improvements 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.

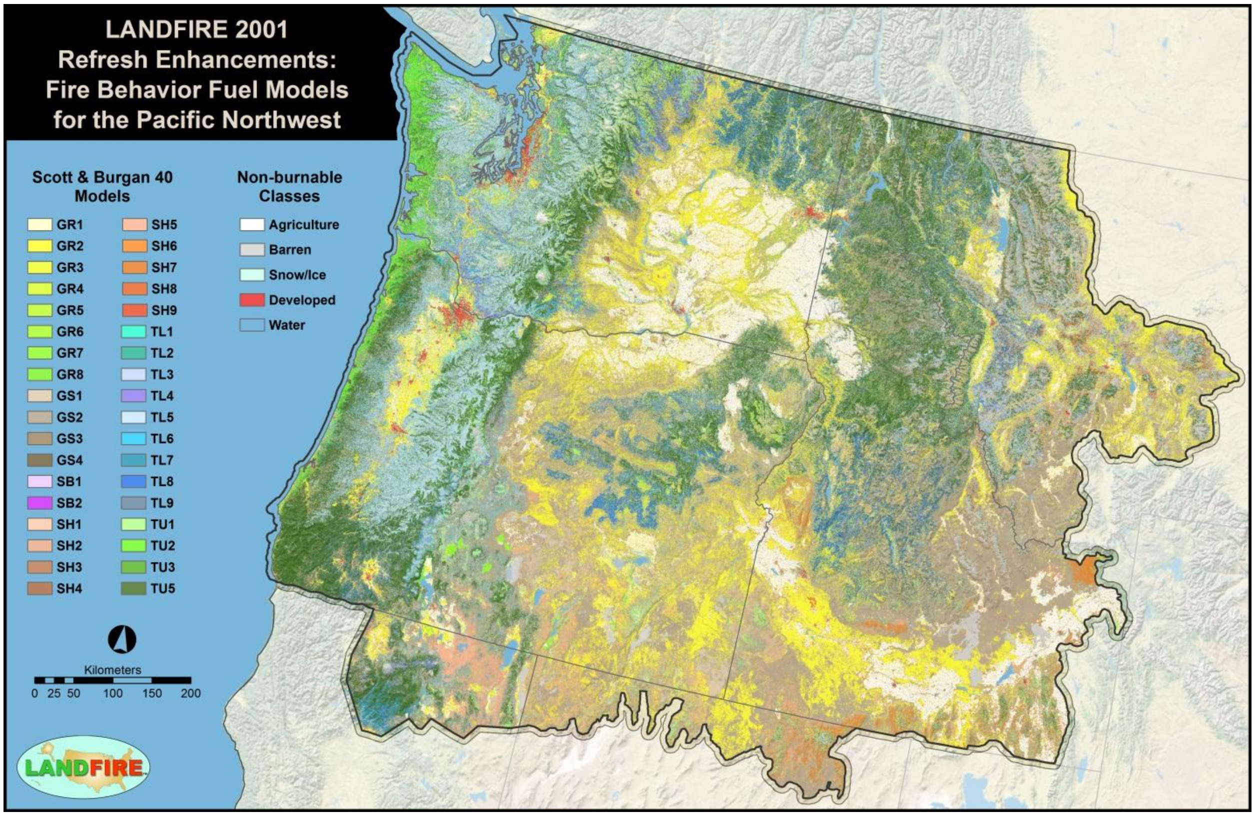

Figure 12 – LF 2001 FBFM40 for the PNW GeoArea.

2.6.2b Enhanced Canopy Fuel

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

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

2.6.2c Modeled Fire Behavior Using LF 2001 Enhanced Products

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

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

Table 30. Fire Behavior Comparison – LF National and LF 2001			
Fire Behavior Characteristic	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
Flame Length (feet)			
No Fire	6,588,466	4,612,419	-30.0
Low(>0 and <=4)	38,701,572	32,501,359	-16.0
Moderate (>4 and <=11)	40,348,316	38,156,838	-5.4
High (> 11)	15,737,362	26,105,100	65.9
Spread Rate (chains/hour)			
No Fire	6,588,466	4,612,419	-30.0
Low (>0 and <=5)	36,363,498	24,433,328	-32.8
Moderate (>5 and <=50)	31,596,528	44,354,079	40.4
High (>50)	26,827,222	27,975,885	4.3
Crown Fire			
No Fire	6,588,466	4,612,419	-30.0
Surface Fire	80,926,862	65,170,029	-19.5
Passive Crown Fire	11,914,597	29,319,731	146.1
Active Crown Fire	1,945,790	2,273,538	16.8

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, and FCCS) 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 FBFM 40/13, FCCS, and canopy fuel 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. The disturbance types include:

- Recent fire activity (1999 - 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 (windthrow, hurricanes, tornados, etc.)
- Insect and disease

The intensity of the disturbance was described as high, moderate, or low. Generally, the guidelines followed were:

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

The severity of the disturbance areas were assigned by either MTBS or the vegetation transition team.

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 FBFM 40/13 and FCCS 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.

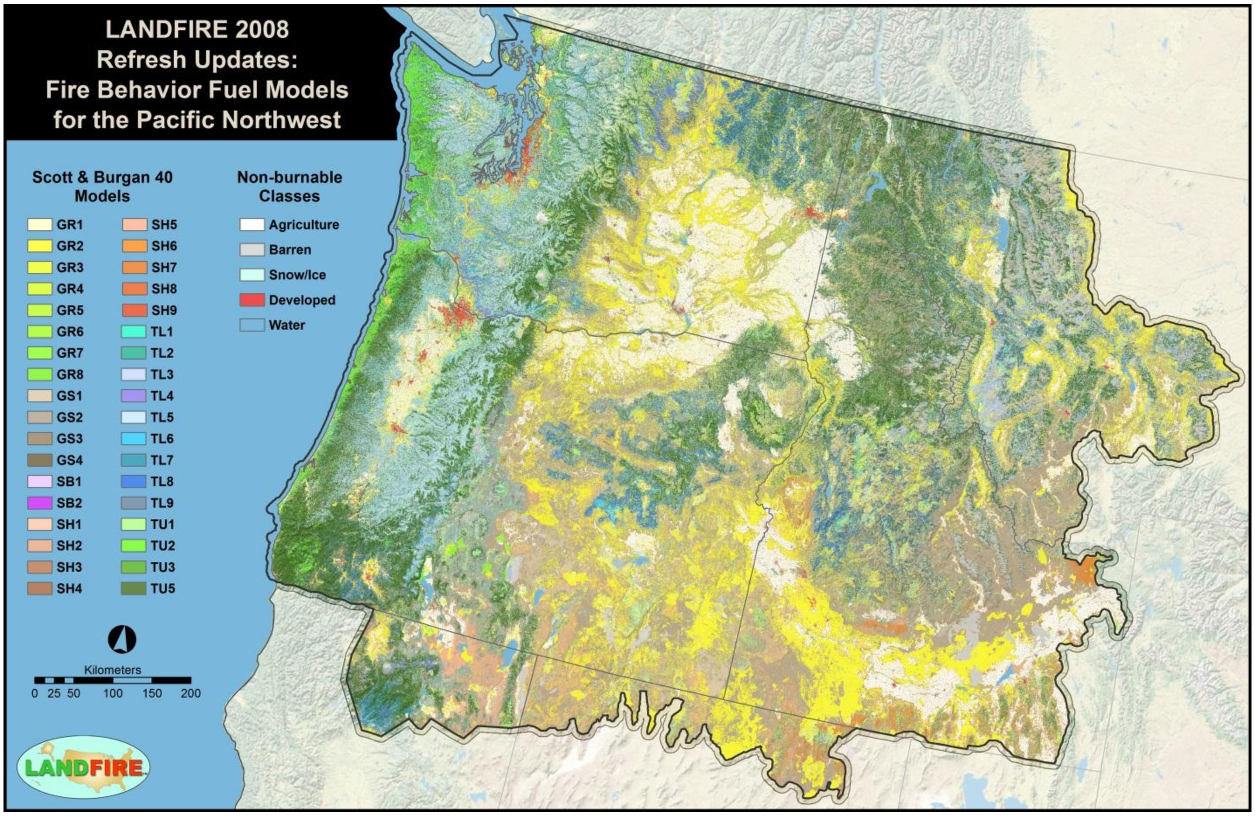

Figure 13 – LF 2008 FBFM40 for the PNW GeoArea.

2.6.3b Updates to Canopy Fuel

The changes in canopy attributes and the growth in non-disturbed areas were modeled through FVS/FFE. As mentioned, severity was determined in the disturbance mapping process by using dNBR classified into high, medium, and low severity levels based on a statistical comparison with the MTBS, BARC, and RAVG fire data. 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; 1) immediately after the disturbance, 2) 3-5 years post disturbance and 3) 7-10 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 LANDFIRE Total Fuel Change Tool (www.niftt.gov). The vegetation transitions were mapped by intersecting the integrated 10-year disturbance map with the LF 2001 vegetation layers. A transition predicted by FVS/FFE was assigned to every disturbance and EVT, height, and cover class on the map. This transition provides the needed data to map LF 2008 EVT in areas where forested EVTs were disturbed or may have succeeded to different conditions.

2.6.3c Modeled Fire Behavior Using LF 2008 Updated Products

The WFAT was used to estimate potential fire behavior using fuel data from LF 2001 and LF 2008. Three fire behavior outputs from these simulations were then compared to quantify changes in LF fuel mapping improvements (Table 31).

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

Table 31. Fire Behavior Comparison – LF 2001 and LF 2008			
Fire Behavior Characteristic	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Flame Length (feet)			
No Fire	4,612,419	4,630,028	0.4
Low(>0 and <=4)	32,501,359	32,893,743	1.2
Moderate (>4 and <=11)	38,156,838	37,638,583	-1.4
High (> 11)	26,105,100	26,213,361	0.4
Spread Rate (chains/hour)			
No Fire	4,612,419	4,630,028	0.4
Low (>0 and <=5)	24,433,328	24,937,872	2.1
Moderate (>5 and <=50)	44,354,079	43,010,661	-3.0
High (>50)	27,975,885	28,797,151	2.9
Crown Fire			
No Fire	4,612,419	4,630,028	0.4
Surface Fire	65,170,029	66,083,513	1.4
Passive Crown Fire	29,319,731	28,117,586	-4.1
Active Crown Fire	2,273,538	2,544,590	11.9

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 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 in fuelbeds across CONUS. An FLM fuelbed is defined as all combustible material below two meters (six feet) and above mineral soil. These fuel are commonly referred to as surface fuel and include live and dead herbaceous and shrub material, down woody material, 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 difference 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

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.

2.7.2a 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 cover and(or) height of the tree cover in forested EVTs. Tables 32 and 33display the FCCS rule sets developed for LF National and LF 2001 and depict the change in acreage between data versions. For example, Table 32 depicts the rule sets and the appropriate FCCS fuelbeds. The number of acres and the percent of each EVT that meet those criteria are also shown. Table 33 depicts the newly mapped FCCS fuelbeds. The amount of area affected by each rule set changed significantly. However, although the area affected by each rule set changed, the rule sets remained the same between LF National and LF 2001.

Table 32 – LF National Mapping Zone 07 FCCS fuel rule sets and number of acres based on the range of EVC and EVH values.

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

Table 33 – LF 2001 Mapping Zone 07 FCCS fuel rule sets and number of acres based on the range of new EVC and EVH values.

Table 33. LF 2001 Fuel Rule Sets					
EVT	Percent Cover	Range of Height (m)	FCCS	Acres	Percent EVT
2027 Med Dry-Mesic Mixed Conifer	10 – 19	0 - 25	4	14,036	1.2
2027 Med Dry-Mesic Mixed Conifer	10 – 19	25 - 50	16	205	0.0
2027 Med Dry-Mesic Mixed Conifer	20 – 100	0 -10	4	31587	2.8
2027 Med Dry-Mesic Mixed Conifer	20 – 100	10 -50	16	1,083,071	95.9
2028 Med Mesic Mixed Conifer	10 – 19	0 - 25	4	47,479	1.8
2028 Med Mesic Mixed Conifer	10 – 19	25 - 50	7	1,688	0.1
2028 Med Mesic Mixed Conifer	20 – 100	0 -10	4	10,161	0.4
2028 Med Mesic Mixed Conifer	20 – 100	10 -50	7	2,552,843	97.8

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 models, 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 NLCD 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. NLCD 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 (FWD), 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 PNW GeoArea. Of 17,708 fire effects records, 2,813 had the necessary measurements to key to a FLM. Because of the limited amount of data available, only 2,813 records were used for mapping each zone. 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. A computer program was used to identify the majority FLM based on existing vegetation database attribute combinations.
4. FLM layers were produced and processed using a pixel populating routine.

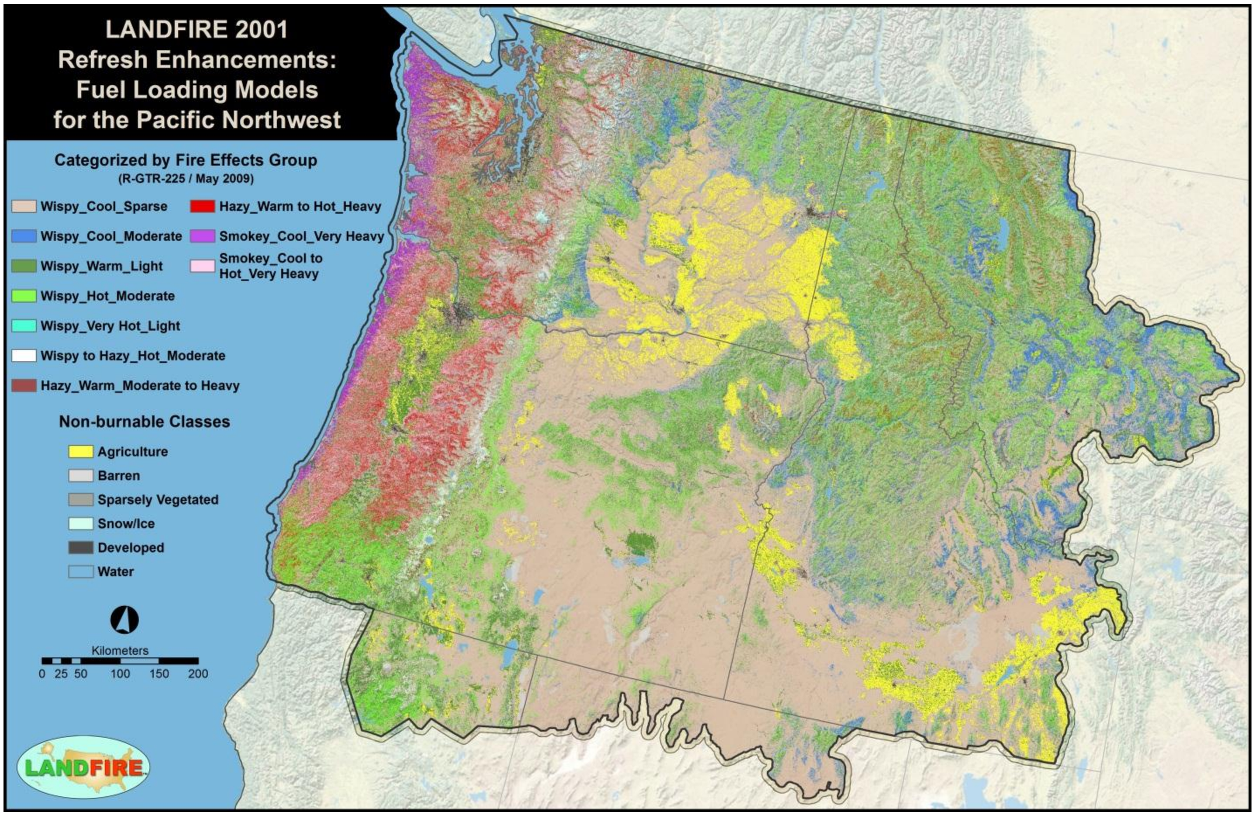

Figure 14 – LF 2001 FLMs for the PNW GeoArea. FLM categories are from Rocky Mountain Research Station General Technical Report 225.

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 fuel loading mapping improvements (Table 34). The FLM grids provided the loadings data for these simulations.

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

Table 34. Fire Effect Characteristics Comparison – LF National to 2001				
Ownership	**Fire Effect Characteristics**	**LF National (acres)**	**LF 2001 (acres)**	**Percent Change**
Particulate Production:				
Federal Lands	No Burnable Fuel	5,246,727	3,243,555	-38.2
Federal Lands	No Burn In Fuel	1,265,423	1,373,580	8.6
Federal Lands	Low (>0 and <=250 lb/ac)	16,457,422	71,296,578	333.2
Federal Lands	Moderate (>250 and <=1000 lb/ac)	37,427,648	18,451,464	-50.7
Federal Lands	High(>1000 lb/ac)	40,978,496	7,010,539	-82.9
Soil Heating:				
Federal Lands	No Burnable Fuel	5,246,727	3,243,555	-38.2
Federal Lands	No Burn in Fuel	1,265,423	1,373,580	8.2
Federal Lands	No Effect	52,290,925	56,415,559	7.9
Federal Lands	Low (>0 and <=3 cm)	23,491,009	5,994,507	-74.5
Federal Lands	Moderate (>3 and <=8 cm)	16,985,681	30,226,271	78.0
Federal Lands	High(>8 cm)	2,095,952	4,126,961	96.9
Fuel Consumption:				
Federal Lands	No Burnable Fuel	5,246,727	3,243,555	-38.2
Federal Lands	No Burn in Fuel	1,265,423	1,373,580	8.6
Federal Lands	Low (>0 and <=33 %)	4,362,171	7,663,878	75.7
Federal Lands	Moderate (>33 and <= 66 %)	9,084,572	50,850,213	459.7
Federal Lands	High (>66 %)	81,416,823	38,244,491	-53.0

2.7.3 LF 2008 Updates to Fire Effects Products

The LF 2008 process was a modeled attempt to update the vegetation and fuel characteristics depicted in the imagery collected from 1999 - 2008 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 model (FBFM40, FBFM13 and FCCS) in the disturbed areas were incorporated according to expert opinion, whereas the changes in canopy characteristics were modeled through FVS/FFE.

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 - 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.

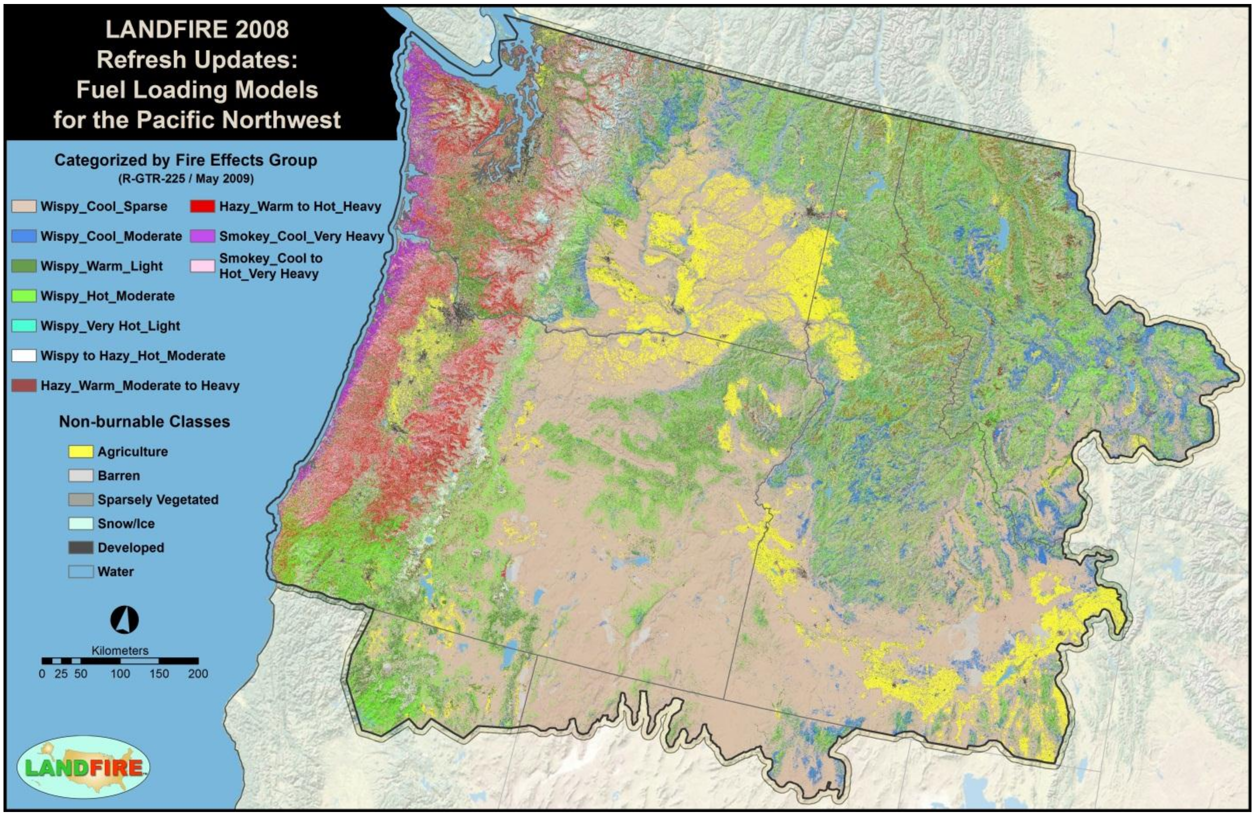

Figure 15 – LF 2008 Fuel Loading Models for the PNW GeoArea. Categories are from the Rocky Mountain Research Station General Technical Report 225.

2.7.3c Modeled Fire Effects Using LF 2008 Updated Products

WFAT was used to estimate potential fire effects using fuel loading data from LF 2001 and LF 2008. Three fire effects outputs from these simulations were then compared to quantify changes in LF fuel loading mapping improvements (Table 35). The FLM grids provided the loadings data for these simulations.

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

Table 35. Fire Effect Characteristics Comparison– LF 2001 to LF 2008				
Ownership	**Fire Effect Characteristics**	**LF 2001 (acres)**	**LF 2008 (acres)**	**Percent Change**
Particulate Production:				
Federal Lands	No Burnable Fuel	3,243,555	3,280,174	1.1
Federal Lands	No Burn In Fuel	1,373,580	1,349,854	-1.7
Federal Lands	No Effect		31,622	
Federal Lands	Low (>0 and <=250 lb/ac)	71,296,578	70,809,500	-0.7
Federal Lands	Moderate (>250 and <=1000 lb/ac)	18,451,464	18,727,656	1.5
Federal Lands	High(>1000 lb/ac)	7,010,539	7,176,911	2.4
Soil Heating:				
Federal Lands	No Burnable Fuel	3,243,555	3,280,174	1.2
Federal Lands	No Burn in Fuel	1,373,580	1,349,854	-1.4
Federal Lands	No Effect	56,415,559	55,542,685	-1.6
Federal Lands	Low (>0 and <=3 cm)	5,994,507	6,652,731	11.0
Federal Lands	Moderate (>3 and <=8 cm)	30,226,271	30,497,080	0.9
Federal Lands	High(>8 cm)	4,126,961	4,053,194	-1.8
Fuel Consumption:				
Federal Lands	No Burnable Fuel	3,243,555	3,280,174	1.1
Federal Lands	No Burn in Fuel	1,373,580	1,349,854	-1.7
Federal Lands	No Effect		31,622	
Federal Lands	Low (>0 and <=33 %)	7,663,878	7,644,024	-0.3
Federal Lands	Moderate (>33 and <= 66 %)	50,850,213	48,085,697	-5.4
Federal Lands	High (>66 %)	38,244,491	40,984,346	7.2

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 (ESSA 2005). 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 (Barrett et al. 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 VCC. Similarly, the FRCC departure has been changed to 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) - for example HUC 12s range typically from 10 to 40 thousand acres [15 to 62 mi^2]) 8, 10, and 12 layers and clipping this combined raster to each GeoArea boundary. 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 (Barrett et al. 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.

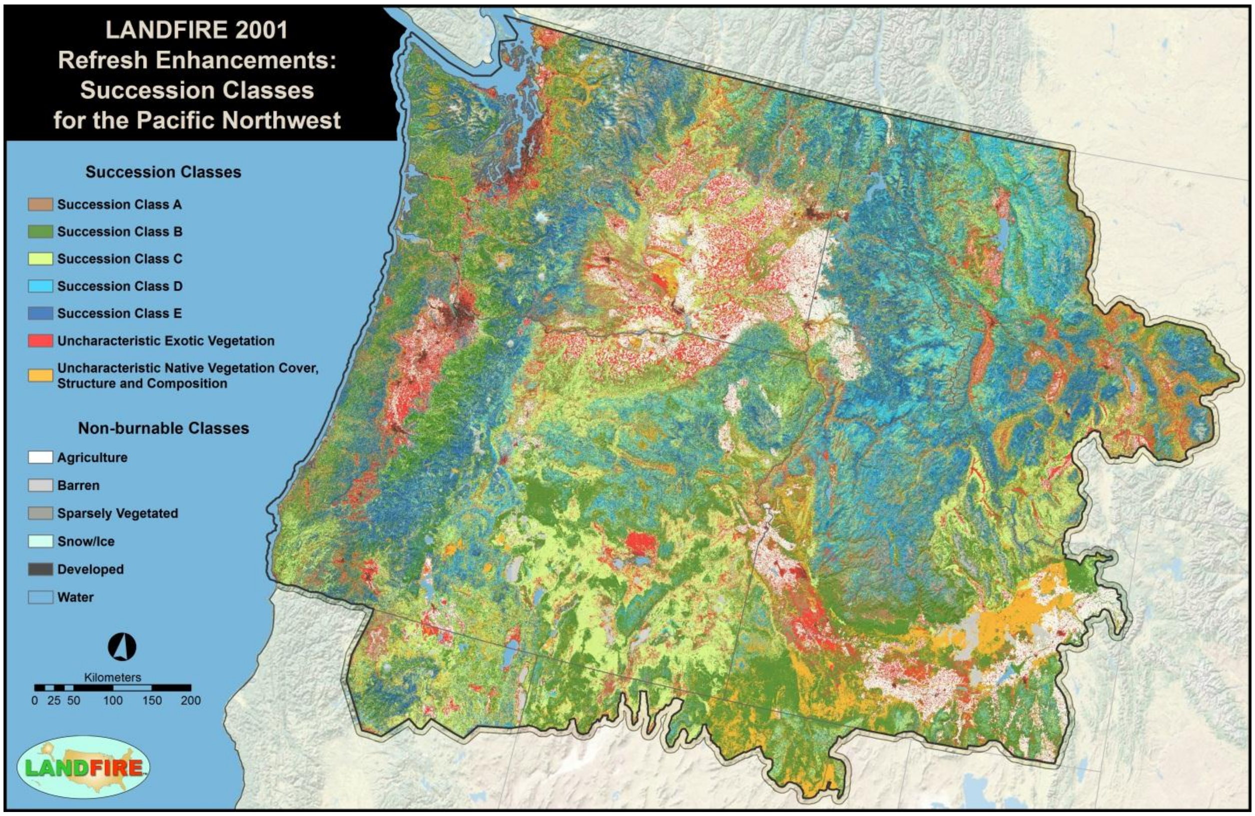

Figure 16 – Map of LF 2001 enhancements of the SCLASS layer for the PNW GeoArea.

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 LF Refresh BpS layer along with a HUC within the layer to stratify the LF Refresh 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

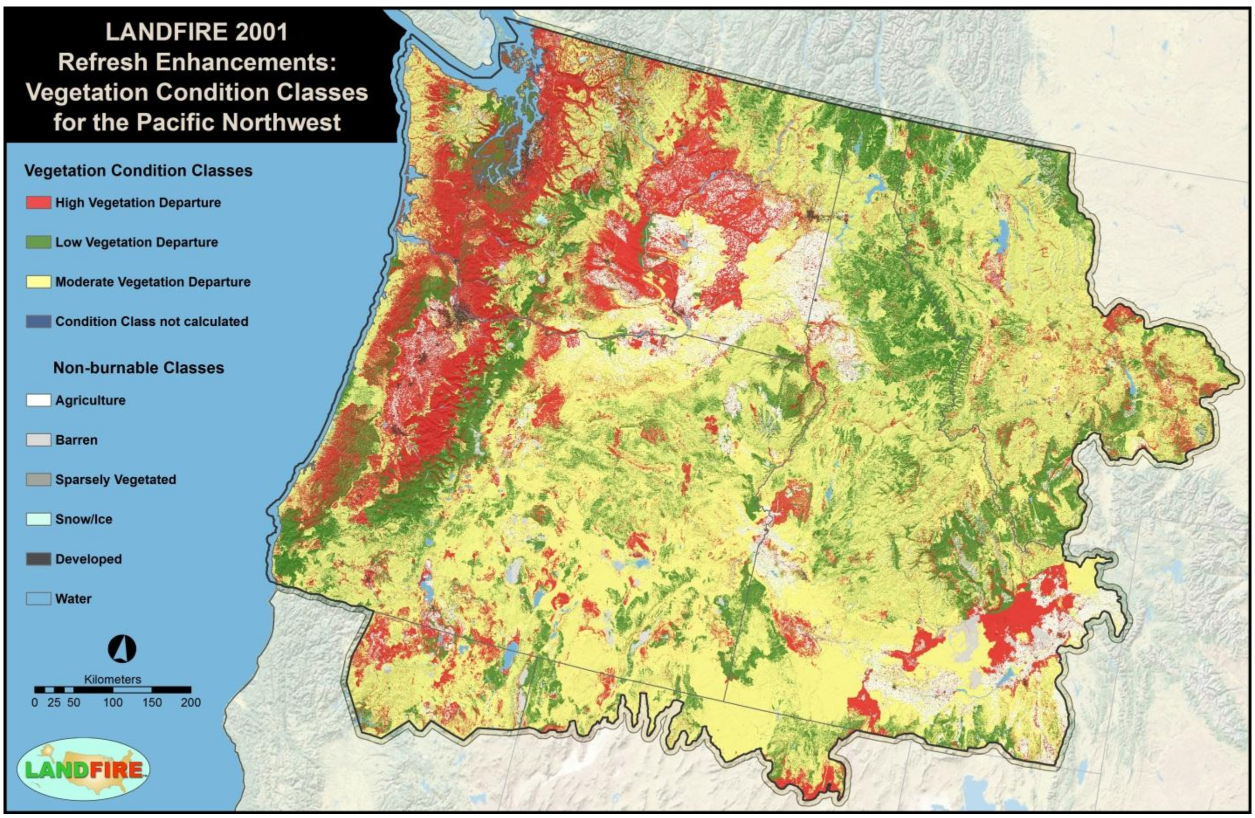

Figure 17 – Map of VCC for the PNW GeoArea from LF 2001 enhancements.

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.

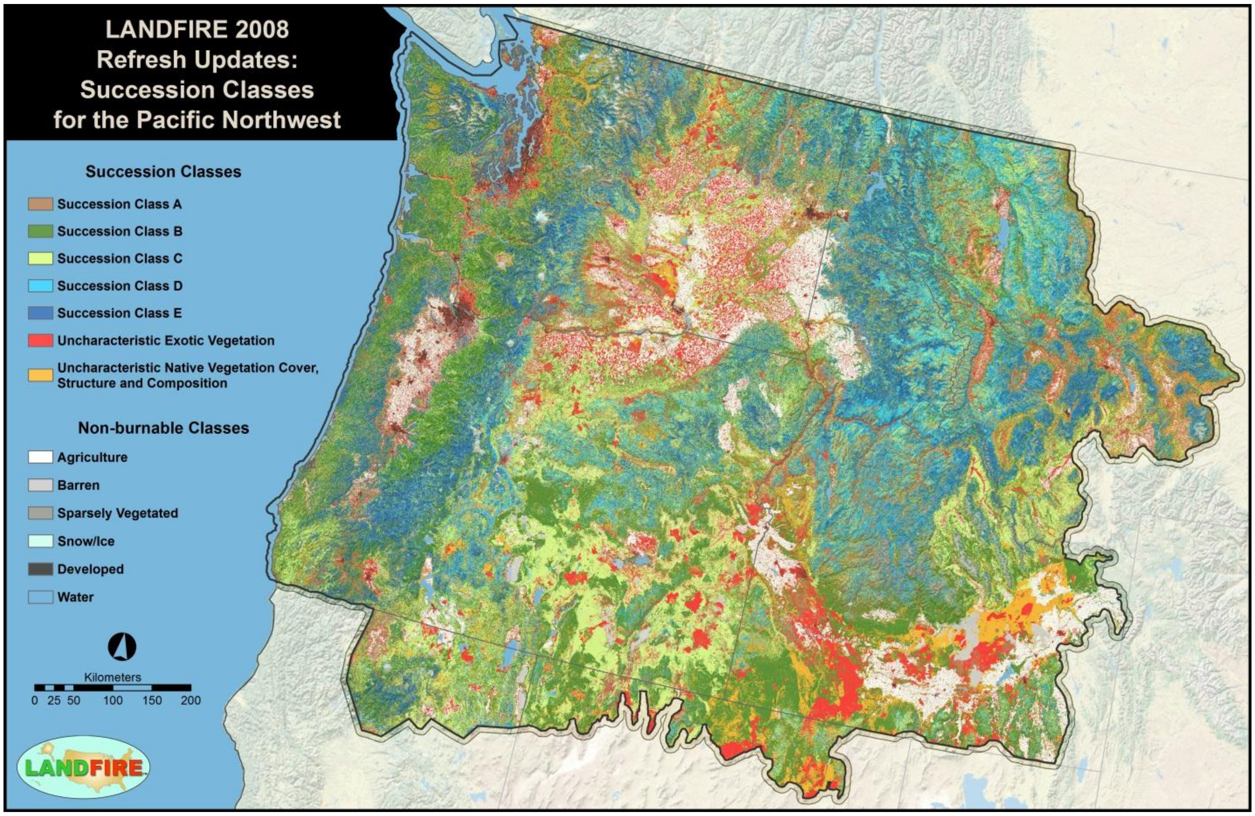

Figure 18 – Map of LF 2008 updates of the SCLASS layer for the PNW GeoArea.

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 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

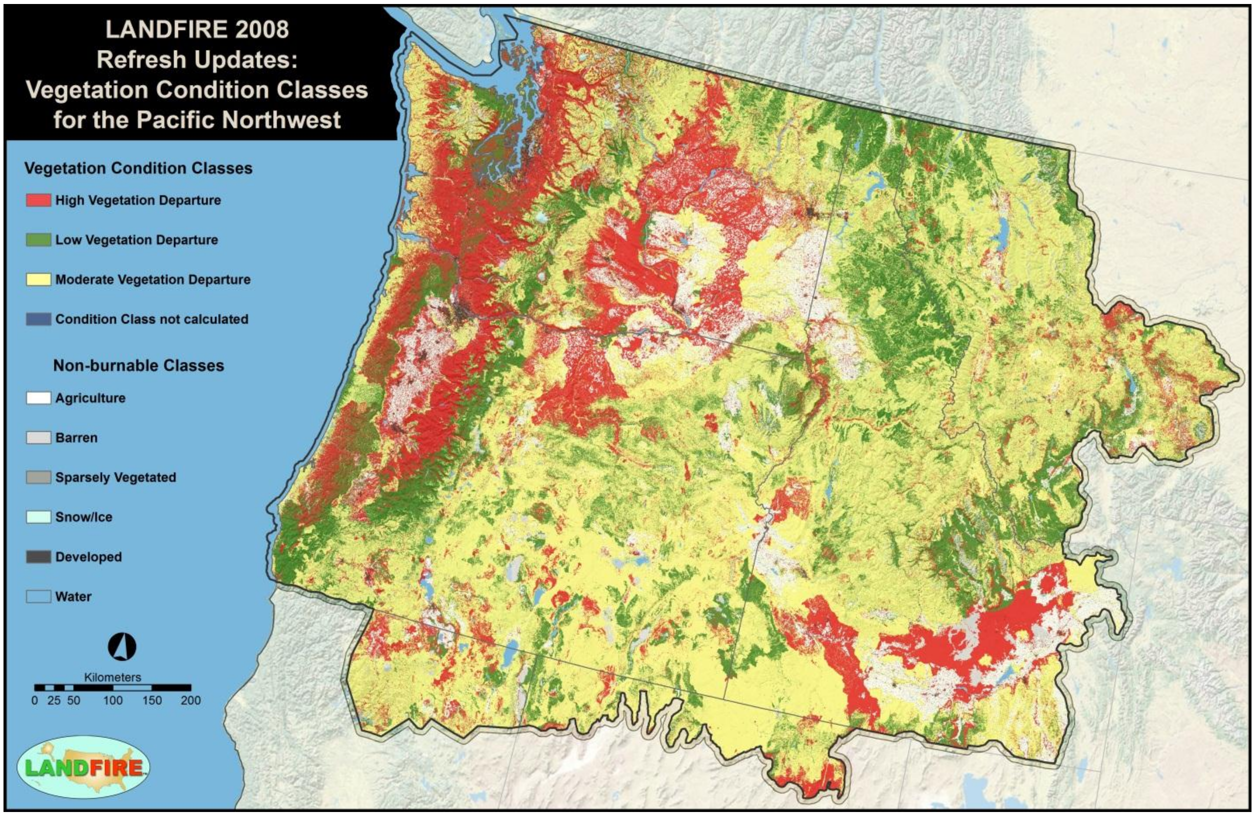

Figure 19 – Map of VCC for the PNW GeoArea from LF 2008 updates.

3.0 FARSITE Comparison of LANDFIRE Fuel Characteristics Versions

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

3.1 Doubleday Fire, 2008

The Doubleday Fire occurred in Southwest Oregon (LF Mapping Zone 07) on September 17th, 2008. The fire burned to nearly its final size on the first day. Suppression actions, in the form of tractor line, took place on the flanks early on in the first shift. Energy Release Component (a component of the National Fire Danger Rating System, http://www.nwcg.gov/) figures show the area in well over the 90th percentile in fuel dryness. Torching and short runs of active crowning were reported by fireline personnel. The fire burned mainly on private land and small parcels of BLM ownership. The fire area vegetation was composed of mixed conifer and hardwoods and was dominated by Douglas fir, ponderosa pine, and other conifer types. A blowdown event occurred throughout this area in 2007, but the effects from the disturbance were not mapped on private land. The BLM ownership within the fire area did not show any effects from the disturbance. Final fire size was reported to be 1,256 acres.

3.1.1 Inputs

Weather, wind, and fuel moisture data for the fire simulation was compiled from two RAWS located to the east and west of the fire area. The Evans Creek RAWS (35228) that lies to the east is a hotter, drier site than the fire area, and the Zimmerman RAWS (35227) is higher in elevation and cooler than the fire area. Median values from the two RAWS were used for fuel moisture, temperature, and relative humidity. The median value for 10-minute average and maximum gust wind speeds was determined for each hour from September 14th through September 19th for each station. A median value between the two stations was used as input into the model. Live woody fuel moisture was the only input not taken from the RAWS data; it was based on the measured live fuel moisture database at the Medford District BLM. The wind speeds recorded at the RAWS may be lower than the reports from the fireline, but there were no numeric observations from the line.

LF National and LF 2001 have very similar FBFM40 values. Approximately 90% of the area was assigned FBFM 165 (Timber Understory (TU) 5). The remaining 10% was a mixture of Timber Litter (TL), Grass/Shrub (GS), and Grass (GR) fuel models. The main difference between these two versions of LF data was CBH, which is generally 1.2 to 2 meters in LF National and 0.6 meters in LF 2001.

Because of the fire disturbance, LF 2008 data showed very different fuel model assignments, with much of the high and moderate severity burn areas in FBFM 101 (GR1), 141 (Shrub [SH]1), 142 (SH2), and 162 (TU2). The CBH for this layer was higher than for that of LF 2001.

A 24-hour window with a 3-hour maximum burn period was used to simulate the fire spread in all three versions of the fuel data. The ignition point was an approximation and was set to allow for backing. Crown fire activity was set to the Scott and Reinhardt (2001) method, and spotting was enabled at 0.2%. A fuel moisture and environmental conditioning period was used from September 15th - 17th, and the weather values were the median of the two RAWS.

3.1.2 Results

As displayed in Figure 20 below, LF National data severely underestimated the fire spread compared to the actual perimeter. The simulation indicated that the fire was spreading as a surface fire with little spotting and no crowning.

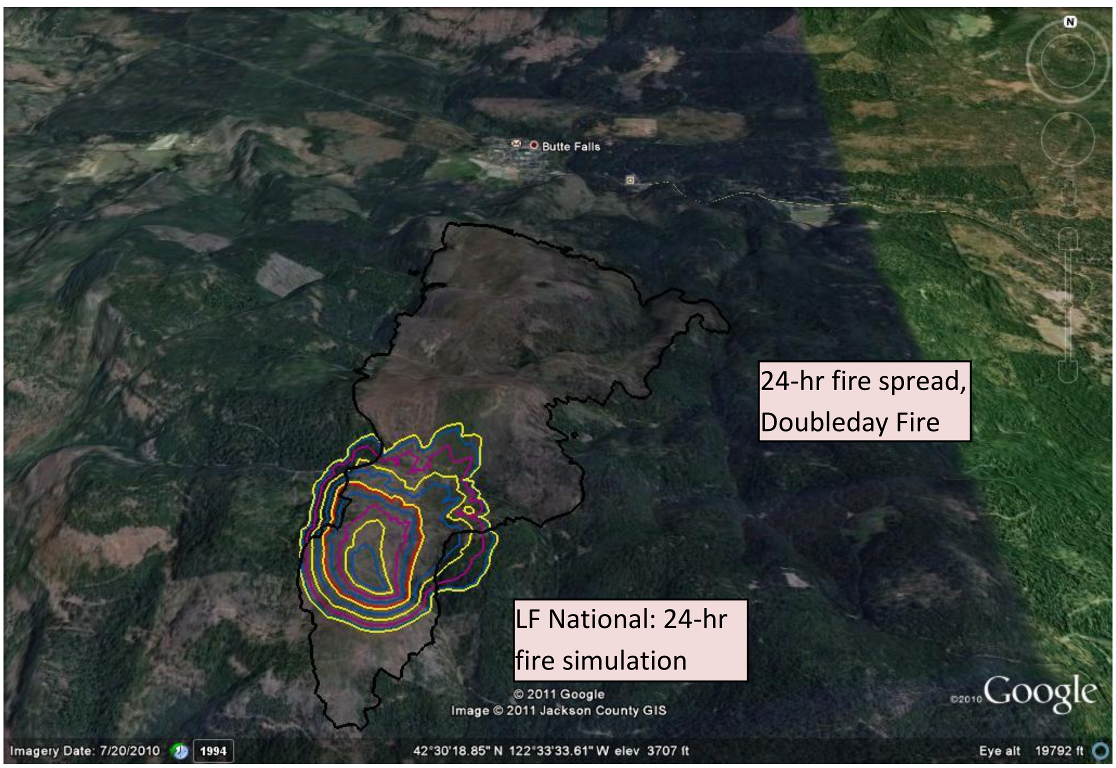

Figure 20 – LF National fire simulation of the Doubleday Fire.

LF 2001 fuel layers provided an improved approximation of fire spread for the same time window and burn period input (Figure 21). The lower CBH allowed for torching and spotting to occur, which allowed the fire to spread closer to the actual perimeter. With adjustment in burn period time, the fire would spread even closer to or beyond the actual fire perimeter. No attempt was made in the simulations to mimic or show fire suppression actions on the flanks of the fire using wildland fire initial attack resources.

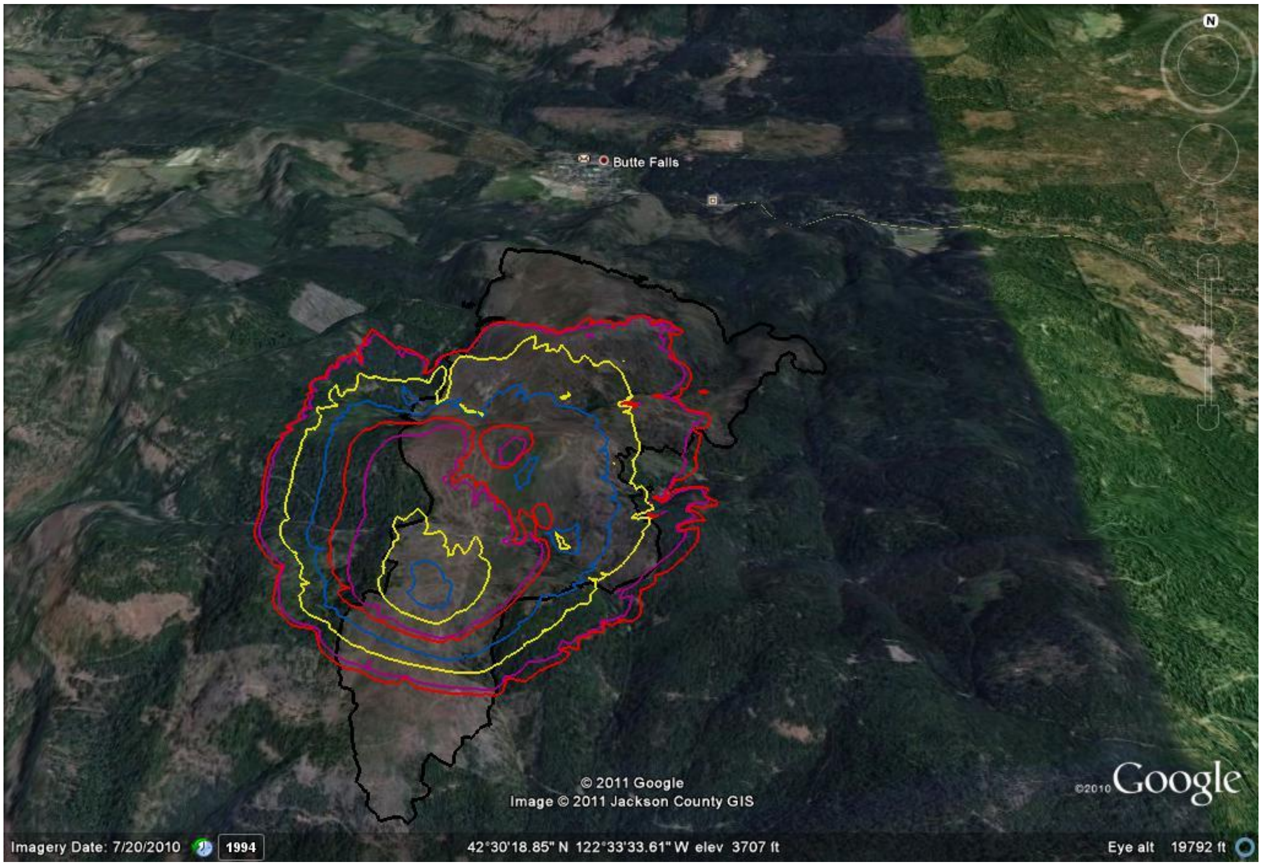

Figure 21 – LF 2001 fire simulation of the Doubleday Fire.

LF 2008 depicts the site after the disturbance occurred and simulates fire activity within the area from 1 to 5 years post disturbance (Figure 22). Much of the area was salvage logged after the fire, so new disturbances may show up in the next LF update - LF 2010, which will then require a re-evaluation of the surface fuel. The CBH and CBD in the LF 2008 update have been modeled to exhibit much higher CBH and much lower CBD from the effects of the fire activity. The model inputs for this simulation remained the same as the previous two model runs. The fuel models outside the fire perimeter (Figure 21 and Figure 22) show more aggressive spread than those inside the fire; again no attempt was made to create a barrier to limit the spread of the fire along the fire perimeters.

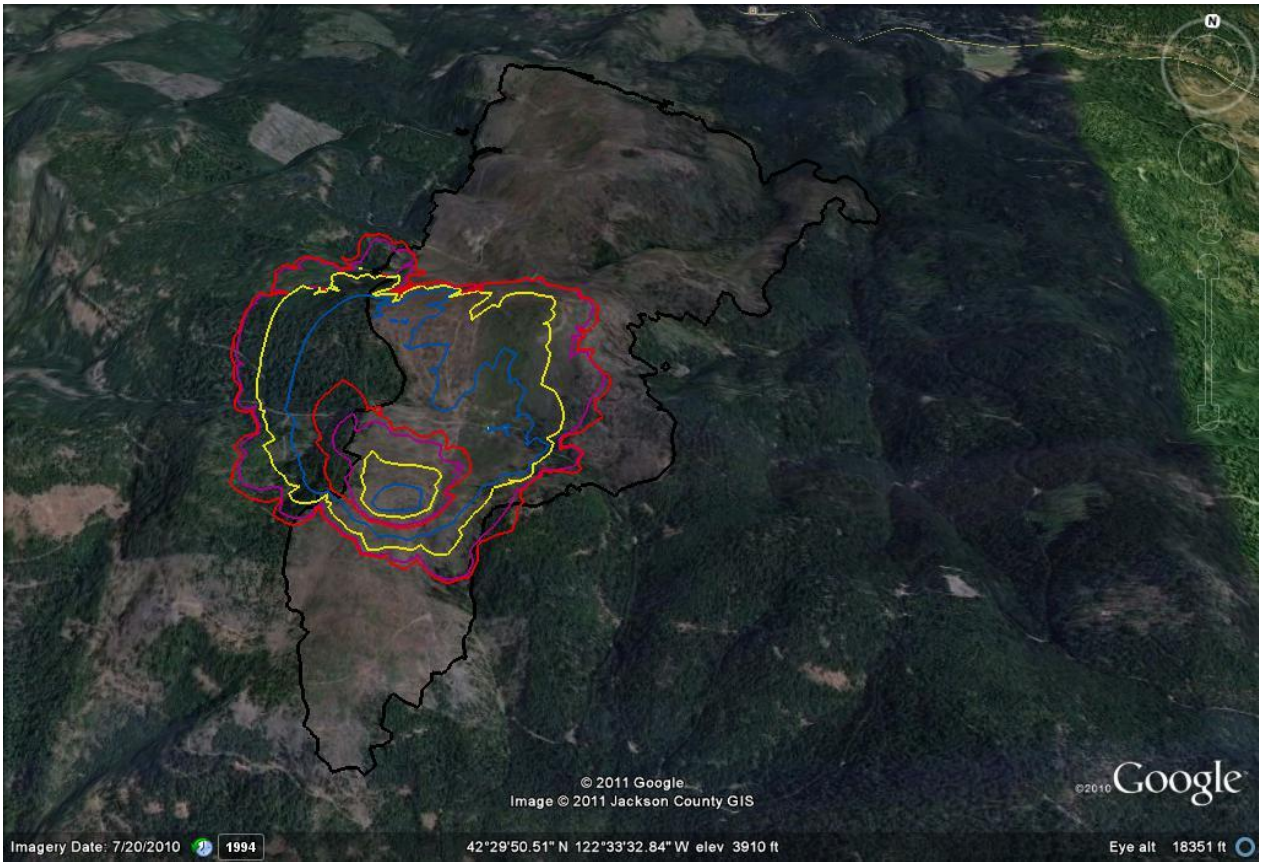

Figure 22 – LF 2008 fire simulation of the Doubleday Fire.

3.2 Alder Gulch Fire, 2010

The Alder Gulch Fire occurred in west central Montana (LF Mapping Zone 19) on August 23rd, 2010. The fire burned to nearly its final size by August 27th. Suppression actions on this fire were unknown, but ridgeline trails and the fire scar of the Alder Fire of 2000 were prominent boundaries of the final fire size. This indicates that burning to those boundaries was the likely cause of the final fire extent. Energy Release Component figures show the area to be very close to the 90th percentile in fuel dryness over a ten-year average. Torching and short runs of active crowning were suspected in the fire activity. The fire originated and burned completely in USFS ownership. The fire Incident Action Plan (IAP) map on the 23rd showed the fire origin as mid-slope, with an east aspect toward the center of the fire area. This indicates that the wind or the burn out activities (or both) caused the fire to spread north, south, and southeast to reach its final extent. The vegetation of the fire area was composed of closed stands of mixed conifer and was dominated by Douglas Fir (Pseudotsuga menziesii). The fire simulations displayed below used the fire perimeter, weather, and fuel moistures on August 27th to project the likely fire behavior characteristics and direction.

3.2.1 Inputs

Weather, wind, and fuel moisture data for the fire simulation were compiled from two RAWS located to the northwest and southeast of the fire area. The Stevi RAWS (242904) is located 13 miles to the northwest and the Grid RAWS (242911) lies 16.3 miles to the southeast. Median values from the two RAWS were used for fuel moisture, temperature, and relative humidity. The median value for 10-minute average and maximum gust wind speeds was found for each hour from August 23rd - 31st for each station. A median value between the two stations was used as input into the model for the first projection across all three versions of LF fuel data. Maximum gust wind speeds and altered wind direction were used in subsequent projections to closer emulate the actual spread and final fire perimeter. There was some moisture in the weather file for August 27th in the amount of .04 inches over a two hour period.

FBFM40 values in LF National were predominantly composed of 165 (TU5), 183 (TL3), and 188 (TL8). Values for CBH were generally between 1.7 and 5.0 meters in all of the fuel models. FBFM40 values in LF 2001 were divided evenly between 165 (TU5) and 183 (TL3), with 188 (TL8) comprising the rest. CBH values were much lower and mainly ranged from 0.1 to 1.2 meters. FBFM40 values in LF 2008 were composed of 183 (TL3), 165 (TU5), 188 (TL8), 122 (GS2), and 102 (GR2). CBH values were very similar in range to those of LF 2001.

A 24-hour window with a 4-hour maximum burn period was used to simulate the fire spread in all three versions of the fuel data. The ignition point was set to the indication given on the IAP map. Crown fire activity was set to the Scott and Reinhardt 2001 method, and spotting was enabled at 1.5%. A fuel moisture and environmental conditioning period from August 24th through August 26th was used, and the weather values were composed of the median values of the two RAWS. A second model run was completed for LF 2001 and 2008 with maximum gust wind speeds from the RAWS that would induce crown fire activity in order to see results of final fire size. These wind speeds values were not run for LF National because the CBH values are so high that it would not have induced crown fire activity. Wind direction was altered from that of the RAWS in order to emulate fire spread through the shape of the final fire within a 24-hour window.

3.2.2 Results

As displayed below, LF National severely underestimates the fire spread compared to the actual perimeter (Figure 23). The simulation indicated that the fire was spreading as a surface fire with little spotting and no crowning.

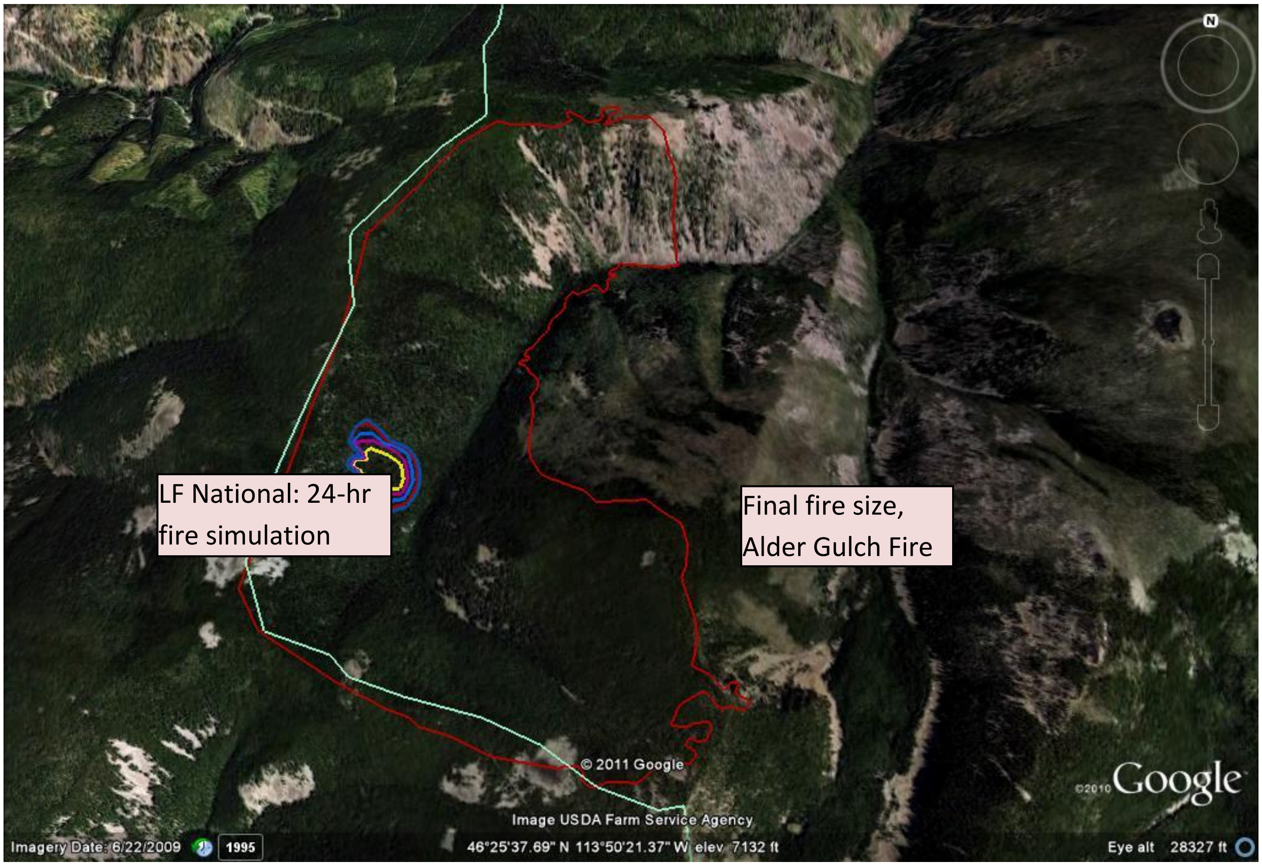

Figure 23 – LF National fire simulation of the Alder Gulch Fire.

LF 2001 fuel layers provided some torching and spotting in the fire spread, but with the median wind speeds based on the 10-minute average, the spread was limited (Figure 24). The lower CBH did allow torching and spotting to occur for the surface fuel model in the wind speeds values from the RAWS.

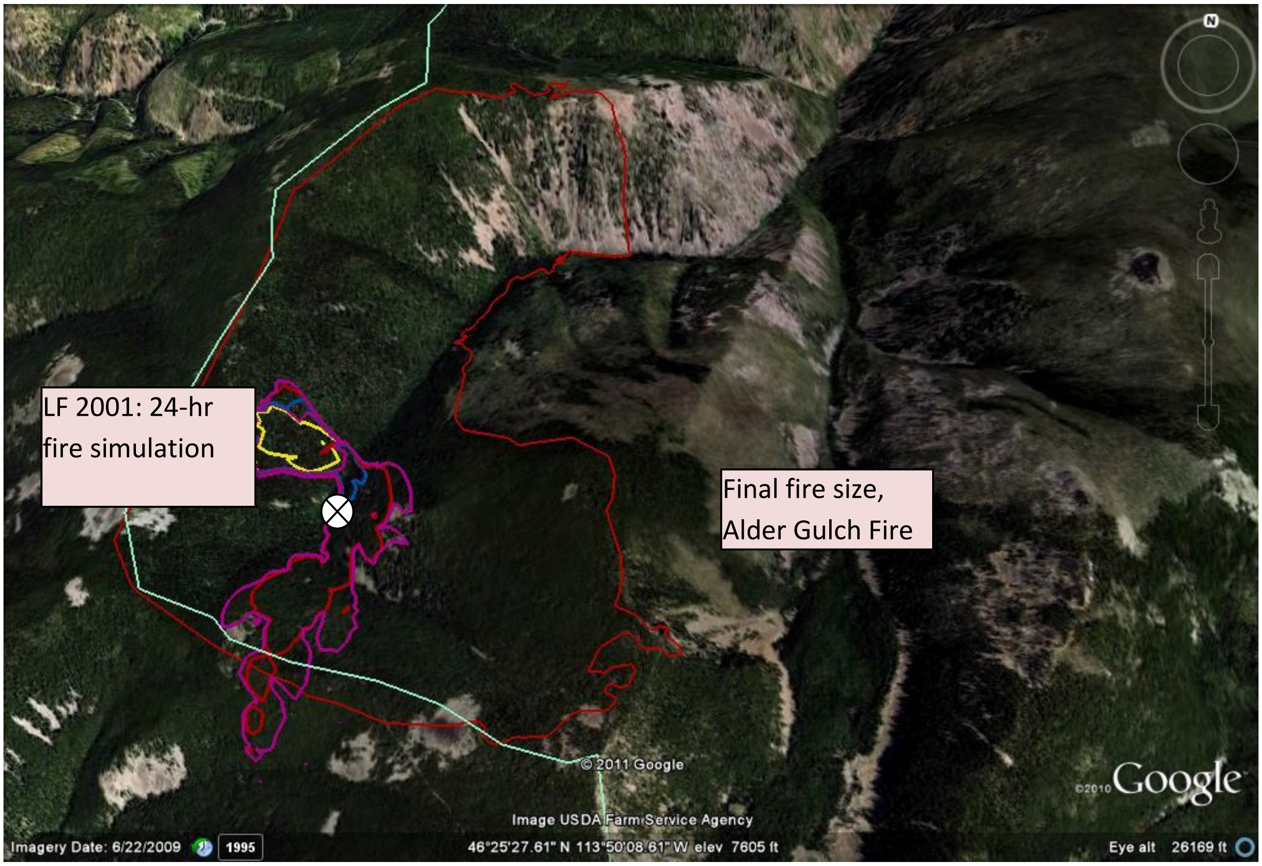

Figure 24 – LF 2001 fire simulation of the Alder Gulch Fire.

Figure 25 also depicts LF 2001 fuel layers with wind speeds values (20 ft.) at maximum gust (10 to 15 mph). The wind directions were altered some to spread the fire within the final perimeter. No attempt was made in the simulations to mimic or show fire suppression actions on the flanks of the fire using wildland fire initial attack resources.

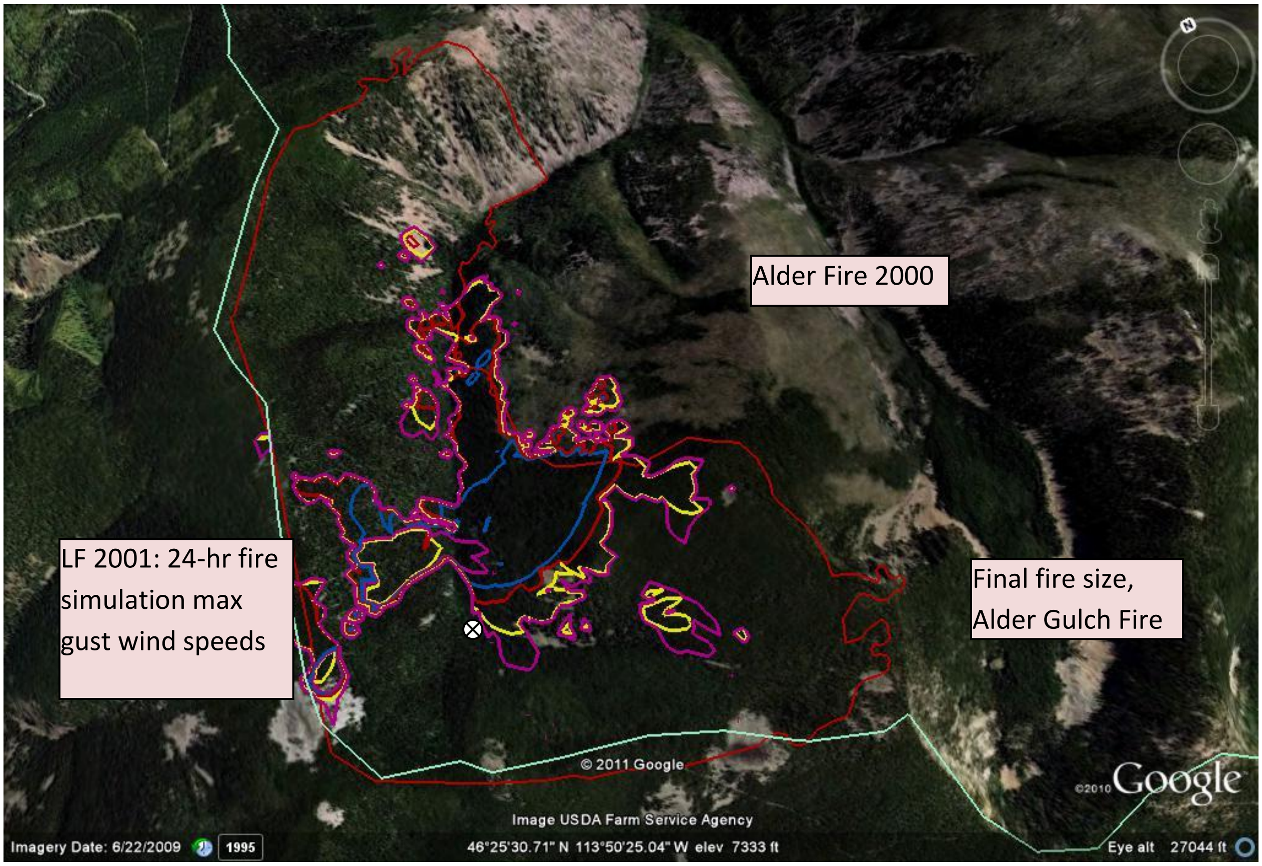

Figure 25 – LF 2001 fire simulation of the Alder Gulch Fire with maximum gust wind speeds.

LF 2008 depicts this site with a fuel model landscape predominantly composed of 183 (TL3). When assessed in an analysis factoring in wind speeds for the fire, the projections showed appreciable fire spread as portrayed in Figure 26. The low CBH allows some torching and crowning, but the RAWS wind direction, again, tends to spread the fire southward.

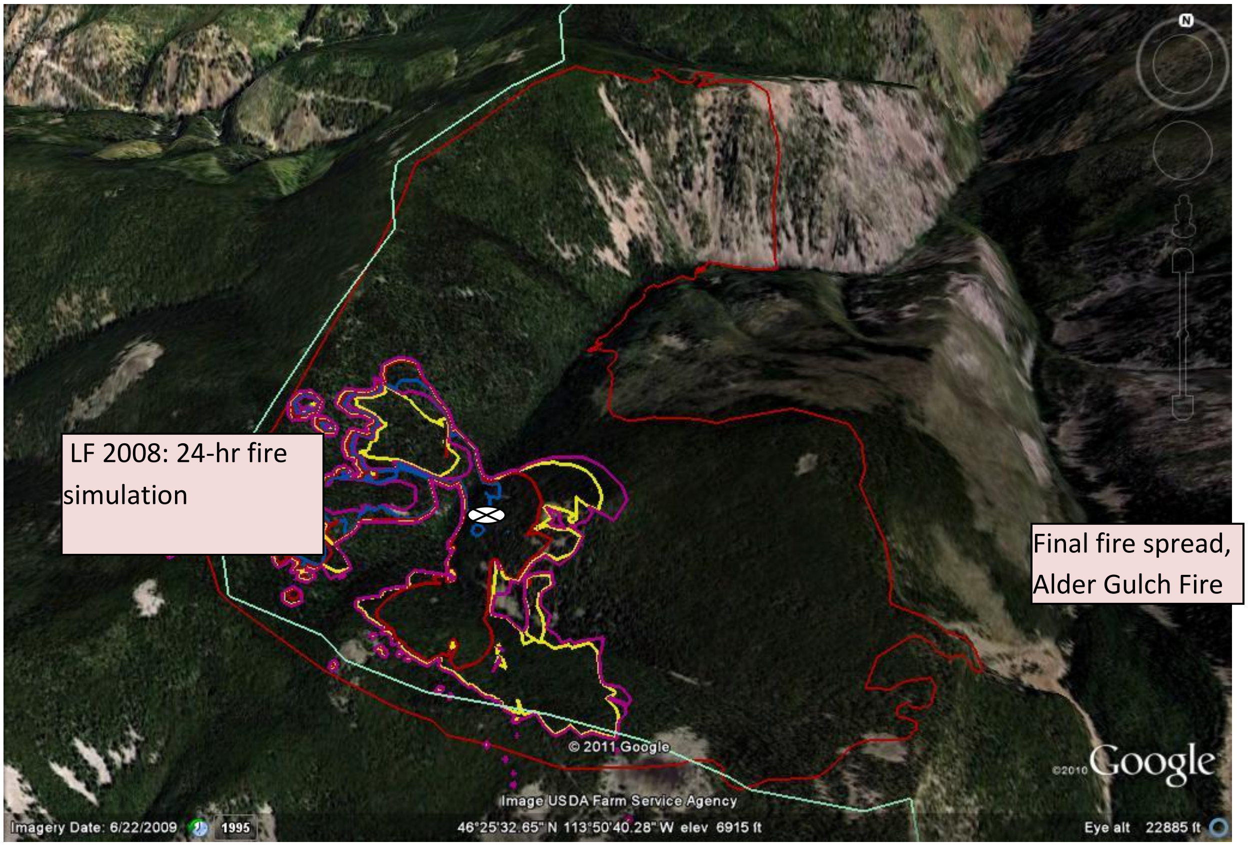

Figure 26 – LF 2008 fire simulation of the Alder Gulch Fire.

Figure 27 depicts modeled fire spread in LF 2008 with the same direction adjustments that were made for LF 2001 as well as the 20-ft wind speeds in the 10-15 mph range.

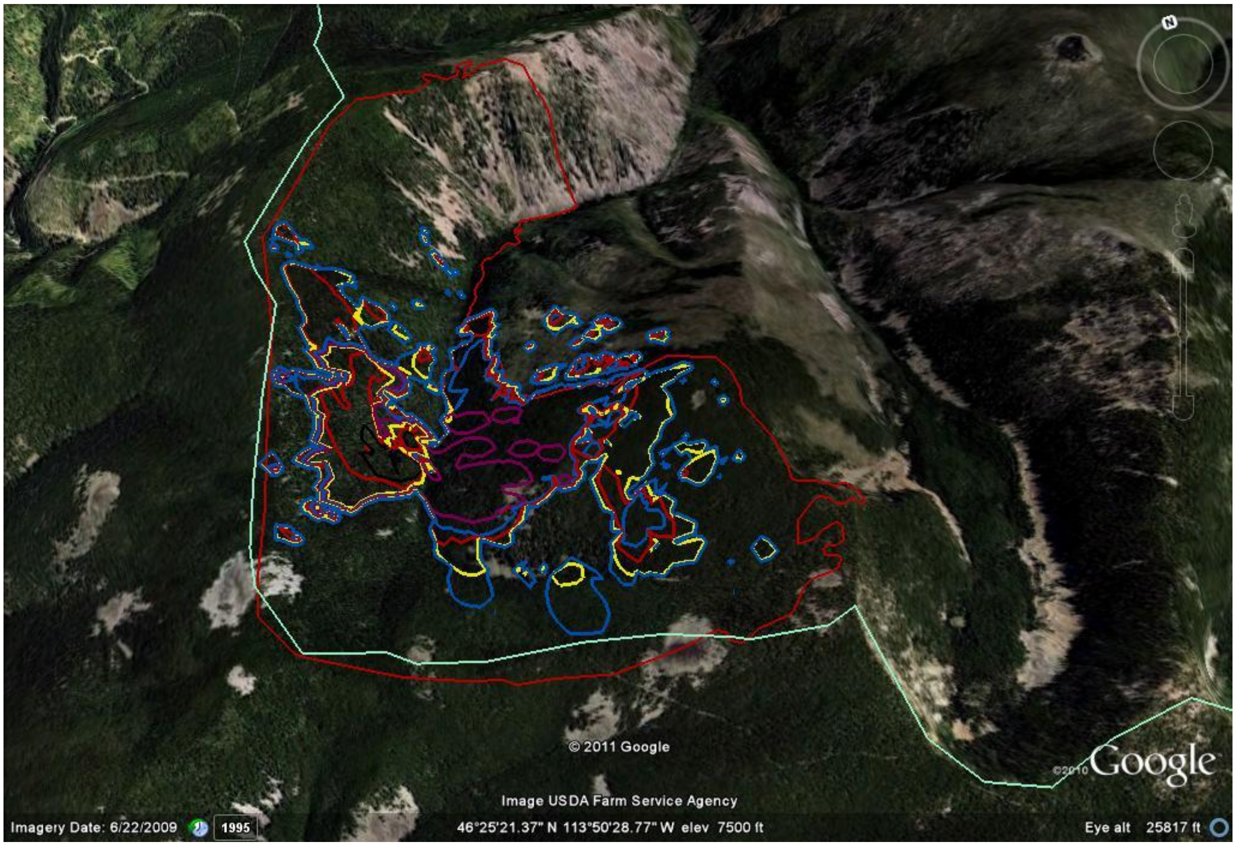

Figure 27 – LF 2008 fire simulation of the Alder Gulch Fire with maximum gust wind speeds.

3.2.3 Results

These evaluations of the LF fuel data sets against known wildland fire perimeters indicate the data have been enhanced and improved. The LF Refresh 2001/2008 data show more representative projections compared to the LF National data to the final fire perimeters.

The model inputs for this simulation remained the same as the two previous model runs. The fuel models outside of the fire perimeter (Figure 21 and Figure 22) show more aggressive spread than those inside the fire.

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

6.2 Forest Inventory Analysis

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

6.3 National Agricultural Statistics Service

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

6.4 Multi-Resolution Land Characteristics Consortium National Land Cover Database

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

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

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7.0 Glossary

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

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

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

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

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

Normalized Burn Ratio - The NBR is temporally differenced between pre- and post-fire data sets to determine the extent and degree of change detected from burning.

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

Remote Sensing Landscape Change (RSLC) — 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	FERA – Fire and Environmental Research Applications Team - USFS
FIA – Forest Inventory and Analysis - USFS	GAP – Gap Analysis Program - USGS
MRLC – Multi-Resolution Land Characteristics Consortium	MTBS – Monitoring Trends in Burn Severity
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
USFWS – U. S. Fish and Wildlife 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 setting	CBD – Canopy bulk density
CBH – Canopy base height	CC – Canopy cover
CFFDRS – Canadian Forest Fire Danger Rating System	CH – Canopy height
CONUS – Conterminous United States	CWD - Coarse woody debris

DDS - LANDFIRE Data Distribution Site	DEM - Digital Elevation Model
DWM – Downed woody material	EDNA - Elevation Derivatives for National Applications
ESP – Environmental site potential	EVC – Existing vegetation cover
EVH – Existing vegetation height	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	FFE – Fire and Fuels Extension
FLM – Fuel loading models	FOD - Fire Occurrence Database
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	GLM – General linear model
HI – Hawaii	LCP – FARSITE landscape file
LF – LANDFIRE	LFRDB – LANDFIRE Reference Database
MFRI - Mean Fire Return Interval	NC – North Central
NE – Northeast	NLCD – National Land Cover Database
PADUS - 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
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

Acronyms

RMT – Refresh Model Tracker (LF 2001/2008)	RSLC - Remote Sensing Landscape Change
SC - South Central	SCLASS - Succession Class
SE - Southeast	SOW - Statement of Work
SRTM - Shuttle Radar Topography Mission	SSURGO – Soil Survey Geographic Database
SW - Southwest	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

9.0 References

Anderson HE (1982) Aids to determining fuel models for estimating fire behavior. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-122. (Ogden, UT).

Barrett S, Havlina D, Jones J, Hann W, Frame C, Hamilton D, Schon K, Demeo T, Hutter L, Manakis J. 2010. Interagency Fire Regime Condition Class Guidebook. Version 3.0 [Homepage of the Interagency Fire Regime Condition Class website, USDA Forest Service, US Department of the Interior, and The Nature Conservancy]. [Online], Available: www.frcc.gov.

Comer P, Faber-Langendoen D, Evans R, Gawler S, Josse C, Kittel G, Menard S, Pyne M, Reid M, Schulz K, Snow K, Teague J (2003) Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, (Arlington, Virginia).

Dixon GE (2002) Essential FVS: A user's guide to the Forest Vegetation Simulator. U.S. Department of Agriculture, Forest Service, Forest Management Service Center, Internal Report (Fort Collins, CO).

Finney MA (2004) FARSITE: Fire Area Simulator - Model Development and Evaluation. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Research Paper RMRS-RP-4. (Ogden, UT).

Finney MA (2006) An overview of FlamMap fire modeling capabilities. In Andrews PL, Butler BW, comps. Fuels Management - How to Measure Success; 28-30 March 2006: Portland, OR. Proceedings Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 213-220.

NWCG [National Wildfire Coordinating Group] 2005. Glossary of Wildland Fire Terminology. http://www.nwcg.gov National Interagency Fire Center. Boise, Idaho.

Homer C, Huang C, Yang L, Wylie BK, Coan MJ (2004) Development of a 2001 National Land Cover Database for the United States. *Photogrammetric Engineering and Remote Sensing* **70**, 829-840.

Homer CG, Ramsey RD, Edwards Jr TC, Falconer A (1997) Landscape cover-type modeling using a multi-scene thematic mapper mosaic. *Photogrammetric Engineering and Remote Sensing* **63**, 59-67.

Huang C, Goward SN, Masek JG, Thomas N, Zhu Z, Vogelmann JE (2010) An automated approach for reconstructing recent forest disturbance history using dense Landsat time series stacks. *Remote Sensing of Environment* **114**, 183-198.

Jones J, Tirmenstein D (2012) Fire Regime Condition Class Mapping Tool User's Guide. National Interagency Fuels, Fire, and Vegetation Technology Transfer Team, www.niftt.gov.

Kellndorfer J, Walker W, Pierce L, Dobson C, Fites JA, Hunsaker C, Vona J, Clutter M (2004) Vegetation height estimation from Shuttle Radar Topography Mission and National Elevation Datasets. *Remote Sensing of Environment* **93**, 339-358.

ESSA Technologies Ltd. (2007) Vegetation Dynamics Development Tool User Guide, Version 6.0. Prepared by ESSA Technologies Ltd., (Vancouver, British Columbia).

Lutes DC, Keane RE, Caratti JF (2009) A surface fuel classification for estimating fire effects. *International Journal of Wildland Fire* **18**, 802-814.

References

Omernik JM (1987) Ecoregions of the conterminous United States. *Annnals - Association of American Geographers* **77**, 118-125.

Ottmar RD, Sandberg DV, Riccardi CL, Prichard SJ (2007) An overview of the Fuel Characteristic Classification System — Quantifying, classifying, and creating fuelbeds for resource planningThis article is one of a selection of papers published in the Special Forum on the Fuel Characteristic Classification System. *Canadian Journal of Forest Research* **37**, 2383-2393.

Reeves MC, Ryan KC, Rollins MG, Thompson TG (2009) Spatial fuel data products of the LANDFIRE Project. *International Journal of Wildland Fire* **18**, 250-267.

Reinhardt E, Crookston NL (2003) The Fire and Fuels Extension to the Forest Vegetation Simulator. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-116. (Ogden, UT).

Riccardi CL, Ottmar RD, Sandberg DV, Andreu A, Elman E, Kopper K, Long J (2007) The fuelbed: a key element of the Fuel Characteristic Classification SystemThis article is one of a selection of papers published in the Special Forum on the Fuel Characteristic Classification System. *Canadian Journal of Forest Research* **37**, 2394-2412.

Schmidt KM, Menakis JP, Hardy CC, Hann WJ, Bunnell DL (2002) Development of coarse-scale spatial data for wildland fire and fuel management. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-87. (Fort Collins, Colorado).

Scott J (2008) Review and assessment of LANDFIRE canopy fuel mapping procedures. White Paper available from www.landfire.gov.

Scott JH, Reinhardt ED (2001) Assessing Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Research Paper RMRS-RP-29. (Fort Collins, CO).

Scott JH, Burgan RE (2005) Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-153. (Fort Collins, CO).

Scott JH, Reinhardt ED (2005) Stereo photo guide for estimating canopy fuel characteristics in conifer stands. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-145. (Fort Collins, CO).

Sikkink PG, Lutes DC, Keane RE (2009) Field Guide for Identifying Fuel Loading Models. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-225. (Fort Collins, CO).

Stocks BJ, Lynham TJ, Lawson BD, Alexander ME, Wagner CEV, Mcalpine RS, Dubé DE (1989) Canadian Forest Fire Danger Rating System: An Overview. *The Forestry Chronicle* **65**, 258-265.

Stratton RD (2006) Guidance on Spatial Wildland Fire Analysis: Models, Tools, and Techniques. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-183. (Fort Collins, CO).

Toney C, Shaw JD, Nelson MD (2009) A Stem-map Model for Predicting Tree Canopy Cover of Forest Inventory and Analysis (FIA) Plots. In Mcwilliams W, Moisen G, Czaplewski R, comps. 2008 Forest Inventory and Analysis (FIA) Symposium; October 21-23 2008: Park City, UT. Conference Proceedings

References

RMRS-P-56CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 1 CD.

Vogelmann JE, Kost JR, Tolk B, Howard S, Short K, Chen X, Huang C, Pabst K, Rollins MG (2011) Monitoring landscape change for LANDFIRE using multi-temporal satellite imagery and ancillary data. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* **4**, 252-264.