LANDFIRE
Total Fuel Change Tool
User Guide

July 2026

Document History

Delivery Date	Version	Action
May 2020	1.0	Initial draft
March 2022	2.0	Updated document to align with newest version of the LFTFC tool
July 2026	3.0	Updated document to align with newest version of the LFTFC tool and switch to be supported only by ArcPro. Significant content updates

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Section 1 About the LFTFC User Guide

1.1 Before You Begin

This user guide describes the basic operation of the LANDFIRE Total Fuel Change Tool (LFTFC), which is used to edit surface and canopy fuel characteristics on a specific site or on large landscapes to support fire and fuels analysis.

Prior to using the tool, LFTFC users must be familiar with Microsoft Access and basic ArcGIS functions.

1.2 How to Use this Guide

It is not necessary to read the entire guide to perform a specific task. Once you are familiar with the basic concepts associated with LFTFC, you can quickly locate commonly performed tasks by reviewing the headings in the Table of Contents. Then you can refer to the specific section pertaining to your needs. Whenever possible, screen captures are used to illustrate steps required to complete a task.

The LFTFC User Guide is not intended to provide step-by-step guidance on the tool's operation; rather, its intention is to serve as a reference guide. The LFTFC Tutorial provides basic step-by-step instructions using a specific management scenario as an example.

1.3 Computer Requirements

Ensure the programs below are installed and functioning properly on your computer. This has been tested with version 3.5 ArcPro (backwards compatible to at least version 3.4).

- Spatial Analyst extension
- 64-bit Microsoft Access

Users also should ensure they have enough space and adequate permission for storing LFTFC outputs on their computer. In a March 2026 ArcPro release, Esri got rid of the standalone ArcCatalog. It is now incorporated into ArcPro and valuable for managing and organizing ArcPro data layers.

Section 2 LFTFC Function

2.1 How LFTFC Operates

LFTFC works through a Microsoft Access database to produce spatial results in ArcPro based on rulesets devised by the user. These rulesets principally consider Fuel Vegetation Type (FVT), Fuel Vegetation Cover (FVC), Fuel Vegetation Height (FVH), Fuel Disturbance (FDist), and Biophysical Setting (BPS) from LF data. Options also exist within the fuel change tool to add discrete variables in raster format using the wildcard option or by subdividing specific areas for different fuel characteristic assignments through the BPS raster.

LFTFC adheres to landscape data file standards for use with FARSITE, FlamMap, WFDSS, FSPRO, and other fire behavior/fire effects programs.

Appendix C has a link to the RMRS Missoula Fire Sciences Lab GitHub Repository, which may be helpful for using the LFTFC Tool.

2.2 Applications

LFTFC has numerous and diverse potential management applications. Fire and fuels managers can use LFTFC for planning purposes, fire behavior analysts can use the tool on actual incidents, and GIS analysts can use it to update national data sets. It can be used to edit surface and canopy fuel characteristics on a specific site at a local scale or across large landscapes used in fire and fuels analysis at a national scale. Specifically, LFTFC can be used to:

- Create Canopy Base Height, Canopy Bulk Density, Canopy Cover, Canopy Height, Canadian Fire Behavior Prediction System Fuel Models, 13 Fire Behavior Fuel Model (Anderson 1982), 40 Fire Behavior Fuel Model (Scott and Burgan 2005), Canopy Cover, Canopy Height and GIS raster/tif layers
- Analyze and validate GIS fire behavior outputs
- Help perform routine and recurring database management operations to allow for progressive manipulation of fuels data during planning efforts, fire incidents, and LF fuel calibrations
- Display and describe vegetation, ecological processes, and how the data are incorporated into final spatial products
- Capture local expertise from a wide range of specialists on fire behavior and fire effects and distribute these data spatially

Section 3 Inputs

3.1 Required Input Data

The Management Unit (MU) serves as the basic building block for changing fuel characteristics in a particular area. The extent of the MU is defined by the user and can be designated by using coordinates or the intersection of the input raster layers. Five separate LF data product layers are required to build an MU and run LFTFC: FVT, FVC, FVH, FDist and BPS.

For development and processing within the LF Program, map zones were used as the standard area for analysis. The default data set was processed by LF map zones and consequently, rulesets for fuels characteristics that are within the default are set at that extent. The Raster layers of FVT FVC, FVH, FDist and BPS (all set to the extent of each LF map zone) were combined for processing.

3.2 Acquiring Input Data

The LF Program has developed nationally consistent data of the spatial themes necessary for running LFTFC as well as those used in FARSITE and FlamMap. The LF website provides links that allow the user to download any of the separate spatial data themes (elevation, slope, aspect, canopy cover, fire behavior fuel model, canopy bulk density, canopy base height, and canopy height). The five required rasters FVT, FVC, FVH, FDist and BPS must be downloaded from the website using our full extent download, Map Viewer, or the option of Web Map Service (WMS) or Web Coverage Service (WCS).

Note: Because LFTFC was developed to process LF data, the classifications of FVT, FVC, FVH, FDist, and BPS are embedded in the tool's nomenclature; therefore, other data sets with different classification systems cannot be used.

These product layers are described briefly below. For additional information on these required input items, consult the LF website.

3.2.1 Biophysical Settings Models and Descriptions (BPS) Product Layer

The Biophysical Settings (BPS) spatial product represents vegetation that may have been dominant on the landscape prior to Euro-American settlement. It is based on the current biophysical environment and an approximation of the historical disturbance regime. Biophysical Settings Models and Descriptions (BPS) models are a refinement of the Environmental Site Potential (ESP) product in that current scientific knowledge regarding the functioning of ecological processes (such as fire) in the centuries preceding non-indigenous human influence is leveraged. Map units are based on NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units (Comer and others 2003). Because LF BPS map units represent the natural plant communities that may have been present during the reference period, they should not be treated as units of existing vegetation. Each BPS map unit is matched with a model of vegetation succession, and both serve as key inputs to the LANDSUM landscape succession model (Keane and others 2002). The LF BPS product layer is similar in concept to potential natural vegetation group product layers produced in conjunction with fire regime condition class (Schmidt and others 2002) during LF National. The BPS spatial product is used in LF to spatially depict reference conditions of vegetation across landscapes. The actual period for this data set is a composite of the historical context provided by the fire regime and vegetation dynamics models and the more recent field and geospatial inputs used to create it. The weather data used in DAYMET were compiled from 1980 to 1997. BPS for CONUS, Puerto Rico and the Virgin Islands, Insular Areas and Hawaii are unchanged from LF 2001 BPS except for updates made to water, barren, and snow classes (additions or removal), so that not vegetated cover types within the spatial BPS product matches LF existing vegetation and fuel products. BPS for Alaska was updated in 2023.

Figure 3-1 shows an example value attribute table for a BPS product layer.

Attributes of bps

Rowid	VALUE *	COUNT	BPS_CODE	ZONE	BPS_MODEL	BPS_NAME
0	11	8464	0			Water
1	12	12	0			Snow/Ice
2	31	207982	0			Barren
3	101	40	10010	16	1610010	Inter-Mountain Basins Sparsely Vegetated Systems
4	102	1026	10060	16	1610060	Rocky Mountain Alpine/Montane Sparsely Vegetated Systems
5	103	229191	10110	16	1610110	Rocky Mountain Aspen Forest and Woodland
6	104	9773	10120	16	1610120	Rocky Mountain Bigtooth Maple Ravine Woodland
7	105	1231503	10160	16	1610160	Colorado Plateau Pinyon-Juniper Woodland
8	106	501643	10190	16	1610190	Great Basin Pinyon-Juniper Woodland
9	107	302	10200	16	1610200	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland
10	108	2750	10500	16	1610500	Rocky Mountain Lodgepole Pine Forest

Record: 1 Show: All Selected Records (0 out of 42 Selected) Options

Figure 3-1. Attribute BpS_model in Value Attribute Table from a BPS layer

Tip: To view an example attribute table, open ArcPro and right-click on any desired layer in the Table of Contents. Select Open Attribute Table from the menu options.

3.2.2 Fuel Vegetation Type (FVT) Product Layer

The LANDFIRE (LF) fuels vegetation products describe the elements of fuels vegetation for each LF vegetation production unit. Fuel Vegetation Type (FVT) represents a modified version of Existing Vegetation Type (EVT). FVT more accurately leverages fuel transition assignments related to disturbed areas by re-establishing pre-disturbance vegetation. Linking disturbed areas to pre-disturbance EVTs allows fuel model transition assignments to properly align with logic developed from Fuels Calibration Workshops, giving more accurate representations during fire behavior analysis.

FVT was developed using the full suite of LF vegetation releases and the most recent 10 years of Annual Disturbance products. The FVT product is then evaluated through a series of Quality

Assurance/Quality Control measures ensuring lifeform of the vegetation type assignment matches the lifeform of associated FVT layers.

3.2.3 Fuel Vegetation Cover (FVC) Product Layer

The LANDFIRE (LF) fuels vegetation products describe the elements of fuels vegetation for each LF vegetation production unit. This product represents pre-disturbance fuels where disturbance has occurred during the last 10 years. Fuel Vegetation Cover (FVC) represents a modified version of Existing Vegetation Cover (EVC). LF 2016 Remap EVC is mapped as continuous estimates of canopy cover for tree, shrub, and herbaceous lifeforms with a potential range from 0-100 percent. To translate continuous EVC values into fuel model assignments, EVC values were binned to correspond with the bins for previous LF versions.

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

3.2.4 Fuel Vegetation Height (FVH) Product Layer

The LANDFIRE (LF) fuels vegetation products describe the elements of fuels vegetation for each LF vegetation production unit. This product represents pre-disturbance fuels where disturbance has occurred during the last 10 years. Fuel Vegetation Height (FVH) represents a modified version of Existing Vegetation Height (EVH). LF 2016 Remap EVH is mapped as continuous estimates of canopy height for tree, shrub, and herbaceous lifeforms. To translate continuous EVH values into fuel model assignments, EVH values were binned to correspond with the bins for previous LF versions.

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

3.2.5 Fuel Disturbance (FDist) Product Layer

LANDFIRE (LF) disturbance products are developed to provide temporal and spatial information related to landscape change. Fuel Disturbance (FDist) uses the latest 10 years of Annual Disturbance products representing disturbance year and original disturbance code. FDist is a refinement of Historical Disturbance (HDist) in LF 2016 Remap to more accurately represent disturbance scenarios within the fuels environment. FDist development involves a comprehensive review of disturbance attributes.

Disturbances older than 10 years follow the existing LF protocol for removal from FDist and are represented by the most recent non-disturbed vegetation. As of 2026, all non-disturbed fuel is based on LF Remap, which is the newest fuel vegetation available. LF uses FDist in the development of Fuels products.

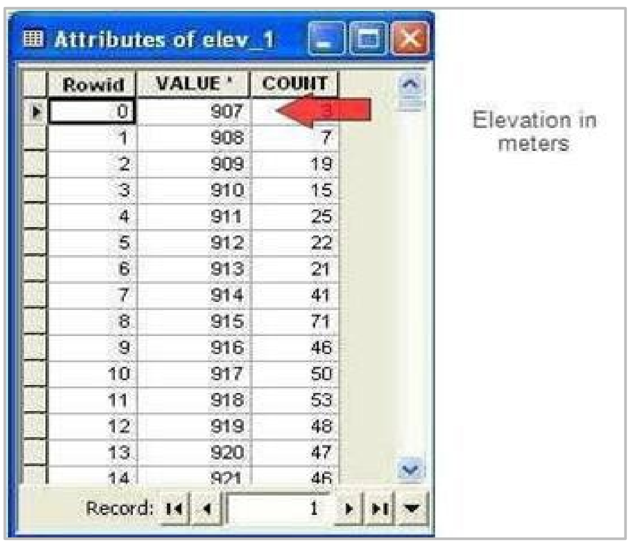
3.3 Optional Input Data

3.3.1 Wildcard

Wildcard inputs to LFTFC can include prepared fuel raster data such as fuel models or canopy attributes. Often, rasters built and processed through the tool are brought into a combine with FVT, FVC, FVH, FDist, and BPS after changes have been made to those layers to set the fuel data. Any other raster/tif data that may influence the fuel type within an Existing Vegetation Type (EVT) may also be used. For example, elevation may be used to differentiate lowland fuel models as opposed to upland areas in the same EVT. Aspect and slope can be included as wildcard data.

3.3.2 Elevation

The elevation layer represents meters or feet above sea level, and zero values are used for those areas that are at or below sea level (Figure 3-2).



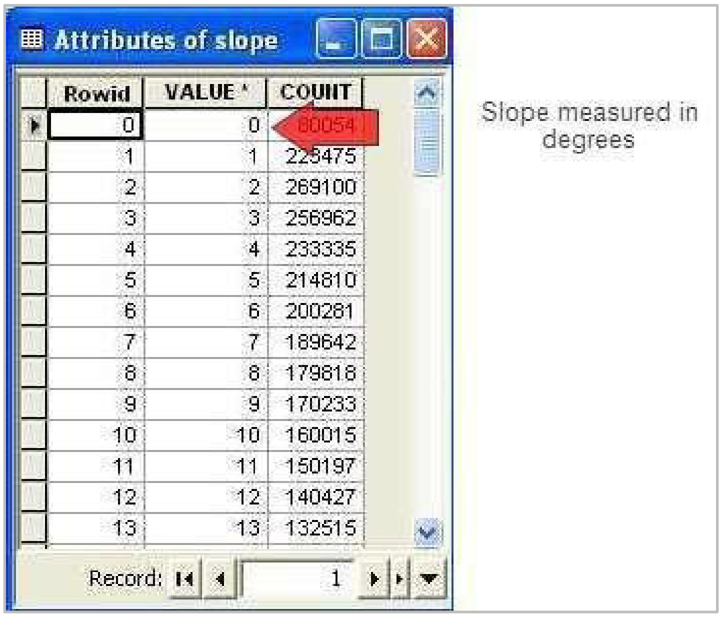
Rowid	VALUE *	COUNT
0	907	3
1	908	7
2	909	19
3	910	15
4	911	25
5	912	22
6	913	21
7	914	41
8	915	71
9	916	46
10	917	50
11	918	53
12	919	48
13	920	47
14	921	46

Figure 3-2. Example value attribute table of an elevation layer

The Value field must depict elevation in meters or feet above sea level.

3.3.3 Slope

The slope layer has cell values represented by integers, and the units may be expressed in either degrees or percent (Figure 3-3).



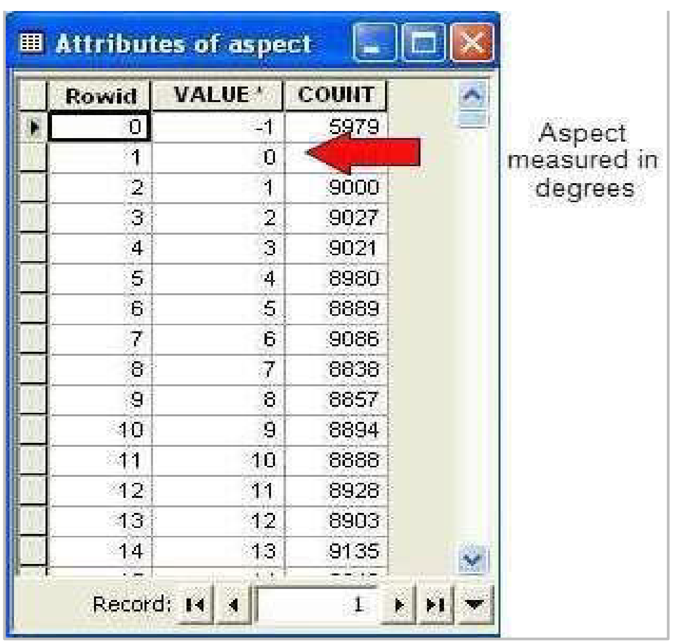
Rowid	VALUE *	COUNT
0	0	80054
1	1	223475
2	2	269100
3	3	256962
4	4	233335
5	5	214810
6	6	200281
7	7	189642
8	8	179818
9	9	170233
10	10	160015
11	11	150197
12	12	140427
13	13	132515

Figure 3-3. Example value attribute table of a slope layer

The Value field must show slope in degrees.

3.3.4 Aspect

The aspect layer must denote slope azimuth in degrees clockwise from the north. Cell values are represented by integers. Flat areas that lack an aspect are identified by a value of -1 (Figure 3-4).



Rowid	VALUE *	COUNT
0	-1	5979
1	0	[illegible]
2	1	9000
3	2	9027
4	3	9021
5	4	8980
6	5	8889
7	6	9086
8	7	8838
9	8	8857
10	9	8894
11	10	8888
12	11	8928
13	12	8903
14	13	9135

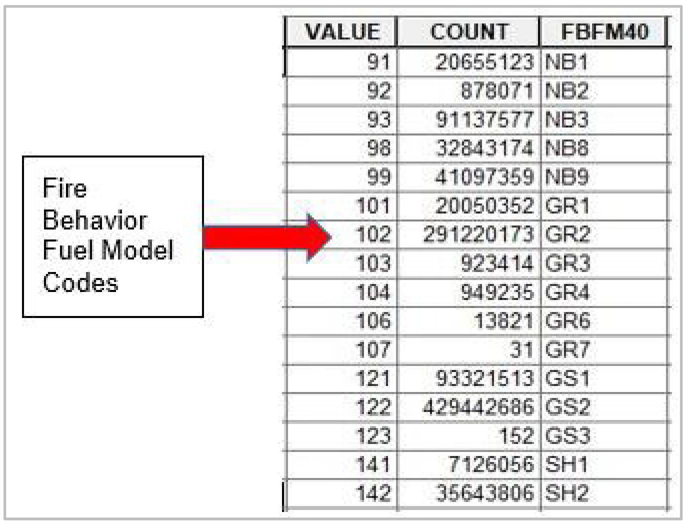
Figure 3-4. Example value attribute table of an aspect layer

The Value field must depict aspect in degrees.

Note: Integers are used for memory and processing efficiency in LF data, rather than floating point rasters.

3.3.5 Fire Behavior Fuel Models (FBFM)

LFTFC uses either the FBFM13 characterized by Anderson (1982) or the FBFM40 characterized by Scott and Burgan (2005). Cells must contain integers denoting the numeric codes of Anderson's (1982) models (values: 1 to 13) or the Scott and Burgan (2005) models (values: 91 to 204). Non-burnable fuels must be denoted by values 91, 92, 93, 98, and 99, which characterize urban/developed, snow/ice, agriculture, water, and bare ground, respectively (Figure 3-5).

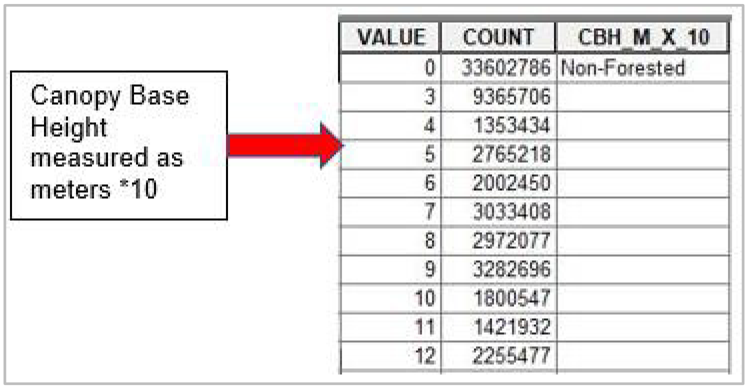


VALUE	COUNT	FBFM40
91	20655123	NB1
92	878071	NB2
93	91137577	NB3
98	32843174	NB8
99	41097359	NB9
101	20050352	GR1
102	291220173	GR2
103	923414	GR3
104	949235	GR4
106	13821	GR6
107	31	GR7
121	93321513	GS1
122	429442686	GS2
123	152	GS3
141	7126056	SH1
142	35643806	SH2

Figure 3-5. Example value attribute table for a FBFM40 layer (Scott and Burgan 2005)
The Value field (FBFM codes) must correspond to the numeric FBFM codes of Anderson (1982) or Scott and Burgan (2005).

3.3.6 Canopy Base Height (CBH)

CBH is a stand attribute that denotes the lowest height above the ground that has enough canopy fuel to propagate fire vertically. The CBH product layer is necessary for determining the transition from a surface fire to a crown fire. Typically, lower canopy base heights increase the likelihood of torching (in other words, lower heights increase the likelihood of passive crown fires). The tool requires the CBH product layer units to be meters*10 (Figure 3-6), meters, feet*10, or feet. A cell value of 0 characterizes a non-forested setting. Integers are used in LF data due to memory and processing efficiency. The operations, meters * 100, and meters * 10 are used to keep numbers expressed as integers. CBH is continuous data in 1/10 of meter increments to 10 meters. All values above 10 meters are grouped into >10 class (value for 10 meters is 100).



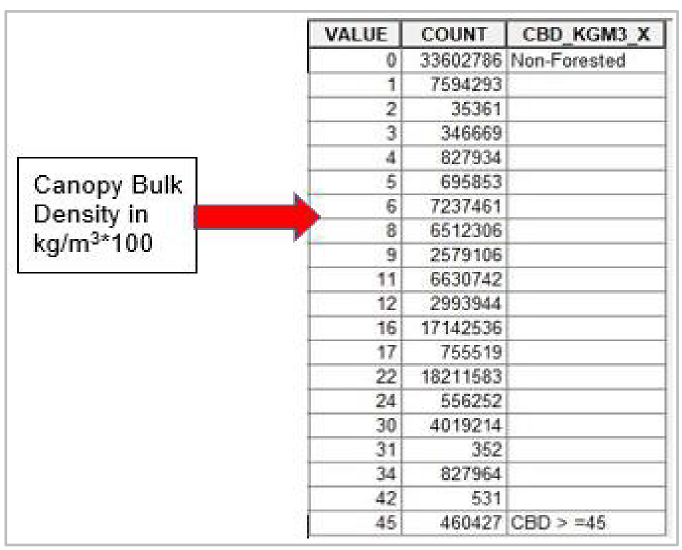
VALUE	COUNT	CBH_M_X_10
0	33602786	Non-Forested
3	9365706	
4	1353434	
5	2765218	
6	2002450	
7	3033408	
8	2972077	
9	3282696	
10	1800547	
11	1421932	
12	2255477	

Figure 3-6. Example value attribute table for a CBH layer

In this example, the Value field depicts heights expressed in meters*10. Thus, a cell value of 12 corresponds to a 1.2-meter canopy base height. This coding structure is the LF Remap standard.

3.3.7 Canopy Bulk Density (CBD)

CBD is a stand attribute that refers to the weight (mass) of "available" canopy fuel, both dead and live, per unit volume of canopy. Available canopy fuel is of a size and type that would be consumed in the flaming front. FARSITE and FlamMap use CBD to determine the transition between passive and active crown fire. (See Scott and Reinhardt [2001] for a discussion on the derivation of crown fire activity.) The tool requires the units of the CBD product layer to be expressed in kg/m3 *100 (Figure 3-7), kg/m3, lb./ft3*1,000, or lb./ft3. Cell values are represented by integers.



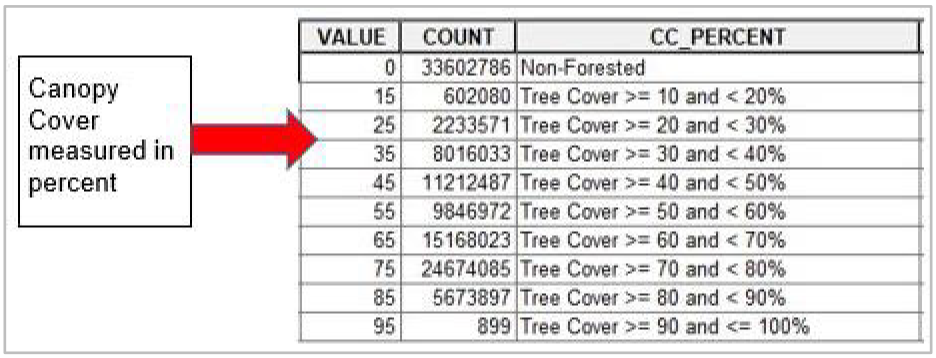
VALUE	COUNT	CBD_KGM3_X
0	33602786	Non-Forested
1	7594293	
2	35361	
3	346669	
4	827934	
5	695853	
6	7237461	
8	6512306	
9	2579106	
11	6630742	
12	2993944	
16	17142536	
17	755519	
22	18211583	
24	556252	
30	4019214	
31	352	
34	827964	
42	531	
45	460427	CBD > =45

Figure 3-7. Example value attribute table for a CBD layer

In this example, the Value field depicts canopy bulk density in kg/m3 *100. Thus, a cell value of 22 corresponds to a 0.22 kgm3 canopy bulk density. A value of 0 identifies a non-forested area.

3.3.8 Canopy Cover (CC)

CC is a stand attribute that corresponds to the proportion of the ground that is covered directly overhead by the overstory canopy (that is, the vertical projection of the canopy to the ground). The CC product layer is used to compute the wind reduction factor attributable to the canopy and the subsequent wind speed at the mid-flame height. The CC product layer is also used to modify solar radiance with the fuel conditioning function of FlamMap and FARSITE. The tool requires that the CC product layer be expressed in percent (Figure 3-8). A cell value of 0 indicates a non-forested setting. The cell values are denoted by integers.



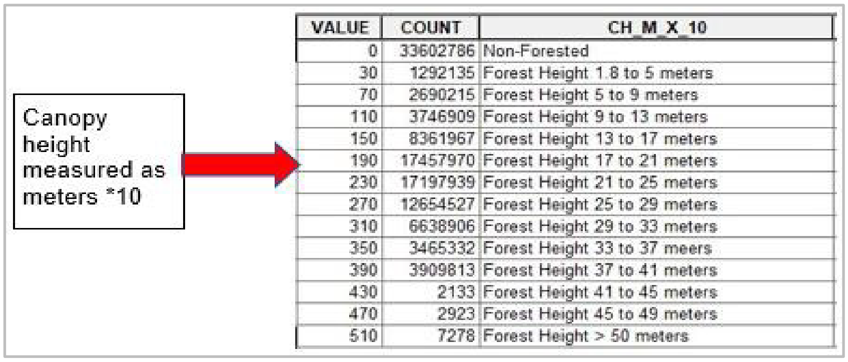
VALUE	COUNT	CC_PERCENT
0	33602786	Non-Forested
15	602080	Tree Cover >= 10 and < 20%
25	2233571	Tree Cover >= 20 and < 30%
35	8016033	Tree Cover >= 30 and < 40%
45	11212487	Tree Cover >= 40 and < 50%
55	9846972	Tree Cover >= 50 and < 60%
65	15168023	Tree Cover >= 60 and < 70%
75	24674085	Tree Cover >= 70 and < 80%
85	5673897	Tree Cover >= 80 and < 90%
95	899	Tree Cover >= 90 and <= 100%

Figure 3-8. Example Value Attribute Table for a CC layer

The value field denotes CC in percent. A value of 0 indicates a non-forested setting. In this example, CC has been grouped into 10 classes in which the cell value corresponds to the class mid-point. Thus, a value of 35 corresponds to Tree Cover >= 30 and <40%.

3.3.9 Canopy Height (CH)

CH is a stand attribute that reflects the average height of the overstory dominant and co-dominant in a stand. The CH product layer along with the CC product layer is used to compute the wind reduction factor attributable to the canopy and the subsequent wind speed at the mid-flame height. In FARSITE, the CH product layer is also used for estimating spotting distances from torching trees. The tool requires the CH product layer units to be in meters*10 (Figure 3-9). A cell value of 0 indicates a non-forested setting. The cell values can be denoted by either floating point numbers (decimals) or integers.



VALUE	COUNT	CH_M_X_10
0	33602786	Non-Forested
30	1292135	Forest Height 1.8 to 5 meters
70	2690215	Forest Height 5 to 9 meters
110	3746909	Forest Height 9 to 13 meters
150	8361967	Forest Height 13 to 17 meters
190	17457970	Forest Height 17 to 21 meters
230	17197939	Forest Height 21 to 25 meters
270	12654527	Forest Height 25 to 29 meters
310	6638906	Forest Height 29 to 33 meters
350	3465332	Forest Height 33 to 37 meers
390	3909813	Forest Height 37 to 41 meters
430	2133	Forest Height 41 to 45 meters
470	2923	Forest Height 45 to 49 meters
510	7278	Forest Height > 50 meters

Figure 3-9. Example Value Attribute Table for a CH layer

The value field must depict CH in meters*10. In this example, the canopy heights have been grouped into 13 classes in which the cell value corresponds to the approximate mid-point of the class in meters.

3.4 Concepts of Ruleset Development for Fuel Characteristics

3.4.1 Fire Behavior Fuel Model Assignments in LF 2001 Data

The LF data are imagery-driven with plot data used to “train” the imagery interpretation. Existing Vegetation Type (EVT), Existing Vegetation Cover (EVC), and Existing Vegetation Height (EVH) derived from this process are the layers primarily used to develop FVT, FVC, FVH, the layers used to create the primary fuel attributes.

First implemented during production of LF 2016 Remap, a new process was developed for fuel layers (FVT, FVC, FVH) to better map fuel succession in disturbed areas. This process involves a new variable called Time Since Disturbance (TSD) and results in differing values between vegetation type (EVT vs FVT), vegetation cover (EVC vs FVC) and vegetation height (EVH vs FVH), for a cycle of 10 years beginning with the first year of disturbance on a pixel.

In disturbed pixels, the Fuels Vegetation Type (FVT) will remain as the undisturbed vegetation type for 10 years. Linking disturbed areas to pre-disturbance EVTs allows fuel accumulation and succession, as expressed by FBFM40 and FBFM13, to more properly align with expert knowledge about fire behavior on a disturbed landscape. FVC and FVH differ from EVC and EVH respectively, through a process which turns the continuous data of EVC and EVH into binned data for FVC and FVH (See Appendix A).

It’s important to remember that disturbed areas time out for fuels-specific adjustments when the TSD reaches 10 years. Disturbances older than 10 years are considered non-disturbed vegetation and the type, cover, and height are sourced from LF Remap existing vegetation data.

This triplet of data is further segregated by life form categories: tree, shrub, or herbaceous. Pixels with less than 10% tree cover are designated as “shrub,” and those with less than 10% shrub cover are designated “herbaceous.”

From these layers, fuel specialists can determine life form, species, vegetation density, and height above ground on a pixel-by-pixel basis. Managers can then use this information to specify a surface fuel model from the original set of 13 (Anderson 1982) or the 40 Fire Behavior Fuel Models developed by Scott and Burgan (2005).

3.4.2 Canopy Guide Toggle

Modeled fire behavior is influenced by many vegetation attributes, but in forested areas, canopy is a particularly important factor affecting fire behavior outputs. A user-defined switch has been incorporated in LFTFC to describe the effects of canopy. The switch has the following three numeric settings.

- **0:** This setting indicates no canopy on the site. Canopy Base Height (CBH) and Canopy Bulk Density (CBD) calculations from the LF data sets would be used to indicate the likelihood of crown fire on the site.
- **1:** This setting would be used on a tree life form site where torching and crowning in the upper strata vegetation is common during fire activity. All four stand attributes (CC, CH, CBD and CBH) are present and unmanipulated.
- **2:** This setting would be used on tree life form sites where torching and crowning are not likely to occur, such as in some hardwood communities. The mapping tool in this setting artificially raises CBH to 10 meters and lowers CBD to 0.012 kg/m^3. Torching and crowning will not occur, but the stand attributes (CH and CC) will be used in the calculations of surface fire behavior characteristics. The reason for keeping the canopy attributes in place is to adjust wind speed, shading, and sheltering for surface fire calculations.
- **3:** This setting would be used on tree life form sites where torching would occur, but active crowning is not likely, such as in mixed hardwood and conifer communities. The mapping tool in this setting artificially lowers CBD to 0.03 kg/m^3, but leaves CBH, CH, and CC as predicted.

3.4.3 Assigning Canopy Characteristics

In fire behavior modeling, surface fire spread, and intensity combine with the vegetation attributes CBH and CBD to add torching and active crowning to projected fire behavior. In the LF data sets, these attributes are calculated by plot data. Several methods for assigning numeric values to these attributes have been investigated. The current preferred approach is to use a General Linear Model (GLM) from plot data to describe the CBD and linear regression equations derived from Forest Vegetation Simulator (FVS) scenario outputs for CBH. (See the LF website for additional information on metadata).

LFTFC allows users to input expert opinion values for CBH and CBD for their desired forested areas instead of the prediction.

Note: The GLM method is described in Reeves and others 2009.

Section 4 Installing LFTFC Toolbar Add-In

4.1 LFTFC Installation

4.1.1 Download

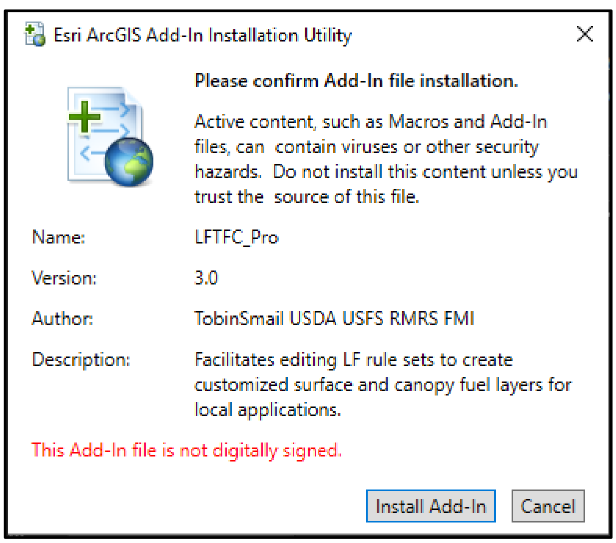
If you have an earlier version of LFTFC installed on your computer, you should uninstall that version before proceeding with installation of the current version. Refer to Section 4.2 for steps to uninstall.

Download LFTFC from the LF website at https://landfire.gov/resources/lftfc .

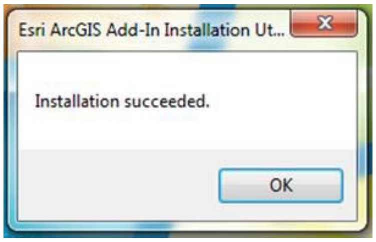
4.1.2 Install

This has been tested with 3.0-3.5 ArcPro, and more recent versions.

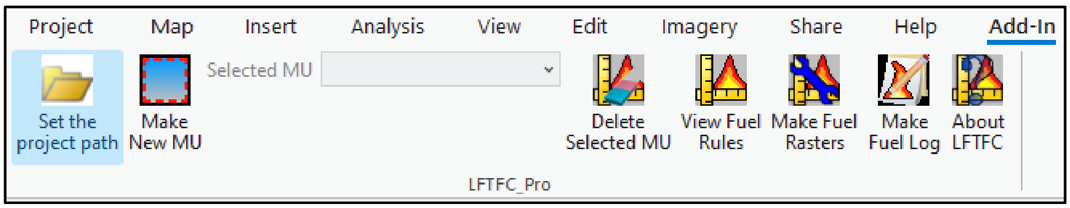
1. Uninstall any previously installed LFTFC toolbars.
    a. Refer to Section 4.2 to uninstall.
2. Installing - Run Setup_LFTFC_####.bat
    a. Make sure ArcPro is closed.
    b. Double left-click to run “Setup_LFTFC_####.bat”.
    c. This copies required files to "C:\Landfire\LFTFC_Pro".
    d. The black command window will automatically close (approx. 2 minutes).
3. ArcGIS Add-in window opens.
   Click Install Add-in.



4. Click OK.

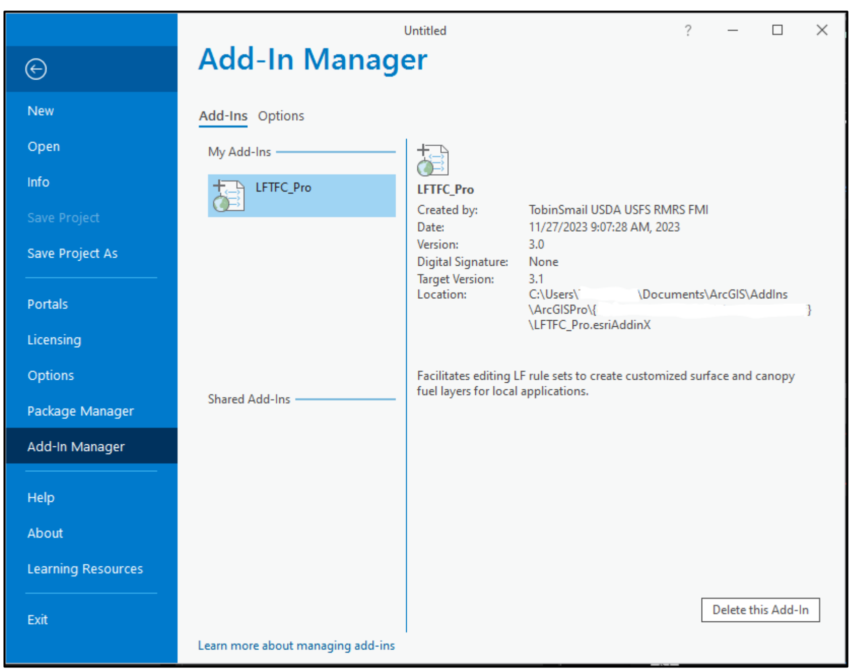


5. Start ArcPro and LFTFC_Pro are visible in the Add-In tab.



4.2 Uninstall

1. Start ArcPro.
   a. Select Project at the top of the screen in the menu bar.
   b. In the Project menu bar, select Add-in Manager.



   c. Select LFTFC_Pro Add-In located under My Add-Ins.
   d. Click Delete this Add-In.
   e. Click Close.

   f. Close ArcPro.
2. Open Windows Explorer.
   a. Navigate to the “(C:\Landfire)” directory.
   b. Delete the folder named Landfire_Pro.
3. Start ArcPro.
   a. LFTFC_Pro toolbar is gone.
   b. Close ArcPro.

Section 5 Quick Start Guide

This chapter will provide a brief overview of the basic steps required to run LFTFC. To learn more about all tool options, proceed to Section 6. This chapter does not discuss every option for each step of the process.

The following flowchart shows the basic steps required to run LFTFC (Figure 5-1).

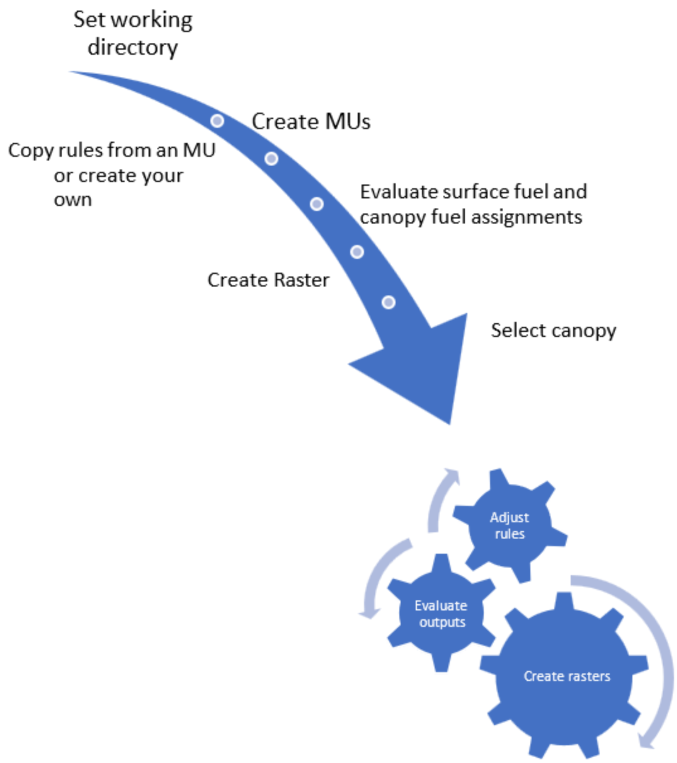
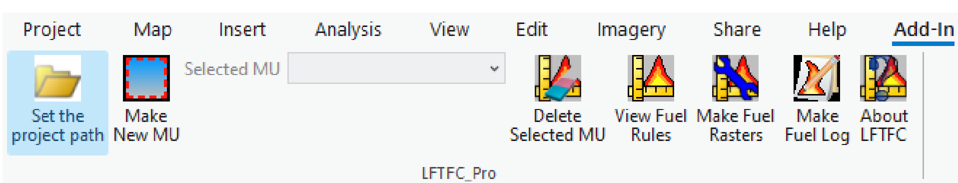


Figure 5-1. Steps required for running LFTFC

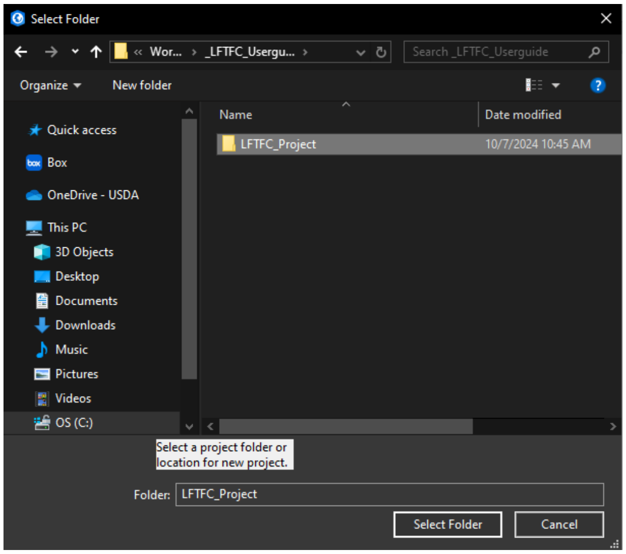
5.1 Creating Working Directory

To get the best working results, always start with a new ArcPro project.

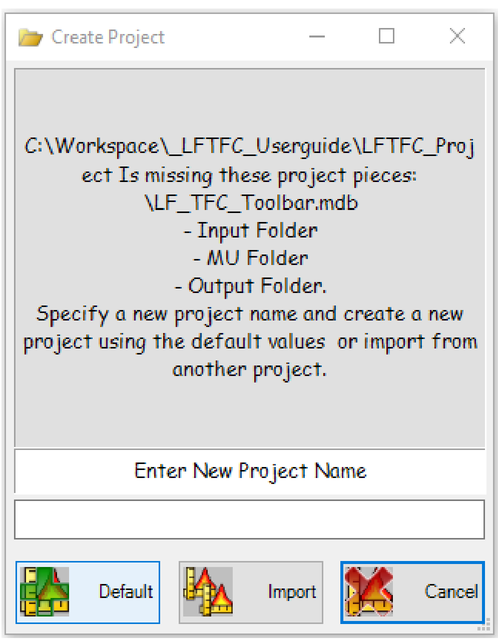
1. Use the LFTFC toolbar to set your working directory by clicking Set the Project Path (below).



2. The Browse for Folder dialog box opens (below). Use this dialog box to select the project folder.



3. Click Select Folder after specifying a location for your project. If this is an existing project, this will be your set project directory. If this is a new project, the project folder is created and the Create Project dialog box opens (below).
4. Use the Create Project dialog box to specify a name in the Enter New Project Name box.

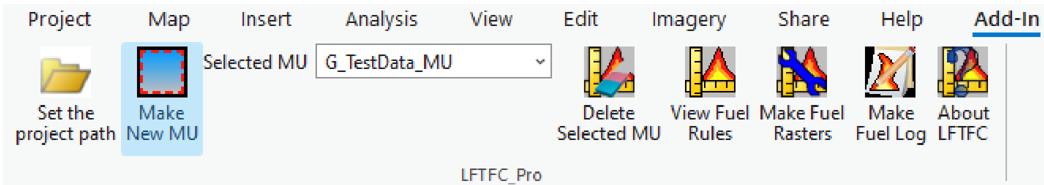


5. Click the Default button when finished to load the database and necessary folders.

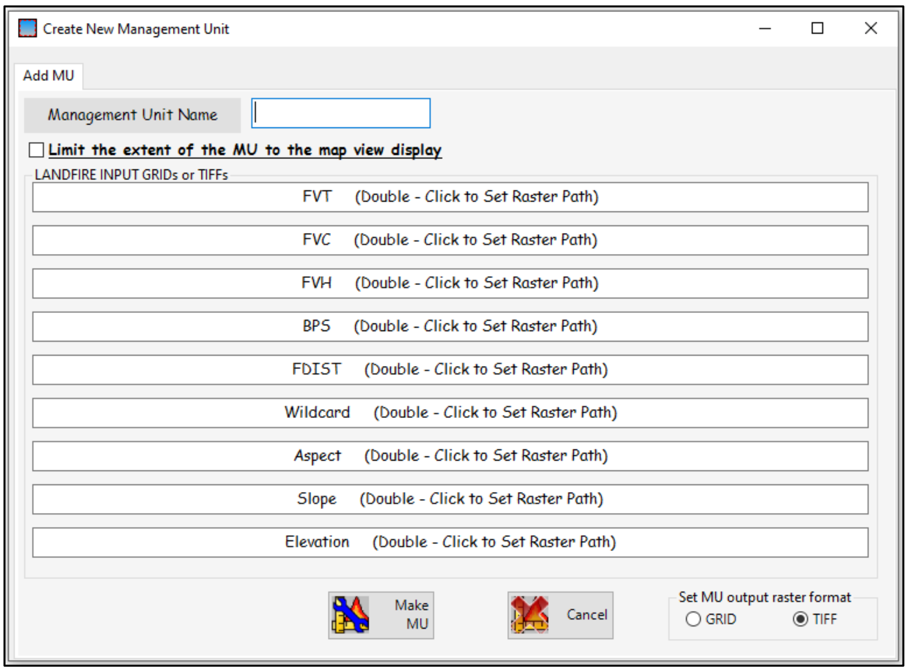
For additional information on default folders, naming conventions, and suggested filing systems, see Section 6.3.

5.2 Creating Management Unit (MU)

1. Click the Make New MU button (below) in the LFTFC toolbar to define a Management Unit.



2. The Add MU dialog box opens (below).



An MU can be defined by Limiting the extent of the MU to the map view display or by default which uses the intersection of the input rasters.

Note: For detailed information on specifying the extent of your MU, see Section 6.5.

3. To limit the extent of the map view, click the checkbox under the MU Name field, otherwise the default is used.
4. Type a Management Unit Name in the field provided.

   Note: The naming convention follows the rules of ArcGIS, which means a layer name can't exceed 13 characters.
5. Input the required data layers (FVT, FVC, FVH, FDist, and BPS) by double-clicking in the boxes to set a raster path.

   Tip: You do not have to load layers in ArcMap first; you can simply double-click in the

Add MU dialog box to load layers.

Note: All five layer tifs (FVT, FVC, FVH, FDist and BPS) must be in the same projection.

The Wildcard selection is optional but may be useful in some situations. A soils layer or other tif can be used in the wildcard to help define fuel rules for a special condition. See Section 6.4 for more information.

6. Enter other optional data layers if desired (Wildcard, Aspect, Slope, and Elevation).

   Note: All rasters must be in the same projection.
7. When complete, click the Make MU button.

For additional information on creating an MU, see Section 6.4.

5.3 Working with Fuel Rules

The Fuel Rules window is where the bulk of the modifications are made to spatial data to prepare them for creation of new fuels layers for fire and fuels analysis. The Fuel Rules dialog box has many functions and display items. For information on additional options, see Section 6.5.

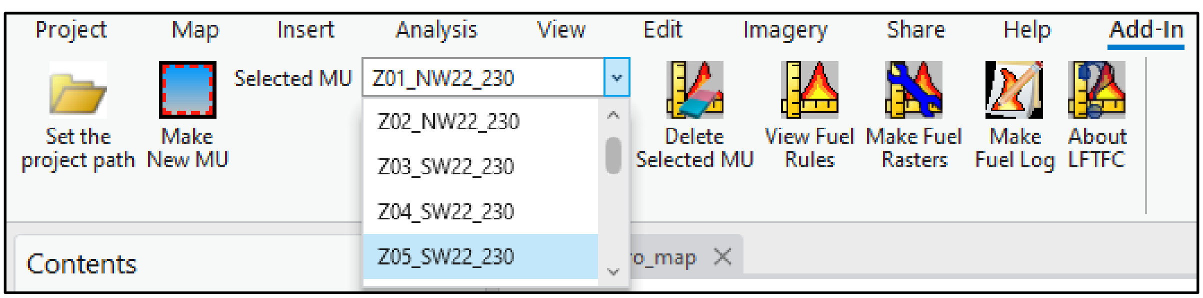
The following description progresses from general to more specific steps. This explanation includes the main Fuel Rules page tabs: Ruleset, Compare FM, Distribution Graph, and EVT Description, as well as the Copy Rule and Add Rule options.

Each EVT has a set of zone-based fuel rules. New rules can be added, edited, deleted, or copied, see Section 6.5.

5.3.1 View Rules

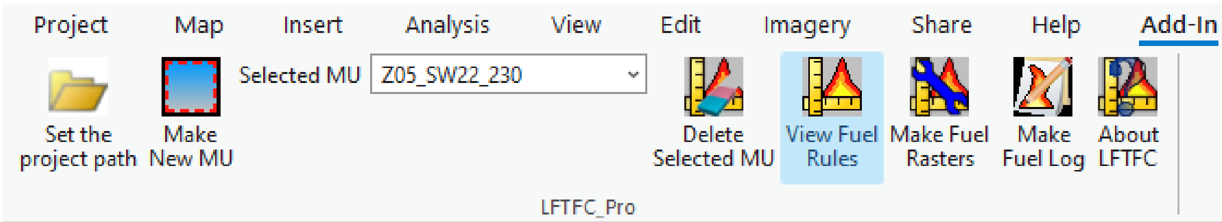
1. To begin, select the MU you created from the list displayed in the dropdown menu.

   Note: MUs appear in alphabetical order in the dropdown menu. Scroll to find the MU of interest.

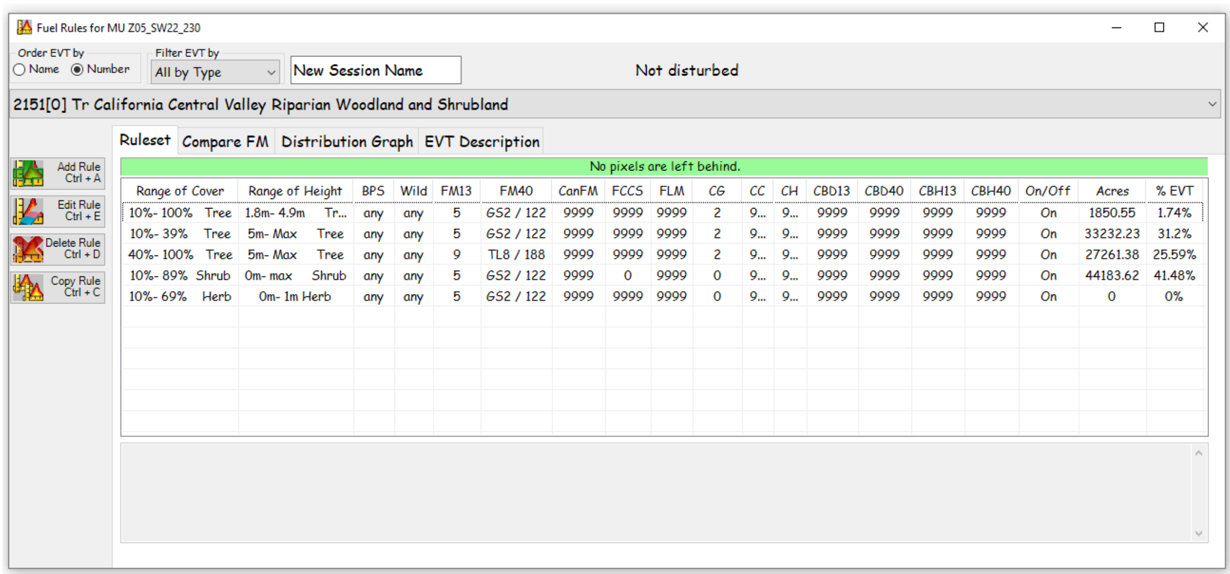


2. To continue, you will need to copy rules from an existing MU or create new rules.

3. Click View Fuel Rules from the LFTFC_Pro menu ribbon (below).



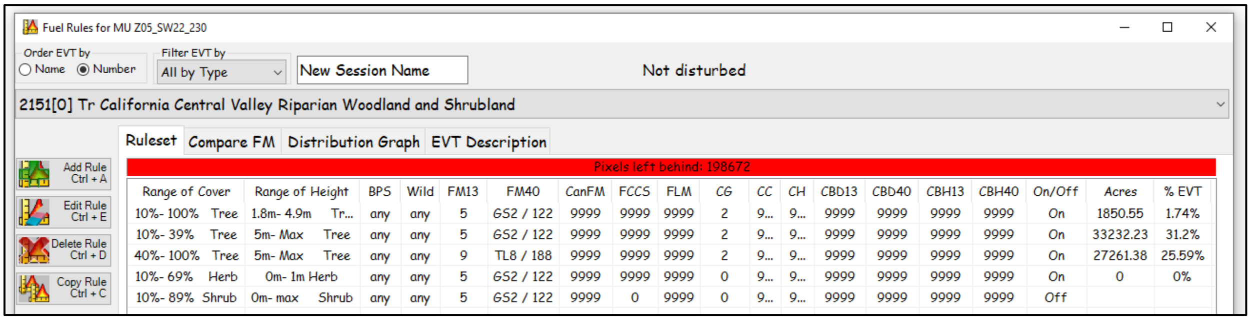
4. The Fuel Rules dialog box opens with the Ruleset page displayed (below).



Tip: Click in the boxes at the top of the columns you are not interested in viewing to collapse those fields so you can more easily view the columns of interest.

5. (Optional) In the Fuel Rules dialog box, add a New Session Name in the field provided. This will be used to track changes in the fuel rules as they are edited.
6. Use the dropdown window to select an appropriate Fuel Vegetation Number and Name (above). This selection allows the user to go directly to the desired FVT and provides information on the dominant species present and type of vegetation that occupies the site. See EVT Description tab in Section 6.5.5 for additional information.

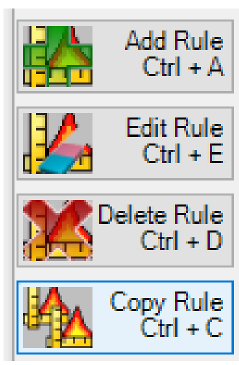
Note: The Pixels Left Behind label appears green (above) when no pixels are left behind. If rules do not account for all pixels or the rules overlap, the label appears red indicating the number of missing pixels (below).



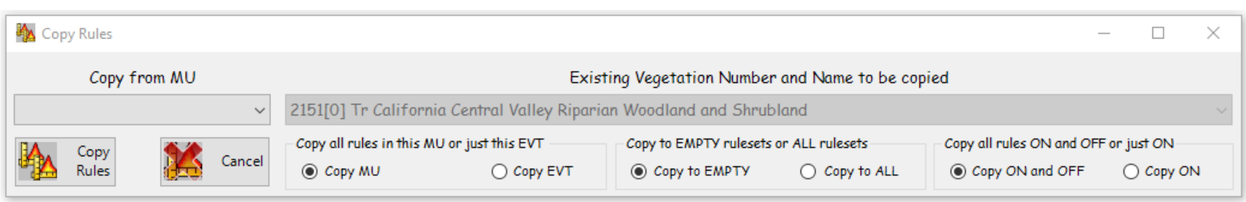
7. Next click a Fuel Rule button (below) from options: Add Rule, Edit Rule, Delete Rule, Copy Rule. Each fuel rule opens a dialog box requiring user input. See Section 6.5.4 for more information.

5.3.2 Copy Rule

1. Click Copy Rule to copy rules from another MU.



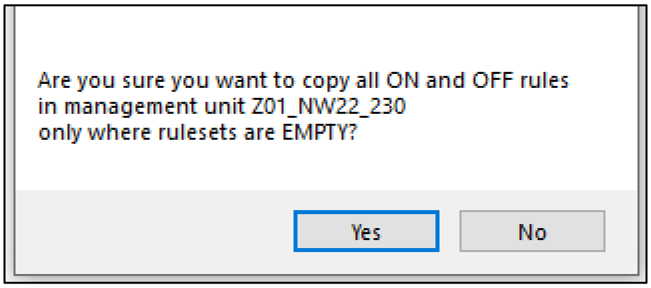
2. The Copy Rules dialog box opens (below).



3. Use the dropdown menu at the top left of the Copy Rules dialog box to select an MU.
4. Use the radio buttons to select whether to copy all the rules from the selected MU or to copy only the ruleset from the selected MU and Existing Vegetation Type (EVT). (Copy MU or Copy EVT).

   Note: Use the dropdown menu under Existing Vegetation Number and Name to be copied to specify an EVT if Copy EVT is selected.
5. Use the radio buttons in the middle to copy rules into only the EVT rulesets that do not already have rules or copy all the rules even if rules already exist in the rulesets. This helps rulesets from getting duplicate rules. (Copy to EMPTY or Copy to ALL)

6. Use the radio buttons at the far right to specify if you would like to Copy all rules turned on and off (Copy On and Off) or only those rules that are turned on (Copy On).
7. Click the Copy Rules button to continue.
8. To verify that you want to copy all On and Off rules, click Yes.

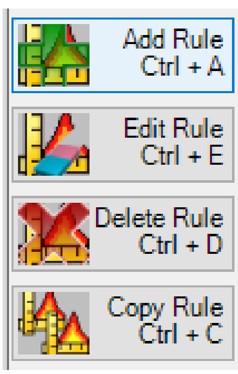


9. Close the Copy Rules dialog box. (It does not automatically close.)

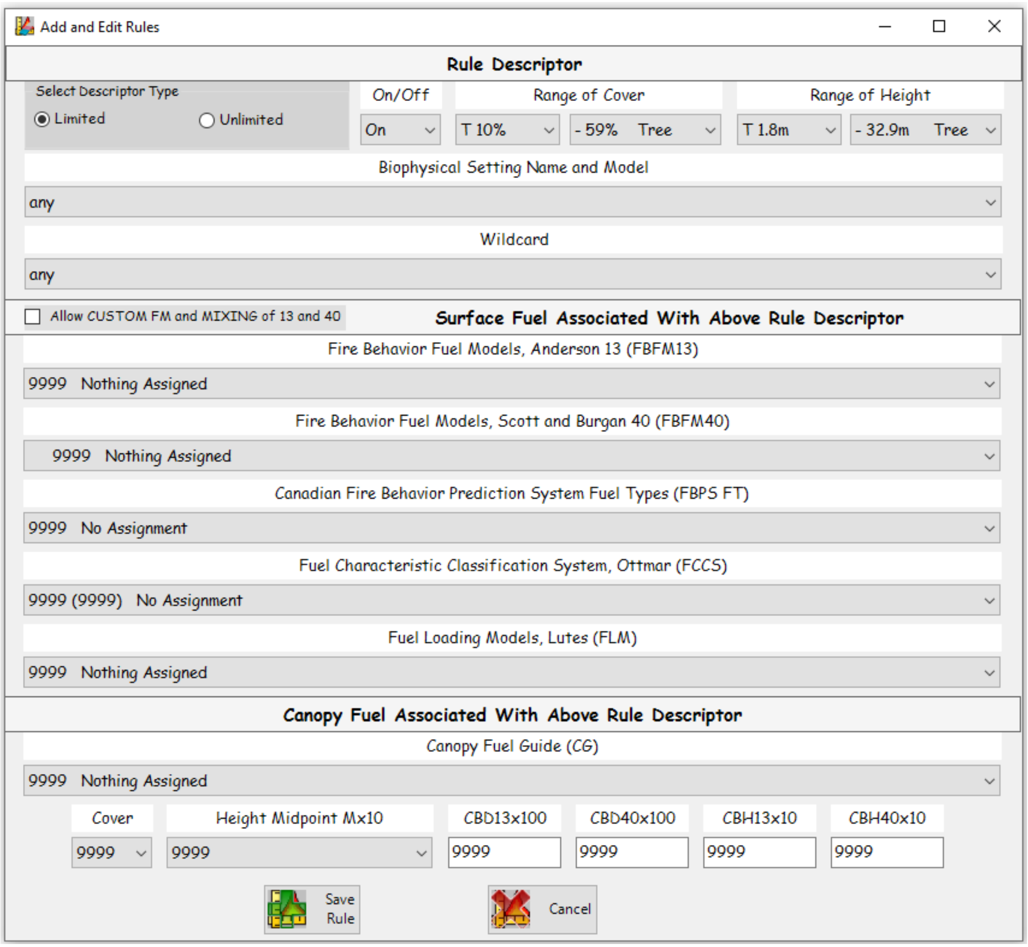
5.3.3 Add Rule

A similar process is followed to add a rule.

1. Click Add Rule.



2. After clicking Add Rule (or Edit Rule), the Add and Edit Rules dialog box opens (below).



3. Select a Descriptor Type.

   Note: Selecting Limited keeps the user from creating illogical combinations that the data do not support. Selecting Unlimited gives the user all combinations of cover and height in all life forms whether they exist in the data or not.
4. Toggle the rule descriptor On or Off using the dropdown menu.
5. Modify other fields as needed.
6. Click Save Rule.

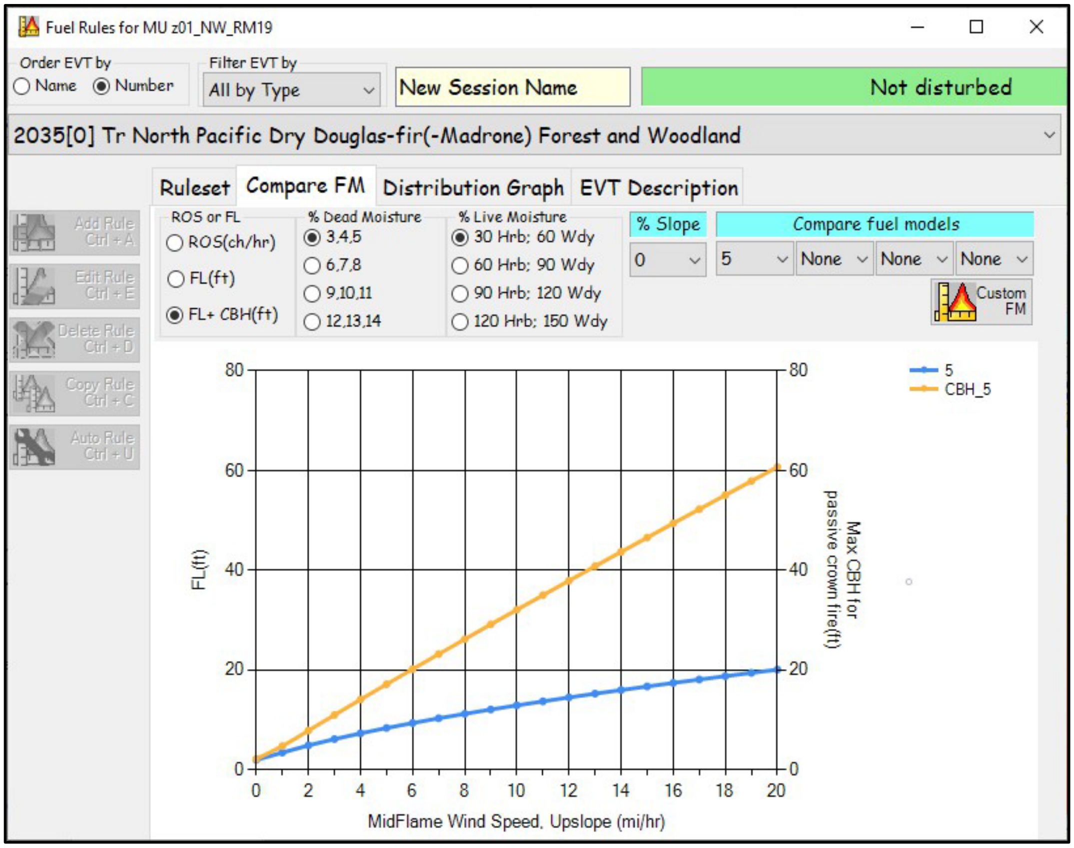
Edit Rule and Delete Rule options are also available, see Section 6.5.4.

5.4 Evaluating Surface and Canopy Fuel Assignments

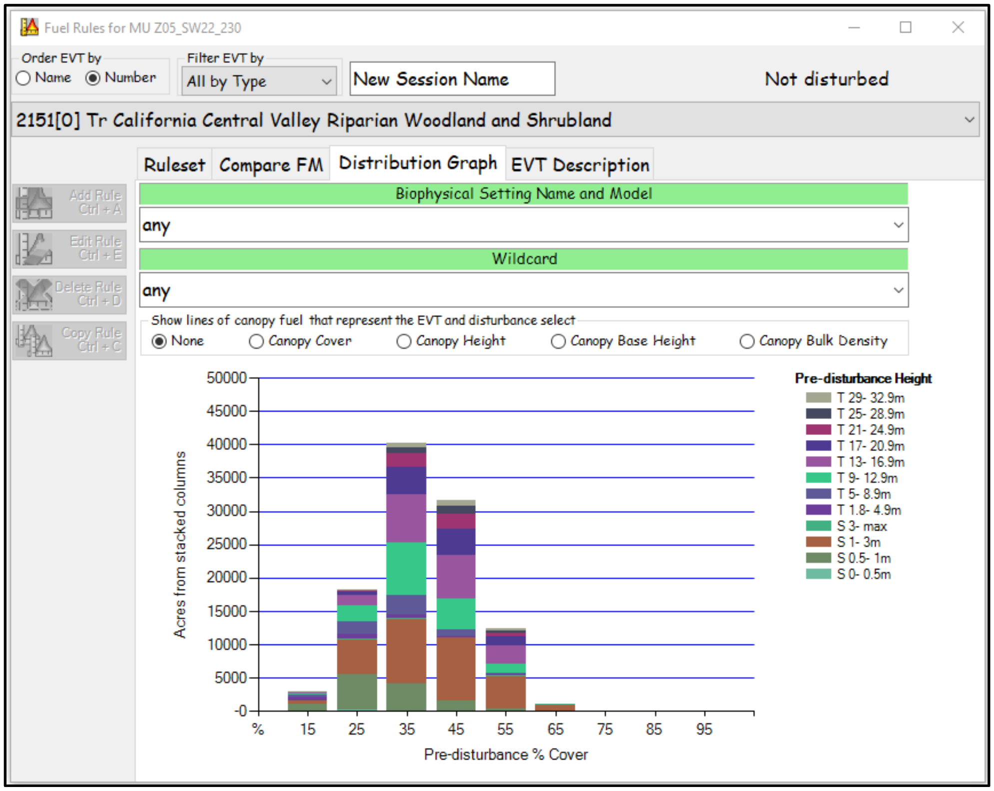
Next, evaluate surface and canopy fuel assignments.

1. Open the Fuel Rules dialog box to the Ruleset page. Use the dropdown menu to select and highlight EVTs to account for all pixels.

2. Select the Compare FM tab to compare the required CBH needed for torching and active crown fire initiation (below).



3. Select the Distribution Graph tab to view the height of the vegetation by cover and the number of acres present in the selected FVT within the defined MU (below).



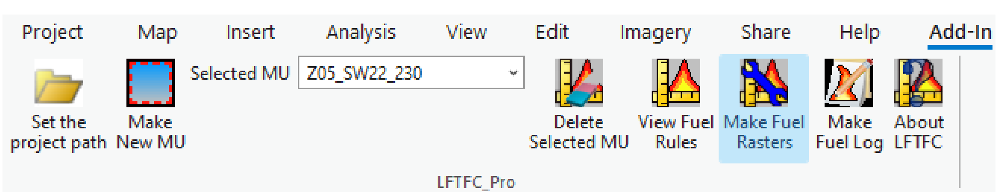
4. Select the EVT Description tab to display an ecological description. This NatureServe website (https://explorer.natureserve.org/) serves as the basis for all LF EVTs.

See Section 6.5 for more information on Fuel Rules.

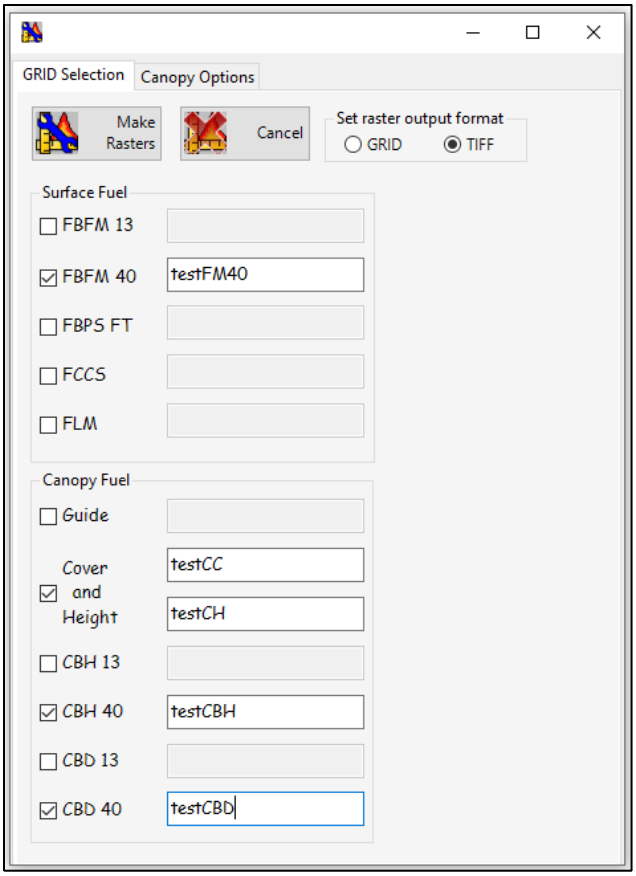
5.5 Making Fuel Rasters

Next, create the raster menu.

1. With the LFTFC_Pro_map tab selected, click Make Fuel Rasters on the LFTFC_Pro ribbon (below).



2. The Fuel Rasters dialog box opens with the GRID Selection tab open (below).



3. Name and create fuel layers.
4. Check all the fuel layers you would like to include.
5. Enter a name for the fuel layers in the boxes provided.

   Note: After the boxes are selected with a check mark, the associated box for naming the layer is enabled.

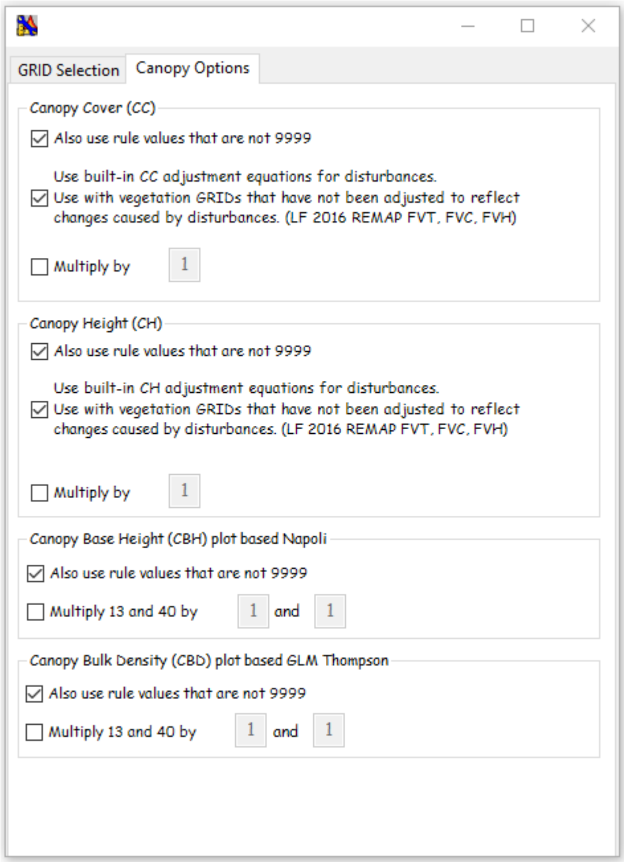
See Section 6.6 for more information on Fuel Rasters.

5.6 Selecting Canopy Options (optional)

1. After selecting the Make Fuel Rasters option on the LFTFC_Pro ribbon menu, click the Canopy Option tab (below).
   a. The Canopy Options tab allows you to make changes to the canopy layers in three ways:
      i. (Default) Use rules that are not coded as “9999”, indicating no data, in the rulesets to overwrite the predicted value.
      ii. (Default) Use built-in adjustment equations for CC and CH in disturbances.

iii. Use a coefficient by which to multiply.

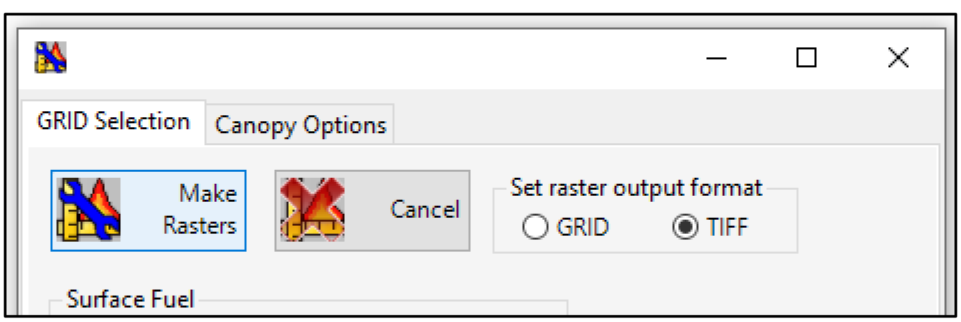
2. Complete the Canopy Options tab by checking the appropriate boxes.



See Section 6.6 more information on Canopy Options.

5.7 Making Rasters

1. When selections are complete, click Make Rasters (below).



Tip: Outputs are finished individually, so be patient.

2. Go to your project folders to view outputs.

5.8 Adjusting Rulesets

At this point, you can adjust rulesets if necessary. If changes are needed, go back to the rules, make your changes, and then recreate the rasters/tifs.

5.9 Evaluating Outputs

Finally, evaluate your outputs. Your edited outputs should better reflect expected fire behavior and fuels characteristics for your area.

Section 6 Using LFTFC_Pro

6.1 LFTFC_Pro Add-In

Figure 6-1 shows elements of the LFTFC_Pro Add-In. The down-arrow on the toolbar is the Selected (MU) dropdown menu, which allows the user to select a MU once the project is set up (Figure 6-2). MUs can be as large as an LF map zone or as small as an initial fire incident that a user would like to calibrate and analyze.

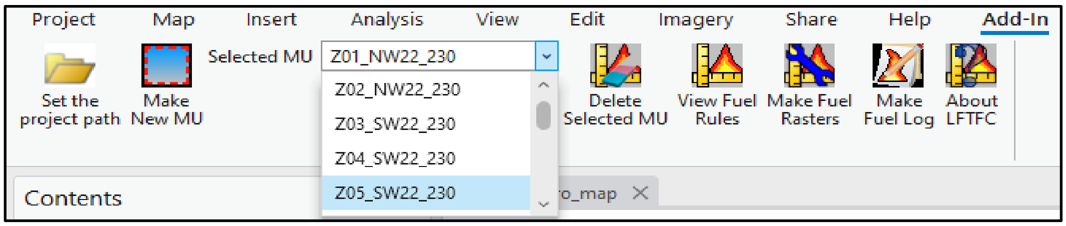


Figure 6-1. LFTFC_Pro's Management Unit selection dropdown menu

The Make New MU button allows the user to select an area of interest, input the required data layers, and clip all the layers to the specified rectangle.

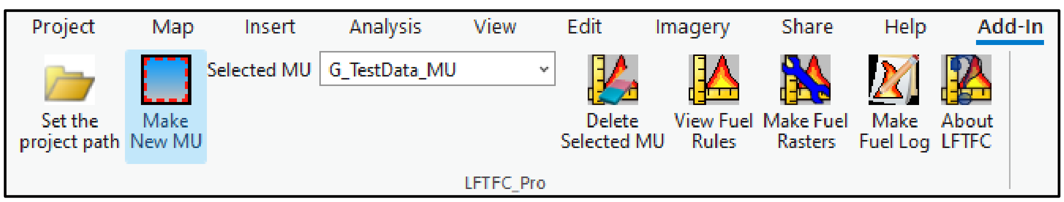
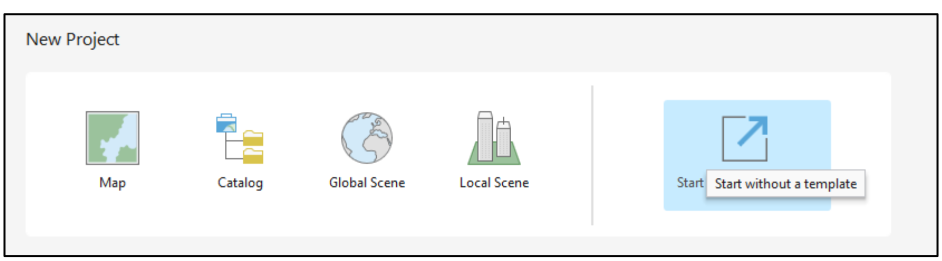


Figure 6-2. LFTFC_Pro's Make New Management Unit button

6.2 Creating a New Project

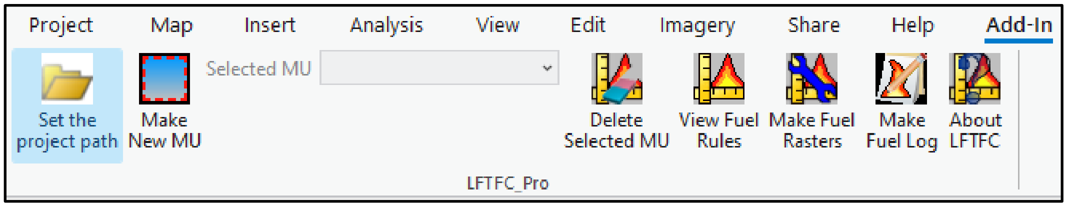
1. Start ArcPro and click Start without a template.



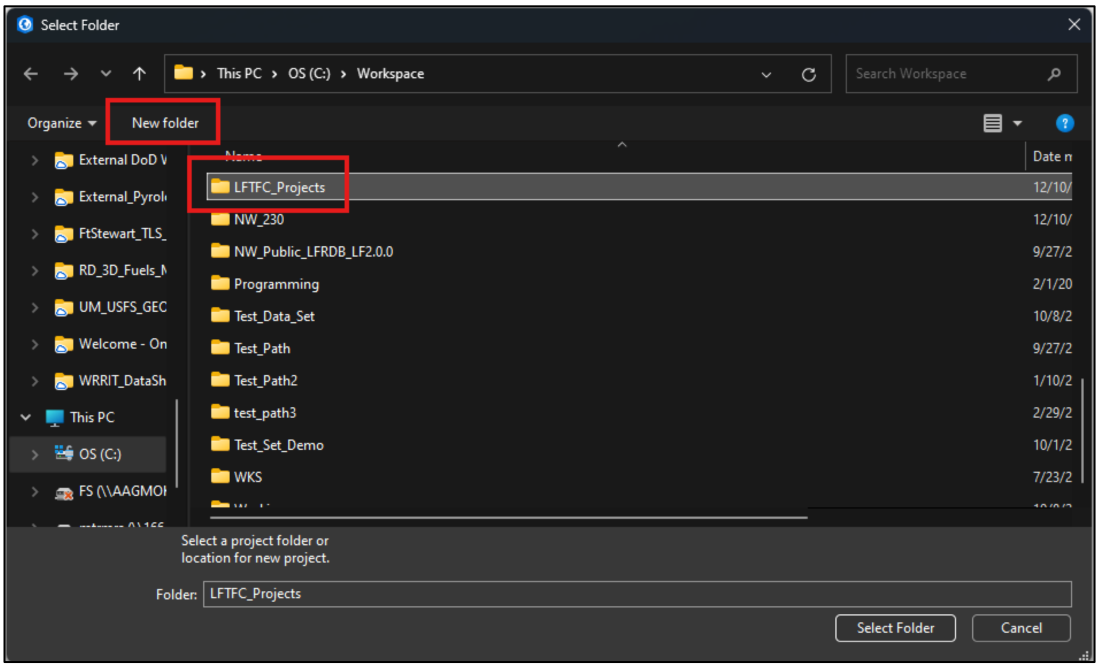
6.3 Workspace Settings

Creating an organized filing system is an important first step. We suggest creating a directory titled LFTFC_Projects on a convenient drive.

1. To create a directory, select the dropdown menu on the LFTFC_Pro Add-In and click Set the project path (below).

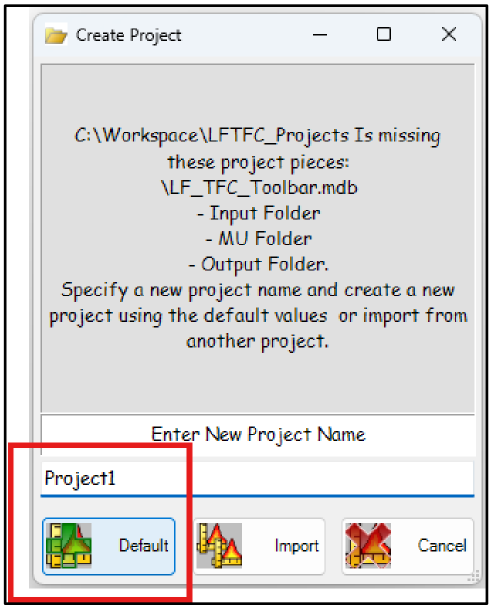


2. A dialog box opens.



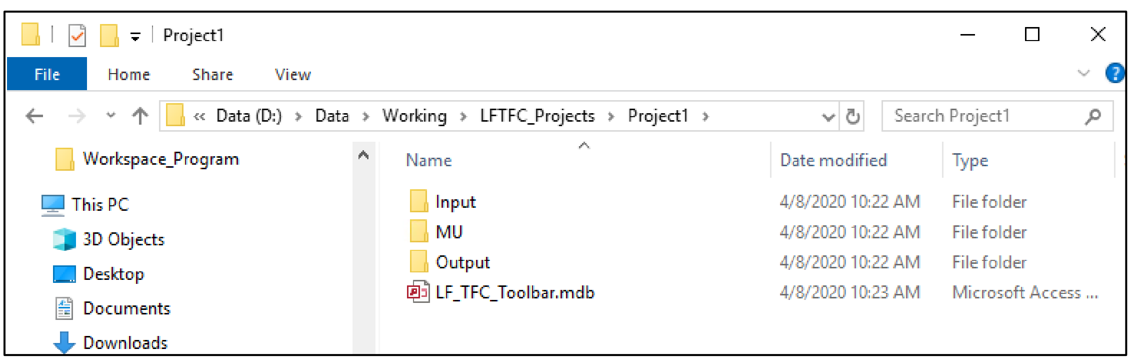
3. Select your LFTFC_Projects folder and click Select Folder.
4. A Create Project window opens (below), allowing you to import data from previous projects or create a project workspace.
5. To create a project workspace, enter a name for the project and click the Default button. The tool will build a workspace folder under the LFTFC_Projects directory in the name you specified.

   Note: A raster name can be no longer than 13 characters according to ArcPro naming convention rules.

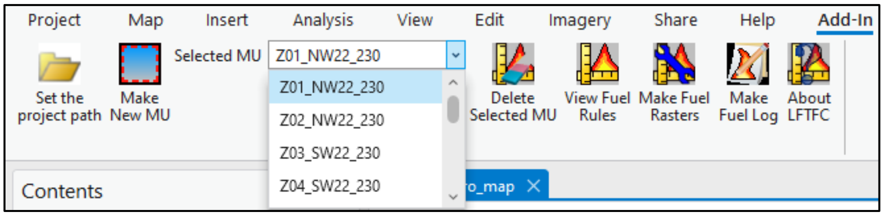


Note: Click the Default button to continue, use the Import button to load an existing project, or click Cancel to close the Create Project dialog box. A new map is added to the ArcPro view called LFTFC_Pro_map and a notification box will pop up letting you know that a folder connection has been created. This allows for faster access to your project when navigating in ArcPro.

6. The new workspace folder (below) will contain the Input, MU, and Output folders. These folders are used to store your work as well as the Microsoft Access database, which is populated with the LF default fuels characteristics.



7. The selected MU dropdown menu is populated in the LFTFC_Pro Add-in ("z01_NW22_230" below). The LF map zone is indicated ("z01") as well as a designation that the information is for the LF Northwest Remap 2019 fuel characteristic data ("NW_RM19").
8. As new projects are developed, additional folders can be added to the LFTFC_Projects directory or new project folders can be created to further organize complex analyses.

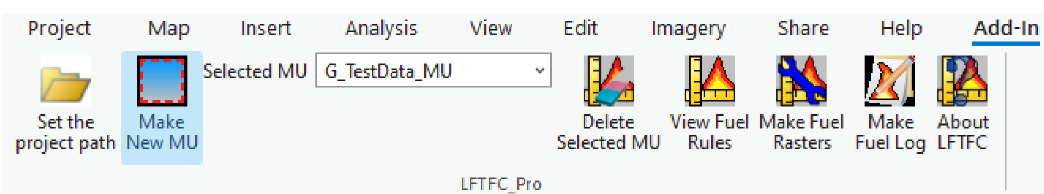


6.4 Management Units (MU)

An MU is the basis for changing fuel characteristics for a particular area. The extent of the MU is user-defined and can be designated by the map view or by the intersection of the input raster layers. Once the appropriate raster layers are combined through the Make New MU function, the user can modify the fuel characteristics of the surface fuel model and canopy attributes as well as Fuel Characteristic Classification System (FCCS) or FLMs (Ottmar and others 2007; Lutes and others 2008). After modifications are complete, new fuel model and canopy attribute rasters can be processed for use in analysis.

Note: The default data set includes MUs created for all LF map zones. These zones exist only in relational Microsoft Access database form and not as spatial rasters in the MU folder. As new MUs are created, they will consist of a combined raster of the layers from the LF data set, and any optional raster layers the user inputs into the wildcard. They will reside in the MU folder.

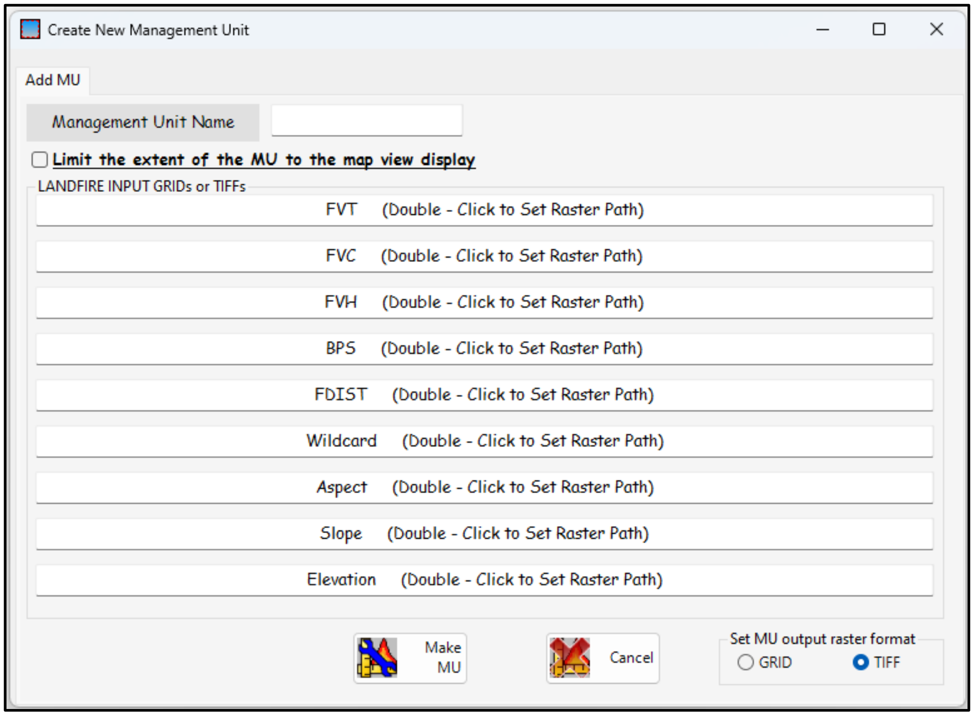
1. Zoom to the view of your desired MU. This will give you the option in the next couple of steps, if you choose, to limit the extent to this view or use the extent of the input rasters that make up the base data.
2. Click the Make New MU button (below).



3. The Create New Management Unit dialog box opens (below).
4. With the Add MU tab selected, enter a Management Unit Name

   The naming convention used to specify an MU in the first box follows ArcPro rules. The raster name cannot exceed 13 characters or include any special characters.

   Note: The Set Project Directory dropdown selection sets the name of the path, but you will still need to name the file here in the Create New Management Unit dialog box. The file will be in your MU folder.



5. LFTFC_Pro clips all rasters to the view extent if the "Limit the extent of the MU to the map view display" box located near the top of the screen is checked.
6. Check the Limit the extent of MU to the map view display box to clip all the rasters to the extent of the zoomed in map view.
7. Uncheck the Limit the extent of MU to the map view display box to clip all rasters to the extent the smallest required INPUT RASTERS or TIFFs.
8. Input required rasters (FVT, FVC, FVH, FDist and BPS) by double-clicking in the associated boxes to set a path.

   Note: All rasters must be in the same projection.
9. Wildcard is an optional category that allows extra flexibility for the LFTFC_Pro user. For example, as discussed in Section 5, Wildcard can be used in instances where a project boundary extends across several map zones. To facilitate ease of processing, the user can create the MU with required rasters by map zone. The boundary raster then can be used as a wildcard to define the area of interest.

   To use this option, double-click the Wildcard button to add a wildcard raster.
10. Aspect, Slope, and Elevation layers are also optional. Double-click those buttons to add rasters, if desired.

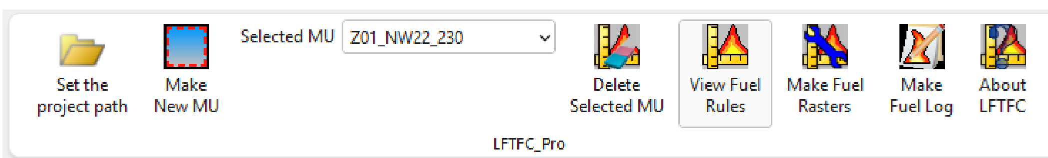
    Note: Recall that all rasters must be in the same projection.

6.5 Fuel Rules

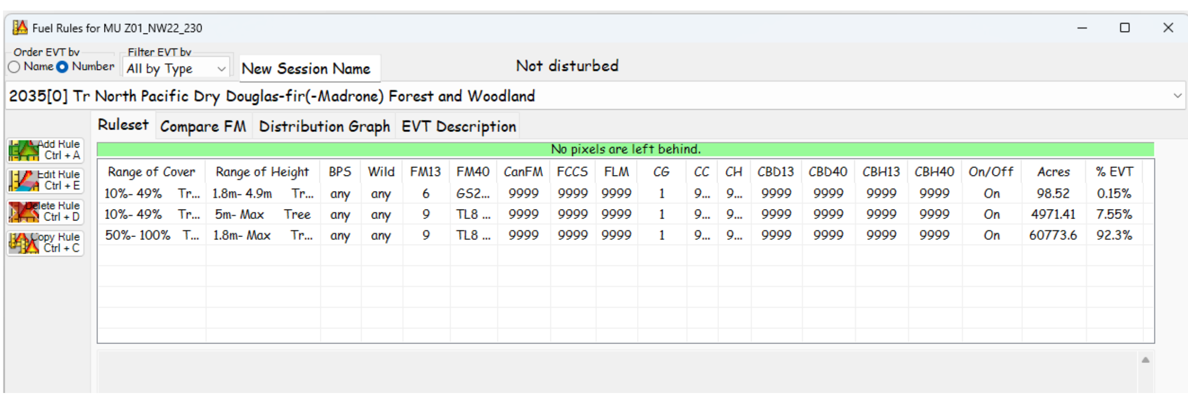
LFTFC's Fuel Rules function offers many features and is where the bulk of the modifications to spatially displayed data are made. The following section includes descriptions of components and available options for: Fuel Rules, Column headers, Tab indicators, Fuel Rule sheets (page tabs), and Rule inputs.

The FVT, FVC, and FVH comprise existing vegetation for non-disturbed and pre-disturbance vegetation for disturbed areas. A fuel model can be assigned to represent how much fuel would describe the fuel bed by vegetation type: life form (Herb, Shrub, Tree) cover, height, biophysical setting, and any optional layer that may be used. In disturbed areas the pre-disturbance vegetation helps fuel specialists assign fuel rules by informing how much fuel was acted upon by the disturbance. For example, if a disturbance is blowdown, it is helpful to know the pre-disturbance vegetation type, tree cover, and tree height so a fuel model can be assigned to represent the type and amount of tree loading on the ground.

1. Click the View Fuel Rules button (below).



2. Fuel Rules screen opens with the Ruleset page displayed (below).



LFTFC users will spend most of their time working with this screen. Rulesets used to modify surface and canopy fuels are accessed here. The default data set loads with fuel rules for the surface fuel models that were developed through the LF Program and LF calibration meetings with local fuel experts.

The default data set is selected by pointing to its folder through "Set Project Directory" (see Section 6.4). The database starts with fuel rules by EVT for all the LF map zones. Rulesets for all the EVTs in the selected map zone (LF Map Zone 01 in this example), become available to view or edit in the Fuel Rules screen.

There is a wealth of information within the default rulesets. Many users work with the Fuel Rules screen just to ensure that they understand the existing default rulesets before opting to make any modifications. A user should have good documentation and adequate reasons before making any changes to these rulesets.

Once you have determined that the rulesets within the default data set will suffice, or you have decided to make an MU with a revised set of rules or modify the existing ruleset in the default data, you can begin to work with LFTFC's Ruleset screen.

Note: Notes can be added or edited by entering a session name at the top of the window, selecting a rule and clicking in the bottom section of the Fuel Rules page. (Figure 6-3)

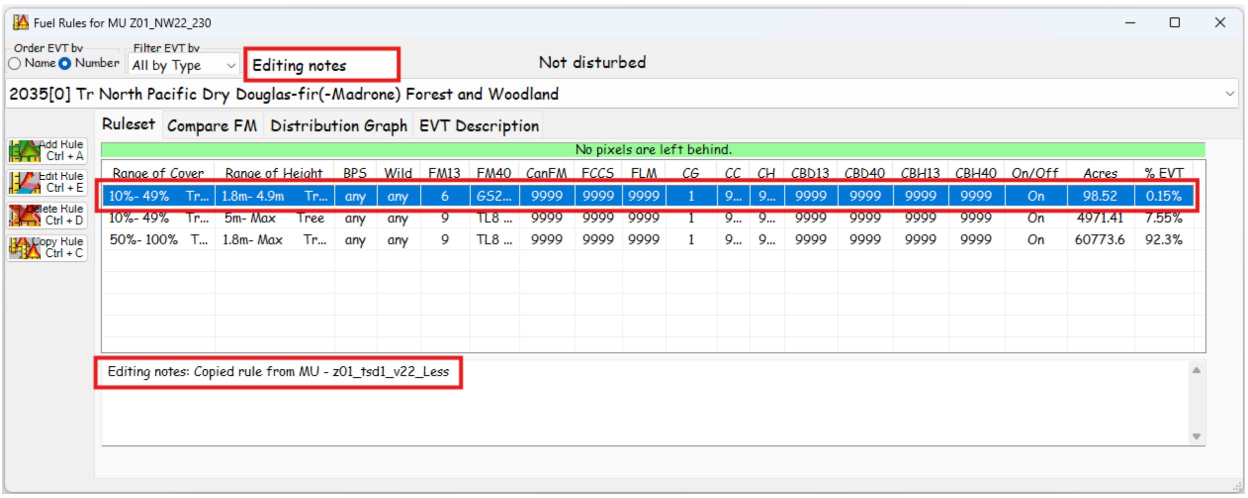


Figure 6-3. Editing notes on Ruleset screen

To summarize, several general options are available at this point:

- If the default data set is reviewed and determined to be usable with no further modifications, a raster of the 13 or 40 FBFM and rasters of canopy attributes (see Section 3) can be made for use in fire potential and simulation software such as FARSITE or FlamMap (see Section 6.6).
- If the edits are made to the default database (see Section 6.5.4), then rasters of the FBFMs and/or canopy attributes can be made. See Section 6.6 for additional information.
- If an MU was created for developing rulesets for fuel characteristics when the MU is selected in the MU window (no fuels layer is added in as a wildcard) and the View Fuel Rules selection is made on the LFTFC toolbar, the Fuel Rules window will open.

A "9999," indicating that there are no data, will be visible where all the ruleset information should be displayed. At this point, the user will need to copy a rule ("Copy Rule"), create a rule through editing ("Edit Rule"), or add a rule ("Add Rule") for the FVC, FVH, FDist, BPS, FBFM, and canopy attributes for each ruleset in each FVT desired in the MU.

Note: Other options for editing rules exist and can be found by clicking the values of existing rules. However, the options described above represent the most common functions in current use.

6.5.1 Fuel Rule Header Selections

Header selection components (Figure 6-4) at the top of the Fuel Rules page are described below.

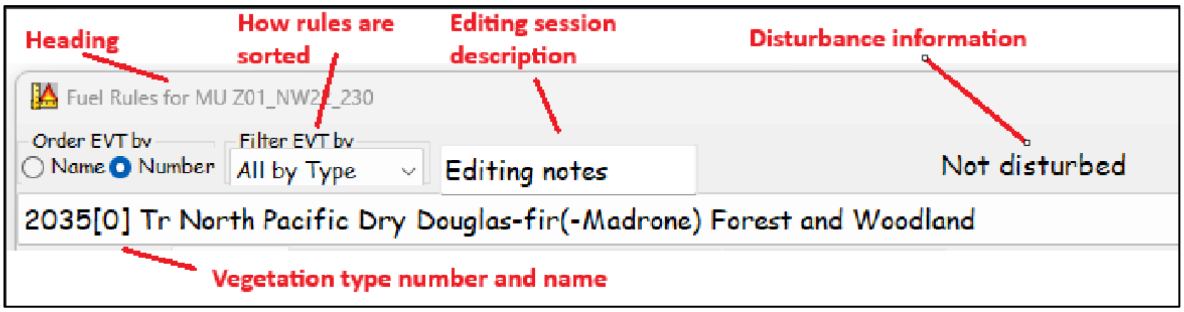


Figure 6-4. Fuel Rule page headers

- **Heading:** Displays Fuel Rules for the MU the user is viewing.
- **Session Name:** Displays the notes for each rule so you can determine when changes were made.
- **Fuel Vegetation Type Number and Name:** Displays FVT number and name in a dropdown window that allows the user to go directly to the desired FVT. The FVT informs the user of the dominant species present as well as the type of vegetation that occupies the site. See Section 6.5.5.4 for additional information.
- **Disturbance information:** Type of disturbance, severity of the disturbance, and time since the disturbance.

6.5.2 Column Headers

The Fuels Rules box (Figure 6-5) is set up in spreadsheet design so that column headers can collapse and expand as needed (Figure 6-5 and Figure 6-6). One of the primary functions of this tool is to enable the user to highlight a row field and then select the Edit Rule button to make changes to any of the attributes describing the fuels. When the row is highlighted, a text box at the bottom of the window opens, indicating any recent editing actions involving that rule.

Modifications are made by changing values directly in the boxes displayed. See Section 6.5.4 for additional information on how headers are modified as rule inputs are developed.

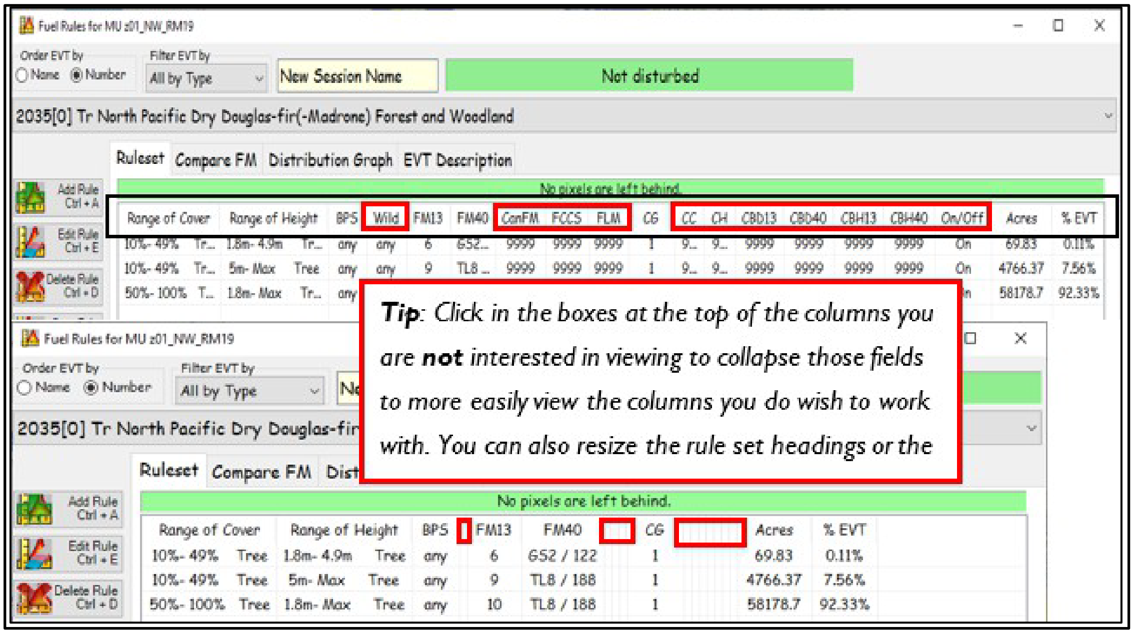


Figure 6-5. Collapse/expand column headers

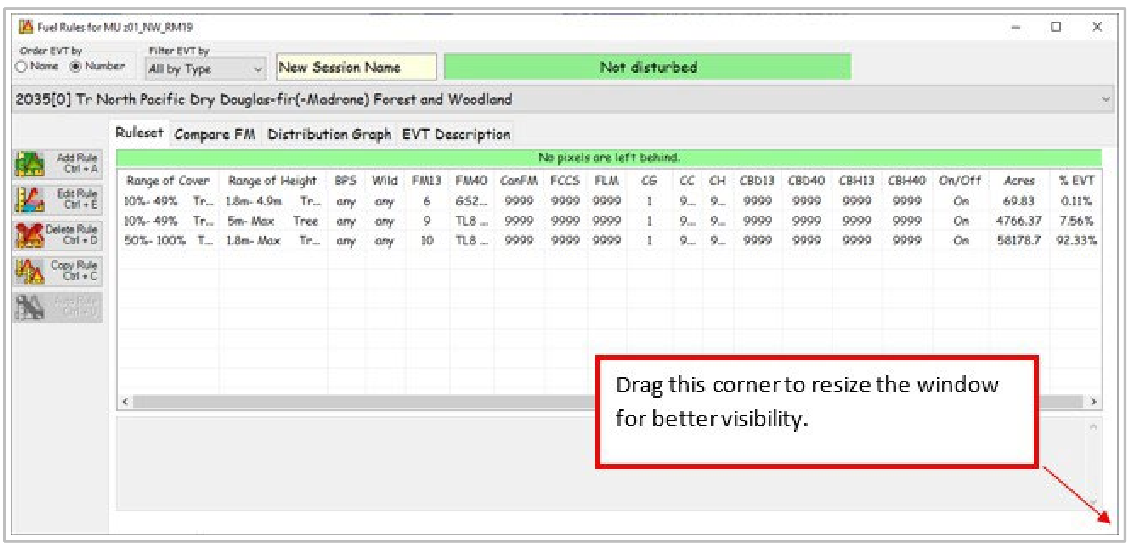


Figure 6-6. Display options

Main column headers are described below.

- **Range of Cover –** Cover ranges used to determine fuel characteristics are based on the pre-disturbance vegetation cover depicted in the pixel. Life form cover provides information that can help determine the surface fire behavior fuel model based on various groups of covers and provides insights into CBH and CBD in the vegetation's canopy attributes.

- **Range of Height –** Height ranges are used to determine fuel characteristics based on the pre-disturbance vegetation height depicted in the pixel. Life form height provides information that helps determine the surface fire behavior fuel model based on various groups of heights and provides insights into CBH and CBD in the vegetation's canopy attributes.

  Example: Mixed Conifer Woodland = FVT (2022, z02); from 10-39% closure (open); 0-max height; tree life form; any BPS; FBFM 6; FBFM40 GS2. In the first set, the rule implies Mixed Confer woodland in this map zone, and if it is open, shrubs or regeneration and grass will be growing in the openings, and it will burn in the surface fuel model as a shrub or grass shrub model.
- **BPS –** If the coverage of the FVT is too great, or if the specified vegetation displays different fuel characteristics within its range, the Biophysical Settings (BPS) may be used to indicate different fuel characteristics in different areas of the same FVT. For example, it might be advantageous to modify fuel characteristics for vegetation occurring on serpentine or other ultramafic soil types.

  Referring to the previous example (Mixed Conifer Woodland), the BPS is given as "any" so that for all BPS designations within z02 and FVT 2022, this rule would apply.
- **Wildcard (Wild) –** Wildcards serve the same general purpose as BPS: to further refine the scale of the fuel characteristic assignment. See Section 6.5 for more information on using wildcards.
- **FBFM 13 – FBFM 40 – Canadian FM – FCCS – FLM assignments –** The next columns indicate the fuel model assignments made for the 13 FBFM and 40 FBFM systems. In the default data set, these fuel model determinations were primarily made because of the calibration workshops held across the country.

LFTFC has been designed to incorporate other fuel descriptions systems, including the Canadian Fire Behavior Prediction System of Fuel Models (CFBPS FM), FCCS, and FLMs. A custom fuel model also can be used. The default data set, however, includes no information from these systems except CFBPS, which is only available in certain parts of the U.S.

- **Canopy Guide (CG) Toggle –** Modeled fire behavior in the wildland settings is dependent on many of the vegetation attributes; but in forested settings, the canopy is an important factor affecting fire behavior outputs. The Canopy Guide Toggle can be used to assess whether crown fire development is likely. In LFTFC, a switch has been incorporated to describe the effects of canopy. The switch has four user-controlled numeric settings:
  - **0 =** No canopy on the site.
  - **1 =** Canopy base height (CBH) and canopy bulk density (CBD) calculations from LF data sets are used to indicate the likelihood of crown fire on the site. This setting is used on a forested site (dominated by "tree" life form) where torching and crowning in the upper strata vegetation is common during times of fire activity.

- **2 =** This setting would be used on tree life form sites where torching and crowning are not likely to occur, such as in some hardwood communities. The mapping tool in this setting artificially raises CBH to 10 meters and lowers CBD to 0.012 kg/m³. Torching and crowning will not occur, but the stand attributes (CH and CC) will be used in the calculations of surface fire behavior characteristics. The reason for keeping the canopy attributes in place is to adjust wind speed, shading, and sheltering for surface fire calculations.
- **3 =** This setting would be used on tree life form sites where torching would occur, but active crowning is not likely, such as in mixed hardwood and conifer communities. The mapping tool in this setting artificially lowers CBD to 0.03 kg/m³, but leaves CBH, CH, and CC as predicted

- **Canopy Cover (CC) and Canopy Height (CH) –** Can be user-designated by individual ruleset while in editing mode. The default data set uses LF cover and height as portrayed in the range of cover and height columns.
- **CBH 13 and CBH 40 –** The user can specify CBH for a given Fuel Rule by individual ruleset for either of the surface fuel model rasters they will be producing, see Section 5.3. Default values are assigned from linear regression equations derived from plots analyzed through various disturbance scenarios in Forest Vegetation Simulator (FVS). (Martin, Napoli, and Smail, personal communication).
- **CBD 13 and CBD 40 –** The user can specify CBD for a given Fuel Rule by individual ruleset for either of the surface fuel model rasters they will be producing, see Section 5.3. Default values are taken from the General Linear Model (GLM).
- **On/Off –** A rule can be turned "On" or "Off" using a toggle switch. If a rule is turned off without accounting for the area in another rule, the total acres and percent coverage of the EVT may become out of balance (less than or greater than 100%). If a rule is turned "Off," the user can still view relevant notes about its history or past use.
- **Acres and Percent of EVT –** Shows how many acres and percent of the FVT a specific rule covers. When out of balance (over or under 100%), the Ruleset sheet labels will indicate the problem, see Section 6.5.3.

6.5.3 FVT Label Indicators

The Ruleset page includes an FVT label that changes from red to green or green to red depending on if the pixels are accounted for in the rules. If the label is red, it will indicate the number of missing pixels left behind or that rulesets caused an overlap in the assignments. (Figure 6-7).

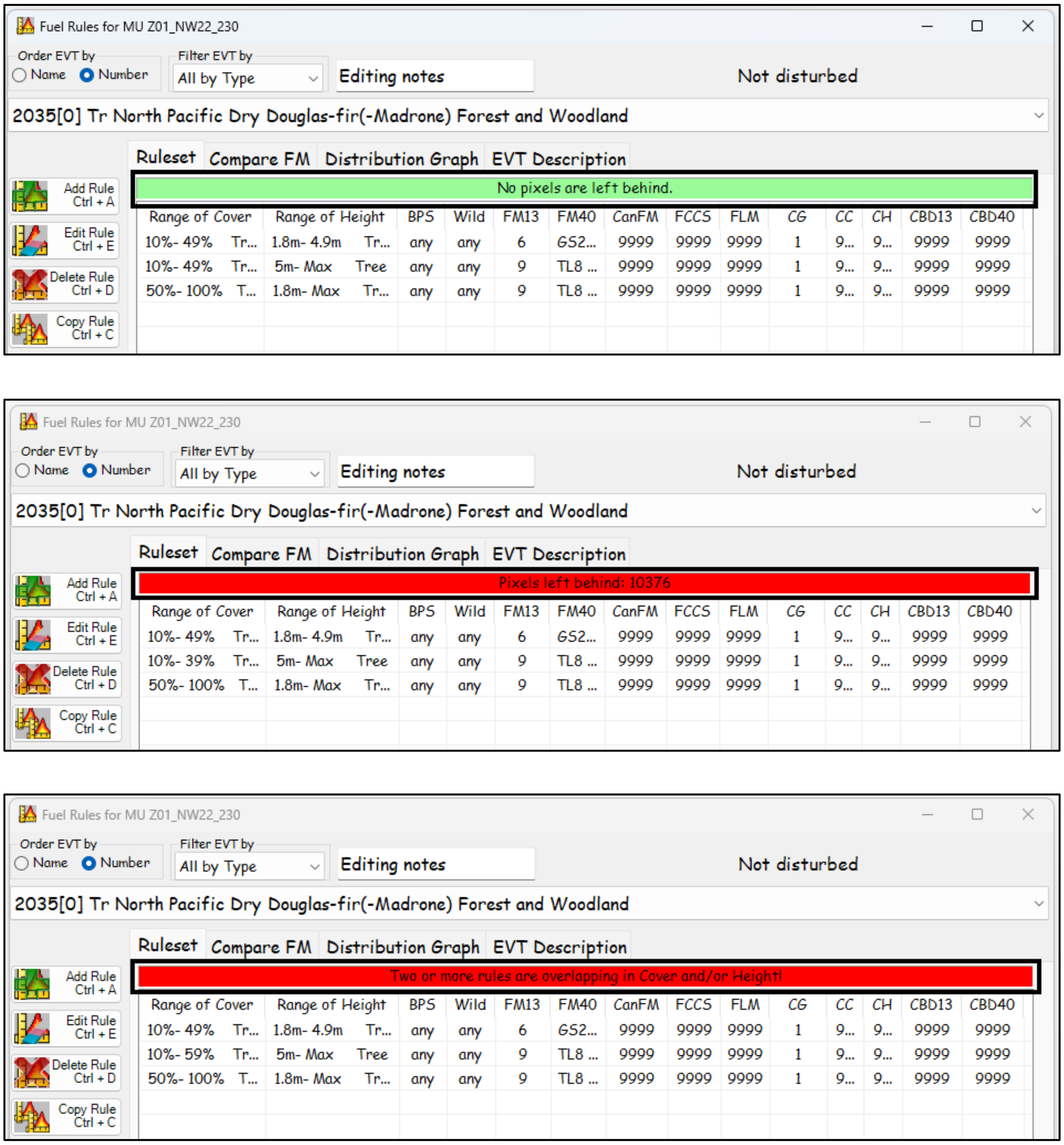


Figure 6-7. Ruleset pixel indicator

Pixels left behind or overlapping – Indicates if there is a problem with the combinations of rulesets covering all the pixels in the Raster of varying covers, heights, BPS, and wildcard. Rules are assigned by the order below:

1. Combinations of FVT, FVC, and FVH cannot overlap. They make up the base rule.
2. If Wildcard or BPS are used in a rule, then that rule takes precedence over any existing base rules that it overlaps.
3. If Wildcard and BPS are both used together in a rule, then that rule takes precedence over any existing base and Wildcard or BPS rules that it overlaps.

If necessary, you can account for missing pixels by using rule input options such as "Add Rule" or "Edit Rule," See Section 6.5.4.

6.5.4 Rule Input Options

The following section describes the function of each available rule input option in detail. A typical LFTFC user might opt to work with several of the rule options. Refer to the descriptions of interest.

LFTFC users can select from the following Rule Input options: Add Rule, Edit Rule, Delete Rule, and Copy Rule.

- **Add Rule –** enables users to create new rules
- **Edit Rule –** used to modify existing rules
- **Delete Rule –** used to delete rules that are no longer needed
- **Copy Rule –** allows users to copy rules from other existing MUs

Rule inputs are selected by clicking one of the buttons at the top left of the Fuel Rules dialog box.

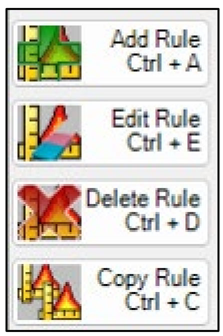


Figure 6-8. Rule input options

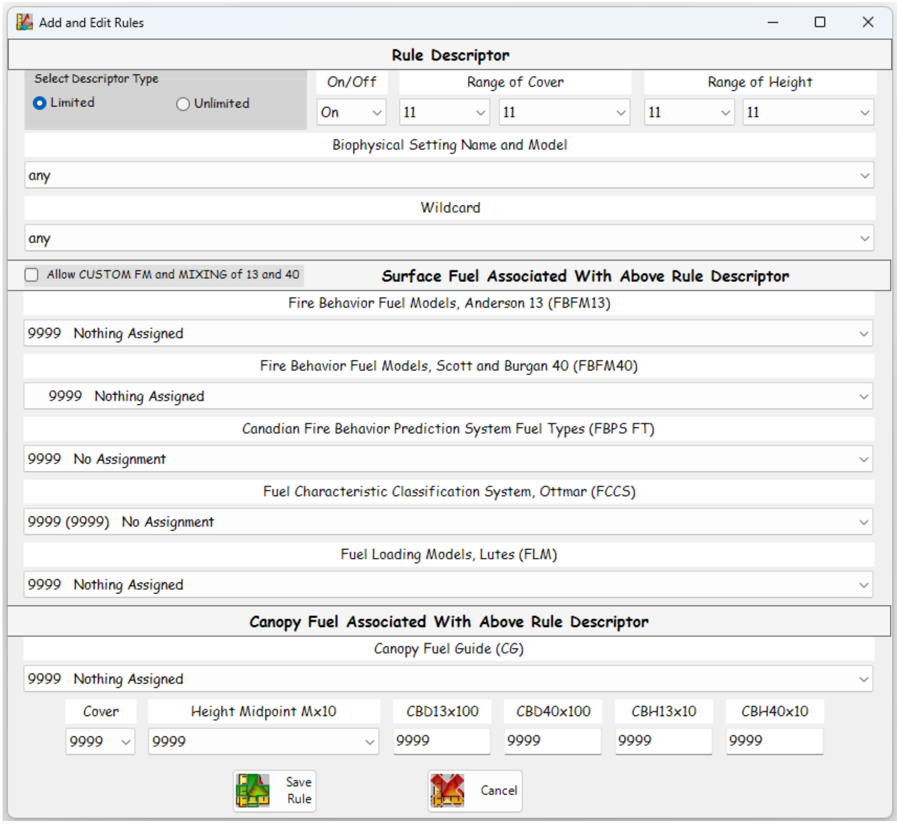
6.5.4.1 Add Rule

The Add Rule option can be used when there are no available rules to edit. The Add Rule option may be appropriate if rules exist and EVTs have been added but EVTs are populated by "9999," indicating "no data," or when rulesets are split out into new cover and height rules and there are no existing applicable rules to edit.

For example, suppose a user had an existing rule specifying canopy cover of 10 to 49%, canopy height of 0-max, 9/TL6, and wanted to use a shrub model to depict the more open condition with smaller trees. The user could add a rule to state: canopy cover of 10 to 29%, canopy height of 0 to 25, 2/GS2, 10-29%, 25 – max, 9/TL6, and edit the existing rule to 30-49%, 0 – max, 9/TL6.

1. Click the Add Rule button.

2. The Add and Edit Rules dialog box opens (below).



3. To use the Add Rule option, you will need to complete the required input for:
   – Rule Descriptor
   – Surface Fuel Associated with Above Rule Descriptor
   – Canopy Fuel Associated with Above Rule Descriptor

   The steps required to use the Add Rule option are discussed in the following sections.

6.5.4.2 Rule Descriptor Box

1. Select Descriptor Type. Use the radio button to select Limited or Unlimited.

   Note: Using the Limited Descriptor Type option keeps the user from creating illogical combinations that the data do not support. The Unlimited option gives the user all combinations of cover and height in all life forms whether they exist in the data or not.
2. Use the dropdown menu to toggle the Rule On or Off.
3. Use the dropdown menus to select a Range of Cover and Range of Height.
4. Specify the Biophysical Setting Name and Model using the dropdown menu, see Section 3.2.1.
5. A Wildcard option can be selected from the associated dropdown menu, see Section 6.5. for more information on wildcards.

6.5.4.3 Surface Fuel Associated with Above Rule Descriptor Box

1. Use dropdown menus to make assignments for FBFM13 and FBFM40, CFBPS FM, FCCS, and FLM.

6.5.4.4 Canopy Fuel Associated with Above Rule Descriptor Box

1. Make a Canopy Fuel Guide (CG) selection using the dropdown box.
2. Add CC, CH, CBD, and CBH values in place of "9999", to express different fire behavior other than the default equation predictions, see Section 6.6.

   Tip: When working with Add Rule, you must specify a Canopy Fuel Guide (CG). If you do not, you will get a "9999" ("no value").
3. Click the Save Rule button at the lower left to save the rule.

6.5.4.5 Edit Rule

Use the Edit Rule selection when rules exist but modifications are desired, such as when there is a need to adjust canopy cover or canopy height from the default predictions.

Note: Other options for editing rules exist and can be found by right-clicking the values of existing rules. However, the options described above represent the most common functions in current use.

Tip: Be aware that you may need to use Add Rule to cover any missing pixels if the whole range in the raster is not covered by the existing rule.

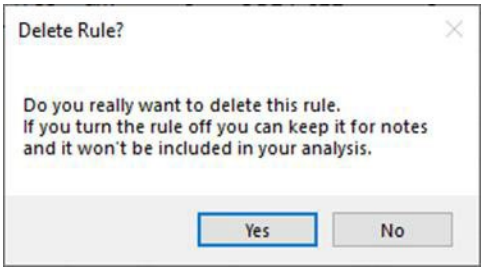
Example: A ruleset for the Cottonwood Bosque FVT has the range of cover and height worked out in logical fashion for the FVT, but you know that under dry conditions, crowning is likely in this vegetation type. Currently, the ruleset has 8/TL3 and a canopy guide (CG) of 2, which will use just canopy to adjust shading and wind reduction. In this situation, to help model crowning, highlight the ruleset for 20-59% 0-max height. Use the dropdown box for FBFM13 to select FM10, hit the dropdown arrow for FBFM40 to select TL8-188, and use the dropdown menu for **Canopy Fuel Guide** (CG) to select "1." Save your edits by clicking on the **Save Rule** button. Subsequently, the Bosque rulesets will be 10-19%, 0-max, 5/GS2; 20- 59%, 0-max, 10/TL8.

1. To use the Edit Rule option, click the **Edit Rule** button on the Fuel Rules dialog box (Figure 6-8).
2. The Add and Edit Rules dialog box opens. Components of the Add and Edit Rule dialog box are the same as those described for the Add Rule option. You will need to complete the required inputs for the Rule Descriptor, Surface Fuel Associated with Above Rule Descriptor, and the Canopy Fuel Associated with Above Rule Descriptor boxes. See Sections 6.5.4.2, 6.5.4.3 and 6.5.4.4 for instructions.

6.5.4.6 Delete Rule

Use this option to delete rules that you no longer want (such as those that may conflict with other rulesets you have added).

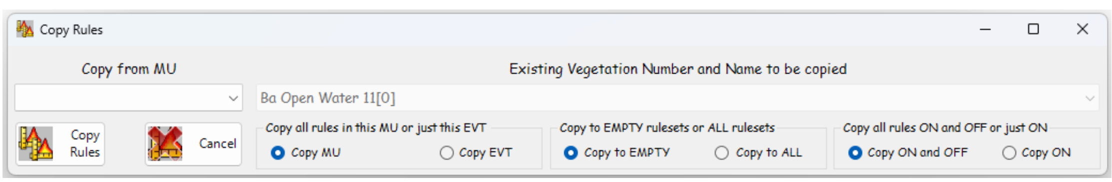
1. Delete rules by selecting the rules you would like to delete and then clicking on the **Delete Rule** button. (Figure 6-8)
2. A dialog box opens (below), allowing you to verify that the rule should be deleted.



6.5.4.7 Copy Rule

For a good starting point, the typical user can use the Copy Rule input option to copy rulesets from updated LF data. For each LF production, the LFTFC tool is updated and released with the most recent fuels ruleset database. To utilize previous LF productions, users can download the standalone database on the Fuel Rulesets Database webpage. Edits then can be made to copied rulesets and additional rules, including BPS segmentations, can be added.

1. Click the Copy Rule button on the Fuel Rules page. A dialog box opens (below).

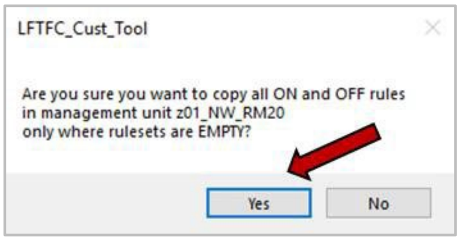


2. Use the dropdown menu at the top left of the Copy Rules dialog box (above) to select a MU to copy from.
3. Use the radio buttons to select whether to copy all the rules from the selected MU or to copy only the ruleset from the selected MU and Existing Vegetation Type (EVT). (Copy MU or Copy EVT)

   Note: Use the dropdown menu under Existing Vegetation Number and Name to be copied to specify an EVT if Copy EVT is selected.
4. Use the radio buttons to select whether to copy all the rules from the selected MU or to copy only the rule set from the selected MU and Existing Vegetation Type (EVT). (Copy MU or Copy EVT)

   Note: Use the dropdown menu under Existing Vegetation Number and Name to be copied to specify an EVT if Copy EVT is selected.

5. Use the radio buttons in the middle to copy rules into only the FVT rulesets that do not already have rules or copy all the rules even if rules already exist in the rulesets. This helps rulesets from getting duplicate rules. (Copy to EMPTY or Copy to ALL)
6. Use the radio buttons at the far right to specify if you would like to Copy all rules turned on and off" (Copy On and Off) or just those rules that are turned on (Copy On).
7. Click on the Copy Rules button.
8. Verify that you want to copy all On and Off rules by clicking Yes (below).



6.5.5 Fuel Rule Page Tabs

Several page tabs are available on the Ruleset sheet to assist users in describing the fuel and fire behavior characteristics portrayed by their rulesets (Figure 6-9).

Tip: Users can easily navigate between pages at any time by clicking the page tabs.

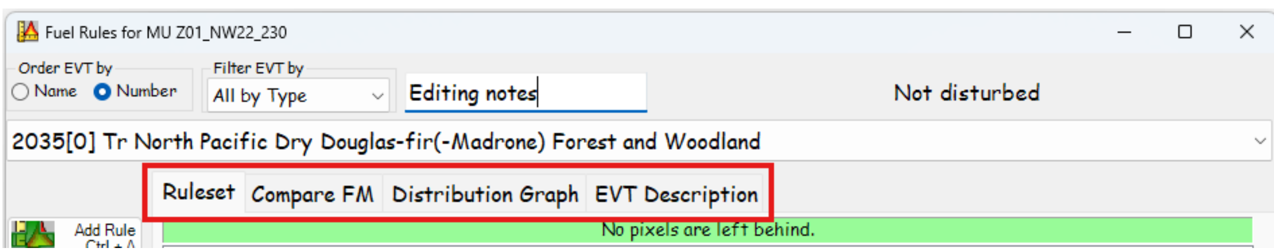


Figure 6-9. Page tabs in Fuel Rules dialog box

These page tabs open tools that help users better understand the vegetation types being depicted on the site, life forms present in the spatial raster by cover and height, and associated fire behavior characteristics. Fuel Rule sheet pages are described below.

6.5.5.1 Ruleset

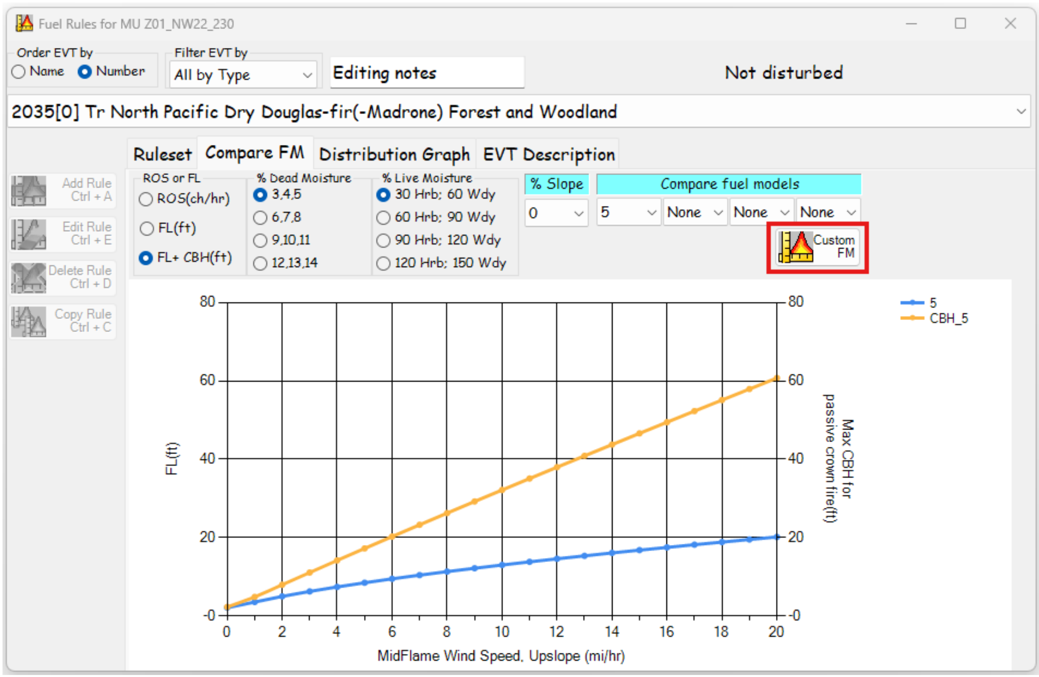
The Ruleset page is visible when the Fuel Rules dialog box opens, see Sections 6.5.1, 6.5.2, 6.5.3 and 6.5.4 for additional information.

6.5.5.2 Compare FM

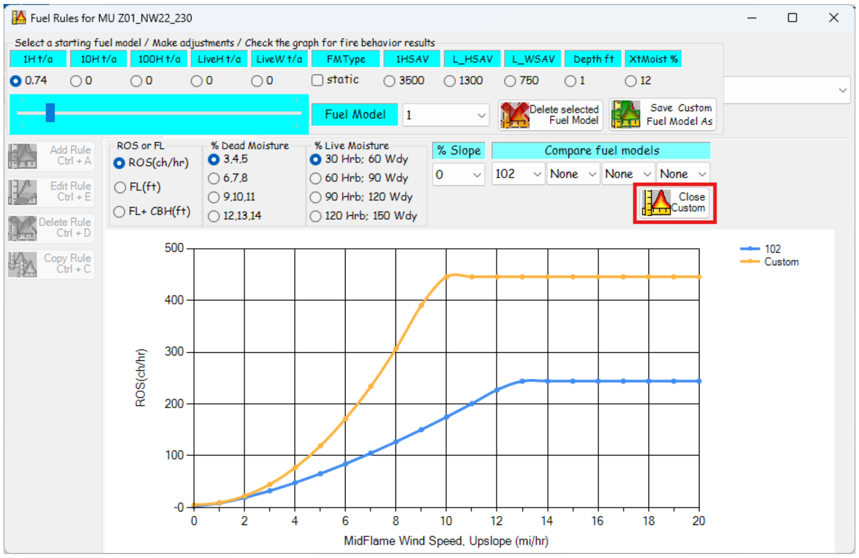
This page graphically illustrates fire behavior traits, such as Rate of Spread (ROS) and Flame Length (FL) for surface fuel models in the FBFM 13 and FBFM 40 systems at various fuel moisture regimes, wind speeds and slope. A graphic display of CBH range that would initiate crown fire behavior at various fuel moisture regimes, wind speeds, and slope is also included.

1. Use radio buttons to select desired ROS or FL, percent Dead Moisture, and percent Live Moisture.
2. Use dropdown menus to enter percent slope and desired fuel models for comparison.

   Note: These options are useful in determining FBFM13, FBFM40, and CBH for the fuel characteristics assignment displayed on the rulesets from the Ruleset sheet.



3. The Compare FM page also allows the user to build and display fire behavior traits (ROS and FL) for custom fuel models at various fuel moisture regimes, wind speeds, and slope. This task is accomplished by clicking the Custom FM button (above).
4. To create a custom model, select the fuel model you would like to start with in the box to the right of “Fuel Model.”
5. Adjust by selecting a parameter and then moving the slide adjustment. Make any other desired adjustments by using appropriate radio buttons
6. Close the custom fuel model interface when finished by clicking the same button, now called Close Custom (below).



7. Once saved, the custom model will be available

6.5.5.3 Distribution Graph

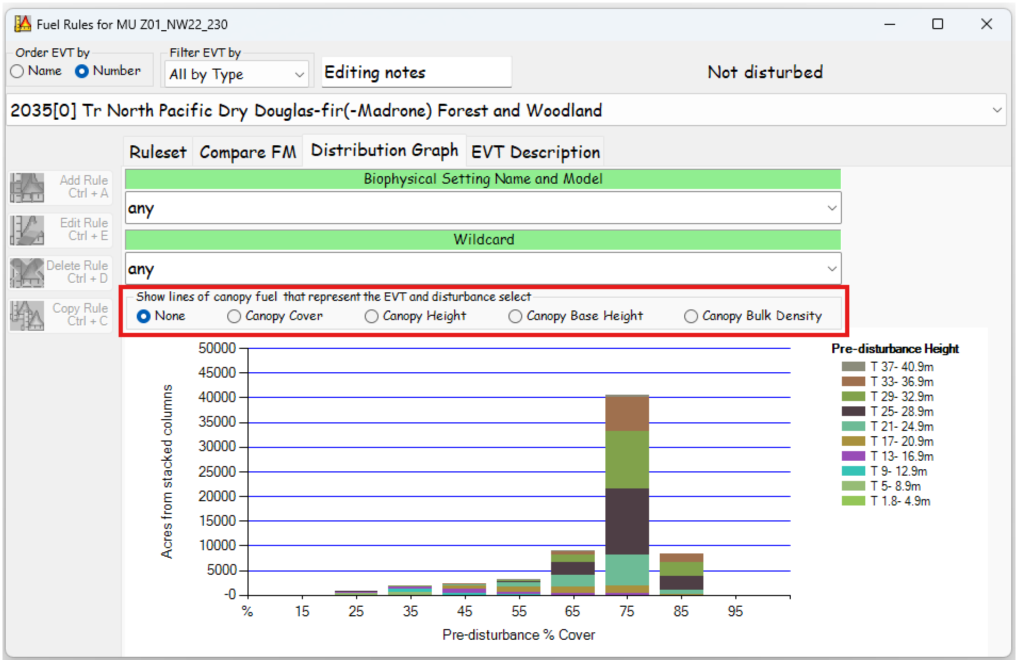
The Distribution Graph tab opens a graph that shows the distribution of acres of classified cover and height by life form that exist in the raster data for the entire FVT or by BPS or Wildcard (if a wildcard is used in the MU raster).

Use the Distribution Graph page (below) to view the height of the vegetation by cover, and the numbers of acres present in the selected FVT within the defined MU.

The x-axis shows 10% breaks of cover by life form; the y-axis corresponds to the number of acres within the FVT in the MU's extent. The legend displays the line indications by height corresponding to the percent cover and represents the number of acres.

1. Click the Distribution Graph tab.
2. Use the relevant dropdown menus to display the distribution of an FVT, BPS, or wildcard.

   Note: In the legend a "T" is tree, "S" is shrub, and "H" is made up of herbaceous life form



Note: The selection buttons shown in the red square (above) can add lines that represent what the predicted canopy fuel would be, non-disturbed and disturbed, for the selected FVT.

6.5.5.4 EVT Description

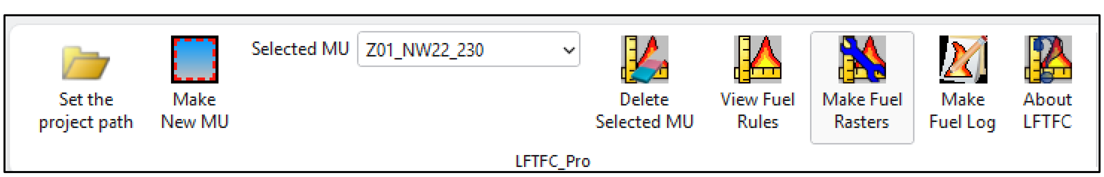
Select the EVT Description tab to display an ecological description. This NatureServe website (https://explorer.natureserve.org/) serves as the basis for all LF EVTs

6.6 Creating New Rasters

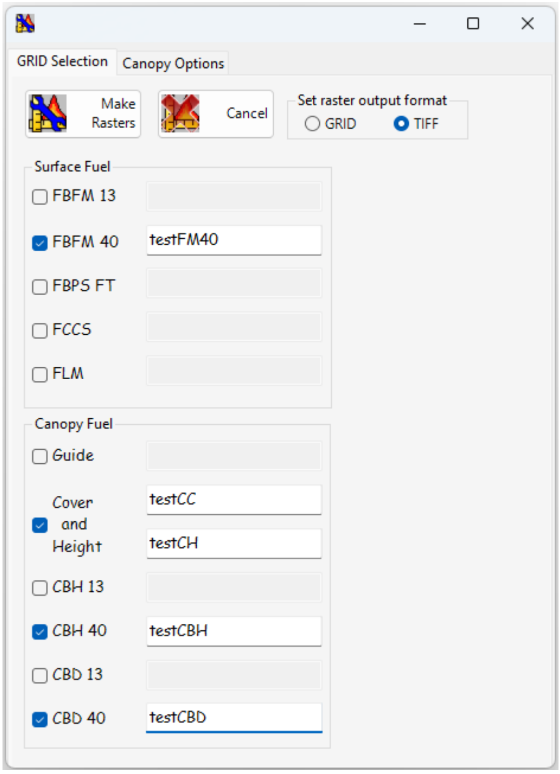
Fuel characteristics can be edited or modified pixel by pixel, based on logical decisions determined by cover, height, vegetation, and biophysical settings incorporated into FBFMs.

Once the fuel rules have been added, deleted, or adjusted (see Section 6.5.4), users are ready to create the new layers.

1. Click the Make Fuel Rasters button on the LFTFC toolbar (below).



2. A dialog box (below) with the Raster Selection tab visible opens.

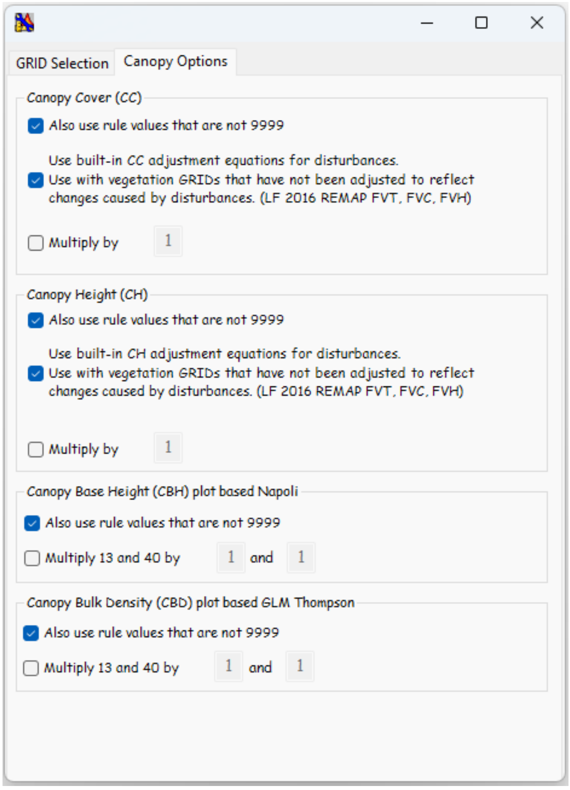


3. Use the Raster Selection tab to create surface fuel layers.
4. Select the layers you would like to include by checking the boxes to the left of the raster.
5. Name the Fuel layers to be created in the box to the right of the selection.
6. Select the output raster format.

Note: When naming the file, a file extension is not needed. However, the file name must not exceed 13 characters and should not contain any spaces, leading numbers, or special characters (`~! @#$^()-+={ }[ ]|\?/:;”’< >, .).

Tip: CBD 13/40 are the same and CBH 13/40 are the same, just check one box for each.

7. The Canopy Options page opens (below).



8. CC and CH have three options:
    a. (Default) by using rules that are not coded as “9999” (indicating no data) in the rulesets to overwrite the predicted value.
    b. (Default) Use built-in adjustment equations for disturbances.
    c. Use a coefficient by which to multiply.
9. CBH and/or CBD have two options:
    a. (Default) by using rules that are not coded as “9999” (indicating no data) in the rulesets to overwrite the predicted value.
    b. Use a coefficient by which to multiply.

    Note: CBH and CBD are calculated using the pre-disturbance FVT, the value used for CC, and the value used for CH. The calculations for CBH and CBD can be overridden if option one is used, and a value is given in the fuel ruleset for a specific CBH and/or CBD rule.
10. When finished with both Raster Selection and Canopy Options tabs, make sure the Raster Selection page is open and click the Create Rasters button.

Errors in raster creation are usually due to naming convention mistakes, i.e., naming rasters too similarly or using names that are too long. If any pixels are left behind, a message will appear telling you which FVT has missing pixels and asking whether you would like to continue.

Tip: If more changes are needed, go back to the rules, make your changes, and then recreate the rasters.

Note: The presence of “9999s” indicates that no relevant data are present in the raster.

6.7 Fuel Raster Color Palette

Upon creation of the rasters, a color map file is applied to the newly created fuel rasters, which follows the standard LANDFIRE symbology.

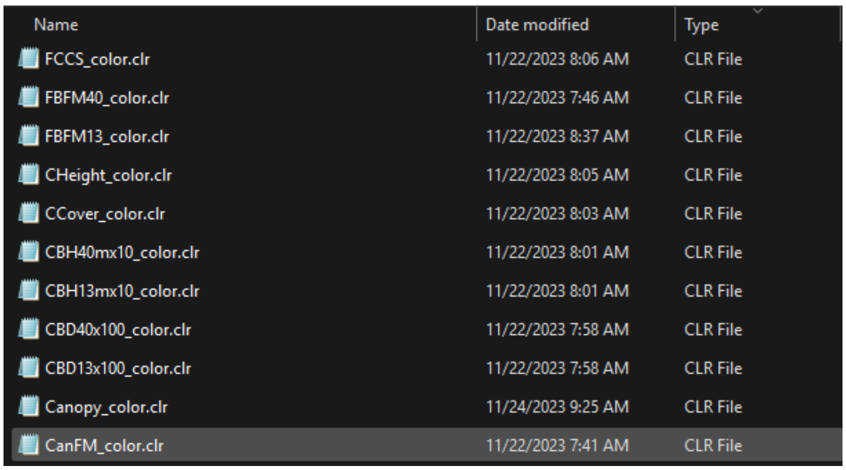
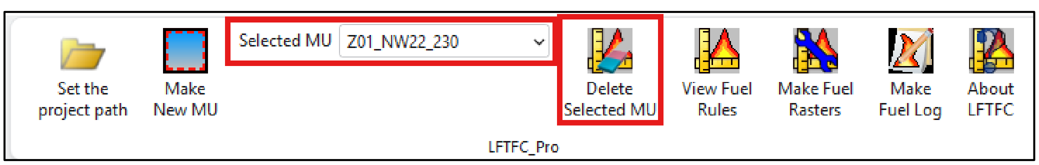


Figure 6-10. LF color map symbology files

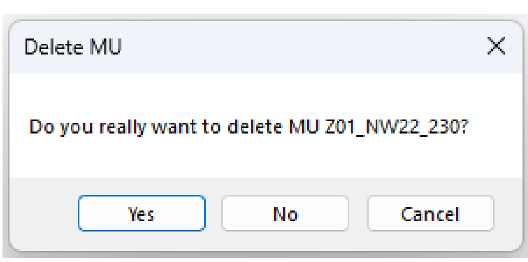
6.8 Deleting Fuel Management Units

Use this function to delete fuel MUs that you no longer need or have replaced.

1. Click Delete Selected MU on the LFTFC toolbar to delete selected Management Units (below).



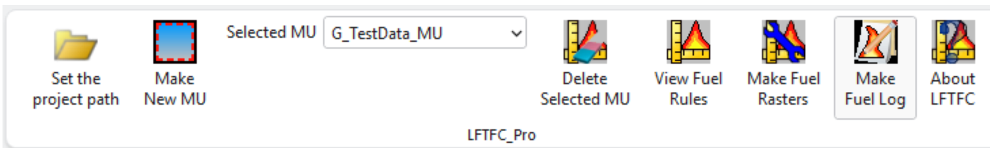
2. The following Delete MU dialog box will open.
3. Click “Yes” to confirm your deletion.



6.9 Fuel Log

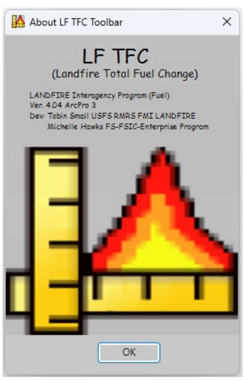
The Fuel Log selection on the toolbar creates a text file consisting of all the changes and notes made for the life of the fuel rulesets.

1. Click the Make Fuel Log button on the LFTFC toolbar to view the text file (below).



6.10 About LFTFC

1. Click About LFTFC in the toolbar menu to display the screen below, which includes information on version number and tool development.



Section 7 Troubleshooting LFTFC

7.1 Common Problems

7.1.1 Installation Errors

Be sure to uninstall any previous versions of LFTFC that may already be installed on your computer (see Chapter 4: Installing LFTFC Toolbar Add-in for additional information).

7.1.2 Naming Issues

Errors in raster creation are usually due to mistakes with naming conventions, naming rasters too similarly, or using names that are too long. File names must not exceed 13 characters in length and should not contain any spaces, leading numbers, or special characters (`~! @#$^()-+={ }[ ]|\?/:;”’< >, .).

If any pixels are left behind, a message will appear telling you which EVT has missing pixels and asking you if you would like to continue.

To report a bug, please go to the Contact Us web page at https://landfire.gov/contact or email us directly at helpdesk@landfire.gov.

Appendix A LF Canopy Cover and Height Classification

A.1 Canopy Cover Classification

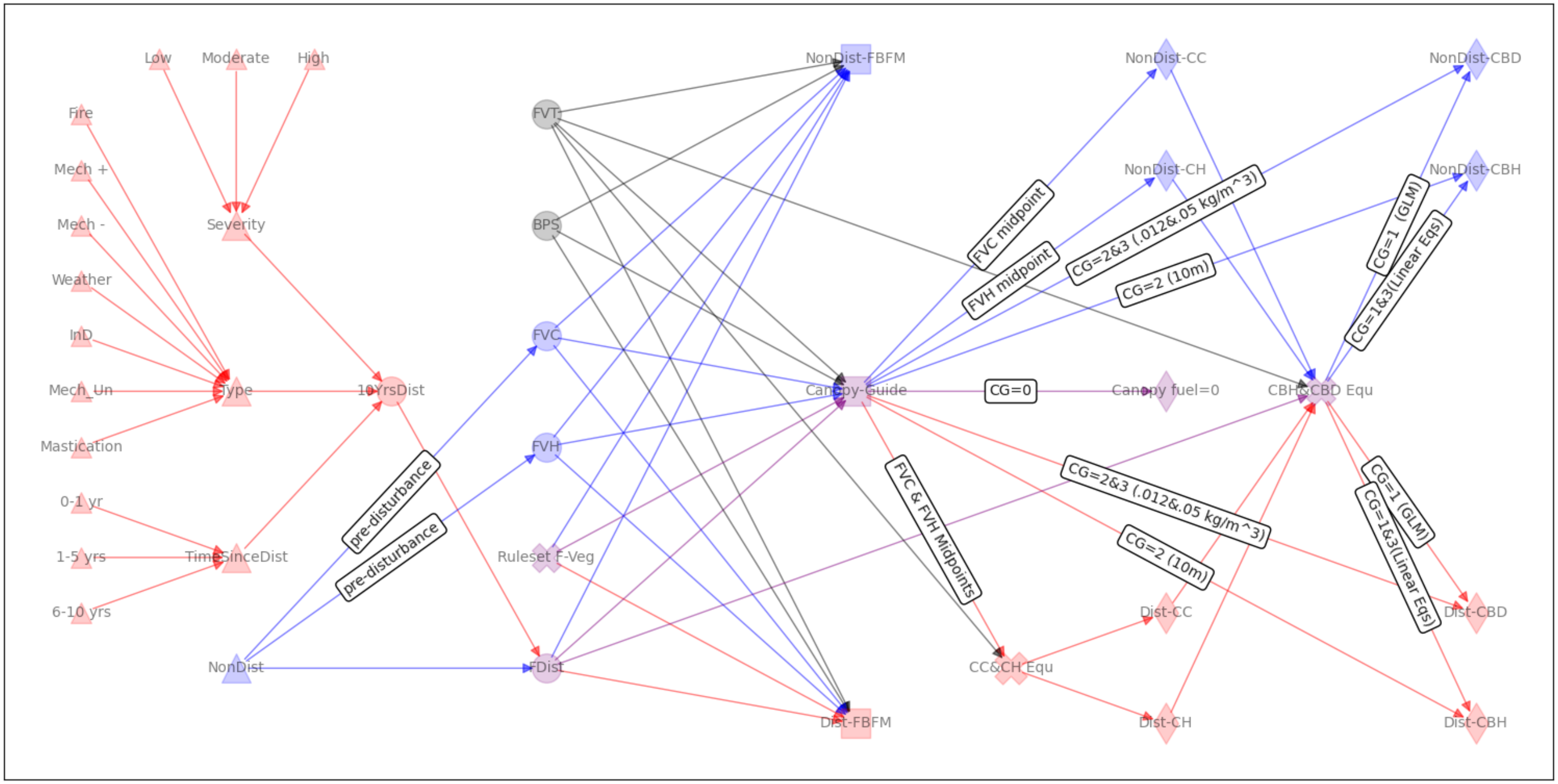
TREE		
101	≥ 10	< 20
102	≥ 20	< 30
103	≥ 30	< 40
104	≥ 40	< 50
105	≥ 50	< 60
106	≥ 60	< 70
107	≥ 70	< 80
108	≥ 80	< 90
109	≥ 90	≤ 100
SHRUB		
111	≥ 10	< 20
112	≥ 20	< 30
113	≥ 30	< 40
114	≥ 40	< 50
115	≥ 50	< 60
116	≥ 60	< 70
117	≥ 70	< 80
118	≥ 80	< 90
119	≥ 90	≤ 100
HERBACEOUS		
121	≥ 10	< 20
122	≥ 20	< 30
123	≥ 30	< 40
124	≥ 40	< 50
125	≥ 50	< 60
126	≥ 60	< 70
127	≥ 70	< 80
128	≥ 80	< 90
129	≥ 90	≤ 100

A.2 Canopy Height Classification

TREE		
	Range (in meters)	
603	1.8	4.9
607	5	8.9
611	9	12.9
615	13	16.9
619	17	20.9
623	21	24.9
627	25	28.9
631	29	32.9
635	33	36.9
639	37	40.9
643	41	44.9
647	45	48.9
651	49	Maximum
SHRUB		
	Range (in meters)	
502	0	0.5
507	0.5	1.0
520	1.0	3.0
530	3.0	Maximum
HERBACEOUS		
425	0	0.5
475	0.5	1.0
499	1.0	Maximum

Appendix B LFTFC Process Diagram

B.1 Process Diagram



Appendix C RMRS Missoula Fire Sciences Lab GitHub Repository

https://github.com/firelab/LFTFC

ReadMe, Source Code, License, and Change log

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