Landscape Fuel Treatment Updating

Using LANDFIRE Vegetation and Fuel transition Data

Applied within

Interagency Fuels Treatment Decision Support System (IFTDSS)

and

Landscape Service

Initial Documentation Authors 2017:
Donald Long, Jim Napoli, and Charley Martin

Finalization Documentation Authors 2019:
Hans Fiedler, Don Long, Nicole Vaillant, and Sam Amato

Summary

The objective of the LANDFIRE Lookup and Fuel Model Lookup effort was to provide databases to inform a user-driven update process of the LANDFIRE fuel data by leveraging LANDFIRE vegetation and fuel transition data. The goal is to provide users the ability to update LANDFIRE fuel data layers with potential fuel treatment scenarios and then test the results with fire behavior and fire effect simulations. Initially, the LANDFIRE vegetation data, specifically Existing Vegetation Type (EVT), Existing Vegetation Cover (EVC), and Existing Vegetation Height (EVH) along with the Map Zone, were required to link transitions to outcomes of fuel treatments.

For applying the Lookup rules, the user defines the area of treatment as well as the LANDFIRE "stock" disturbance type, severity, and time input in order to assess the effects of the treatment on the fuel data (fuel data inputs for treated pixels). The current vegetation conditions are then extracted from each treated pixel on the landscape, linked to a vector of post treatment fuel conditions (including Fuel Model 40 (Fire Behavior Fuel Model {FBFM40}), Canopy Bulk Density (CBD), Canopy Base Height (CBH), Canopy Cover (CC), and Canopy Height (CH)), and then mapped to a new landscape containing the treated pixels. These data can then be used to "update" the fuel map and to initialize fire behavior and fire effects simulations.

At the writing of this documentation the LANDFIRE Lookup rules have been applied within the Interagency Fuels Treatment Decision Support System (IFTDSS) and work is being done in development work of a Landscape Service. At this point in time, the Landscape Service does not support Lookup rules for Fuel Model 13.

The LANDFIRE Vegetation Transition process couples disturbance and simulation models in order to model the resulting vegetation composition and structure. In addition, these data are leveraged to predict/map change in fuel attributes of the associated vegetation and the resulting fire regime attributes. Information from a variety of sources was used to inform vegetation transition assignments. The majority of vegetation and canopy transitions were developed using the Forest Vegetation Simulator (FVS) model, along with the Fire and Fuels Extension (FFE) model for fire simulations. These simulations were run on approximately 60,000 forested plots for all FVS variants nationwide. These data were initially developed in 2015 and the initial LANDFIRE vegetation lookup tables and refined through 2017 to provide an additional fuel treatment update tables.

As was previously mentioned, the Existing Vegetation characteristics are used by LANDFIRE Lookup to perform the mapping. However, there are instances when users need to pre-edit their landscape before applying LANDFIRE Lookup. And since the Existing Vegetation

characteristics can typically not be edited by existing fire applications, LANDFIRE Lookup rules frequently cannot be utilized once a user has modified their landscape. That is, if they manually edit the fire behavior fuel model (FBFM40), the canopy cover (CC), or the canopy height (CH) of a cell, will not have made a corresponding change to the EVT, EVC or EVH causing data conflicts and mismatches. Since this process risks having a mismatch between the edited pre-treatment fuel data and the post-treatment fuel data, it was decided at this point to develop transition data based solely on pre-treatment FBFM40, CC classes, and CH classes. The additional table of fuel transition data (referred to as Fuel Model Lookup) was developed since the associated rules are based upon the fuel model, canopy cover, and canopy height as opposed to EVT, EVC, and EVH or vegetation lookup.

Introduction

The objective of this effort is to provide a user-driven update process for leveraging LANDFIRE vegetation and fuel transition data. This will enable users to update LANDFIRE fuel data layers with potential fuel treatment outcomes and then test results with fire behavior and fire effects simulations. Users are required to use LANDFIRE "stock" disturbance type, severity, and time inputs in order to populate vegetation and fuel data for treated pixels.

Two potential approaches were proposed and discussed. The first was a geo-spatial approach that used the LANDFIRE transition data to create "wall-to-wall" post disturbance fuel data layers for all possible disturbance type/severity/time transitions. This data could then be stored and as users "treat" fuels on the landscape, these data would populate treated pixels. A second approach was also considered. This tabular approach would use the same LANDFIRE transition data to create a tabular database to store post treatment fuel data inputs for all possible disturbance type/severity/time transitions. As users "treat" fuels on the landscape, these data are used to create post-treatment fuel attributes for treated pixels using a lookup to the tabular transition data.

The preferred approach was to leverage tabular data and populate "treated" pixels with the results of the LANDFIRE vegetation transition databases along with LANDFIRE fuel transition databases. To assess the effects of a treatment, the user must first define the area of treatment as well as the treatment type, treatment severity, and desired time period (i.e. one year after, 2-5 years after, or 6-10 years after). The current vegetation conditions are then extracted from each treated pixel and linked to a vector of post treatment Existing Vegetation conditions and their associated fuel conditions including FBFM40, CBD, CBH, CC, and CH. Post disturbance

values are then mapped into each treated pixel and then used to "update" the fuel maps and to initialize fire behavior and fire effects simulations.

Materials, Approach, and Methods

Methods Used to Develop LANDFIRE Vegetation Transition Data

The LANDFIRE Vegetation Transition process couples disturbance and simulation models in order to model the resulting vegetation composition and structure. In addition, these data are leveraged to predict/map change in fuel attributes of the associated vegetation and the resulting fire regime attributes. Information from a variety of sources was used to inform vegetation transition assignments. It should be noted that LANDFIRE transitions were only defined for the continental United States (CONUS).

In forested EVTs, the majority of vegetation and canopy transitions were developed using the Forest Vegetation Simulator (FVS) model along with the Fire and Fuels Extension (FFE) model for fire simulations. These simulations were run on approximately 60,000 forested plots for all FVS variants nationwide. The plot data, contained within the Forest Vegetation Simulator (FVS) Ready Database (FVSRDB), contain all attributes necessary for FVS simulations. These data also include predefined input tables used for initializing stand/plot information (StandInit and TreeInit tables) for FVS. More detailed descriptions and input data requirements can be found in the FVS User Guide. Following simulations, a database was derived from post-disturbance FVS/FFE outputs covering all FVS Variants at multiple severities and time-steps (Table 1).

Table 1.

Disturbance Type	Severity	Time Since Disturbance (TSD)	Time Since Disturbance (TSD)	Time Since Disturbance (TSD)
Fire	**High**	**1 Year**	**2-5 Years**	**6-10 Years**
	Moderate	**1 Year**	**2-5 Years**	**6-10 Years**
	Low	**1 Year**	**2-5 Years**	**6-10 Years**
Mechanical Add	**High**	**1 Year**	**2-5 Years**	**6-10 Years**
	Moderate	**1 Year**	**2-5 Years**	**6-10 Years**
	Low	**1 Year**	**2-5 Years**	**6-10 Years**
Mechanical remove	**High**	**1 Year**	**2-5 Years**	**6-10 Years**
	Moderate	**1 Year**	**2-5 Years**	**6-10 Years**
	Low	**1 Year**	**2-5 Years**	**6-10 Years**

These disturbances include fire, insect and disease, wind, mechanical add, and mechanical remove, and are implemented in FVS using keyword component (KCP) files (see Appendix 2). Each disturbance was simulated with three severities and results output at three different time steps. Severities include high severity where >75% above ground vegetation mortality is achieved in the simulation process, medium severity where 25-75% above ground vegetation mortality is achieved in the simulation, and low severity where 0-25% above ground vegetation mortality is achieved in the simulation. Output time steps determine the Time Since Disturbance (TSD) and occur: Initially (one year) after disturbance, 2-5 years (4 years) post disturbance, and 6-10 years (8 years) post disturbance.

Outputs from low and moderate severity simulations were synthesized in order to make them available for use in transition queries. The resulting disturbance effects on tree EVC and EVH were tabulated across all EVT's and summarized using a majority solution derived for low, moderate, and high levels of aggregation of the EVT legend. This resulted in a single EVC/EVH outcome for every simulation type across all input EVC/EVH combinations. It was assumed that low and moderate severity disturbance did not change EVT.

A number of transitions were derived without the use of FVS or FFE. These transitions were instead based on a more heuristic approach. Stand-replacing events such as high severity fire and mechanical remove activities in forested EVTs were transitioned to an herbaceous or shrubland EVT's with a cover and height appropriate for an early seral expression of that EVT and for that geographic location. 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. 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. However, EVC and EVH were reset to values generally found after such disturbances.

LANDFIRE vegetation and fuel transition databases based on LANDFIRE Map Zone, EVT, EVC, and EVH provided the initial data for fuel transition data. The pre-treatment LANDFIRE vegetation data, including Map Zone, EVT, EVC, and EVH, were required to link transitions to outcomes of fuel treatments. These data were developed in 2015 to provide the initial databases.

Methods Used to Develop LANDFIRE Fuel Transition Data

Similar to the vegetation transition process, the fuel transition process brings the fuel data to a more current time period with subsequent biennial updates and is based on the modeled change in vegetation (type, cover, height) through disturbance and natural processes. The same set of disturbances, severities, and TSD's are used for fuel as are used for vegetation.

For surface fuel, transitions are based on the intensity of the disturbance and the time since the event. The surface fuel model was changed to reflect the change in surface vegetation from modeling and expert opinion inputs. Determination of the change in FBFM13/40 due to disturbance or natural processes was not based on information attained from Forest Vegetation Simulator. Instead, we looked at the relative change in fuel loading from the original LANDFIRE calibrated fuel model to help inform the surface fuel model transition due to disturbance.

An important distinction between vegetation, canopy fuel and surface fuel post disturbance assignments is worth highlighting. In determining post disturbance surface fuel model assignments, there is no consideration of a fuel model call directly after a disturbance event (TSD 1). Since LANDFIRE data has traditionally been on 2 year update cycles, disturbance products are typically 2 years behind putting all new disturbances in TSD2. The assignments for surface fuels are expert opinion driven, based on the second growing season after a disturbance event. This essentially makes the TSD 1 & 2 assignments the same due to LANDFIRE data production being 2 years behind the actual date. In some areas, the second time step since disturbance returned the fuel model to its original state due to the quick return of the vegetation. Vegetation in areas that were not included in the disturbance layer was modeled through growth simulation models.

Transitions in canopy fuel due to disturbance and succession were modeled using the FVS and FFE. The resulting disturbance effects on CC, CH, CBD, and CBH were tabulated across all EVT's and summarized using a mean solution derived for low, moderate, and high levels of aggregation of the EVT legend. This resulted in a single canopy fuel outcome for every simulation type across all input EVC/EVH combinations.

Methods Used to Develop Fuel Treatment Updating version 1.0

LANDFIRE vegetation and fuel transition databases based on LANDFIRE Map Zone, EVT, EVC, and EVH provided the initial data. The pre-treatment LANDFIRE vegetation data, including Map Zone, EVT, EVC, and EVH were required to link transitions to outcomes of fuel treatments.

Subsequent to the initial effort, the process evolved to provide users the ability to edit the pre-treatment LANDFIRE fuel data for their area of analysis. This ability to edit includes the fire behavior fuel model (FBFM40) data, along with tree canopy cover (CC) and tree canopy height (CH) are utilized to modify the landscape characteristics where users feel improvements may be needed to improve simulation accuracies. However, this process risks having a mismatch between the edited pre-treatment fuel data and the post-treatment fuel data. It was decided at this point to develop transition data based solely on pre-treatment FBFM40, CC classes, and CH classes and development of an additional version of the fuel transition data; referred to as Fuel Treatment Updating version 2.0 or Fuel Model Lookup.

Methods Used to Develop Fuel Treatment Updating version 2.0

A number of processing steps were necessary to mine V 1.0 databases and develop V 2.0 databases along with the associated completion dates. Basically, these steps started with unique combinations of Map Zone, pre-disturbance/treatment fuel model, stand cover class, and stand height class and selected the most commonly occurring post-disturbance/treatment fuel model and the average or mean canopy cover, stand height, canopy base height and canopy bulk density values. This database was developed through a hierarchical process in order to leverage disturbance and fuel treatment outcomes nationally, regionally, and sub-regionally so all possible outcomes are addressed and data populated all possible combinations of the pre-treatment fuel data.

Before making a final data deliverable package, process checks were implemented to ensure the canopy assignments did not create erroneous values. A general check was first implemented to ensure canopy structure and canopy fuel values aligned in a logical manner. If the canopy cover was less than 10% or canopy bulk density was equal to zero it was assumed there was not enough canopy present to carry canopy fire and subsequent canopy characteristics (CC, CH, CBD and CBH) were masked out. Finally, to ensure no illogical canopy base height values were assigned, a check was implemented to check for and reduce values to 2/3 the canopy height if the calculated value was greater than that.

Results

For each disturbance type, severity, and TSD, an Excel table was constructed through a series of database queries. Table 2 shows the structure of those tables.

Table 2. Database structure for V 1.0 Fuel Transition databases.

Field Name	Field Description
MZ	**MapZone**
VDIST	**Concatenated disturbance type/severity/TSD code**
EVT01	**Pre-disturbance EVT**
EVH01	**Pre-disturbance EVH**
EVC01	**Pre-disturbance EVC**
EVT12	**Post-disturbance EVT**
EVT_Fuel	**Post-disturbance EVT recoded to EVT fuel**
EVH12	**Post-disturbance EVH**
EVC12	**Post-disturbance EVC**
FBFM13	**Post-disturbance Fire Behavior Fuel Model 13**
FBFM40	**Post-disturbance Fire Behavior Fuel Model 40**
CanCov	**Post-disturbance Canopy Cover**
CanHgt	**Post-disturbance Canopy Height**
CBD	**Post-disturbance Canopy Bulk Density**
CBH	**Post-disturbance Canopy Base Height**

All in all, 27 individual tables were derived for this effort using these methods. A number of caveats exist that one should be aware of while using these data. Using each one of these 27 tables created above, another set of Excel tables was constructed through a series of database queries. Table 3 shows the structure of those tables.

Table 3. Database structure for V 2.0 Fuel Transition databases.

Field Name	Field Description
MZ	**MapZone**
VDIST	**Concatenated disturbance type/severity/TSD code**
FBFM40	**Pre-disturbance Fire Behavior Fuel Model 40**
CanCovCls	**Pre-disturbance Canopy Cover Class**
CanHgtCls	**Pre-disturbance Canopy Height Class**
FBFM40	**Post-disturbance Fire Behavior Fuel Model 40**
CanCov	**Post-disturbance Canopy Cover**
CanHgt	**Post-disturbance Canopy Height**
CBD	**Post-disturbance Canopy Bulk Density**
CBH	**Post-disturbance Canopy Base Height**

Discussion

It should be noted that although developed from LANDFIRE base data, logic, and databases, it is likely that post disturbance vegetation and fire behavior characteristics of the Fuel Model Lookup will differ from those of standard LANDFIRE data. These differences will occur due to process and logic framework that is dissimilar between the two systems. There are at least three fundamental differences between LANDFIRE and Fuel Model Lookup fuel production and resultant fire behavior characteristics.

1. In the process of building the assignment databases, cover and height bins were abbreviated into 3 groups for cover and 3 groups for height, condensing the current data. In LANDFIRE data, canopy cover (CC) is derived by taking the midpoint of EVC bins, which are in 10% increments (0 to 100%). Similarly, canopy height (CH) is derived by taking the midpoint of EVH bins (5 bins for tree pixels). The canopy attributes of LANDFIRE CC and CH play a pivotal role in the calculations of canopy base height (CBH) and canopy bulk density (CBD). The differentiation from the grouping of these classes creates the likelihood that combinations of CC, CH, CBH, and CBD will not match those of current LANDFIRE. For instance, it is possible that applying the Fuel Model Lookup tables will subsequently produce higher Canopy Cover value than the original LANDFIRE data due to this grouping. There will also be other fire behavior differences caused by the grouping of canopy values:
    - Fire behavior characteristics will differ considerably due to increases and decreases in CC & CH and the resultant variation in wind reduction factors (especially in the moderate cover ranges) which affects the amount of wind interacting with the surface fire.
    - The ability for crowning to initiate will be considerably different between the Lookup table canopy values and standard LANDFIRE.
2. The Fuel Model Lookup process differs from the original LANDFIRE data in terms of the potential for crown fire activity in certain vegetation types. In the LANDFIRE fuel and fire behavior process, the tree species that are reluctant or resistant to crown fire initiation or propensity (often time's deciduous tree species) can be addressed through a canopy guide that makes them unable to crown. There is no such system built into the Fuel Model Lookup process.
3. Although EVT, EVC, EVH, Biophysical Settings (BPS), and Disturbance are inherent in the development of the original LANDFIRE fuel rulesets to achieve a surface fire behavior fuel model assignment, that is not necessarily the case in the Lookup tables. The processes are fundamentally different in that the pathway to the post disturbance fuel model are different. Within original LANDFIRE data, the vegetation type, the structure

characteristics, and the non-disturbed (beginning) fuel model are the basis for determining the change to the post disturbance fuel model assignment. With Fuel Model Lookup, only the beginning fuel model and disturbance are utilized to generate the pathway to the post disturbance fuel model assignment.

4. Because the LANDFIRE surface fuel models reflect a site condition 2 growing seasons post disturbance (TSD 1 and 2), the resultant fuel model assignment is always a burnable fuel model. Users may want to reflect a site condition within the first 2 years post disturbance (TSD 1) that may reflect a non-burnable surface fuel model.

References

- LANDFIRE - **https://landfire.gov/**
- Master Fuels Rulesets Database - **https://landfire.gov/fuel.php**
- Forest Vegetation Simulator - **https://www.fs.fed.us/fmsc/fvs/**
- Fire and Fuels Extension to the Forest Vegetation Simulator - **https://www.fs.fed.us/fmsc/ftp/fvs/docs/gtr/FFEguide.pdf**
- LANDFIRE FVS Ready Database - **https://landfire.gov/reference.php**
- LANDFIRE FVS Simulator Database - **https://landfire.gov/disturbance.php**
- Further Help Documentation Available from IFTDSS - **https://iftdss.firenet.gov/**

Appendix 1 – Veg/Fuels Transitions and Table Summarization

This appendix summarizes the logic of the vegetation and fuels transitions. The information provided covers the excel database tables along with information on the column headings definitions.

A section of this report describes some of the thinking with how disturbances play out for grass, shrub, and forests. It is important to note that a number of the transitions were derived without the use of FVS or FFE. These transitions were instead based on a more heuristic approach.

Stand-replacing events such as high severity fire and mechanical remove activities in forested EVTs were transitioned to herbaceous or shrubland EVTs with a cover and height appropriate for an early seral expression of a given EVT for that geographic location. 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. 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. However, EVC and EVH were reset to values generally found after such disturbances.

- There are a total of 27 tables representing the following disturbance types.
    - 9 - Fire
        - The Fire tables contain 100 series VDist codes. More information on the code structure is provided under the VDist description that follows.
    - 9 - Mechanical Add
        - The Mechanical Add tables contain 200 series VDist codes.
    - 9 - Mechanical Remove
        - The Mechanical Remove tables contain 300 series VDist codes.

Column A – Vegetation Disturbance Code (VDist)

VDIST = Vegetation Disturbance. This is a three digit code comprised of the following:

a. The first digit is the disturbance type where 1 is Fire, 2 is Mechanical Add, and 3 is Mechanical Remove.

b. The second digit is the severity value ranging from 1 to 3 where 1 is Low, 2 is Moderate, and 3 is High.

c. The third digit is the time since disturbance (TSD) value ranging from 1 to 3. 1 is immediately after the disturbance to 1 year; 2 is 2 to 5 years after disturbance, and 3 is 6 to 10 years after disturbance.

For example a code number of 133 would represent a high severity fire 6-10 years after disturbance.

Disturbance	
Fire	1
Mechanical Add	2
Mechanical Remove	3
Wind	4 – Was not developed here
Insect & Disease	5 - Was not developed here

Severity	
Low	1
Medium	2
High	3

Time Since Dist	
1 year after	1
2 to 5 years after	2
6 to 10 years after	3

Column B – Original Fuel Model 40 Value

FBFM40p = Fire Behavior Fuel Model 40 pre change/disturbance.

Column C – Original Canopy (Stand) Height Classification

HC_ID = Height of the Canopy Identification Number pre-disturbance.

This is a one digit value ranging from 0 to 3 in height bins of meters.

Code	Height_Class_Name	Height Class Description
0	Non-Forest	No Forest Height / Canopy
1	Short Forest and Woodland	Forest Height 0 to 10 meters
2	Medium Forest and Woodland	Forest Height 10 to 25 meters
3	Tall Forest and Woodland	Forest Height 25 meters +

Column D – Original Canopy Cover Classification

CC_ID = Canopy Cover Identification Number pre-disturbance. These are canopy cover values and range across the change or disturbance type based on disturbance type, severity, and time since disturbance.

This is a one digit value ranging from 0 to 3 in percentage (%) cover bins.

Code	CLASSNAMES	
0	Non Forest	< 10% Tree Cover
1	Open Tree Cover	Tree Cover >= 10 and < 30%
2	Moderate Tree Cover	Tree Cover >= 30 and < 60%
3	Dense Tree Cover	Tree Cover >= 60 and <= 100%

Column E – Geographic Area

GA = Geographic Area. This rule or relationship of change is defined for this LANDFIRE geographic area (SW for Southwest, SC for South Central, SE for Southeast, NW for Northwest, NC for North Central, and NE for Northeast). The Geographic Area is essentially for reference purposes only. That is, it was not used to load the Fuel Model Lookup tables into the database.

Column F – Map Zone

MZ = Map Zone. The LANDFIRE zone number is required as an input parameter to obtain the correct mapping when LANDFIRE Fuel Model Lookup is applied to a landscape file. The map zone is merged with the LANDFIRE data when the landscape file is requested for an area of interest. The map zone code is carried along as edits are made to generate new landscapes from the original.

The Map Zone data is relatively stable and frequently does not change like many of the LANDFIRE attributes change over time.

Column G – Mapped Fuel Model 40 Value

FBFM40 = Fire Behavior Fuel Model 40 values post change/disturbance.

Column H – Mapped Canopy Cover Percentage

CanCov = Canopy Cover value post change/disturbance continuous values as derived from FFE/FVS. Units are in percentages. These percent tree canopy cover values range across the change or disturbance type based on disturbance type, severity, and time since disturbance. The values range from 0 to 91%.

Column I – Mapped Canopy (Stand) Height

CanHgt = Canopy Height post change/disturbance continuous values as derived from FFE/FVS . The units are meters X 10. The values range from 0 to 542 (54.2 m).

Column J – Mapped Canopy Bulk Density

CBD = Canopy Bulk Density post change/disturbance values as derived from FFE/FVS. The units are kilograms per meter cubed X 100. The values range from 0 to 25 (0.25 kg/m^3).

Column K – Mapped Canopy Base Height

CBH - Canopy Base Height post change/disturbance values as derived from FFE/FVS. The units are meters * 10. The values range from 0 to 346 (34.6 m).

Column L - Level

LEVEL = The level or relationship at which this rule is applied. Values range from CONUS, GA, to MZ.

a. CONUS implies that this rule is the default rule if a more specific rule does not exist for a geographic area or a specific map zone.

b. GA means that this rule applies at the Geographic Area level unless it is superseded by a rule for a specific map zone.

c. MZ means that this rule applies for the given map zone.

It should be noted that the CSV files supplied for processing were flattened files. That is, a rule existed for every map zone regardless of whether it was defined at the Map Zone, Geographic Area, or CONUS level.

Sample Data from the LANDFIRE_FM_LOOKUP Table

Type	Sev	Time	Zone	Orig FM40	Orig SH	Orig CC	Mapped FM40	Mapped CC	Mapped SH	Mapped CBD	Mapped CBH
1	1	1	1	101	0	0	121	0	0	0	0
1	1	1	1	101	1	1	101	13	63	4	15
1	1	1	1	101	1	2	101	24	60	5	14
1	1	1	1	101	1	3	101	59	76	9	13
1	1	1	1	101	2	1	101	17	141	3	42
1	1	1	1	101	2	2	101	28	178	8	34
1	1	1	1	101	2	3	101	71	196	6	49
1	1	1	1	101	3	1	101	14	299	2	20
1	1	1	1	101	3	2	101	32	298	10	33
1	1	1	1	101	3	3	101	73	271	5	81

Note that the Vegetation Disturbance (VDist) was separated into three distinct values – (disturbance type, severity, and time since disturbance).

There are 651,240 rules in the LANDFIRE_FM_LOOKUP table.

651,240 is the product of 27 X 10 X 36 X 67 which is the number of Vegetation Disturbance Types times 10 Rules per Fuel Model times 36 Fuel Models times 67 CONUS Map Zones. Note that there are no fuel model lookup rules for the four 200 series (slash blowdown) fuel models. Also note that LANDFIRE Lookup rules were not established for Alaska and consequently there was no need for corresponding Fuel Model Lookup rules.

Sample Data from the LANDFIRE_LOOKUP Table

Type	Sev	Time	Zone	Orig EVT	Orig EVH	Orig EVC	Map'd EVT	Map'd EVH	Map'd EVC	Map'd FM13	Map'd FM40	Map'd CC	Map'd SH	Map'd CBD	Map'd CBH
2	3	1	6	3011	111	106	3011	111	105	8	183	54	264	8	58
2	3	1	6	3011	111	107	3011	111	107	8	183	68	267	11	75
2	3	1	6	3011	111	108	3011	111	103	8	183	30	258	6	27
2	3	1	6	3011	111	109	3011	111	108	8	183	78	319	11	74
2	3	1	6	3017	109	109	3017	110	102	5	142	22	115	1	43
2	3	1	6	3017	110	101	3017	110	101	5	142	15	130	1	95
2	3	1	6	3017	110	102	3017	110	102	5	142	21	126	1	87
2	3	1	6	3017	110	103	3017	110	102	5	142	27	129	1	73
2	3	1	6	3017	110	104	3017	110	103	5	142	37	130	3	30
2	3	1	6	3017	110	105	3017	110	104	10	162	43	130	4	21

Note that the Vegetation Disturbance (VDist) was separated into three distinct values – (disturbance type, severity, and time since disturbance).

There are 2,326,182 rules in the LANDFIRE_LOOKUP table. There are a variable number of records for each Map Zone as the defined rules were based upon Existing Vegetation values that existed in the original LANDFIRE data. That is, if a particular combination of EVT, EVH, and EVC values did not exist within a given map zone, a rule was not defined for that combination. Also notice that there is a mapping for the Existing Vegetation values. As a result, applying a LANDFIRE Lookup rule to a landscape cell does not preclude applying a LANDFIRE Lookup rule to the same cell in a subsequent edit.

Appendix 2 – FVS Disturbance/KCP Logic

Note: Although listed below the Wind and Insect/Disease were not developed for this effort.

Fire

- High – High Severity with additional mortality when necessary.
    - Some variants do not predict crown fire, requiring fixed mortality to be added. If variant did have ability to predict crown fire fixed mortality was removed
    - Wind: 20, Moisture: 1, Temp: 90, %-Area: 95
- Mid – altered SimFire variables accordingly
    - Wind: 7, Moisture: 2, Temp: 75, %-Area: 75
- Low – altered SimFire variables accordingly
    - Wind: 4, Moisture: 3, Temp: 67, %-Area: 45

Mechanical Remove

- High
    - Clear-cuts the stand and simulates a prescribed burn
- Med
    - Thins the stand to 35% of present density
    - Pile and Burns adding additional mortality to the small trees (0-5") based on the thinning activity and pile and burning
- Low
    - Thins the stand from below leaving 20% in the 0-6"
    - Pile and Burns adding additional mortality to small trees (0-5") based on the thinning activity and pile and burning

Mechanical Add

- High
    - Mastication, fells 90% of the 0-8" material, leaves it on the ground then masticates it by breaking it into smaller fuel category
- Med
    - Mastication, fells 75% of the 0-6" material, leaves it on the ground then masticates it by breaking it into smaller fuel category
- Low
    - Fells 55% of the 0-6" material, leaves it on the ground then treats it by lopping and scattering

Wind

- High
    - Fells 85% all trees from the largest to smallest
    - Yard-loss leaves trees in the stand and on ground
- Med
    - Fells 55% all trees from the largest to smallest
    - Yard-loss leaves trees in the stand and on ground
- Low
    - Fells 10% all trees from the largest to smallest
    - Yard-loss leaves trees in the stand and on ground

Insect and Disease

- High
    - Kills 85% all trees, leaves them standing dead at disturbance date
- Med
    - Kills 55% all trees, leaves them standing dead at disturbance date
- Low
    - Kills 10% all trees, leaves them standing dead at disturbance date

Appendix 3 – Use of LANDFIRE Lookup Rules and Fuel Model Lookup Rules within the Landscape Service

The Landscape Service Application of Lookup Rules

The Landscape Service will apply both LANDFIRE Lookup rules and Fuel Model Lookup rules when landscape data is being edited. The rule that is applied is based solely upon the data that exists for the given landscape cell that is being edited. That is, if Existing Vegetation attributes exist for that cell, the appropriate LANDFIRE Lookup rule is applied. Otherwise, the corresponding Fuel Model Lookup rule is applied. Existing Vegetation characteristics exist for a given cell until a user-defined edit rule modifies the fuel model, canopy cover, or canopy height of that cell. When this condition occurs, the Landscape Service removes the Existing Vegetation characteristics for the cell. Consequently, prior to user-defined edit rules being applied to a landscape, LANDFIRE Lookup rules will be applied to every cell on the landscape. If only some cells have had user-defined edit rules applied to them (that modified at least one of the fuel model, canopy cover, or canopy height attributes), Fuel Model Lookup rules will be applied to those cells while LANDFIRE Lookup rules will be applied to the remainder of the landscape. And finally, if every cell has had either its fuel model, canopy cover, or canopy height modified by a user-defined rule, then only Fuel Model Lookup rules will be applied to the landscape file in subsequent edits.

Combining LANDFIRE Lookup and User-Defined Edit Rules

When a landscape is being edited, multiple LANDFIRE Lookup rules and multiple User-Defined Edit rules can be applied to the landscape. When this occurs, LANDFIRE Lookup rules are always applied before user-defined edit rules. The primary reason for this is that LANDFIRE Lookup rules are based upon the Existing Vegetation characteristics (type, height, and cover) as well as the LANDFIRE map zone of a cell. And since the vast majority of users are not aware of the Existing Vegetation characteristics of a cell, users are not allowed to edit the EV characteristics when they define a user-defined edit rule. As was previously discussed in this document, Fuel Model Lookup rules are a generalized version of LANDFIRE Lookup rules and consequently not as precise.

The important point to take from this section is that regardless of the relative order of Lookup and user-defined edit rules, the Lookup rules are always applied before the user-defined edit rules. This does not mean that you cannot apply edit rules prior to Lookup rules – but to do so, you must first create an intermediate landscape to which the user-defined edit rules have been applied. Next, you would apply Lookup rules to the intermediate landscape.