



Fuel Rules for MUPFW, WFDNS, etc.

Auto Rule Add Rule Edit Rule Delete Rule Copy Rule

Session Name: Select rules: All FC25 FPMK FLM

New Session

Existing Vegetation Number and Name

2460 Southern Coastal Plain Nonriverine Cypress Dome

Ruleset Compare FM Distribution Graph EVT Description

100% of EVT 0% of BPS 0% of W140 0% of BPS W140 Fixed left behind: 0

Range of Cover	Range of Height	BPS	FMS3	FMS40	CG	On/Off	Area	% EVT
10%-70%	Tree 0(m)-50(m)	Tree any	5	S47 / 147	2	On	0	76.47%
80%-100%	Tree 0(m)-50(m)	Tree any	8	TL2 / 182	2	On	3	23.53%
10%-100%	Tree 0(m)-50(m)	Tree any	8	TL2 / 182	1	Off		

The LANDFIRE Total Fuel Change Tool (ToFuΔ) User's Guide



The National Interagency
Fuels, Fire, & Vegetation
Technology Transfer
and
the LANDFIRE Fuels Team

Version Beta 0.12
for ArcMap 9.2 or 9.3
March 2011



Preface

LANDFIRE fuel data were originally developed from coarse-scale existing vegetation type, existing vegetation cover, existing vegetation height, and biophysical setting layers. Fire and fuel specialists from across the country provided input to the original LANDFIRE National (LF_1.0.0) fuel layers to help calibrate fuel characteristics on a more localized scale. The LANDFIRE Total Fuel Change Tool (ToFuΔ) was developed from this calibration process.

Vegetation is subject to constant change – and fuels are therefore also dynamic, necessitating a systematic method for reflecting changes spatially so that fire behavior can be accurately assessed. ToFuΔ allows local experts to quickly produce maps that spatially display any proposed fuel characteristics changes.

ToFuΔ works through a Microsoft Access database to produce spatial results in ArcMap based on rule sets devised by the user that take into account the existing vegetation type (EVT), existing vegetation cover (EVC), existing vegetation height (EVH), and biophysical setting (BpS) from the LANDFIRE grid data. There are also options within ToFuΔ to add discrete variables in grid format through use of the wildcard option and for subdividing specific areas for different fuel characteristic assignments through the BpS grid.

The ToFuΔ user determines the size of the area for assessment by defining a Management Unit, or “MU.” User-defined rule sets made up of EVT, EVC, EVH, and BpS layers, as well as any wildcard selections, are used to change or refine fuel characteristics within the MU. Once these changes have been made to the fuel characteristics, new grids are created for fire behavior analysis or planning. These grids represent the most common ToFuΔ output.

ToFuΔ is currently under development and will continue to be updated in the future. The current beta version (0.12), released in March 2011, is compatible with Windows 7 and will be the last release until the fall of 2011.

Prerequisites

ToFuΔ is compatible with ArcGIS 9.2 and 9.3. When installed, the software will create a toolbar within ArcMap to access the spatial features of the program. Users need to be familiar with ArcGIS. More importantly, users must have a good understanding of fire behavior and effects, as well as knowledge pertaining to fuels (such as fuel loading models and fire behavior fuel models), weather, topography, and wildland fire situations. Users should also understand the relationships between disturbance, vegetation attributes, and fuel characteristics. This knowledge should be accompanied by the ability to use non-spatial fire behavior and effects prediction systems such as [BehavePlus](#), [NEXUS](#), and [FOFEM](#).

Specific computer requirements are described in detail in [Chapter 1](#) of this guide.

Obtaining copies

To obtain the latest version of ToFuΔ, additional copies of this ToFuΔ User's Guide, the ToFuΔ Tutorial, or the ToFuΔ Help Utility, follow these steps:

1. Go to Wildland Fire Management RD&A: Fuels and Fire Ecology (formerly NIFTT) at <https://www.frames.gov/partner-sites/wfmrda-ffe/home/>
2. Under Tools, select Archived Tools and User Documents. ToFu Delta is listed here.
3. Select the material you wish to download from those listed in the right-hand column.

Credits

The beta version of ToFuΔ was developed and is maintained for the National Interagency Fuels, Fire, and Vegetation Technology Transfer (NIFTT) by the LANDFIRE Fuels Team: Tobin Smail¹, developer/programmer, and Charley Martin¹ and Jim Napoli¹, user interface and function testing.^{2,3}

¹Stinger Ghaffarian Technologies, Inc., contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD. Work performed under contract G10PC00044.

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Your input

We value your input. Please forward any questions, comments, reports of bugs, or ideas to <https://www.frames.gov/myframes/forum>.

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Chapter 1: About the ToFuΔ User's Guide

- 1.1 Before you begin
- 1.2 How to use this guide
- 1.3 Computer requirements

1.1 Before you begin

This user's guide describes the basic operation of ToFuΔ, 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, ToFuΔ users must be familiar with Microsoft Windows and basic ArcGIS functions.

1.2 How to use this guide

It is not necessary to read the entire guide to carry out a specific task. Once you are familiar with the basic concepts associated with ToFuΔ, you can quickly locate commonly performed tasks by reviewing the headings in the '[Table of Contents](#)' located near the beginning of this guide. You can then refer to the specific section pertaining to your needs. Whenever possible, screen captures are used to illustrate steps required to complete a task.

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

1.3 Computer requirements

Ensure the following programs are installed and functioning properly on your computer:

- ArcGIS 9.2 or 9.3
- Spatial Analyst extension of ArcGIS 9.2 or 9.3
- Microsoft Excel (2000 or higher, with version 2007 preferred)
- Microsoft Access (2000 or higher, with version 2007 preferred)

Although system requirements to run ArcGIS 9.2 will suffice to run NIFTT tools, at least 10 GB of free hard drive space and 2 GB of RAM are recommended. Generally, faster processors, more memory, and increased free hard drive space will improve performance. In addition, NIFTT tools were developed for Windows Operating Systems.

Note: *Ensure that you have sufficient space and adequate permissions for storing ToFuΔ outputs on your computer.*

Tip: *Ensure that the ToFuΔ version you are using matches the version of ArcGIS on your computer. This version of ToFuΔ does not work with older versions of ArcGIS (9.0, 9.1, etc.).*

Note: *Although not required, ArcCatalog is a highly valuable tool for managing and organizing ArcMap data layers and should be used for all data manipulation such as copying, pasting, renaming, and deleting.*

Chapter 2: ToFu Δ Function

2.1 How ToFu Δ operates

2.2 Applications

2.1 How ToFu Δ operates

ToFu Δ works through a Microsoft Access database to produce spatial results in ArcMap based on rule sets devised by the user. These rule sets principally take into account the existing vegetation type (EVT), existing vegetation cover (EVC), existing vegetation height (EVH), and biophysical setting (BpS) from the LANDFIRE grid data. There are also options within the fuel change tool to add discrete variables in grid format through use of the wildcard option or by subdividing specific areas for different fuel characteristic assignments through the BpS grid.

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

2.2 Applications

ToFu Δ has numerous and diverse potential management applications. Fire and fuels managers can use ToFu Δ 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, ToFu Δ can be used to:

- Create Canopy Base Height, Canopy Bulk Density, Canadian Fire Behavior Prediction System Fuel Models, 13 - Fire Behavior Fuel Model (Anderson 1982), 40 – Fire Behavior Fuel Model (Scott and Burgan 2005), and GIS GRID 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 LANDFIRE fuel calibration.
- 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.

Chapter 3: Inputs

3.1 Required input data

- 3.1.1 Biophysical Settings (BpS) layer
- 3.1.2 .2 Existing Vegetation Type (EVT) layer
- 3.1.3 .3 Existing Vegetation Cover (EVC) layer
- 3.1.4 .4 Existing Vegetation Height (EVH) layer

3.2 Optional input data

- 3.2.1 Disturbance
- 3.2.2 Wildcard
- 3.2.3 Slope
- 3.2.4 Aspect
- 3.2.5 Elevation

3.3 Other data

- 3.3.1 Fire Behavior Fuel Models (FBFM)
- 3.3.2 Canopy Base Height (CBH)
- 3.3.3 Canopy Bulk Density (CBD)
- 3.3.4 Canopy Cover (CC)
- 3.3.5 Canopy Height (CH)

3.4 Concepts of rule set development for fuel characteristics

- 3.4.1 Fire Behavior Fuel Model assignments in LANDFIRE National data
- 3.4.2 Canopy guide toggle
- 3.4.3 Assigning canopy characteristics

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 grid layers. Four separate LANDFIRE data sets are required to build an MU and run ToFuΔ: Existing Vegetation Type (EVT), Existing Vegetation Cover (EVC), Existing Vegetation Height (EVH), and Biophysical Settings (BpS).

For development and processing within the LANDFIRE Project, map zones were used as the standard area for analysis. The default data set was processed by LANDFIRE map zones and consequently, rule sets for fuels characteristics that are within the default are set at that extent. The grid layers of EVT, EVC, EVH, and BpS (all set to the extent of each LANDFIRE map zone) were combined for processing.

The four required grids EVT, EVC, EVH, and BpS must be downloaded from the LANDFIRE Data Distribution Site at <http://landfire.gov/viewer/>. (See [Chapter 4](#) for additional information on how to access and download required data.)

Note: *Because ToFuΔ was developed to process LANDFIRE data, the classifications of EVT, EVC, EVH, and BpS are imbedded in the tool's nomenclature; therefore other data sets with different classification systems cannot be used.*

These layers are described briefly below. For additional information on these required input items, consult www.landfire.gov.

3.1.1 Biophysical Settings (BpS) layer

Biophysical settings reflect the integration of soils, climate, and topography which define native disturbance regimes and the composition of resulting plant communities. Biophysical settings are the taxonomic units used to characterize reference conditions. The natural composition of succession classes has been determined for each BpS by using either spatial vegetation succession and disturbance models, such as LANDSUM (Keane and others 2006) and TELSA (ESSA Technologies Ltd. 2005a) or aspatial vegetation succession and disturbance models, such as the Vegetation Dynamics Development Tool (VDDT; ESSA Technologies Ltd. 2005b).

Depending on the analysis area, there may be as many as one hundred or more BpS types. Biophysical settings lacking a set of reference conditions (such as barren, water, agriculture, and urban) are ignored when calculating landscape composition and deriving departure indices. For example, if agriculture comprises 10 percent of a landscape, the composition of succession classes is determined from the remaining 90 percent of that landscape. An example value attribute table for a BpS layer is shown below (fig. 3-1).

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

Figure 3-1. The attribute *Bps_model* in the Value Attribute Table from a BpS layer.

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

3.1.2 Existing Vegetation Type (EVT) layer

“The Existing Vegetation Type (EVT) layer represents the vegetation currently present at a given site. LANDFIRE vegetation map units are derived from [NatureServe’s Ecological Classifications](#), which is a nationally consistent set of mid-scale ecological units (Comer and others 2003). Existing vegetation is mapped through a predictive modeling approach using a combination of field reference information, Landsat imagery, and spatially explicit biophysical gradient data. Field data keyed to dominant vegetation type at the plot level were used as "training data" to drive the modeling process. Attribute information is provided that links the LANDFIRE EVT map units to existing classifications such as the National Vegetation Classification System and those of the Society of American Foresters and Society of Range Management” (from www.landfire.gov).

3.1.3 Existing Vegetation Cover (EVC) layer

“Vegetation cover represents the average percent cover of existing vegetation for a 30-m grid cell. The Existing Vegetation Cover layer was generated using a predictive modeling approach that related Landsat

imagery and spatially explicit biophysical gradients to calculated values of average canopy cover from field training sites and digital orthophoto quadrangles” (from www.landfire.gov).

TofuΔ “reads” the life form of the pixels within each grid and displays the life form that the rule set will be describing. The LANDFIRE numbering scheme for EVC denotes which vegetation strata are being identified as well as the range of cover in 10% increments of that life form. The LANDFIRE data used by the tool are coded within the grid according to the numeric values described below. (These values will be used to edit fuel rules.)

- **Tree** – Tree cover is numerically structured 101 to 109 in cover classes of 10%: 101 = 10-19% with a midpoint of 15%, 102= 20-29%, and so on to 109 = 90-99% tree cover.
- **Shrub** – Shrub cover is expressed in an “11 series” so that a coding of 111= 10-19% and so on to 119 = 90-99% shrub cover.
- **Herbaceous** – Herbaceous cover is expressed in a “12 series” of 10% class increments so that a 121 class = 10-19%, 122 = 20-29%, and so on to 129 = 90-99% herbaceous cover.

***Note:** After editing cover in the fuel rules and creating a grid, the midpoint of the range (the 10% increment) of cover will be used to describe canopy cover if the grid is then input into a Landscape file for spatial fire behavior analysis.*

3.1.4 Existing Vegetation Height (EVH) layer

“Vegetation height represents the average height of the dominant vegetation for a 30-m grid cell. The LANDFIRE Canopy Height layer was generated using a predictive modeling approach that related Landsat imagery and spatially explicit biophysical gradients to calculated values of average dominant height from field training sites” (from www.landfire.gov).

The LANDFIRE numbering scheme for EVH denotes which vegetation strata are being identified and the range of height in 10% increments of that life form. Life forms are coded as follows.

- Tree – Pixels are coded in classes as follows: 108 (0-5.0m), 109 (5.0-10.0m), 110 (10.0-25.0m), 111 (25.0-50.0m), and 112 (>50m).
- Shrub – Pixels are coded in classes as follows: 104 (0-0.5m), 105 (0.5-1.0m), 106 (1.0-3.0m), and 107 (>3.0m).
- Herbaceous – Pixels are coded in classes as follows: 101 (0-0.5 meters), 102 (0.5- 1.0m), and 103 (> 1m).

See [Appendix B: LANDFIRE Canopy Cover and Height Classification](#) for additional information.

3.2 Optional input data

3.2.1 Disturbance

The Disturbance layer is used in the LANDFIRE Refresh process (see www.landfire.gov) to update circa 2001 data to 2008 given the effects of disturbance on the landscape. Raster data sets are made up of disturbance polygons that included fuel rules for disturbance type, intensity, and time since disturbance. This functionality will be available for user input in the final version of ToFuΔ.

3.2.2 Wildcard

Wildcard inputs to ToFuΔ can include prepared fuel raster data such as fuel model or canopy attributes. Often, grids built and processed through the tool are brought into a combine with EVT, EVC, EVH, and BpS after changes have been made to those layers in order to set the fuel data. Any other grid data that may have an effect on the fuel type within an 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.

3.2.3 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 (fig. 3-2).

The screenshot shows a window titled "Attributes of elev_1" containing a table with three columns: Rowid, VALUE, and COUNT. The first row is selected, and a red arrow points to the value '3' in the COUNT column. The text "Elevation in meters" is written to the right of the table.

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.

3.2.4 Slope

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

The screenshot shows a window titled "Attributes of slope" containing a table with three columns: Rowid, VALUE, and COUNT. The first row is selected, and a red arrow points to the value '80054' in the COUNT column. The text "Slope measured in degrees" is written to the right of the table.

Rowid	VALUE	COUNT
0	0	80054
1	1	225475
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.

3.2.5 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 (fig. 3-4).

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

Aspect measured in degrees

Figure 3-4. Example value attribute table of an aspect layer. The Value field must depict aspect in degrees. (A value of -1 denotes flat areas that have no aspect.)

Note: In LANDFIRE data, integers are used rather than floating point grids for memory and processing efficiency.

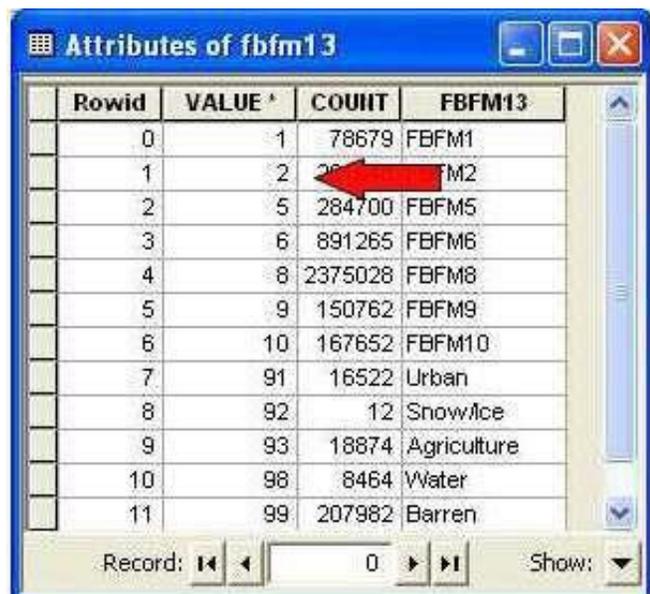
3.3 3 Other data

The LANDFIRE calibration data are located in the default Microsoft Access database (.mdb) within the program. Copying (or creating a grid and using “auto rule”) will give the user the starting rule sets developed for the EVT’s within their desired map zone. This provides a starting point for any further editing or for adding any additional rules. More specifically, it provides the means for addressing rules through biophysical settings.

Note: Users should be familiar with the LANDFIRE zone numbers for their selected map areas.

3.3.1 Fire Behavior Fuel Models (FBFM)

ToFuΔ uses either the 13 fire behavior fuel models characterized by Anderson (1982) or the 40 fire behavior fuel models 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 (fig.3-5). Additional attributes (such as a text descriptor of the model) are commonly included in the fuel model layer.



Rowid	VALUE *	COUIT	FBFM13
0	1	78679	FBFM1
1	2	26700	FBFM2
2	5	284700	FBFM5
3	6	891265	FBFM6
4	8	2375028	FBFM8
5	9	150762	FBFM9
6	10	167652	FBFM10
7	91	16522	Urban
8	92	12	Snow/Ice
9	93	18874	Agriculture
10	98	8464	Water
11	99	207982	Barren

Fire Behavior Fuel Model codes

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

3.3.2 Canopy Base Height (CBH)

Canopy base height (CBH) is a stand attribute that denotes the lowest height above the ground that has sufficient canopy fuel to propagate fire vertically. The CBH 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 layer units to be in meters*10 (fig. 3-6), meters, feet*10, or feet. A cell value of 0 characterizes a non-forested setting.

Integers are used in LANDFIRE data due to memory and processing efficiency. The operations, meters * 100, and meters * 10 are used to keep numbers expressed as integers.

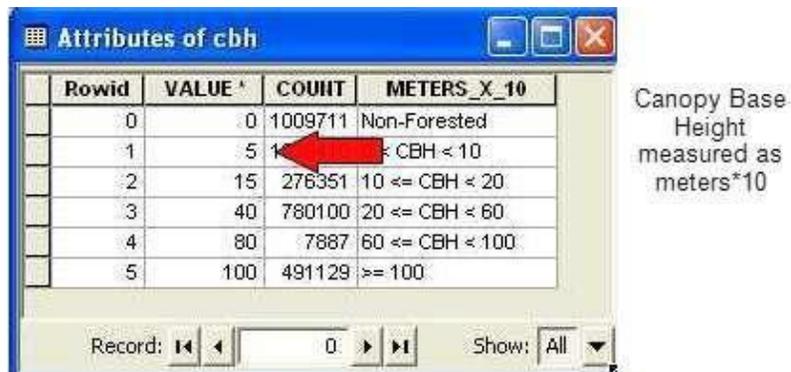


Figure 3-6. Example value attribute table for a CBH layer. In this example, the Value field depicts heights expressed in meters*10. Thus, a cell value of 20 corresponds to a two meter canopy base height. This coding structure is the LANDFIRE standard.

3.3.3 Canopy Bulk Density (CBD)

Canopy bulk density (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 layer to be expressed in kg/m³ *100 (fig. 3-7), kg/m³, lb/ft³*1,000, or lb/ft³. Cell values are represented by integers.

Rowid	VALUE ^	COUIT	CBDKGM3_X_100
0	0	1009711	Non-Forested
1	6	31	CBD < 12
2	14	78856	12 <= CBD < 16
3	20	155876	16 <= CBD < 24
4	27	15801	24 <= CBD < 30
5	35	140	30 <= CBD < 40
6	40	192	>= 40

Canopy Bulk Density in kg/m³*100

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 20 corresponds to a 0.2 kgm³ canopy bulk density. A value of 0 identifies a non-forested area.

3.3.4 Canopy Cover (CC)

Canopy cover (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 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 layer is also used to modify solar radiance with the fuel conditioning function of FlamMap and FARSITE. The tool requires that the CC layer be expressed in percent (fig. 3-8). A cell value of 0 indicates a non-forested setting. The cell values are denoted by integers.

Rowid	VALUE ^	COUIT	CANOPYCOVER_PERC
0	0	1009711	Non-Forested
1	15	14	10 <= CC < 20
2	25	538852	20 <= CC < 30
3	35	410617	30 <= CC < 40
4	45	351280	40 <= CC < 50
5	55	386181	50 <= CC < 60
6	65	363689	60 <= CC < 70
7	75	169659	70 <= CC < 80
8	85	50732	80 <= CC < 90
9	95	8735	90 <= CC <= 100

Canopy Cover measured in percent

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 cell value of 15 represents a CC class with values ranging from 10 to 20 percent.

3.3.5 Canopy Height (CH)

Canopy height (CH) is a stand attribute that reflects the average height of the overstory dominant and co-dominant in a stand. The CH layer along with the CC 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 layer is also used for estimating spotting distances from torching trees. The tool requires the CH layer units to be in meters*10 (fig. 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.

Rowid	VALUE *	COUIT	CANOPYHEIGHT_MET
0	0		-Forested
1	25	2892412	0 < CH < 50
2	75	902	50 <= CH < 100
3	175	498560	100 <= CH < 250
4	375	3	250 <= CH < 500

Canopy height measured as meters*10

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 five classes in which the cell value corresponds to the mid-point of the class. For example, a value of 25 relates to a CH class that ranges between 0 and 5 meters.

3.4 Concepts of rule set development for fuel characteristics

3.4.1 Fire Behavior Fuel Model assignments in LANDFIRE National data

The LANDFIRE data are imagery-driven with plot data used to “train” the imagery interpretation. EVT, EVC, and EVH derived from this process are the layers primarily used to develop fuel characteristics. (Visit www.landfire.gov for additional information on the development of these 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 “shrubs,” 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 ToFuΔ to describe the effects of canopy. The switch has the following three numeric settings.

- 0 – This setting indicates no canopy on the site.
- 1 – Canopy Base Height (CBH) and Canopy Bulk Density (CBD) calculations from the LANDFIRE data sets would be used to indicate the likelihood of crown fire on the site. This setting would be used on a tree life form site 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 and CBD to a point where 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.

3.4.3 Assigning canopy characteristics

In fire behavior modeling, surface fire spread and intensity combine with the vegetation attributes CBH and CBD to add torching and crowning to projected fire behavior. In the LANDFIRE 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 a standard deviation method to describe the CBH. (See www.landfire.gov for additional information in the metadata).

ToFuΔ allows users to input values for CBH and CBD for their desired forested areas.

Note: The GLM describes the standard deviation CBH method described in Reeves and others 2009.

Chapter 4: Obtaining Input Data from the LANDFIRE Data Distribution Site

4.1 Acquiring input data

4.2 Downloading data directly from the LANDFIRE Data Distribution site

4.1 Acquiring input data

The LANDFIRE Program has developed nationally consistent data – across ownerships – of the spatial themes necessary for running ToFuΔ as well as those used in FARSITE and FlamMap. The LANDFIRE 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 four grids required to run ToFuΔ are: Existing Vegetation Type (EVT), Existing Vegetation Cover (EVC), Existing Vegetation Height (EVH), and Biophysical Settings (BpS). All of these grids can be downloaded from www.landfire.gov.

4.2 Downloading data directly from the LANDFIRE Data Distribution site

On www.landfire.gov, click on the **Data Distribution Site** link and download the desired input layers. Explore the site for additional information on resources offered.

Once you are familiar with the Data Distribution Site, acquiring LANDFIRE data using the LANDFIRE Data Access Tool (LFDAT) is the most efficient method for both downloading and processing LANDFIRE data directly within ArcMap. See [Appendix C](#) for details on how to use LFDAT to download data.

Chapter 5: Installing ToFuΔ

- 5.1 General installation instructions
- 5.2 ToFuΔ installation
 - 5.2.1 Downloading ToFuΔ
 - 5.2.2 Beginning the installation process
 - 5.2.3 Obtaining the latest .NET framework
 - 5.2.4 Finishing the installation
- 5.3 Troubleshooting ToFuΔ installation

5.1 General installation instructions

All NIFTT tools, including ToFuΔ are now downloaded and installed as single tools. A complete or package install is no longer available for versions of NIFTT tools compatible with ArcMap 9.2 or 9.3.

Note: For ToFuΔ version 1.0 to operate properly, verify that you are using ArcGIS 9.2 or 9.3.

If you have an earlier version of ToFuΔ installed on your computer, you will first need to uninstall it before proceeding with installation of the current version (fig. 5-1).



Figure 5-1. Error message indicating need to uninstall a previous version of ToFuΔ.

To determine which version is currently installed on your computer, go to **Start > Control Panel > Add or Remove Programs** as shown (fig. 5-2).

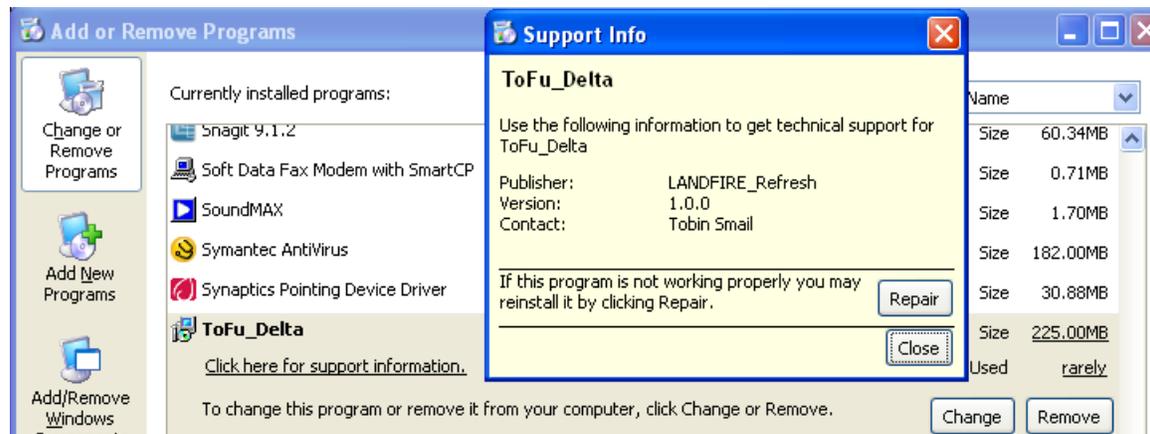


Figure 5-2. ToFuΔ version and support information.

You may need administrative privileges to install ToFuΔ on your computer. Contact your system administrator if you experience problems with the installation.

5.2 ToFuΔ installation

5.2.1 Downloading ToFuΔ

Note: *If you have an earlier version of ToFuΔ installed on your computer, you will first need to uninstall it before proceeding with installation of the current version. Refer to [section 5.1](#) for more information on this subject.*

Download ToFuΔ from the Wildland Fire Management RD&A: Fuels and Fire Ecology website (formerly NIFTT) at <https://www.frames.gov/partner-sites/wfmrda-ffe/home/>. Under Tools, select 'Archived Tools & User Documents.' ToFu Delta can be found there.

5.2.2 Beginning the installation process

The installation format of ToFuΔ is .msi and, upon initiation, the software will create a default directory structure with the LANDFIRE National fuel characteristics rule sets by map zone.



Figure 5-3. ToFuΔ installation files.

The box shown in Figure 5-3 will open. Unzip the files to the default location (C:\Program Files\LANDFIRE_Refresh, as shown in fig. 5-4) or to another location of your choice by right-clicking on the file name. Select the option **Extract to folder**.

The files should include a main directory located where the user indicated or by default in C:\Program Files\LANDFIRE_Refresh. The main folder, Tofu_Delta, contains three sub-folders: Input, MU, and Output. It also contains several additional files, including the Microsoft Access database (.mdb).

Go to the folder in which you stored the ToFuΔ installation file (fig. 5-4).

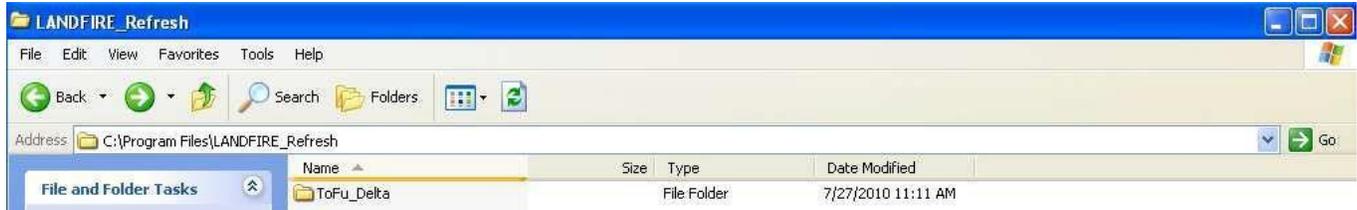


Figure 5-4. Self-extracting ToFuΔ installation file has been downloaded and saved.

Click on **ToFuDelta_Beta_1.10.msi**.

Note: If the setup determines that an earlier version of ToFuΔ is already installed on your computer, go to **Start > Control Panel** and select **Add/Remove Programs** as explained in [section 5.1](#). Uninstall the previous version of ToFuΔ and then rerun setup.exe.

If the setup.exe determines that you already have the proper .NET Framework installed on your computer, the ToFuΔ zip file contains everything that you will need for installation. A series of dialog boxes will now open. Skip to [section 5.2.4](#) to continue installation.

5.2.3 Obtaining the latest .NET Framework

If the installer determines that the setup requires a .NET Framework that has not been previously installed on your computer, you will see a dialog box similar to that in figure 5-5 instead of the first screen of the ToFuΔ Setup Wizard as shown in [figure 5-15](#).



Figure 5-5. Dialog box indicating the need to first install .NET Framework for installation to proceed.

Click **Yes** and follow all prompts as directed. If the correct .NET Framework has not been previously installed on your computer, the setup will at this point direct you to a website where you will be able to download the appropriate file (see fig. 5-6).

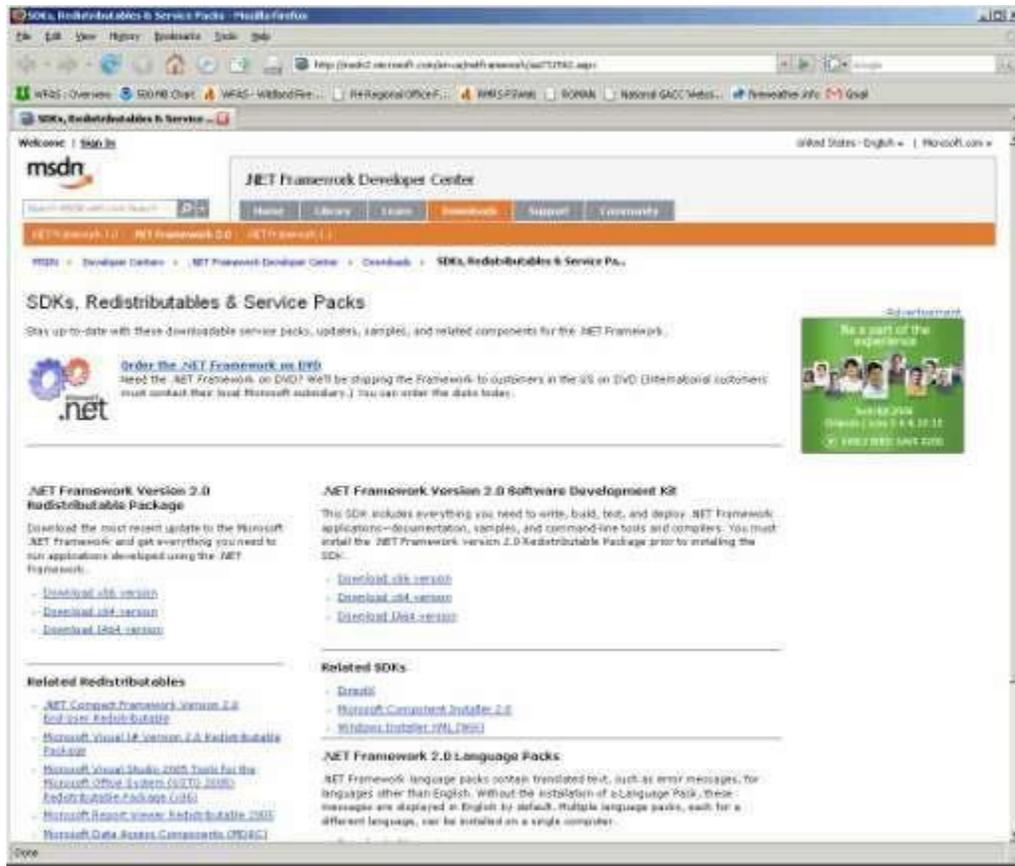


Figure 5-6. Website for downloading .NET Framework.

As shown in Figure 5-7, you will now need to specify which version of .NET Framework you would like to install on your computer. Select the x86 version if you have a Pentium (or other 32-bit) computer. Click on **Download x86 version**.

Tip: Most users will need to specify the x86 version of .NET Framework. If you are unsure, contact your system administrator.

.NET Framework Version 2.0 Redistributable Package

Download the most recent update to the Microsoft .NET Framework and get everything you need to run applications developed using the .NET Framework.

- [Download x86 version](#)
- [Download x64 version](#)
- [Download IA64 version](#)

Figure 5-7. Select the appropriate version of .NET Framework.

A screen similar to the following (fig. 5-8) will appear after your selection has been made. Click on the **Download** button to continue.

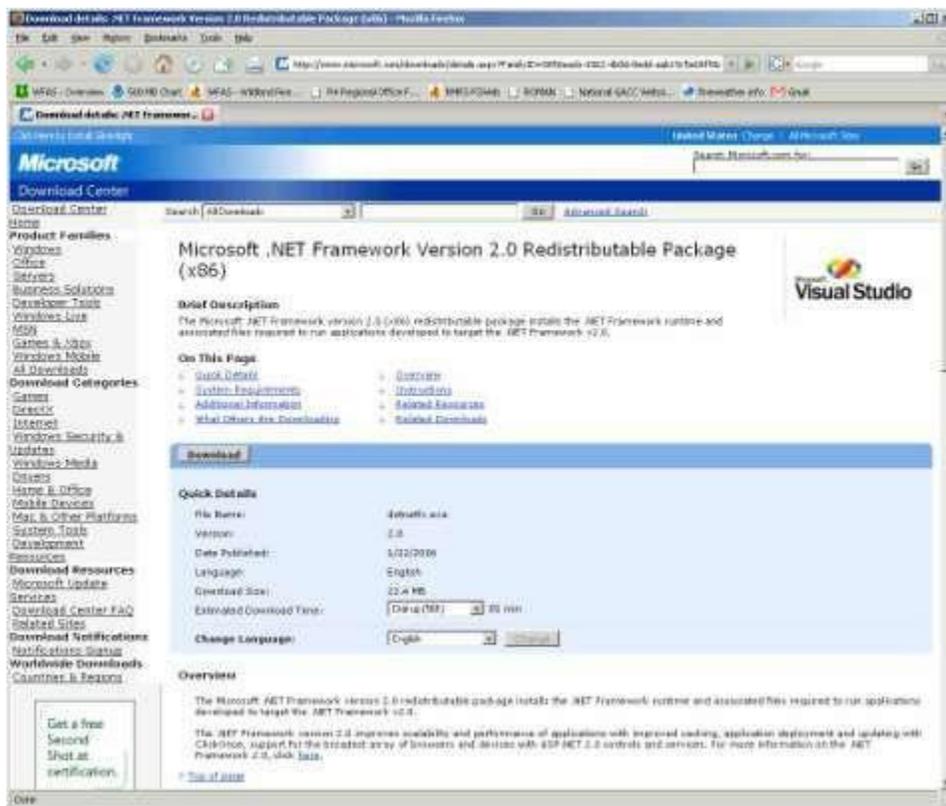


Figure 5-8. Microsoft .NET Framework Version 2.0 (x86) download page.

Browse to the location of your choice. Download and save the dotnetfx.exe file as shown in Figure 5-9.

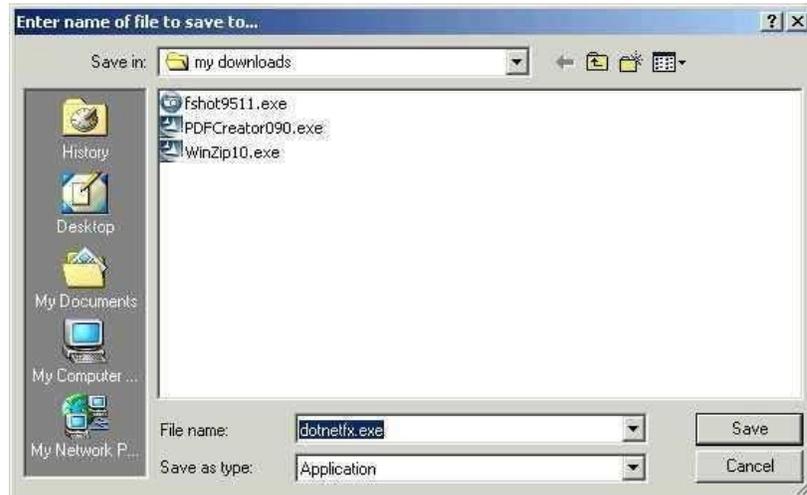


Figure 5-9. Save the file to a location of your choice.



Figure 5-10. An example progress bar indicating download of dotnetfx.exe.

The Microsoft .NET framework will download, extract, and install automatically as shown in figures 5-10 and 5-11.

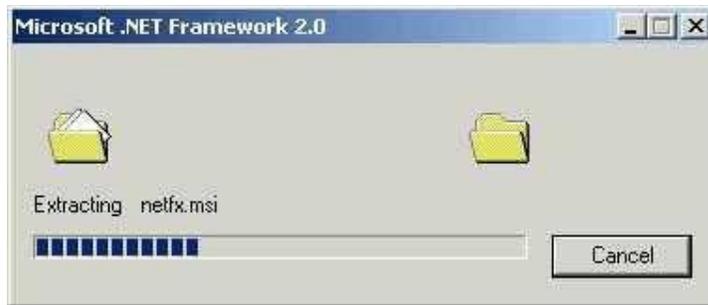


Figure 5-11. .NET Framework installation.

Click on the **ToFuDelta_Beta_1.10.msi** file as shown in [Figure 5-3](#) to initiate the setup wizard and to continue installation of ToFuΔ.

At this point, you may need administrative privileges to continue. Contact your system administrator if you experience problems.

5.2.4 Finishing the installation

After clicking on the setup.exe file, the first in a series of ToFuΔ Setup Wizard dialog boxes will open (fig. 5-12).



Figure 5-12. First dialog box of the ToFuΔ setup wizard.

Select an appropriate folder or accept the default location. During the installation process, you may see a radio button asking you to specify whether the tool is to be installed for “Everyone” or “Just Me.” Select the “Everyone” option (fig. 5-13).

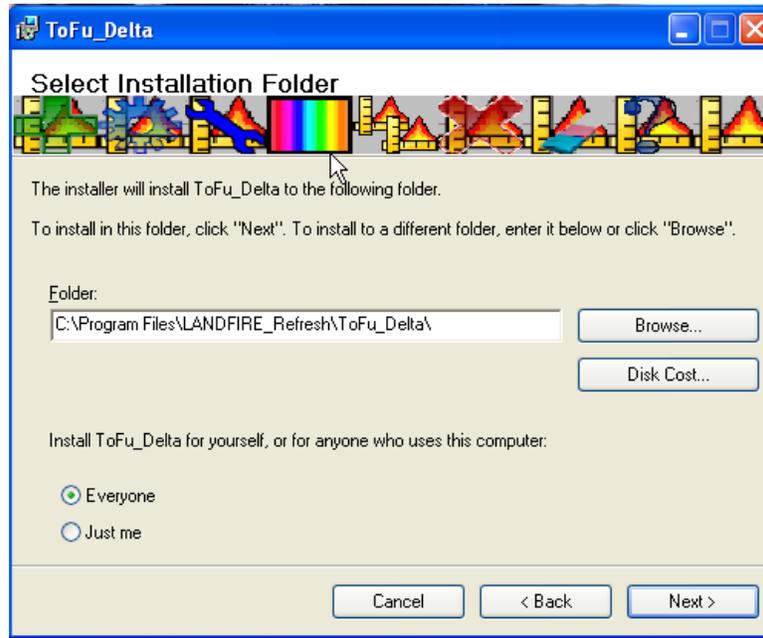


Figure 5-13. Select appropriate folder or accept default.

Follow instructions as directed by the dialog boxes in the Setup Wizard until you are notified that installation is complete.

Open ArcMap and make sure that the ToFu Δ toolbar



Note: The toolbar may be “floating,” and if so, you will need to anchor it in a convenient location.

Tip: For best results, make sure that you have installed the most recent ArcGIS service packs and patches. Go to www.esri.com to verify that you have the most recent versions for 9.2 or 9.3 already installed on your computer. If you do not, download the newer service packs and patches as directed on the website.

5.3 Troubleshooting ToFu Δ installation

If the ToFu Δ toolbar as shown here  is not visible when you open ArcMap, select **View > Toolbars** and check the box next to **Tofu Delta Toolbar** to turn it on (fig. 5-14).

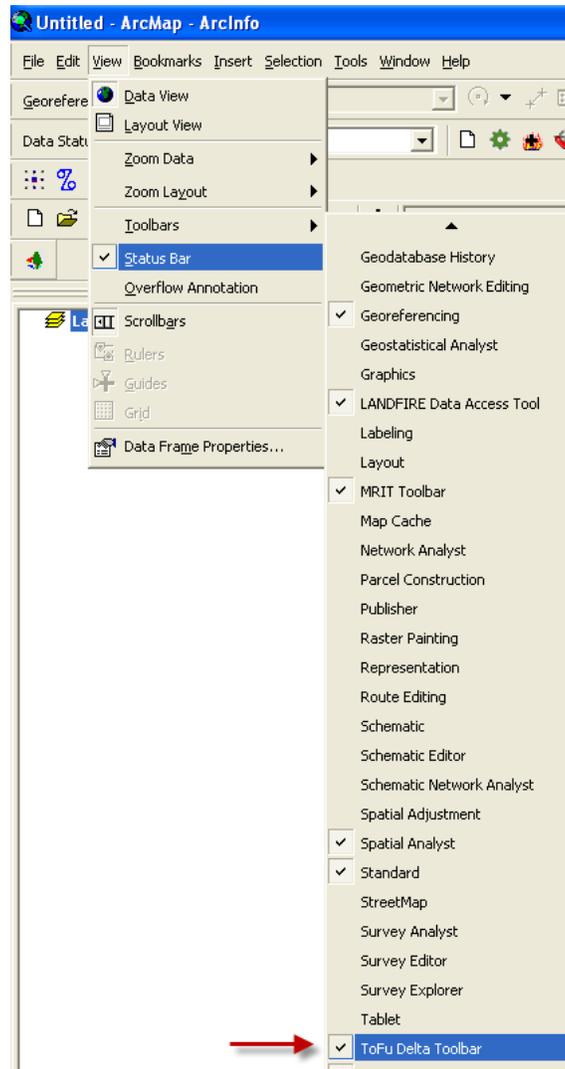


Figure 5-14. Select “Tofu Delta Toolbar.”

If the tool still does not install, you may need to select **Tools > Customize** and check the box to the left of *Tofu Delta 1.0*, as shown in Figure 5-15.

Note: To continue this process, it may first be necessary for you to log on as an “Administrator.” Contact your systems administrator if you experience problems.

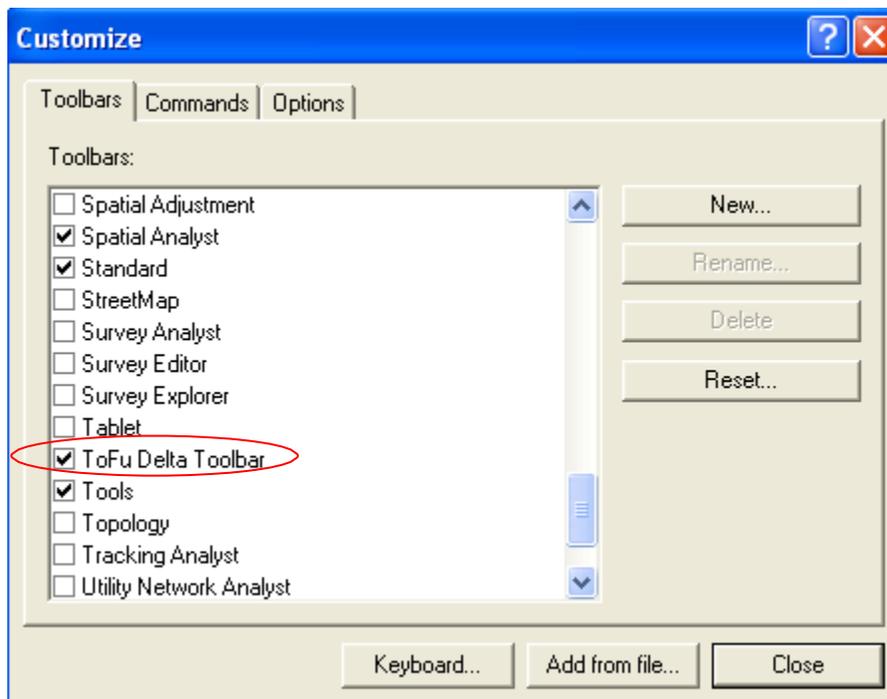


Figure 5-15. Select ToFu **Delta Toolbar** in **Customize** dialog box.

Chapter 6: A quick start guide to running ToFu Δ

- 6.1 Setting up the working directory
- 6.2 Creating a Management Unit (MU)
- 6.3 Working with fuel rules
- 6.4 Evaluating surface and canopy fuel assignments
- 6.5 Creating the grid menu
- 6.6 Selecting canopy options
- 6.7 Applying changes to specified areas
- 6.8 Creating grids
- 6.9 Adjusting rule sets
- 6.10 Evaluating outputs

The purpose of this chapter is to provide a brief overview of many of the basic steps required to run ToFu Δ . To learn more about all available tool options, proceed to [Chapter 7: Using ToFu \$\Delta\$](#) . Advanced users seeking detailed information on all available options, or users looking for help on a specific topic may find the next chapter to be more useful. This chapter does not discuss every option for each step of the process.

The following flowchart shows the basic steps required to run ToFu Δ (fig. 6-1). Click on the flowchart's links for information describing each stage of the process.

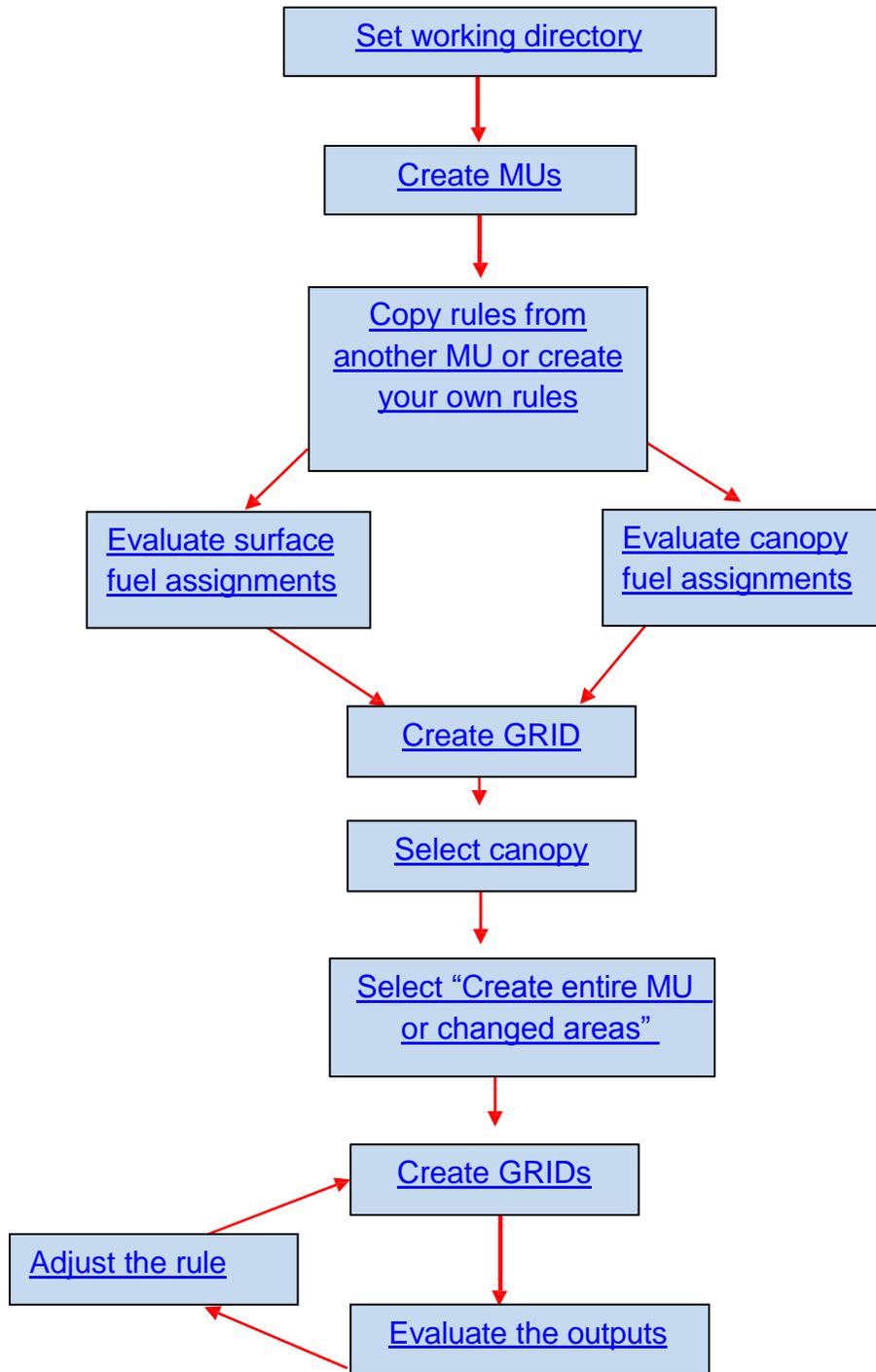


Figure 6-1. Steps required for running Tofu Δ.

6.1 Setting up the working directory

- First, use the ToFuΔ toolbar to set your working directory by clicking on the **Set Project Directory** option as shown below (fig. 6-2).

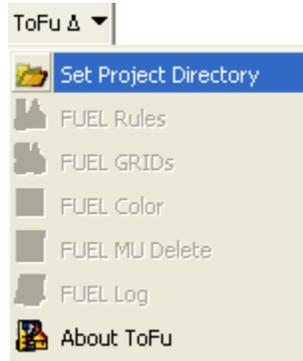


Figure 6-2. Use drop-down menu to **Set Project Directory**.

- The following **Browse For Folder** dialog box will open. Use this dialog box to select the project folder (fig. 6-3).

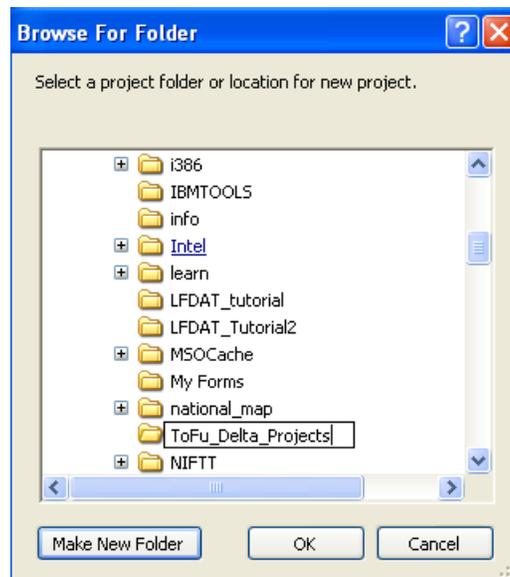


Figure 6-3. Use dialog box to create a project folder.

- Click **OK** after you have specified a location for your project.
- After your project folder has been created, the **Create Project** dialog box will open (fig. 6-4).
- Use the **Create Project** dialog box to specify a name in the Enter New Project Name box (fig 6-4).



Figure 6-4. Specify a project name.

- 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 7.4: Workspace settings](#).

6.2 Creating a Management Unit

- Click the **Add Management Unit** icon on the ToFuΔ toolbar (fig. 6-5) to define a Management Unit.



Figure 6-5. Use the **Add Management** Icon to create an MU.

The **Add Management Unit** dialog box opens as shown with the **Add MU** tab visible (fig. 6-6).

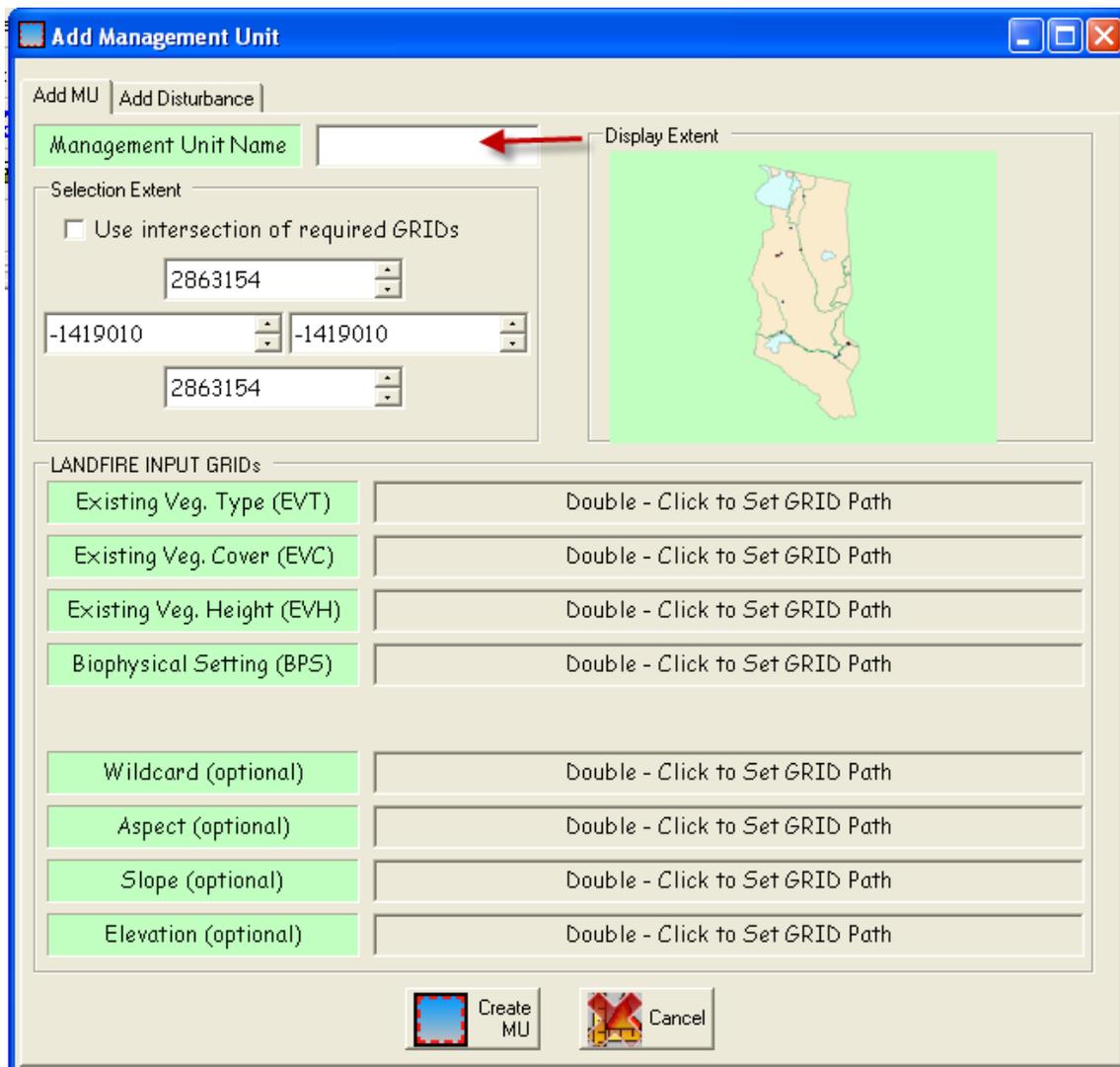


Figure 6-6. Select the Management Unit Name (**ADD MU** screen visible).

An MU can be defined by specifying coordinates or by using the drawing rectangle.

Note: For more detailed information on specifying the extent of your MU, see [section 7.5](#).

- To use the drawing rectangle, drag your cursor to draw an extent rectangle in the “Display Extent” window of the dialog box (fig. 6-6).
- With the **Add MU** tab selected, type a **Management Unit Name** in the box provided (fig 6-6).

Note: The naming convention follows the rules of ArcMap, which means a grid name can be no longer than 13 characters.

- Check the “**Use intersection of required GRIDS**” box if you want to clip all grids to the extent of the specified rectangle.
- Input the required data layers (EVT, EVC, EVH, and BpS) by double-clicking in the adjacent boxes to set a grid path.

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

Add Management Unit dialog box to load grids.

Note: All four grids (EVT, EVC, EVH, and BpS) must be in the same projection.

The Wildcard selection is optional but may be useful in some situations. If the project crosses map zone boundaries, the user can create the Management Unit with required grids by map zone and then use its boundary as a wildcard to convert the boundary shapefile to a grid and thus define the area of interest. When clipped, the area of interest will be available. See [section 7.5](#) for more information.

- Enter other optional data layers if desired (Wildcard, Aspect, Slope and Elevation). See [section 7.5](#) for additional information on using the Wildcard option.

Note: All grids must be in the same projection.

The **Add Disturbance** tab (fig. 6-7) is also optional and will not be discussed in detail here. This option allows the user to select five basic types of disturbance and three intensity levels (which correspond to the disturbance types in the LANDFIRE Reference Database; see www.landfire.gov).

- (Optional) Click on the **Add Disturbance** tab at the top of the Add Management dialog box to select the type and characteristics of disturbance if desired. (For more information on working with the disturbance option, see [section 7.5.](#))

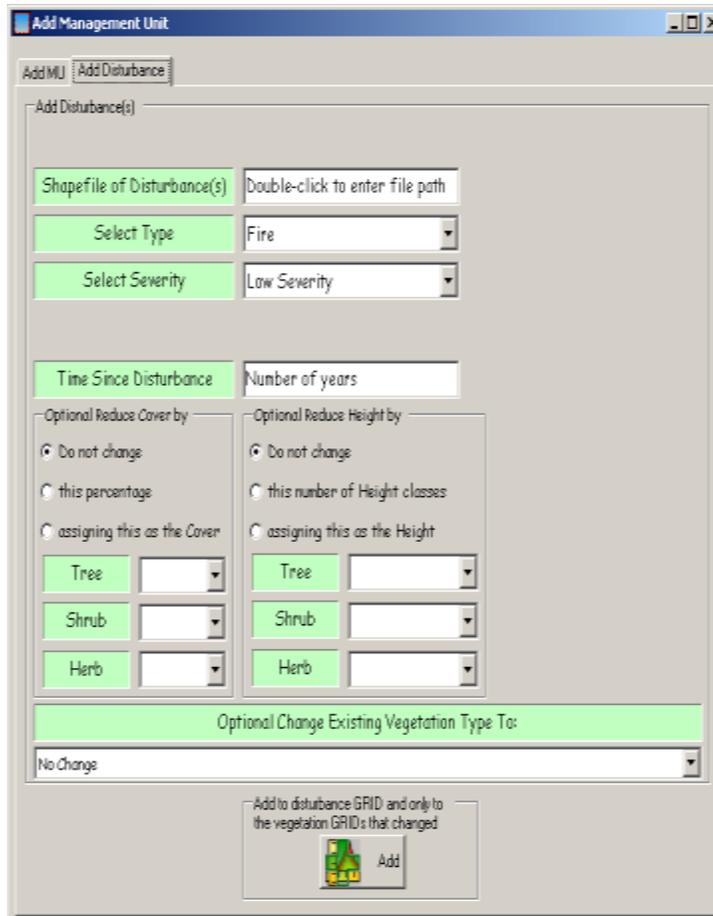


Figure 6-7. **Add Management Unit** dialog box with **Add Disturbance** screen visible.

- When you have completed filling out the **Add Management Unit** dialog box, click the **Create MU** button at the bottom of the **Add MU** page ([fig. 7-16](#)).

For additional information on creating a Management Unit, see [section 7.5.](#)

6.3 Working with fuel rules

The **Fuel Rules** window is where the bulk of the modifications will be 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 additional information on other available options, refer to [section 7.6](#).

The following description will progress from general to more specific steps and in the order a typical ToFuΔ user would follow. This explanation includes, in order, the main **Fuel Rules** page tabs **Ruleset**, **Compare FM**, **Distribution Graph**, and **EVT Description**) as well as several of the more commonly used Rule input icons located in the **Fuel Rules** window (**Copy Rule** and **Add Rule**).

Each EVT has a set of zone-based fuel rules. New rules can be added, edited, deleted, or copied (see [section 7.6](#) for more detailed information).

- To continue, you will need to copy rules from another existing MU or create your own rules.
- To begin, select **FUEL Rules** from the drop-down menu on the left-hand icon of the toolbar (fig. 6-8).



Figure 6-8. Select **FUEL Rules** option from the drop-down menu.

- Select the MU you created from the list displayed in the drop-down menu.

Note: *Management Units appear in alphabetical order in the drop-down menu. You may have to scroll down to view the MU of interest.*

The **Fuel Rules...** dialog box with the **Ruleset** page displayed will open (fig. 6-9).

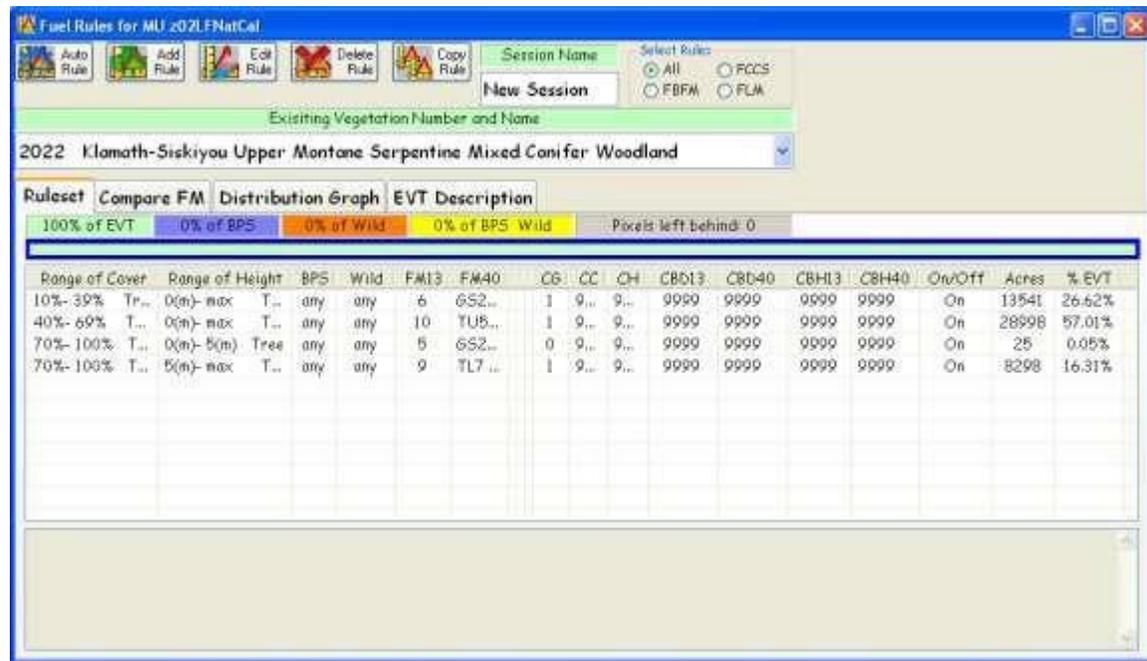


Figure 6-9. **FUEL Rules** dialog box.

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 you wish to work with.

- (Optional) In the Fuel Rules dialog box (fig. 6-9), add a **Session Name** in the box provided if desired.
- Use the radio buttons at the top right to “**Select Rules**” to view all forms of rules. Accept the default selection “All.” Other options include those applying only to FBFMs, FCCs, or FLMs (fig. 6-9). (See [section 7.6.1](#) for more information).
- Use the drop-down window to select an appropriate “**Existing Vegetation Number and Name**” (fig. 6-9). (This selection allows the user to go directly to the desired EVT and provides information on the dominant species present and type of vegetation that occupies the site). (See EVT Description tab in [section 7.6](#) for additional information.)

Note: Acres and percent EVT are calculated and appear on the rule set tab indicators when changes are made (fig. 6-10). The percent of EVT, BpS, and Wildcard as shown on the tab indicators should always total 100% with no pixels left behind. If rules exceed 100%, the blue box shown below will appear red, indicating that the rules are overlapping in cover or height ranges and need to be readjusted.

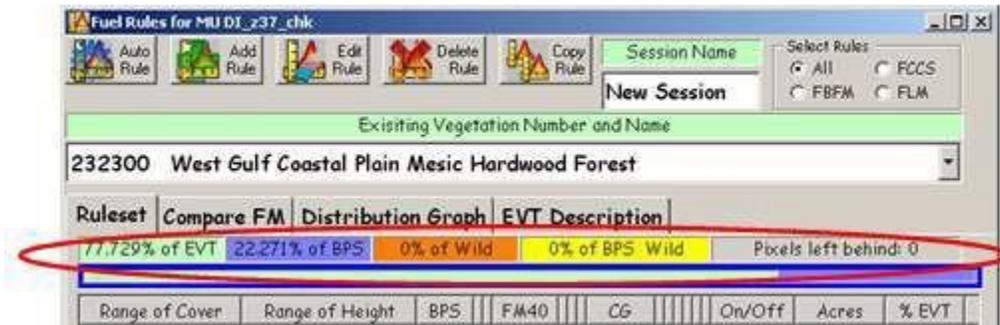


Figure 6-10. **FUEL Rules** dialog box showing percent and pixels left behind.

- Next you will need to choose a Fuel Rule icon (fig. 6-11). Available options include the following: **Auto Rule**, **Add Rule**, **Edit Rule**, **Delete Rule**, and **Copy Rule**. Each fuel rule opens a dialog box requiring user input. (See [section 7.6.4](#) for detailed information about each possible option.)

Copy Rule

- For this example, select the **Copy Rule** icon to copy rules from another Management Unit (fig. 6-11).



Figure 6-11. Select the **Copy Rule** icon.

The following **Copy Rules** dialog box will open (fig. 6-12).



Figure 6-12. **Copy Rules** dialog box.

- Use the drop-down menu at the top left of the **Copy Rules** dialog box to select an MU (Management Unit) to copy from (fig. 6-12).
- Use the radio buttons to select whether to copy all of the rules from the selected MU or to just copy the rule set from the selected MU and Existing Vegetation Type (EVT). (**Copy MU** or **Copy EVT**.)

Note: Use the drop-down menu under “**Existing Vegetation Number and Name to be copied**” to specify an EVT if **Copy EVT** is selected.

- 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**).
- Click on the **Copy Rules** icon to continue.
- Verify that you want to copy all On and Off rules by clicking Yes (fig. 6-13).

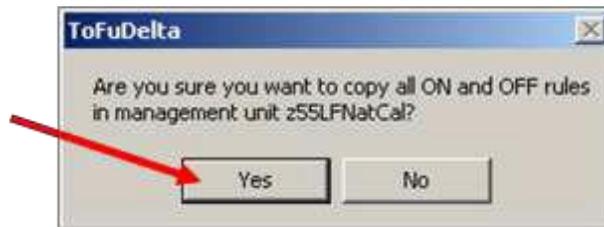


Fig. 6-13. Verify that you want to copy all rules.

- Close the **Copy Rules** dialog box when you are finished with edits. (It does not close automatically.)

Add Rule

A similar process is followed if a user wants to add a rule.

- To create new rules, click the **Add Rule** icon on the **Fuel Rules** page (fig. 6-14).

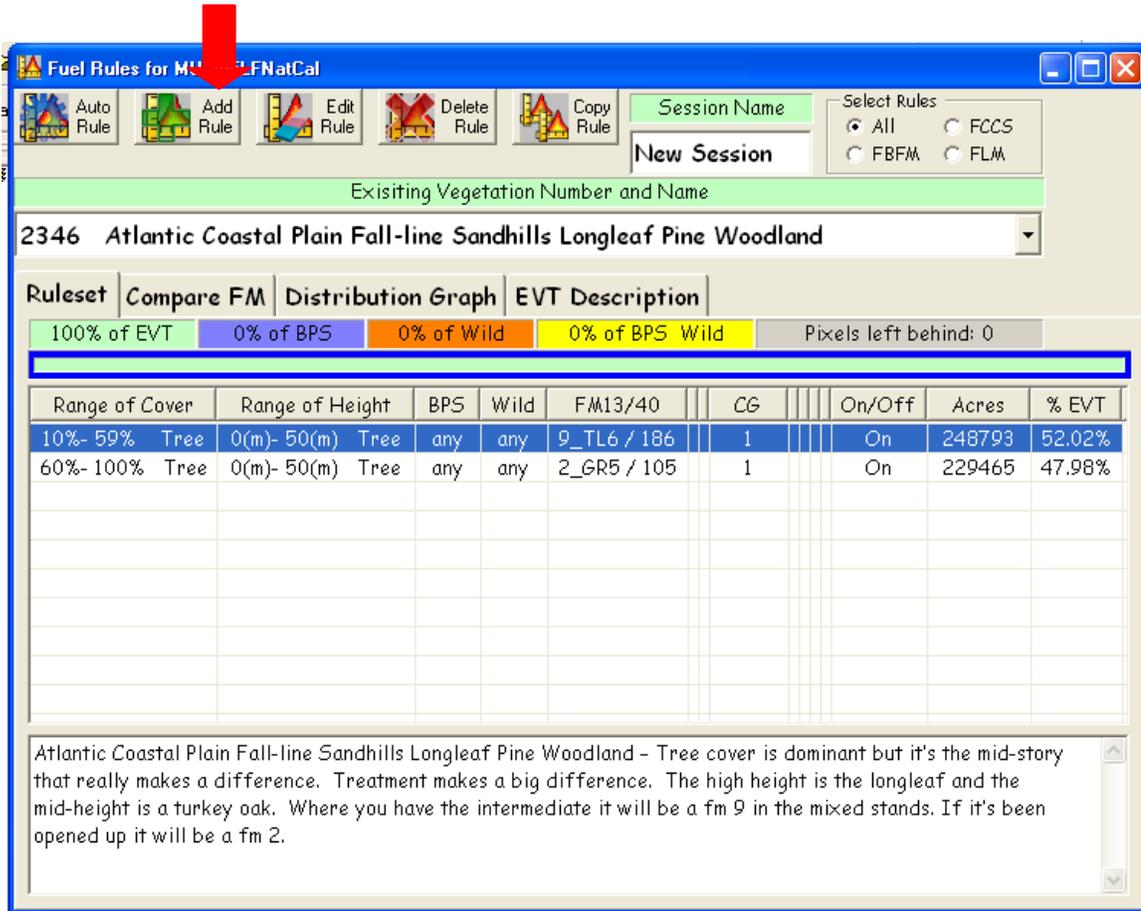


Figure 6-14. Select the **Add Rule** icon on the **FUEL Rules** page to create your own rules.

- After clicking **Add Rule** (or **Edit Rule**), the following **Add and Edit Rules** dialog box will open (fig. 6-15).

Figure 6-15. **Add and Edit Rules** dialog box.

- Select a **Descriptor Type** using the associated radio buttons at the upper left corner of the dialog box (fig. 6-15).
- Toggle the rule descriptor **On** or **Off** using the drop-down menu (fig. 6-15).
- Modify other fields as needed.
- Click the **Save Rule** button after changes have been made.
- Close the dialog box when you are finished with your edits. (It does not close automatically.)

Note: Selecting 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.

Tip: Use the ideas shown in [figure 7-24](#) to improve your space management.

Other fuel rule input options are also available (**Auto Rule**, **Edit Rule**, and **Delete Rule**). See [section 7.6.4](#) for detailed information describing these options.

6.4 Evaluating surface and canopy fuel assignments

The next step is to evaluate both surface and canopy fuel assignments.

- Open the **Fuel Rules** dialog box to the **Ruleset** page. Use the drop-down menu to select and highlight EVT's to account for all pixels. (See [section 7.6.3](#) for additional information on this subject.)
- Select the **Compare FM** tab on the **Fuel Rules** screen to compare the required canopy base heights (CBH) needed for torching and crowning fire initiation (fig. 6-16). (For additional information refer to [section 7.6.5](#).)

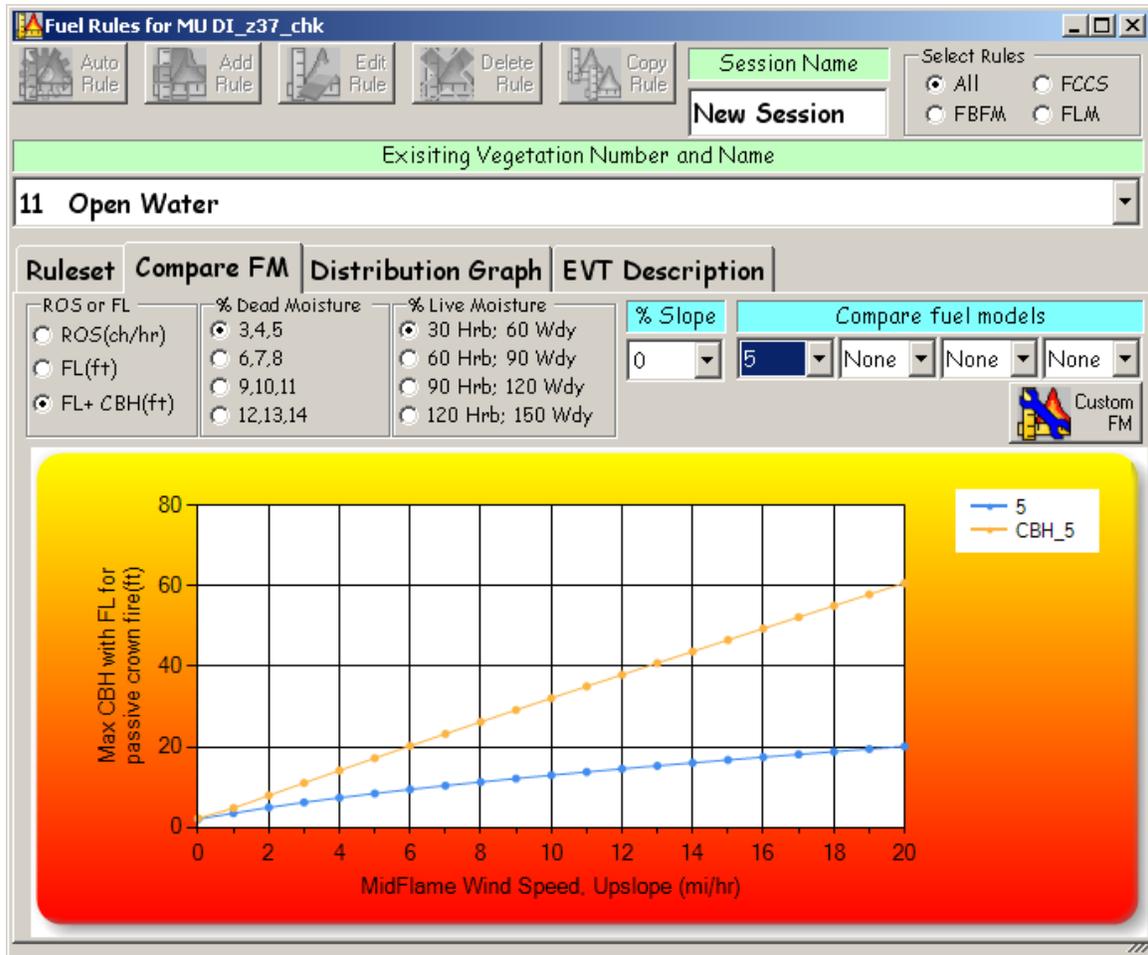


Figure 6-16. Select **Compare FM** page tab.

- Use the **Distribution Graph** tab to view the height of the vegetation by cover and the numbers of acres present in the selected EVT within the defined MU (fig. 6-17). (For more information see [section 7.6.5.](#))

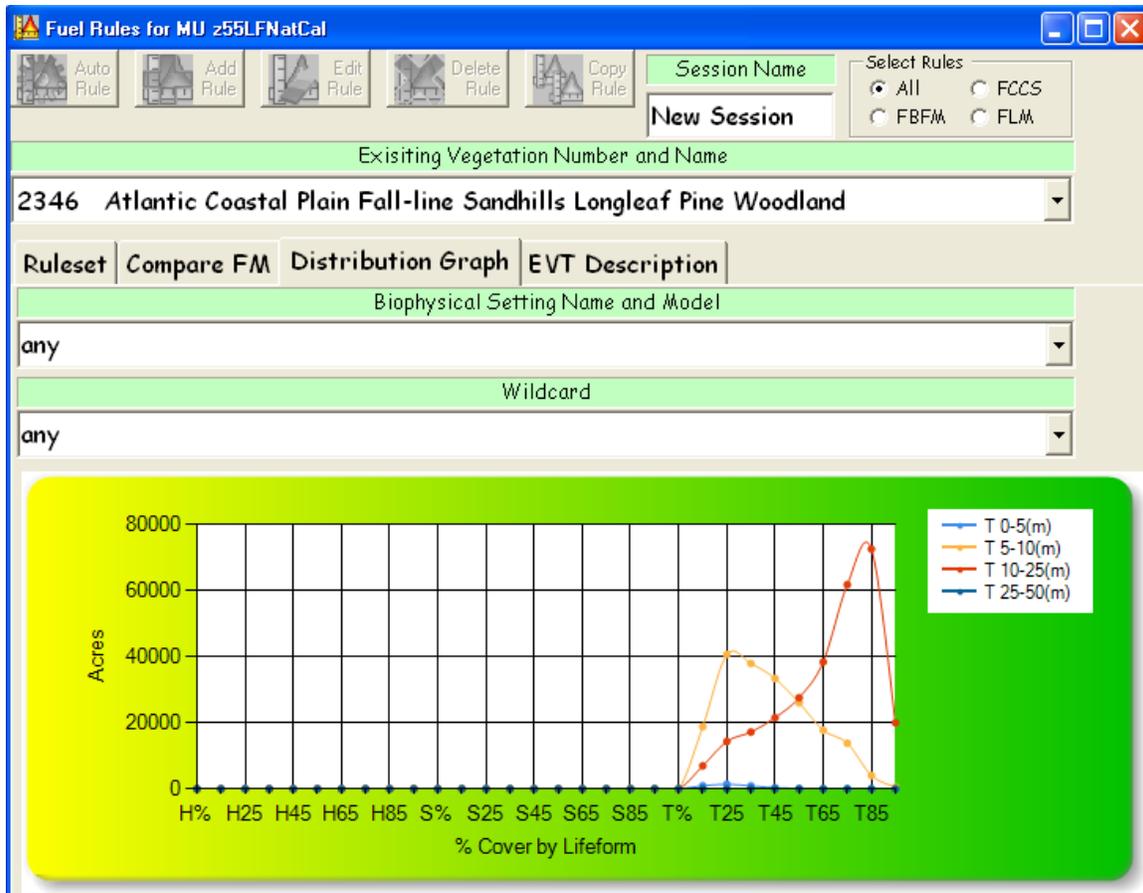


Figure 6-17. Select **Distribution Graph** page tab.

- Select the **EVT Description** tab to display an ecological description. This NatureServe (www.natureserve.org) description serves as the basis for all LANDFIRE EVTs.

For additional information on all aspects of working with Fuel Rules, refer to [section 7.6](#).

6.5 Creating the grid menu

The next step is to create the grid menu.

- When the rules have been completed to your satisfaction as described above, select **FUEL GRIDS** on the ToFuΔ drop-down menu (fig. 6-18).

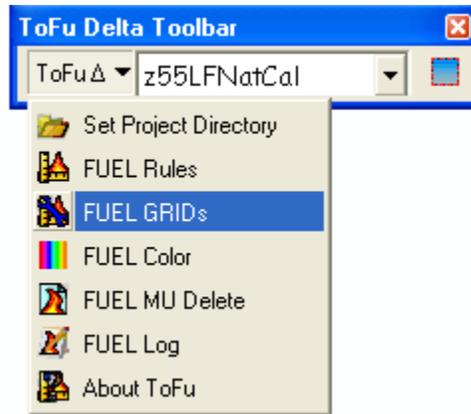


Figure 6-18. Select **FUEL GRIDS** on the drop-down menu.

The following dialog box will open with the **Fuel Selection** tab visible as shown in Figure 6-19.

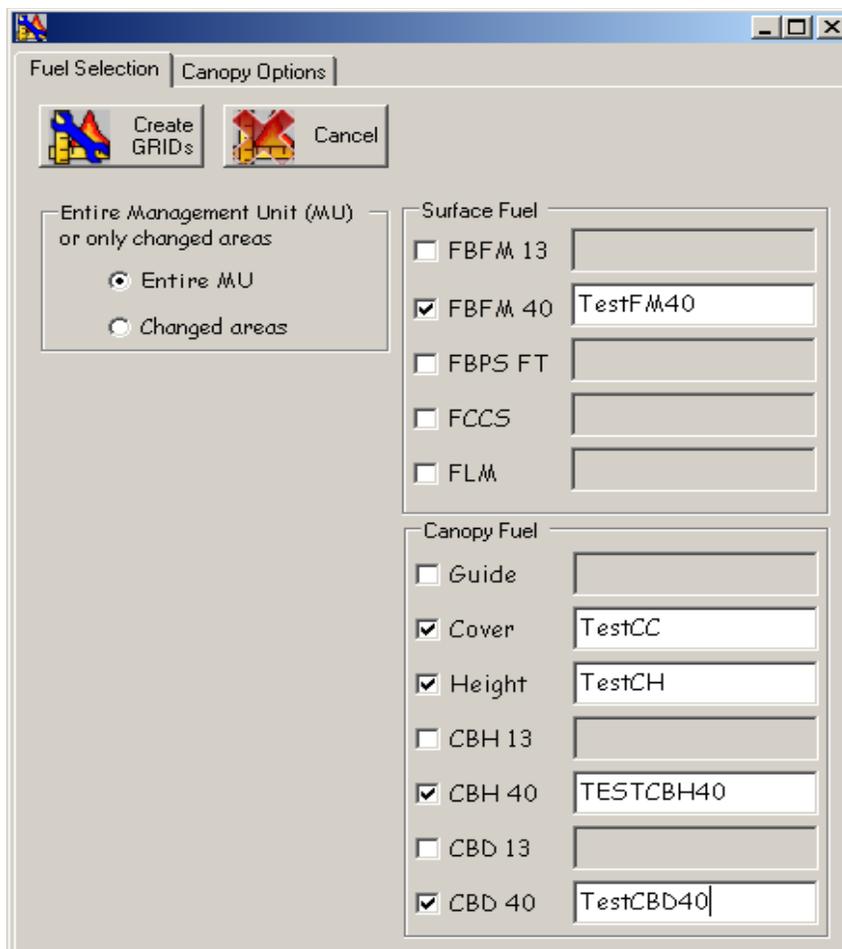


Figure 6-19. Complete the **Fuel Selection** tab and click **Create GRIDs** when done.

- Use the **Fuel Selection** tab to create surface fuel layers as desired.
- Check all of the surface fuel layers you would like to include.
- 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 (fig. 6-19).

For more information on creating the grid menu, see [section 7.7](#).

6.6 Selecting canopy options (optional)

- Select **FUEL GRIDs** on the drop-down menu to open a dialog box (fig. 6-19).
- Click the **Canopy Option** tab to work with select canopy options if desired (fig. 6-20).

The **Canopy Options** tab allows you to make changes to the canopy layers in two ways: 1) by using rules that are not coded as “9999” (indicating no data) in the rule sets to overwrite the predicted value or 2) by adding a coefficient by which to multiply.

- Complete the **Canopy Options** tab by checking the appropriate boxes as desired.

The screenshot shows a software window with two tabs: "Fuel Selection" and "Canopy Options". The "Canopy Options" tab is selected and contains the following settings:

- Canopy Cover (CC)**
 - Also use rule values that are not 9999
 - Multiply by
- Canopy Height (CH)**
 - Also use rule values that are not 9999
 - Multiply by
- Canopy Base Height (CBH)**
 - Also use rule values that are not 9999
 - Multiply 13 and 40 by and
- Canopy Bulk Density (CBD) plot based GLM Thompson**
 - Also use rule values that are not 9999
 - Multiply 13 and 40 by and

Figure 6-20. Complete the **Canopy Options** tab (optional).

For additional information, see [section 7.7](#).

6.7 Applying changes to specified areas

You can choose to apply your changes to the entire Management Unit or to certain changed areas only.

- After you have completed the **Canopy Options** tab, return to the **Fuel Selection** tab (fig. 6-19).

- In the top left portion of the **Fuel Selection** page labeled “**Entire Management Unit (MU) or only changed areas**,” use the radio buttons to select either “**Entire MU**” or “**Changed areas**” to specify if you would like these changes applied to the entire MU or to changed areas only (fig. 6-21). (For more specific information consult [section 7.7](#).)

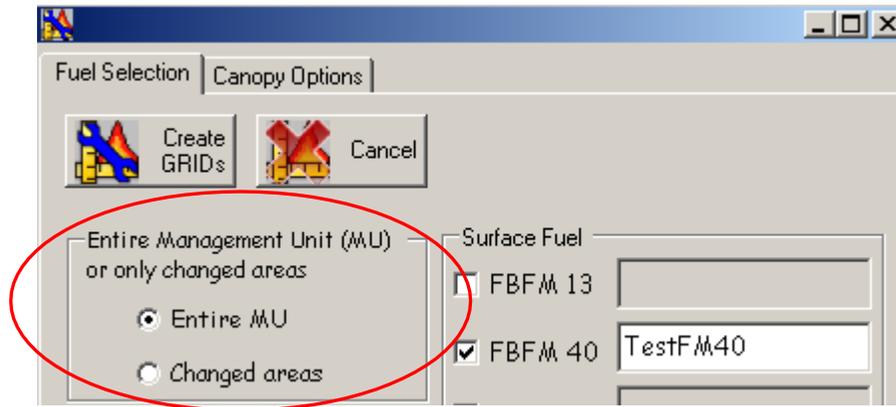


Figure 6-21. Use the radio buttons to select **Entire MU** or **Changed areas** only.

6.8 Creating grids

- After you have finished making your selections, click **Create GRIDs** at the top left corner of the screen (fig. 6-22).

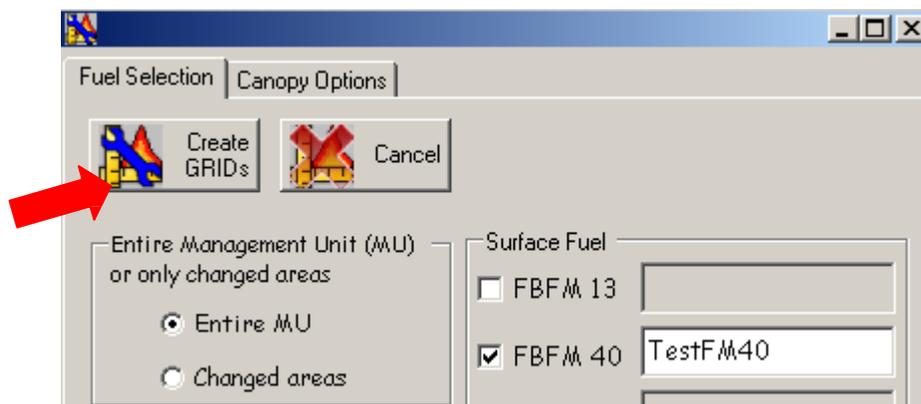


Figure 6-22. Click **Create GRIDs** when finished.

Tip: *Outputs are finished individually so be patient.*

- Go to your project folders to view outputs.

6.9 Adjusting rule sets

At this point, you can adjust rule sets if necessary. If changes are needed, go back to the rules, make your changes, and then create the grids again.

6.10 0 Evaluating outputs

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

Chapter 7: Using ToFu Δ

- 7.1 The ToFu Δ toolbar
- 7.2 Creating a new project
- 7.3 Loading data
- 7.4 Workspace settings
- 7.5 Management Units
- 7.6 Fuel rules
 - 7.6.1 Fuel rule header selections
 - 7.6.2 Column headers
 - 7.6.3 Tab indicators
 - 7.6.4 Rule input options
 - 7.6.5 Fuel rule page tabs
- 7.7 Creating new grids
- 7.8 Fuel grid color palette
- 7.9 Deleting fuel Management Units
- 7.10 log
- 7.11 About ToFu Δ
- 7.12 7.12 Help

This chapter describes ToFu Δ 's functionality in detail. Each available option is described in a sequential order wherever possible. If you would prefer to see an overview of generalized tool operation, refer to [Chapter 6](#). Because ToFu Δ offers many options, you may prefer to skip to sections of particular interest.

7.1 The ToFu Δ toolbar

The following diagram shows elements of the ToFu Δ toolbar (fig. 7-1). Refer to the discussions below to learn more about the basic functions of each icon.



Figure 7-1. The ToFu Δ toolbar.

The down-arrow on the left opens the ToFu Δ drop-down menu, which contains seven functions as shown below (fig. 7-2). With this menu, the user can save, create, and import multiple projects with multiple Management Units.

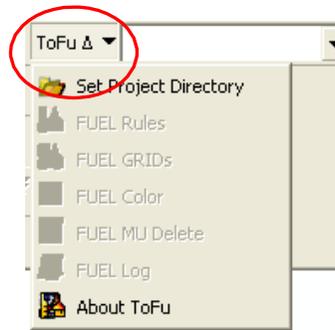


Figure 7-2. The ToFuΔ drop-down menu.

The second down-arrow on the toolbar is the Management Unit selection drop-down menu, which allows the user to select a Management Unit (MU) once the project is set up (fig. 7-3). Management Units can be as large as a LANDFIRE map zone or as small as an initial fire incident that a user would like to calibrate and analyze.



Figure 7-3. ToFuΔ's Management Unit selection drop-down menu.

The icon on the right of the toolbar is the **Add Management Unit** rectangle (fig. 7- 4).



Figure 7-4. ToFuΔ's Management Unit creation icon.

This icon allows the user to select an area of interest, input the required data layers, and clip all of the layers to the specified rectangle. There is also additional functionality to add disturbances via shapefiles and specify the type of disturbance (fire, mechanical, wind, etc.). The time since disturbance can be specified, as well as disturbance severity and how the vegetative cover and height have changed.

7.2 Creating a new project

- Start ArcMap and select **A new empty map** as shown in Figure 7-5:

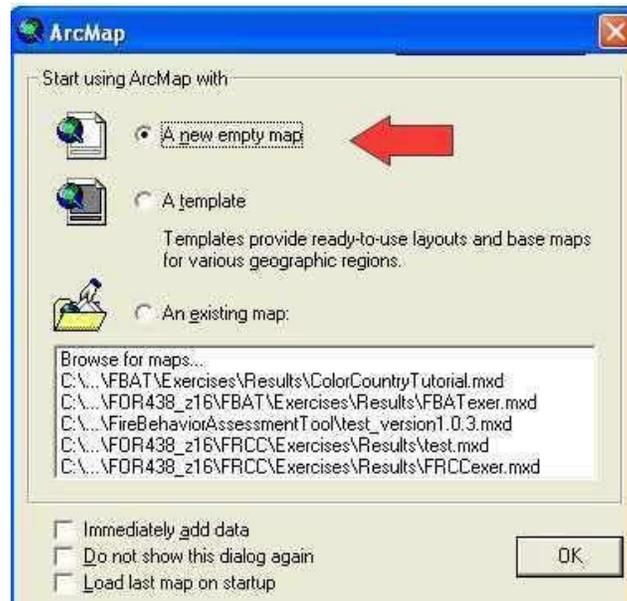


Figure 7-5. Creating a new project.

7.3 Loading data

- Click on the **Add Data** icon to load input layers (fig. 7-6).

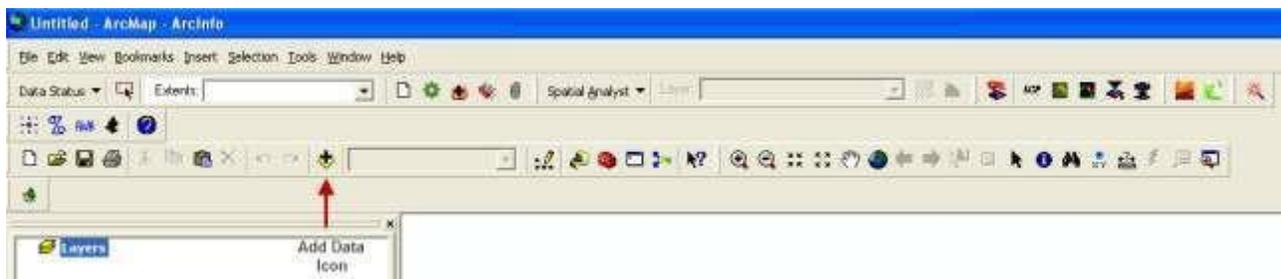


Figure 7-6. Adding data.

- Navigate to the directory where data layers are stored and add desired layers.
- Add the four required input layers: BpS, EVC, EVH, and EVT (fig. 7-7).
- You can also add any additional optional layers for use as a wildcard selection, such as elevation, aspect, or slope.
- Disturbance layers can also be added.

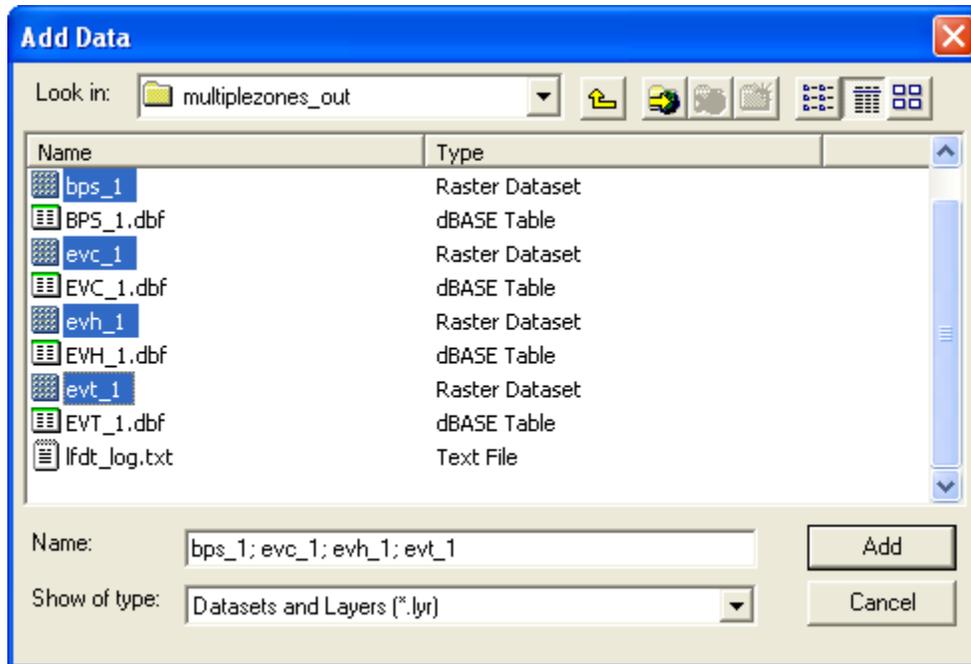


Figure 7-7. Adding required input layers.

Tip: You may see the following “**Create pyramids**” dialog box at this point (fig. 7-8). Click **No** to speed up processing. If you do not want to see this box again, put a check in the lower left-hand corner to disable it.

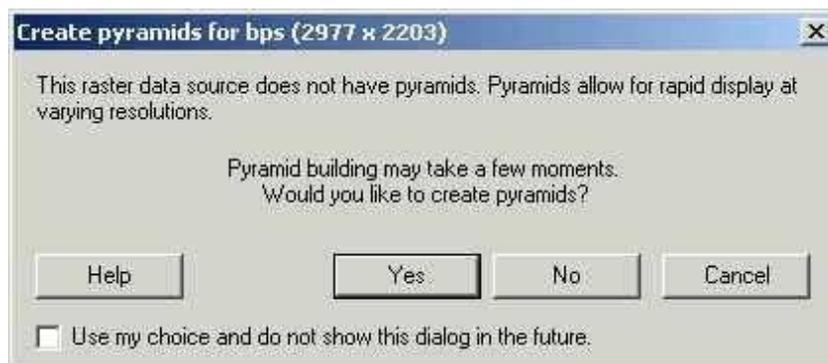


Figure 7-8. Create pyramids dialog box.

Note: The path and folder name containing your input layers should not exceed a total of 13 characters in length and should not contain any spaces, leading numbers, or special characters (`~! @#\$%^&()-+= { } [] \ | ? / : ; ' " < > , .)

Save your project and, if desired, rename it by clicking on **Layers** as shown in Figure 7-9:

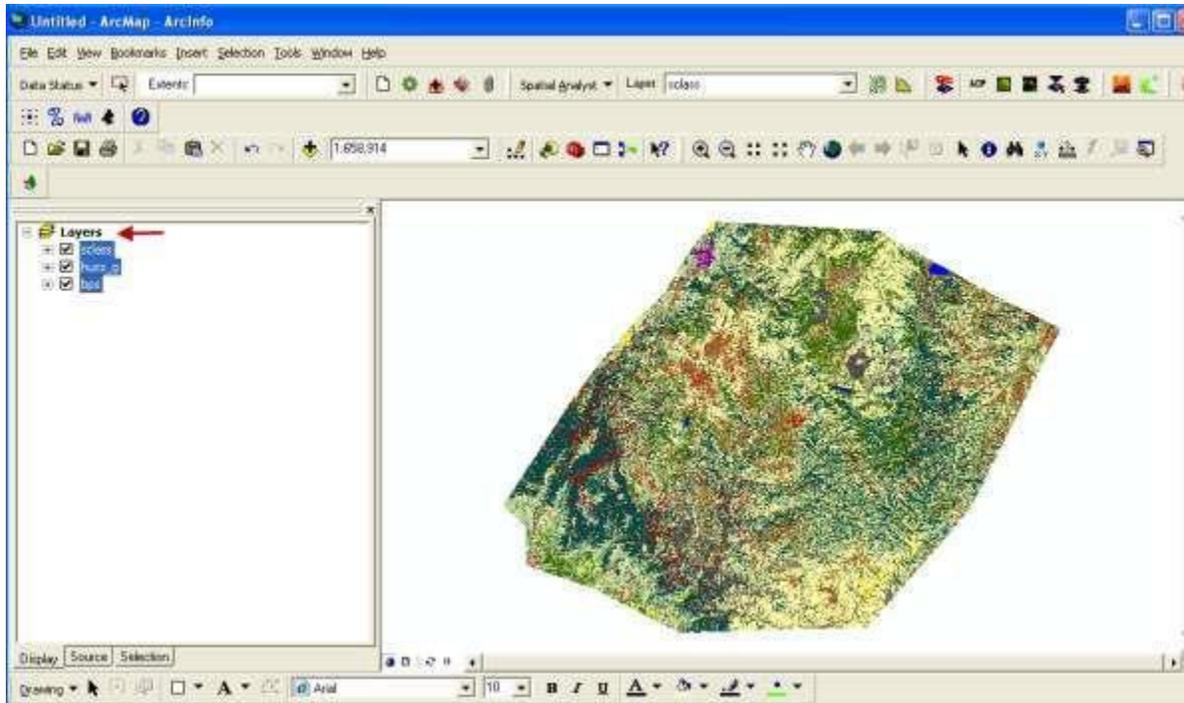


Figure 7-9. If desired, rename the project.

Note: When naming the file, you do not need to include a file extension. However, the file name must not exceed a total of 13 characters in length and should not contain any spaces, leading numbers, or special characters (`~! @#\$%^&()-+= { } [] \ | ? / : ; ' " < > , .)

Tip: Convenient file names might include a location, a run number, or perhaps an indication of the number of landscape levels analyzed (such as SmithCr, sc1, or sc1_1).

7.4 Workspace settings

Creating a filing system using good organization is an important first step. We suggest creating a directory called “**ToFu_Delta_Projects**” on a convenient drive.

- To create a directory, click the drop-down menu on the ToFu Δ toolbar and select “**Set Project Directory**” (fig. 7-10).

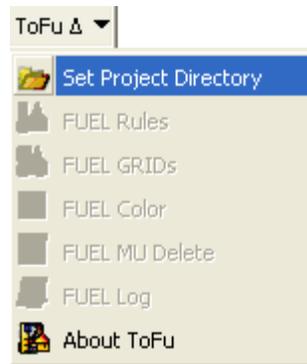


Figure 7-10. Use the drop-down menu to select **Set Project Directory**.

The following dialog box will open, allowing you to create a new directory as described (fig. 7-11).

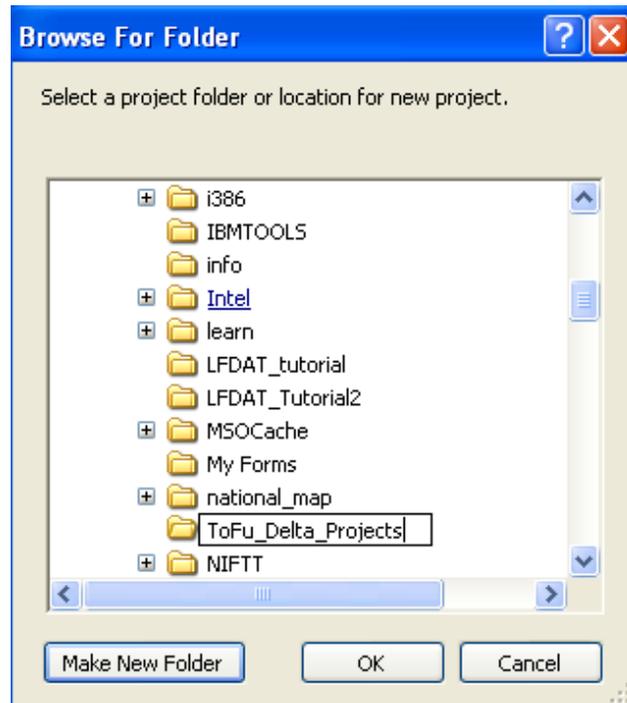


Figure 7-11. Select a project location.

- Navigate to the **ToFu_Delta_Projects** directory you just created and click **OK**.

A **Create Project** window opens, allowing you to import data from previous projects or to create a project workspace (fig. 7-12).

- 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 **ToFu_Delta_Projects** directory in the name you have specified.

Note: The naming convention follows the rules of ArcMap, which means a grid name can be no longer than 13 characters.



Figure 7-12. **Create Project** window is used to enter a Project Name.

Note: Click the **Default** button to continue, use the **Import** button to load an existing project, and click **Cancel** to close the **Create Project** dialog box.

The newly created workspace folder will contain the **Input**, **MU**, and **Output** folders (fig. 7-13). These folders are used to store your work as well as the Microsoft Access database which is populated with the LANDFIRE National fuels characteristics.

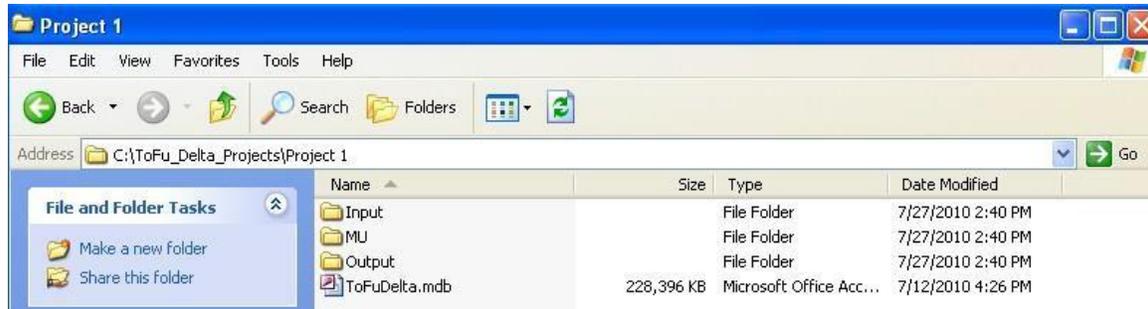


Figure 7-13. Contents of newly-created folder.

When the workspace folder is opened, the window next to the drop-down menu arrow is populated ("z01 LFNatCal" is shown in the following example). The LANDFIRE map zone is indicated ("z01") as well as a designation that the information is for the LANDFIRE National Calibrated fuel characteristic data ("LFNatCal") (fig. 7-14).

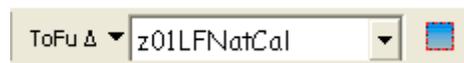


Figure 7-14. Drop-down menu showing LANDFIRE map zone.

As new projects are developed, additional folders can be added to the **ToFu_Delta_Projects** directory or new project folders can be created to further organize complex analyses.

7.5 Management Units

The Management Unit, or 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 coordinates or by the intersection of the input grid layers. Once the appropriate grid layers are combined through the **Add MU** function, the user can modify the fuel characteristics of the surface fuel model and canopy attributes. In a later, final version of ToFu Δ , users will also be able to modify FCCS or FLMs (Ottmar and others 2007; Lutes and others 2008). After modifications are complete, new fuel model and canopy attribute grids can be processed for use in analysis.

Note: The default data set includes MUs created for all LANDFIRE map zones except Alaska and Hawaii. These zones exist in relational Microsoft Access database form only and not as spatial grids in the MU folder. As new MUs are created, they will consist of a combined grid of the four mandatory grid layers from the LANDFIRE data set and any optional grid layers the user inputs. They will reside in the MU folder.

- To begin, add Management Units by clicking on the MU icon located at the far right of the ToFu Δ toolbar, as shown below (fig. 7-15).



Figure 7-15. Creating a Management Unit.

The **Add Management Unit** dialog box opens, as shown below (fig. 7-16). It serves as a drawing rectangle, which is used to identify the spatial extent of the area to be analyzed or to define the Management Unit. In ArcMap, the icon works the same way as any tool used to define an extent.

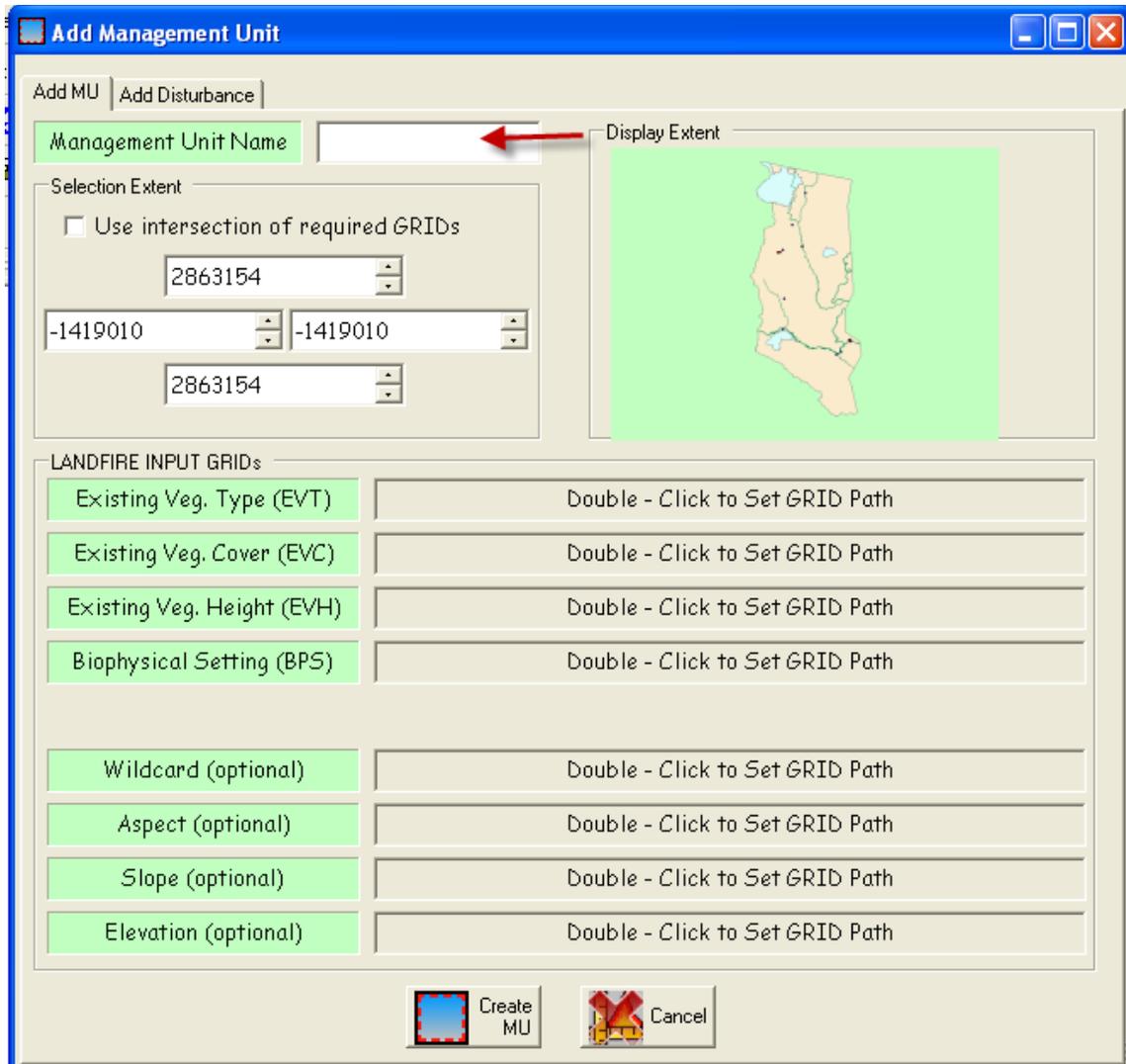


Figure 7-16. **Add Management Unit** dialog box.

- Specify coordinates in the **Selection Extent** window or use your cursor to drag an extent rectangle.
- With the **Add MU** tab selected, enter a Management Unit Name in the box provided.

The naming convention used to specify a Management Unit Name in the first box follows ArcMap rules. The grid name you use should not exceed 13 characters in length or include any special characters.

Note: The “**Set Project Directory**” drop-down selection ([section 7.4](#)) sets the name of the path, but you will still need to name the file here in the **Add Management Unit** box. The file will be located in your MU folder.

ToFu Δ clips all grids to the extent of the smallest grid if the “**Use intersection of required GRIDS**” box located near the top of the screen is checked.

- Check the “**Use intersection of the required GRIDS**” box to clip all grids to the extent of the rectangle you specified.
- Input required layers (EVT, EVC, EVH, and BpS) by double-clicking in the associated boxes to set a grid path.

Note: All grids must be in the same projection.

The Wildcard option is optional and allows extra flexibility for the Tofu Δ user in some cases. For example, as discussed in [Chapter 6](#), the wildcard option can be used in instances where a project boundary extends across several map zones. To facilitate ease of processing, the user can create the Management Unit (MU) with required grids by map zone. The boundary can then be used as a wildcard to convert the boundary shapefile to a grid that defines the area of interest.

- To use this option, double-click in the **Wildcard** box to add a wildcard layer.

Aspect, slope, and elevation layers are optional.

- To add these optional layers, return to the **Add MU** page and double-click to add Aspect, Slope, and Elevation grids if desired.

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

The Disturbance layer is also optional.

- To add a disturbance layer, click on the **Add Disturbance** tab at the top of the **Add Management Unit** dialog box to specify the type and specific characteristics of disturbance if desired. (For additional information, review [section 3.2.1](#).) The following screen will open (fig. 7-17).

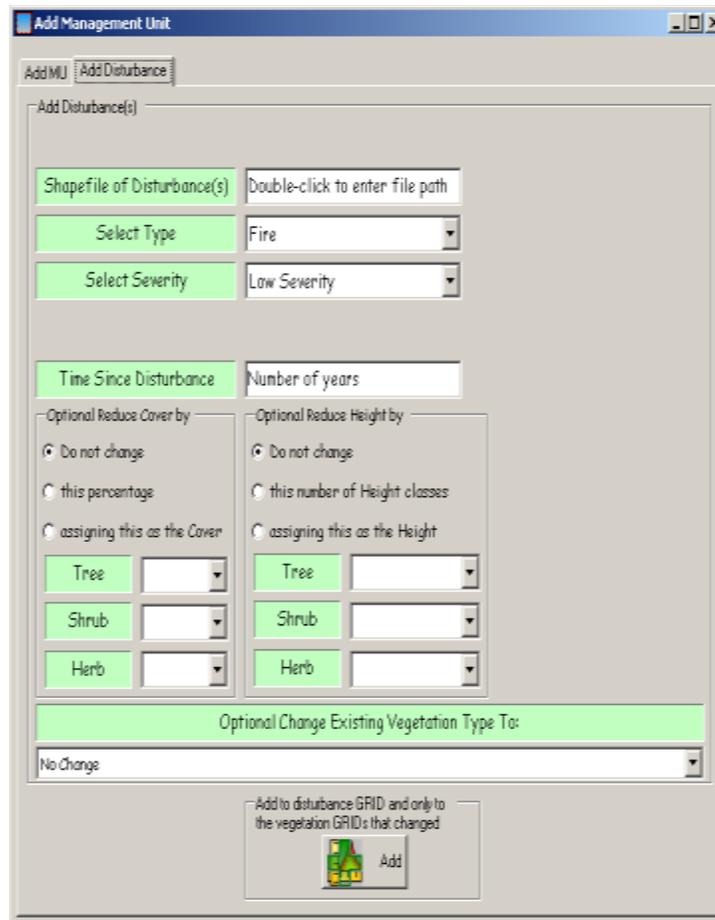


Figure 7-17. **Add Management Unit** dialog box with **Add Disturbance** screen visible.

The **Add Disturbance** tab includes five basic types of disturbances, three intensity levels, and two “times since disturbance” options to correspond with disturbance types in the LANDFIRE Reference Database (www.landfire.gov). They are:

Disturbance Type –

- Fire
- Mechanical A – fuels are arranged
- Mechanical B – fuels are removed
- Wind
- Insect and disease

Intensity –

- High – greater than 70% mortality of aboveground vegetation

- Medium – greater than 25% but less than 70% mortality of aboveground vegetation
- Low – less than 25% mortality of aboveground vegetation

Time Since Disturbance –

- 0-5 years (5-10 years in the western U.S.)
- 0-3 years (3-10 years in the southeastern U.S.)

To use the Disturbance option:

- Double-click in the box to the right of “**Shapefile of Disturbance(s)**” at the top of the screen to specify a particular shapefile. The shapefile you select must be in the same project as the MU.
- Next, select a disturbance type (“**Select Type**”) using the drop-down menu provided. Possible options include: fire, mechanical A and B, wind, and insect and disease.
- Select the severity of disturbance (“**Select Severity**”) using the drop-down menu. Options include: high, medium, and low.
- Enter “**Time Since Disturbance,**” expressed in years, in the box provided.
- (Optional) Complete the information in the box labeled “**Optional Reduce Cover by**” or in the “**Optional Reduce Height by**” box. (Select only one.) (fig. 7-18).

The image shows two side-by-side panels. The left panel is titled "Optional Reduce Cover by" and the right panel is titled "Optional Reduce Height by". Both panels have three radio buttons: "Do not change" (selected), "this percentage", and "assigning this as the Cover/Height". Below each panel are three rows for "Tree", "Shrub", and "Herb". Each row has a green button with the life form name and a dropdown menu to its right.

Figure 7-18. Options to reduce cover and height.

Note: You can use the associated radio buttons if you opt to leave cover or height “as is,” change cover to a certain cover percentage for all three life forms (Tree, Shrub, and Herb), or reduce height by a specific number of Height classes. Similarly,

you can use the spinner boxes to assign specific values as Cover or to assign specific values as Height.

- Use the drop-down menu to select a value for the “**Optional Change Existing Vegetation Type to**” box as shown below (fig. 7-19).



Figure 7-19. Select EVT from drop-down menu to change (optional).

- Finally, click the **Add** icon at the bottom of the dialog box to “**Add to disturbance GRID and only to the vegetation GRIDs that changed.**”
- When you have finished all entries for both tabs on the **Add Management Unit** dialog box, click the **Create MU** button at the bottom of the **Add MU** page (fig. 7-16).

7.6 Fuel rules

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

Fuel rules describe the fuel bed by vegetation type: life form (Herb, Shrub, Tree) cover, height, biophysical setting, and any optional layer that may be used.

The second option on the ToFuΔ drop-down menu is “**FUEL Rules,**” as shown below (fig. 7-20).

- Select **FUEL Rules** from the drop-down menu on the ToFuΔ toolbar.

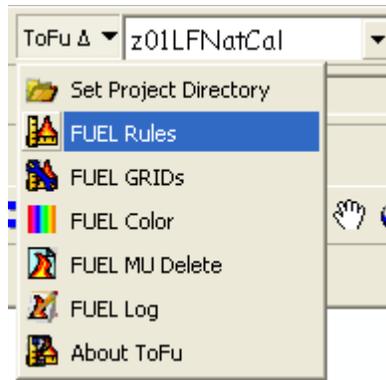


Figure 7-20. Selecting **FUEL Rules** from drop-down menu.

The **Fuel Rules** screen will open with the **Ruleset** page displayed initially, as shown below (fig. 7-21).

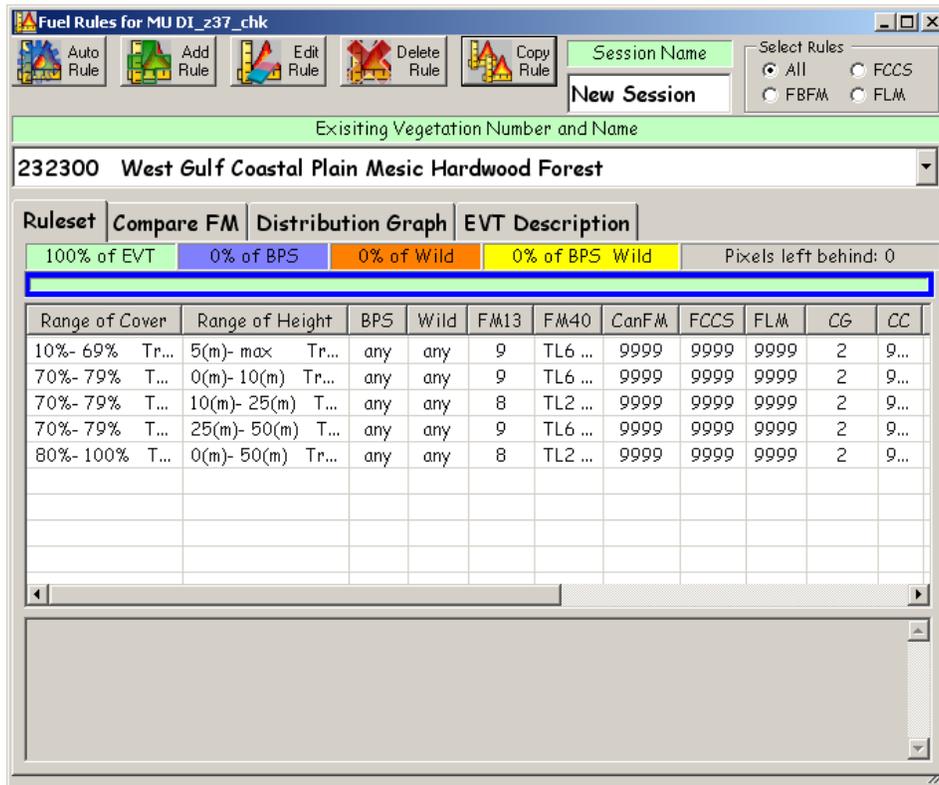


Figure 7-21. **Fuel Rules** dialog box showing **Ruleset** page.

ToFuΔ users will spend most of their time working with this screen. Rule sets 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 during the LANDFIRE Project and through LANDFIRE calibration meetings with local fuel experts.

The default data set is selected by pointing to its folder through “**Set Project Directory**” (see [section 7.4](#)). The database starts with fuel rules by EVT for all of the LANDFIRE National map zones in the lower 48 states. Rule sets for all of the EVTs in the selected map zone (LANDFIRE 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 rule sets. Many users work with the **FUEL Rules** screen just to ensure that they understand the existing default rule sets before opting to make any modifications. The user should have good documentation and adequate reasons before making any changes to these rule sets. For additional information on calibration workshops and fuel model determination, see www.landfire.gov.

Once you have determined that the rule sets 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 rule set in the default data, you can begin to work with ToFuΔ's **Ruleset** screen (fig 7-21).

Note: You can add or edit existing notes in the bottom section of the **Fuel Rules** page by double-clicking inside of that screen.

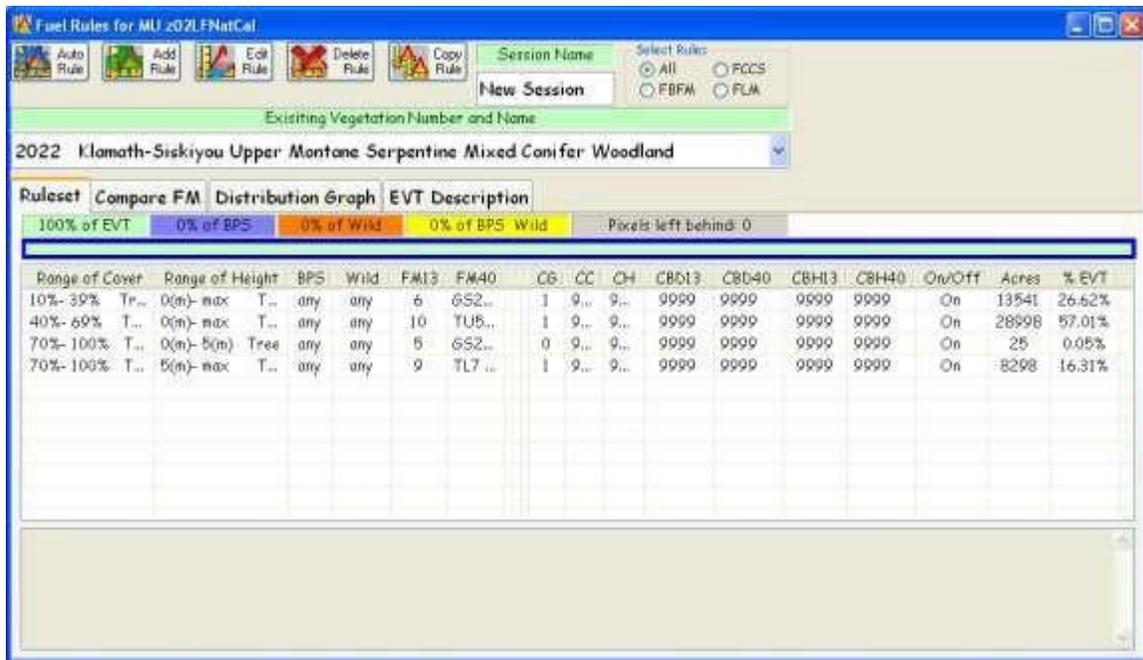


Figure 7-21. ToFuΔ's **Ruleset** screen on the **Fuel Rules** dialog box.

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 grid of the 13 or 40 Fuel Behavior Fuel Models (FBFM) and grids of canopy attributes (see [Chapter 3](#)) can be made for use in fire potential and simulation software such as FARSITE or FlamMap (see “Creating new grids” in [section 7.7](#)).
- If the edits are made to the default database (see “Rule input options” in [section 7.6.4](#) later in this chapter) then grids of the FBFMs and/or canopy attributes can be made. For additional information on this subject, see “Creating new grids” in [section 7.7](#).
- If an MU was created for the purpose of developing rule sets for fuel characteristics when the MU is selected in the MU window (no fuels layer is added in as a wildcard) and the **FUEL Rules** selection is made on the ToFuΔ drop-down menu, the **FUEL Rules** window will open.

A “9999,” indicating that there are no data, will be visible where all of the rule set information should be displayed. At this point, the user will need to copy a rule (“**Copy Rule**”), use auto rule (“**Auto Rule**”), create a rule through editing (“**Edit Rule**”), or add a rule (“**Add Rule**”) for the EVC, EVH, BpS, FBFM, and canopy attributes for each rule set in each EVT desired in the MU.

***Note:** Other options for editing rules exist and are available through ToFuΔ. However, the options described above represent the most common functions in current use.*

7.6.1 Fuel rule header selections

The following header selection components are found at the top of the **Fuel Rules** page (fig 7-22).



Figure 7-22. 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.
- **Select Rules** – allows the user to reframe the window to view just the fuel information desired (FBFMs, FCCs, or FLMs) or alternately, all forms of rules (All). If you would like to work only with the Fire Behavior Fuel Models (FBFM), for example, then selecting **FBFM** will only allow for rules that have an FBFM assignment to be displayed. If the rule has an FBFM assignment of “9999” (= no data), then it will not be displayed in the rule set.
- **Existing Vegetation Type Number and Name** – displays EVT number and name in a drop-down window that allows the user to go directly to the desired EVT. The EVT informs the user as to the dominant species present as well as the type of vegetation that occupies the site. (See “EVT Description” in [section 7.6.5](#) for additional information).

When working with ToFuΔ’s fuel header selections, complete the following steps.

- Enter a Session Name in the box provided if desired (optional).
- Use the radio buttons at the top right of the dialog box in the **Select Rules** section to choose desired fuel information (select “**All**,” “**FBFM**,” “**FCC**,” or “**FLM**”).

7.6.2 Column headers

The **Fuels Rules** box (fig. 7-23) is set up in spreadsheet design so that column headers can be collapsed and expanded as needed (figs. 7-23 and 7-24). One of the primary functions of this tool is to enable the user to highlight a row field and then select the **Edit Rule** icon 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 particular rule.

Modifications are made by changing values directly in the boxes displayed. (See [section 7.6.4](#) for additional information on how headers are modified as rule inputs are developed).

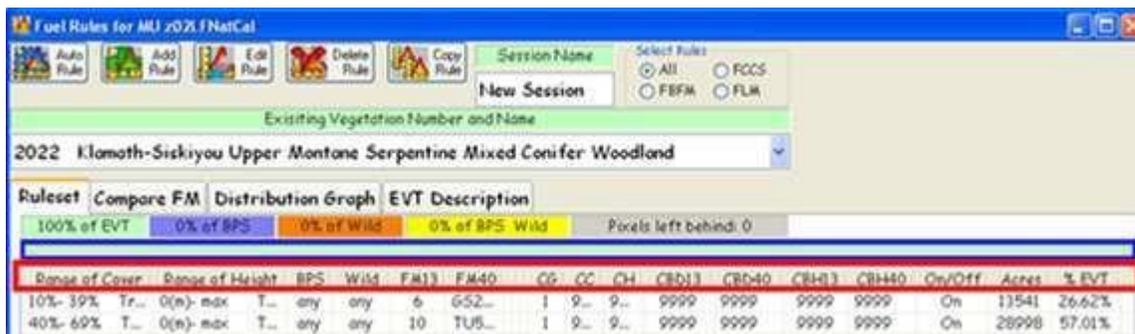


Figure 7-23. Column headers can be collapsed or expanded for convenience.

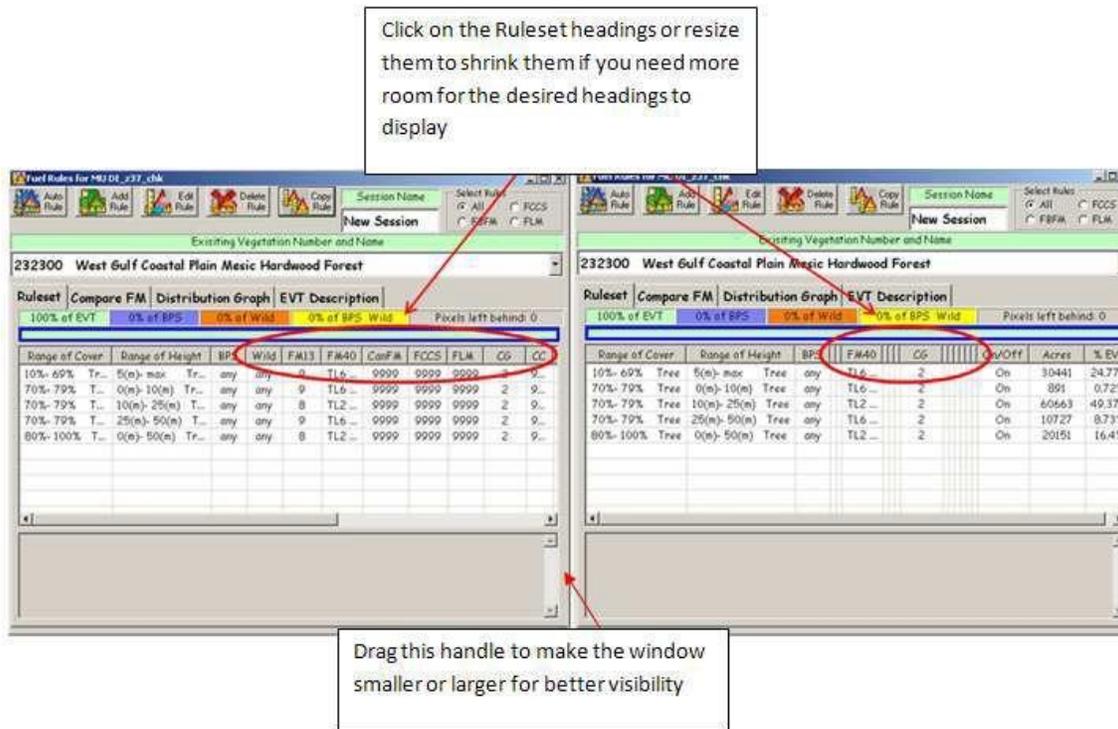


Figure 7-24. Working with display options.

Tip: Click in the boxes at the top of the columns you are **not** interested in viewing to collapse those fields to more easily view the columns you do wish to work with. You can also resize the rule set headings or the windows themselves to better display your selections (fig 7-24).

Main column headers are described below.

- **Range of Cover** and **Range of Height** – cover ranges used to determine fuel characteristics based on the existing vegetation depicted in the pixel are displayed. Life form cover and height provide information that can help determine fuel bed density in surface fuels and provide insights into CBH and CBD in the vegetation’s canopy attributes.
- **Range of Height** – height ranges used to determine fuel characteristics based on the existing vegetation depicted in the pixel are displayed. Life form height and cover provide information which can help determine fuel bed density in surface fuels and provide insights into CBH and CBD in the vegetation’s canopy attributes

Example: Mixed Conifer Woodland = EVT (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 Conifer 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 EVT 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 EVT. For example, it might be advantageous to modify fuel characteristics for vegetation occurring on serpentine or other ultramafic soil types.

Referring back to the previous example (Mixed Conifer Woodland), the BpS is given as “any” so that for all BpS designations within z02 and EVT 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 7.5](#) 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 as a result of the calibration workshops held across the country.

ToFuΔ has been designed to incorporate other fuel descriptions systems, including the Canadian Fire Behavior Prediction System of Fuel Models (CFBPS FM), the Fuel Characteristic Classification System (FCCS), and Fuel Loading Models (FLMs). A custom fuel model can also be used. The default data set, however, includes no information from these systems.

- **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 ToFuΔ, a switch has been incorporated to describe the effects of canopy. The switch has three user-controlled numeric settings as described below.

- 0 = no canopy on the site.
 - 1 = canopy base height (CBH) and canopy bulk density (CBD) calculations from LANDFIRE 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 = used on forested sites (“tree” life form) where torching and crowning will not occur but where the stand attributes will be used in the calculations of surface fire behavior characteristics. (The reason for keeping the canopy attributes in place is to adjust wind speeds, shading, and sheltering for surface fire calculations).
-
- **Canopy Cover (CC) and Canopy Height (CH)** – can be user-designated by individual rule set while in editing mode. The default data set uses LANDFIRE 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 rule set for either of the surface fuel model grids they will be producing (see [section 6.3](#) for more information). Default values are derived from the standard deviation plot data approach (Martin, Napoli, and Smail, personal communication).

 - **CBD 13 and CBD 40** – The user can specify CBD for a given Fuel Rule by individual rule set for either of the surface fuel model grids they will be producing (see [section 6.3](#) for more information). 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 EVT a specific rule covers. When out of balance (over or under 100%), the **Ruleset** sheet tabs will indicate the problem (see [section 7.6.3](#)).

7.6.3 Tab indicators

The **Ruleset** page includes tab indicators for **percent of EVT**, **percent of BpS**, **percent of Wildcard**, and **Pixels left behind** as shown (fig 7-25).

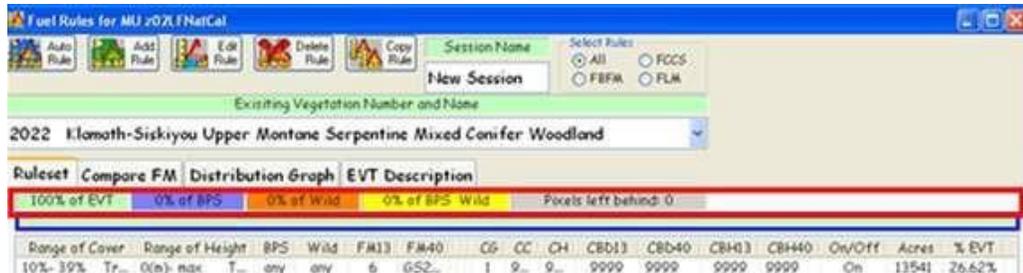


Figure 7-25. Ruleset page tab indicators.

Brief descriptions of each tab indicator (from left to right) are as follows:

- **Percent of EVT** – percent of the EVT that the combined rule set covers. If no BpS or Wildcard rules are used, all pixels should be accounted for here.
- **Percent of BpS** – percent of pixels covered by a BpS rule. The EVT tab shows the percent of pixels covered outside of this rule.
- **Percent of Wildcard** – percent of pixels covered by a wildcard rule. The EVT tab shows the percentage of pixels covered outside of this rule.
- **Percent BpS Wild** - percent of pixels covered by both BpS and wildcard rules.
- **Pixels left behind** – indicates if there is a problem with the combinations of rule sets covering all of the pixels in the grid of varying covers and height.

Note: A color slide bar appears below the tab indicators. When the bar is green, all of the pixels identified by rules are covered in the grid. When the bar is red, however, the area has been covered by overlapping rules or there

are not enough rule combinations to cover all of the pixels. Corrective action is required!

Tab indicators are used to determine if there are problems with missing pixels. If necessary, you can account for missing pixels by using rule input options such as “**Add Rule**” or “**Edit Rule**.” See section 7.6.4 for additional information on how to work with input rule options.

7.6.4 Rule input options

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

ToFuΔ users can select from the following **Rule** input options: **Auto Rule**, **Add Rule**, **Edit Rule**, **Delete Rule**, and **Copy Rule** (fig. 7-26).

- **Auto Rule** – creates options for fuel rules from existing surface fuel models.
- **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 Management Units (MUs).



Figure 7-26. Rule input options.

- Rule inputs are selected by clicking one of the icons at the top left of the Fuel Rules dialog box (fig. 7-26).

Auto Rule

Auto Rule is used with surface fuel model grids incorporated into the wildcard slot. This function automatically builds rule sets and assigns surface fuel models to other extents of the MU.

The **Auto Rule** icon creates options for fuel rules from existing surface fuel model layers. For this option to work, the surface fuel model layer must be included when creating the Management Unit, and it must include an FBFM option.

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 EVT's have been added but EVT's are populated by "9999," indicating "no data," or when rule sets 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.

- To use the Add Rule option, click the **Add Rule** icon (fig. 7-26).

The **Add and Edit Rules** dialog box opens as shown (fig. 7-27).

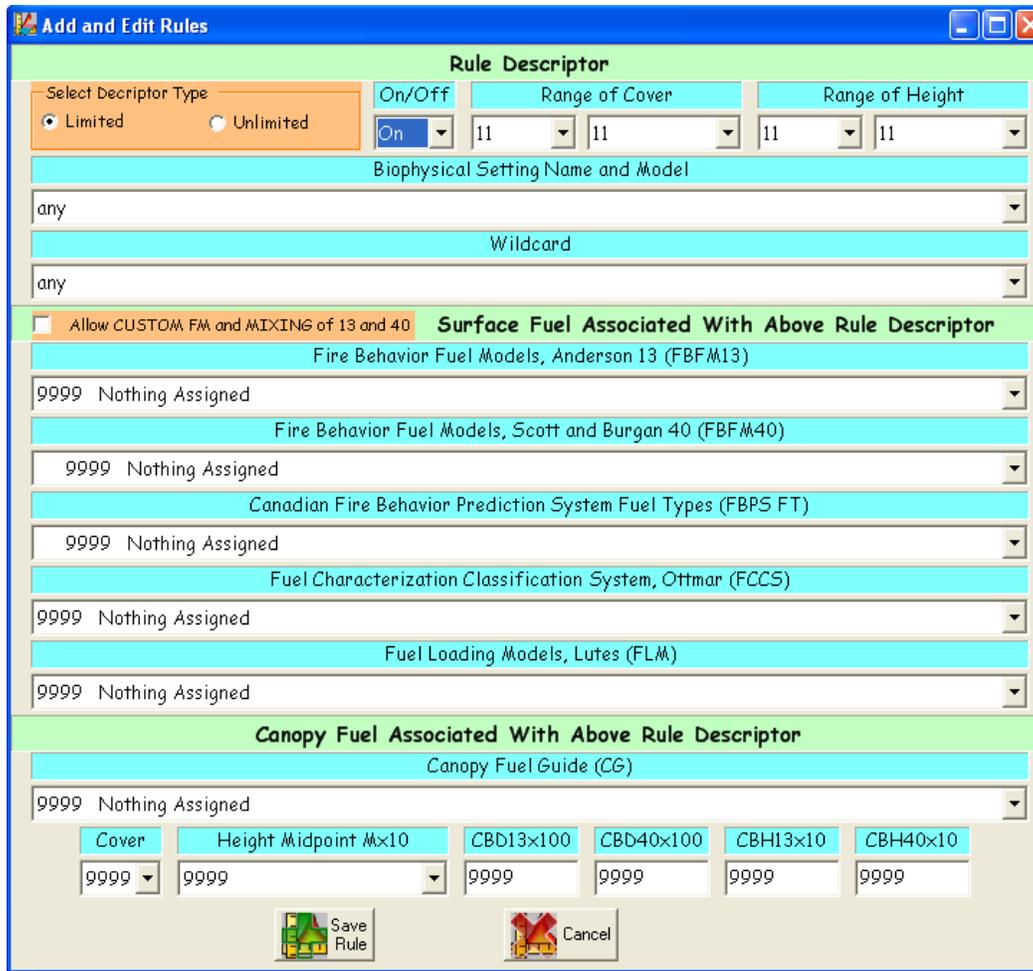


Figure 7-27. Add and Edit Rules dialog box.

Components of the **Add and Edit Rules** dialog box and the steps required to use the Add Rule option are discussed below.

- To use the Add Rule option, you will need to complete the required input for the **Rule Descriptor**, **Surface Fuel Associated with Above Rule Descriptor**, and finally the **Canopy Fuel Associated with Above Rule Descriptor** boxes (fig. 7-27).

Rule Descriptor box

The **Rule Descriptor** box occupies the top portion of the **Add and Edit Rules** dialog box (fig. 7-27). Components are described as follows.

- **Select Descriptor Type** – Use the radio button to make your selection of either “**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.

- Use the drop-down menu to toggle the Rule “**On**” or “**Off**.”
- Use the drop-down menus to select a **Range of Cover** and **Range of Height**.
- Specify the **Biophysical Setting Name and Model** using the drop-down menu. (Refer to [section 3.1.1](#) for additional information on BpSs.)
- A **Wildcard** option can be selected from the associated drop-down menu. (Refer to [section 7.5](#) for more information on wildcards.)

Surface Fuel Associated with Above Rule Descriptor box

Use the “**Surface Fuel Associated with Above Rule Descriptor**” section in the middle of the **Add and Edit Rules** dialog box to make the following selections.

- Use drop-down menus to make assignments for Fire Behavior Fuel Models (13 and/or 40; FBFM13 and FBFM40), the Canadian Fire Behavior Prediction System Fuel Models (FBPS FM), Fuel Characteristic Classification System (FCCS) and Fuel Loading Models (FLM).

Canopy Fuel Associated With Above Rule Descriptor box

This section of the dialog box is used to make canopy selections as described below.

- Make a Canopy Fuel Guide (**CG**) selection using the drop-down box.
- Modify CBD and CBH to express different fire behavior in different conditions if desired.

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”).

- Save rule by clicking on the **Save Rule** icon at the lower left.
- Close the **Add and Edit Rules** dialog box when you are finished. (It does not close automatically).

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.

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

Example: A rule set for the Cottonwood Bosque EVT has the range of cover and height worked out in logical fashion for the EVT, but you know that under dry conditions, crowning is likely in this vegetation type. Currently, the rule set 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 rule set for 20-54% 0-max height. Use the drop-down box for FBFM13 to select FM10, hit the drop-down arrow for FBFM40 to select TL8-188, and use the drop-down menu for **Canopy Fuel Guide (CG)** to select "1." Save your edits by clicking on the **Save Rule** icon. Subsequently, the Bosque rule sets will be 10-19%, 0-max, 5/GS2; 20-59%, 0-max, 8/TL3.

- To use the Edit Rule option, click the **Edit Rule** icon on the Fuel Rules dialog box (fig. 7-26).

The **Add and Edit Rules** dialog box opens (fig. 7-27). Components of the Add and Edit Rule dialog box are the same as those described for the Add Rule option. They are repeated here for convenience. Components of the **Add and Edit Rules** dialog box and the steps required to use the Edit Rule option, are discussed below.

- To use the Edit Rule option, you will need to complete the required input for the **Rule Descriptor**, **Surface Fuel Associated with Above Rule Descriptor**, and finally the **Canopy Fuel Associated with Above Rule Descriptor** boxes ([fig. 7-27](#)).

Rule Selector Box

The **Rule Descriptor** box occupies the top portion of the **Add and Edit Rules** dialog box ([fig. 7-27](#)). Components are described as follows.

- **Select Descriptor Type** – Use the radio button to make your selection of either “**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.*

- Use the drop-down menu to toggle the Rule “**On**” or “**Off.**”
- Use the drop-down menus to select a **Range of Cover** and **Range of Height.**
- Specify the **Biophysical Setting Name and Model** using the drop-down menu. (Refer to [section 3.1.1](#) for additional information on BpSs).
- A **Wildcard** option can be selected from the associated drop-down menu. (See [section 7.5](#) for more information on using the wildcard option).

Surface Fuel Associated with Above Rule Descriptor Box

Use the “**Surface Fuel Associated with Above Rule Descriptor**” section in the middle of the **Add and Edit Rules** dialog box to make the following selections.

- Use drop-down menus to make assignments for Fire Behavior Fuel Models (13 and/or 40) (FBFM13 and FBFM40), the Canadian Fire Behavior Prediction System Fuel Models (FBPS FM), Fuel Characterization Classification System (FCCS) and Fuel Loading Models (FLM).

Canopy Fuel Associated With Above Rule Descriptor box

This section of the dialog box is used to make canopy selections as described below.

- Make a **Canopy Fuel Guide (CG)** selection using the drop-down box.
- Modify CBD and CBH to express different fire behavior in different conditions if desired.
- Save rule by clicking on the **Save Rule** icon at the lower left corner of the dialog box.
- Close the **Add and Edit Rules** dialog box when you are done with your edits (it does not close automatically.)

Delete Rule

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

- Delete rules by selecting to highlight the rules you would like to delete and then clicking on the **Delete Rule** icon near the top of the screen (fig. 7-28).



Figure 7-28. **Delete Rule** option.

The following dialog box (fig. 7-29) opens, allowing you to verify that you really want to delete the rule.

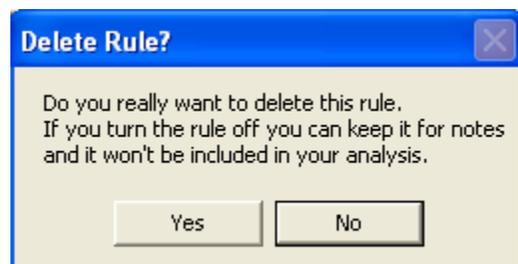


Figure 7-29. Dialog box verifying rule deletion.

Copy Rule

Copying rule sets from LANDFIRE National calibrated data using the **Copy Rule** input option gives the typical user a good starting point. From here, edits can be made to the copied rule sets and additional rules including BpS segmentations can be added.

- To copy a rule, click the **Copy Rule** icon on the **Fuel Rules** page. The following dialog box (fig. 7-30) will open.



Figure 7-30. **Copy Rules** dialog box.

- Use the drop-down menu at the top left of the **Copy Rules** dialog box to select an MU to copy *from* (fig. 7-30).
- Use the radio buttons in the **Existing Vegetation Number and Name to be copied** box to specify whether you would like to copy all of the rules from the selected MU (**Copy MU**) or to copy only the rule set from the selected MU and Existing Vegetation Type (EVT) (**Copy EVT**).
- If “Copy EVT” is selected, you will need to use the drop-down menu under “**Existing Vegetation Number and Name to be copied**” to specify an EVT.
- 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**).

Note: You may be asked to verify that you want to **Copy On and Off** rules. Click “**Yes**” to continue (fig. 6-13).

- After making your selections, click the **Copy Rules** icon to continue.
- Close the Copy Rules dialog box when you are finished (it does not close automatically).

7.6.5 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 rule sets (fig. 7-31).

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



Figure 7-31. **Fuel Rules** dialog box showing page tabs.

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

Ruleset

The **Ruleset** page is visible when the **Fuel Rules** dialog box opens. The **Ruleset** page and its features were described in detail in [sections 7.6.1-7.6.4](#). Refer to the appropriate sections for additional information.

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 (fig. 7-32).

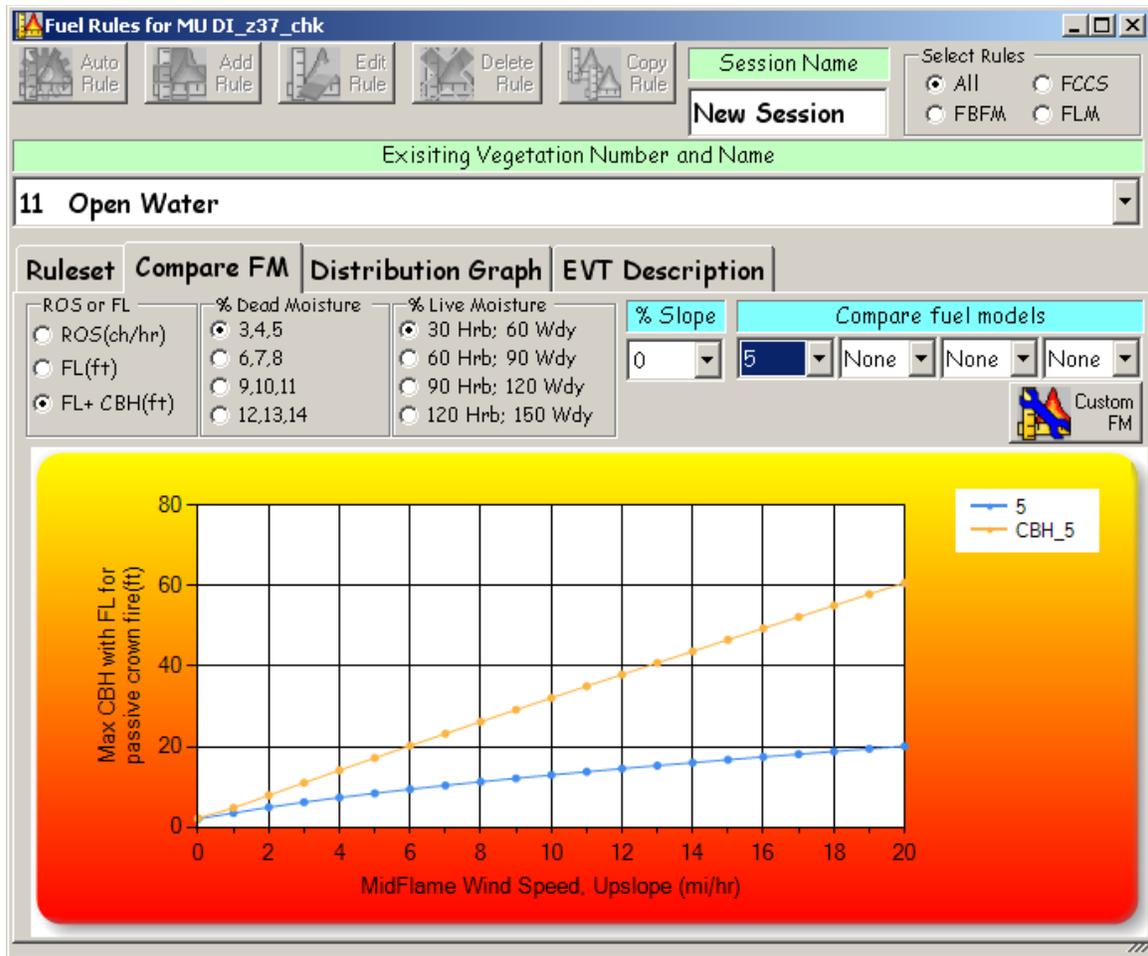


Figure 7-32. Fuel Rules screen with Compare FM page displayed.

- Use radio buttons to select desired ROS or FL, percent Dead Moisture, and percent Live Moisture.
- Use drop-down menus to enter percent slope and desired fuel models for comparison.

Note: These options are very useful in determining FBFM 13, FBFM 40, and CBH for the fuel characteristics assignment displayed on the rule sets from the Ruleset sheet.

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 icon shown above (fig. 7-32).

- To create a custom model, select the fuel model you would like to start with in the box to the right of “**Fuel Model.**”
- Make adjustments by selecting a parameter and then moving the slide adjustment (fig. 7-33).
 - Make any other desired adjustments by using appropriate radio buttons.
- Close the custom fuel model interface when finished by clicking the same button, now called “**Close Custom**” (fig. 7-33).

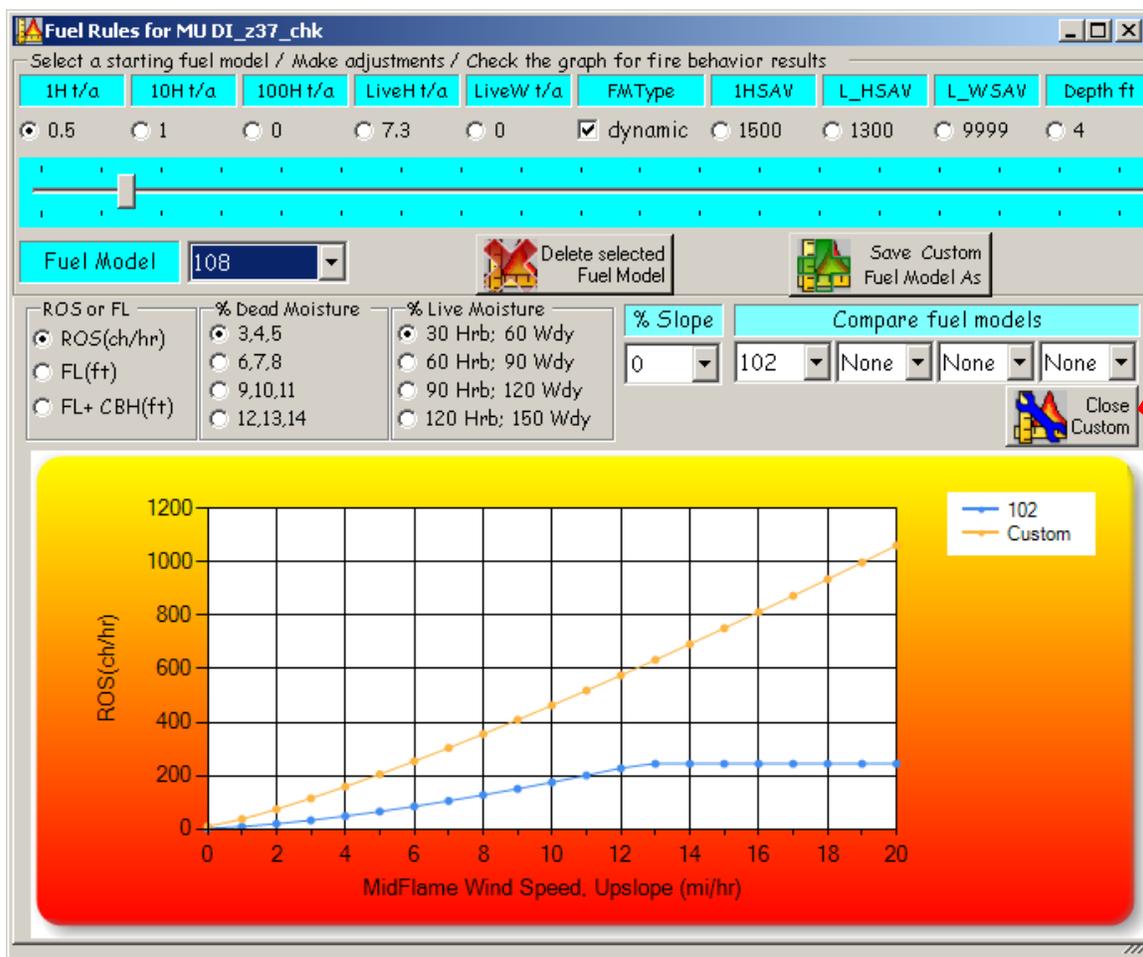


Figure 7-33. Create Custom Fuel Models page with Close Custom Fuel Model function.

- Once saved, the custom model will be available.

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 grid data for the entire EVT or by BpS or Wildcard (if a wildcard is used in the MU grid) (fig. 7-34).

You can use the **Distribution Graph** page (fig. 7-34) to view the height of the vegetation by cover and the numbers of acres present in the selected EVT 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 EVT in the MU's extent.

The legend displays the line indications by height corresponding to the percent cover and represents the number of acres.

To work with the Distribution Graph:

- Click on the **Distribution Graph** tab.
- Use the relevant drop-down menus to display the distribution of an EVT, BpS, or wildcard.

Note: If the graph is in the “T” category, tree cover is represented; if “S” then shrub cover is represented; and if H, it is made up of herbaceous cover.

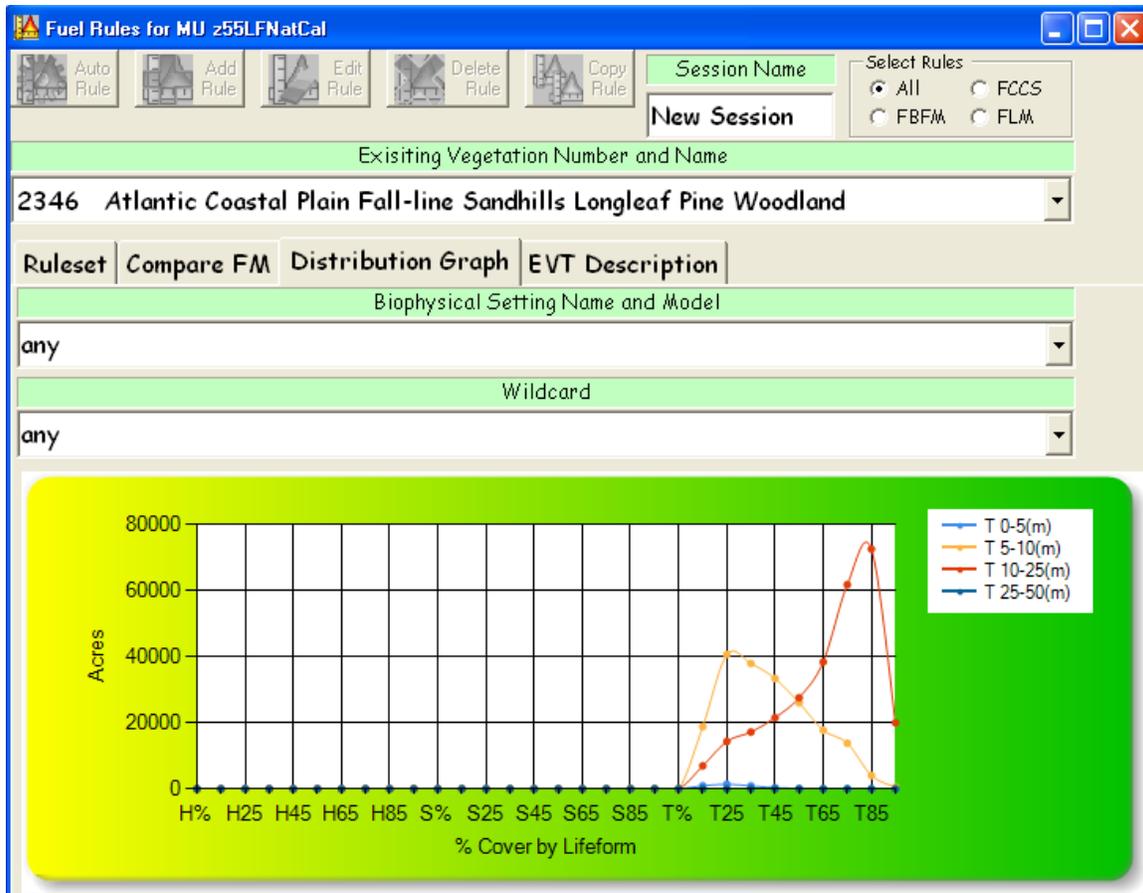


Figure 7-34. Fuel Rules screen with **Distribution Graph** page displayed.

EVT Description

The **EVT Description** page provides a summary of the concepts behind the vegetation type determination (fig. 7-34). It provides a geographical range as well as information on scale, soil, climate, and species. This page can help with determination of cover and height by breakpoints for the Fuel Rules. Follow the steps listed below to work with this page.

- Click on the **EVT Description** tab to open the page.
- Use the **Existing Vegetation Number and Name** drop-down menu to view a description of the EVT you specified (fig. 7-35).

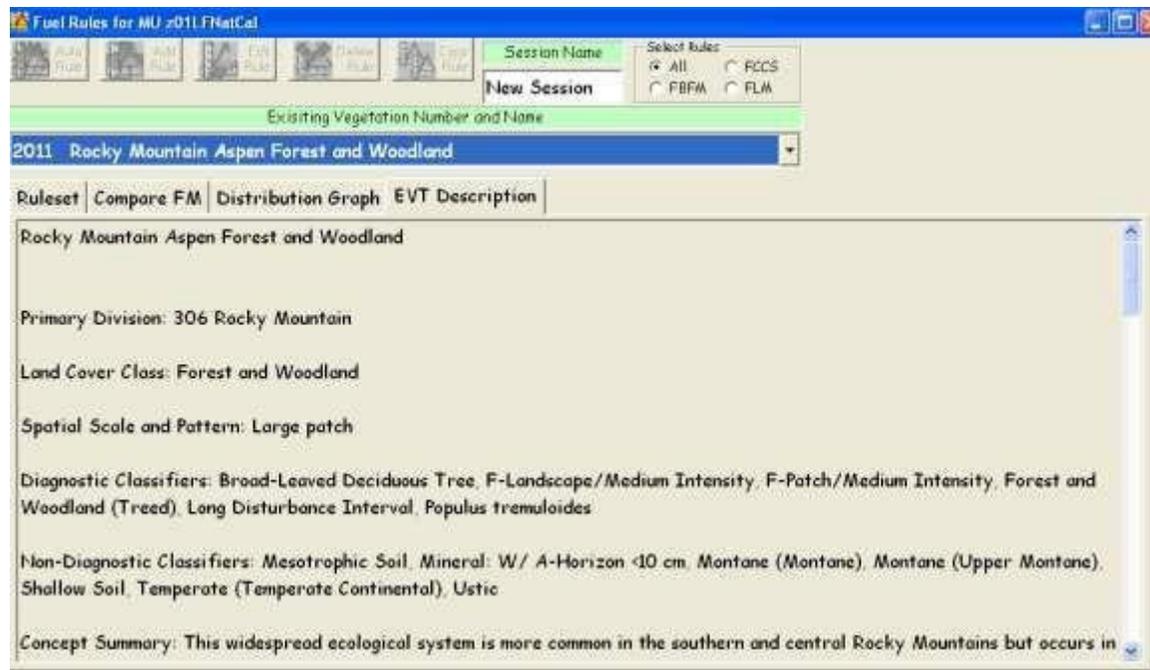


Figure 7-35. **EVT Description** page in **Fuel Rules** screen.

7.7 Creating new Grids

Fuel characteristics can be edited or modified on a pixel by pixel basis, based on logical decisions determined by cover, height, vegetation, and biophysical settings incorporated into the Fire Behavior Fuel Models.

Once the fuel rules have been added, deleted, or adjusted ([section 7.6.4](#)), you are ready to create the new layers.

- Select **FUEL GRIDS** on the ToFuΔ drop-down menu as shown (fig. 7-36).



Figure 7-36. Use the ToFuΔ drop-down menu to select **FUEL GRIDS**.

The following dialog box with the **Fuel Selection** tab visible will open (fig. 7-37).

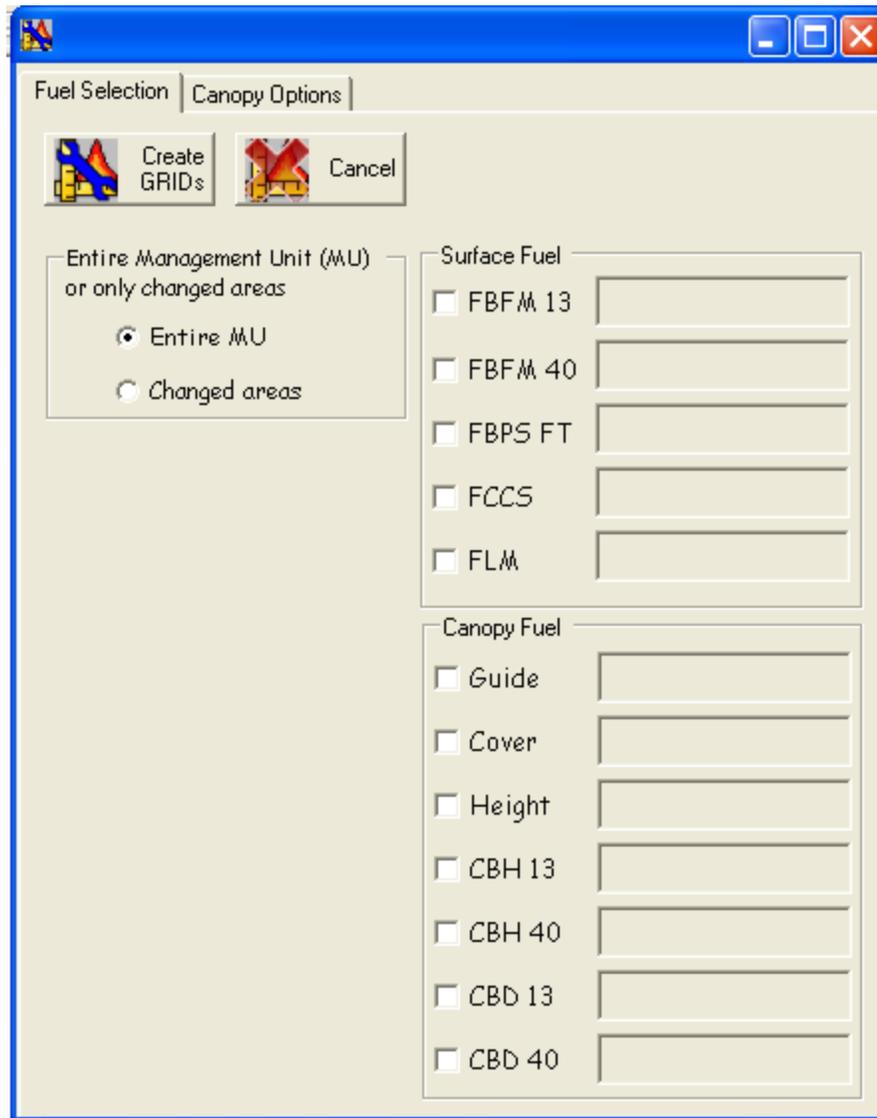


Figure 7-37. Fuel and canopy option selection box with **Fuel Selection** screen visible.

- Use the **Fuel Selection** tab to create surface fuel layers.
- Select the layers you would like to include by checking the boxes to the left of the grid.
- Name the **Surface Fuel** layers to be created in the box to the right of the selection.

Note: When naming the file, you do not need to include a file extension. However, the file name must not exceed a total of 13 characters in length and should not contain any spaces, leading numbers, or special characters (^~! @#\$%^&*+={}[]\|?/:;'"<>, .).

- Similarly, you can select any **Canopy Fuel** layers by checking the boxes and name the selections in the box to the right.

Tip: If CBD and CBH Fire Behavior Fuel Models 13/40 are the same, just check one box.

- Use the radio buttons in the upper right corner to specify if you would like these changes applied to the entire MU or Changed areas only (Options are “**Entire MU**” or “**Changed areas**”).
- If you did not alter any of the canopy parameters, click **Create GRIDs** when you have completed the **Fuel Selection** tab.
- If you did alter any canopy parameters, click the **Canopy Options** tab.

The **Canopy Options** page opens (fig. 7-38).

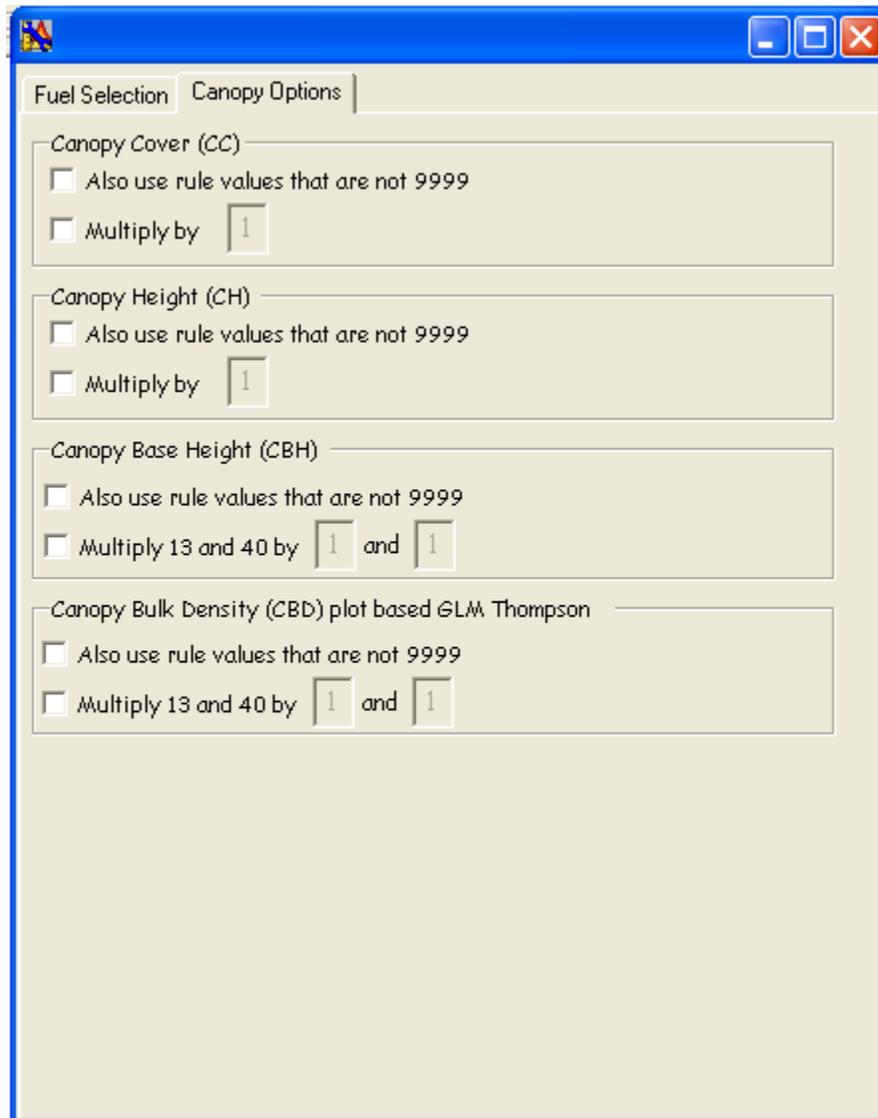


Figure 7-38. Fuel and canopy option selection box with **Canopy Options** screen visible.

- Check “**Also use rule values that are not 9999**” or change the Canopy Cover (CC) and/or Canopy Height (CH) by checking the “**Multiply by**” box and entering desired values.
- To change Canopy Base Height (CBH) and/or Canopy Bulk Density (CBD) if desired, select either “**Also use rule values that are not 9999**” or “**Multiply 13 and 40 by.**” If the second option is selected, you will also need to specify associated values of your choice for Canopy Base Height (CBH) and/or Canopy Bulk Density (CBD) by checking the appropriate box and/or adding an associated value.

- When finished with both **Fuel Selection** and **Canopy Options** tabs, make sure the **Fuel Selection** page is open and click the **Create GRIDs** button at the upper right ([fig. 7-37](#)).

Errors in grid creation are usually due to mistakes with naming conventions, naming grids too similarly, or using names that are too long. 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.

Tip: *If more changes are needed, go back to the rules, make your changes, and then create the grids again.*

The **Canopy Options** tab allows you to make changes to the canopy layers by adding a coefficient to multiply by, or by using rules that are not “9999” in the rule sets, to overwrite the predicted value ([fig. 7-38](#)).

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

7.8 Fuel grid color palette

Fuel grid colors of your choice can be applied to Fire Behavior Fuel Models (FBFM 13 and FBFM 40) as well as to the Canadian Fire Behavior Prediction System Fuel Models (FBPS FM).

- To apply fuel grid colors, click **FUEL Color** on ToFuΔ's drop-down menu ([fig. 7-39](#)).



Figure 7-39. **Select FUEL Color** from the drop-down menu.

The **Fuel Color Renderer** dialog box opens, as shown below (fig. 7-40).

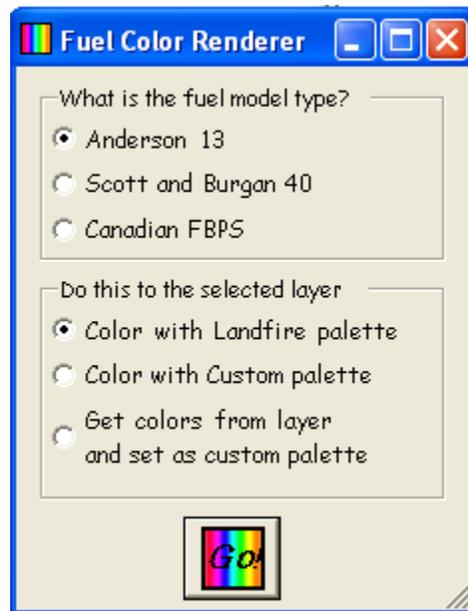


Figure 7-40. **Fuel Color Renderer** dialog box.

The first box (“**What is the fuel model type?**”) is used to select the surface fuel layer.

- Select the option of your choice (Anderson 13, Scott and Burgan 40, or Canadian Fire Behavior Prediction System of Fuel Models (CFBPS FM)).

The second box (“**Do this to the selected layer**”) selects one of three possible options to set the color or to obtain the colors from the selected surface fuel layer. The user may choose to color selected layers with a LANDFIRE palette, color with a custom palette, or to obtain colors from a layer and then set as a custom palette.

- Complete the box as desired using the radio buttons to make your selection.

7.9 Deleting fuel Management Units

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

- Click **FUEL MU Delete** on the ToFuΔ drop-down menu to delete selected Management Units (fig. 7-41).



Figure 7-41. Select **FUEL MU Delete** from the ToFuΔ drop-down menu.

The following **Delete MU** dialog box will open (fig. 7-42).

- Click “**Yes**” to confirm your deletion.

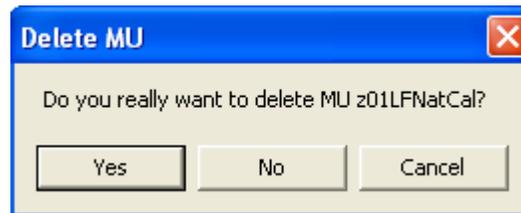


Figure 7-42. Dialog box verifying deletion of MU.

7.10 0 Fuel Log

The **Fuel Log** selection on the drop-down menu creates a text file consisting of all of the changes and notes made for the life of the fuel rule sets.

- Select **FUEL Log** on the ToFuΔ drop-down menu to view the text file (fig. 7-43).

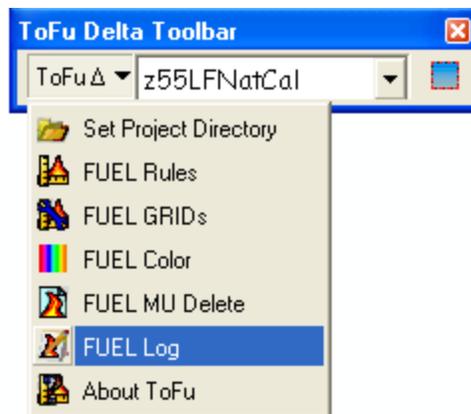


Figure 7-43. Use the drop-down menu to

open the FUEL log file.

7.11 About ToFu Δ

Clicking on **About ToFu Δ** in the drop-down menu displays the following screen (fig. 7-44), which includes information on version number and tool development.

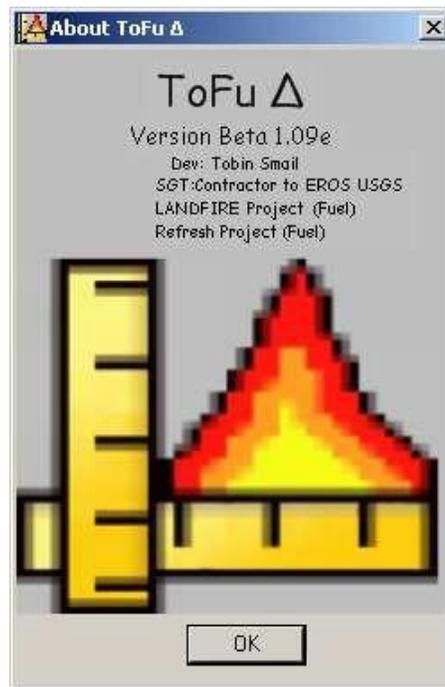


Figure 7-44. **About ToFu Δ** screen.

7.12 Help

The help button provides information about the program. Click on the icon to open the Help Utility.

Chapter 8: Troubleshooting To FuΔ – Common Errors, Symptoms, and Solutions

8.1 Common problems

8.1.1 Installation errors

8.1.2 Naming problems

8.1 Common problems

8.1.1 Installation errors

Be sure to uninstall any previous versions of ToFuΔ that may already be installed on your computer (see [Chapter 5](#) for additional information). The following error message warns that installation cannot proceed until previous versions of the tool are removed (fig. 8-1).



Figure 8-1. Error message notifying of an existing version.

8.1.2 Naming problems

Errors in grid creation are usually due to mistakes with naming conventions, naming grids too similarly, or using names that are too long. File names must not exceed a total of 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 contact helpdesk@nifft.gov.

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Appendix B: LANDFIRE Canopy Cover and Height Classification

B.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

B.2 Canopy Height Classification

TREE		
	Range (in meters)	
108	0	5
109	5	10
110	10	25
111	25	50
112	> 50	
SHRUB		
	Range (in meters)	
104	0	0.5
105	0.5	1.0
106	1.0	3.0
107	> 3.0	
HERBACEOUS		
101	0	0.5
102	0.5	1.0
103	> 1	

Appendix C: Downloading data using the LANDFIRE Data Access Tool (LFDAT)

1. Once you are familiar with the LANDFIRE Data Distribution site, acquiring LANDFIRE data using the LANDFIRE Data Access Tool (LFDAT) is the most efficient method and recommended if a broadband Internet connection is available. LFDAT allows a user to download and process LANDFIRE data directly within ArcMap.
2. LFDAT can be obtained directly from www.nifft.gov on the Tools and User Documents page. Because the following information only briefly describes the use of the LFDAT, it is strongly recommended that the LFDAT tutorial be taken prior to this tutorial. (The tutorial is found at the same location as the tool.)
3. Open ArcMap to a new map document. From the LFDAT toolbar, click on the  button to add the LANDFIRE data availability layer to your project. Notice that the green polygons represent zones where data are available for download.
4. To begin, click the **Get LANDFIRE National Map Data** tool icon: . With the tool, click to the upper left of the area of interest and drag a box to the lower right (fig. 4-1).

Draw a box as many times as needed until you have the extent that you want. To do so, you will need to close out the *Download Data* window that appears after every extent box has been drawn.

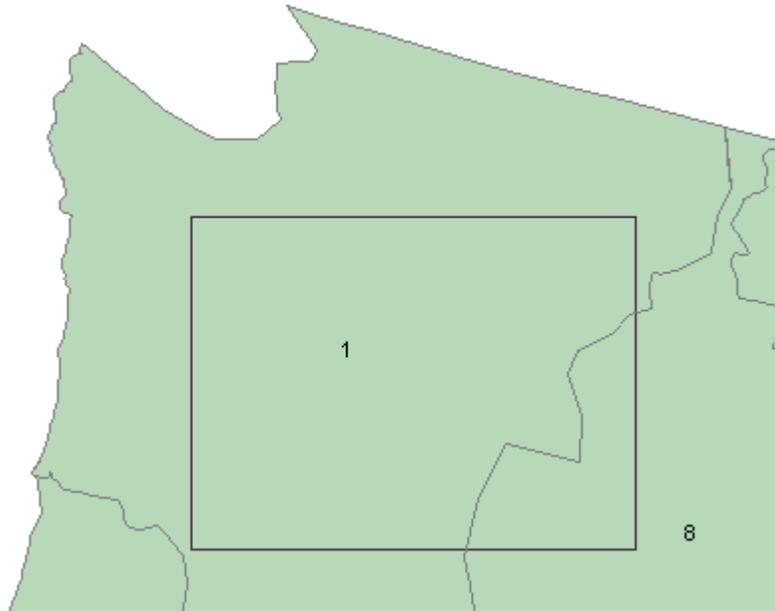


Figure C-1. Draw extent box.

5. Once you have the extent you want, save the extent in the *Download Data* window by typing a meaningful name in the box labeled *Save this extent as:* and click the **Save** icon: . You will only need to do this once for each extent. This allows you to go back and download additional data with the same extent.
6. Click the down arrow to the left of *Request Download* and select the desired layer. For demonstration purposes, we will choose the first layer, *13 Anderson Fire Behavior Fuel Models* (fig. 4-2).

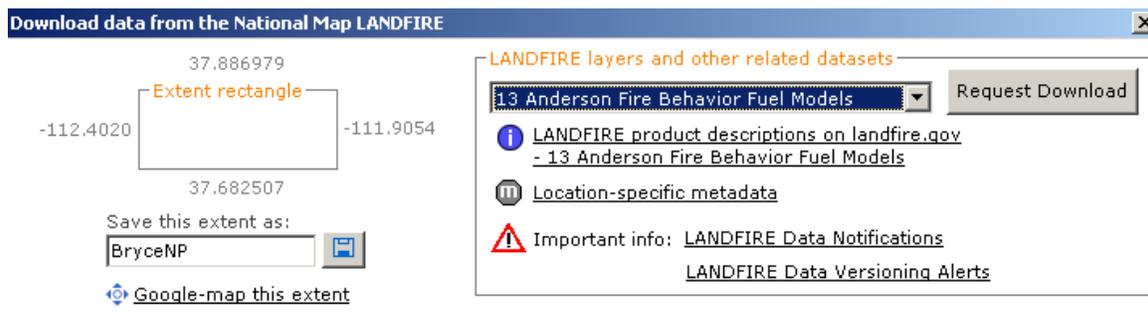


Figure C-2. Request Download from LANDFIRE Data Distribution site.

If you experience difficulties downloading data from the LANDFIRE Data Distribution site via LFDAT, click the About LANDFIRE Data Access Tool button on the LFDAT toolbar and check for updates. If you continue to have problems, open your Internet browser to the LANDFIRE Data Distribution site

(<http://landfire.cr.usgs.gov/viewer/>) and click on **Help for LF Data Access Tool**.

7. With the 13 Fire Behavior Fuel Models selected from the list, click on the **Request Download** button. This button initiates a process that extracts the data from the Data Distribution site.
8. Click on the **Download** button from the *SDDS Request Summary Page* to save the data to your computer. After the Raster Extract completes, a File Download dialog box appears. Click **Save**.
9. In the *Save As* dialog box, navigate to a location of your choice, right-click in the white space in the dialog box and select **New > Folder** (fig. C-3).

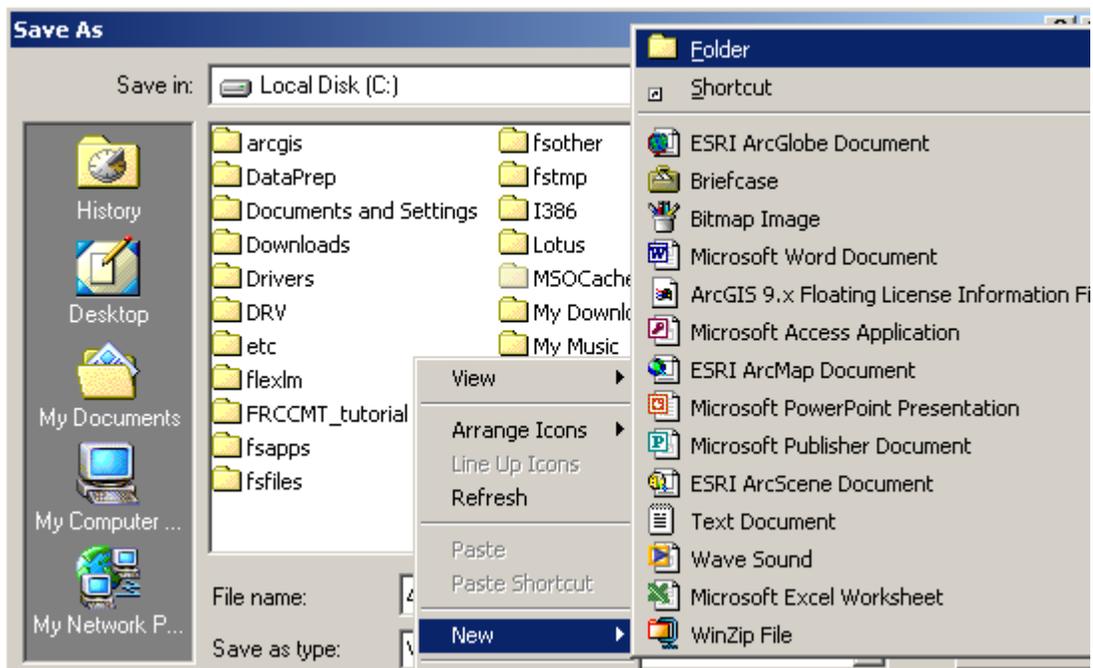


Figure C-3. Create new folder.

10. Name the new folder *LF_Inputs* and double-click on it to save and open this folder. Click the **Save** button and the file will download into the *LF_Inputs* folder.
11. A progress window opens during the save process. After the download is complete, close the *Raster Extract Has Completed* window. To download additional files, you need to repeat this process for each data layer.

12. Close the *Download Data* window from the LANDFIRE Data Distribution Site. Next, click on the *Process and Assemble LANDFIRE National Map Data* tool, also referred to as the Smart Assembler.
13. In the top entry of the dialog box, navigate to the *LF_Inputs* folder. Click the folder icon for an output location. Click **New Folder** and name the new folder *LF_Outputs*. Keep the default output file type ESRI GRID. Use separate input and output folders for each download and processing session for best results. The ESRI GRID format will allow the Smart Assembler to attach attributes. Other options are available, but LFDAT does not automatically add the attributes with the Smart Assembler (fig. C-4).

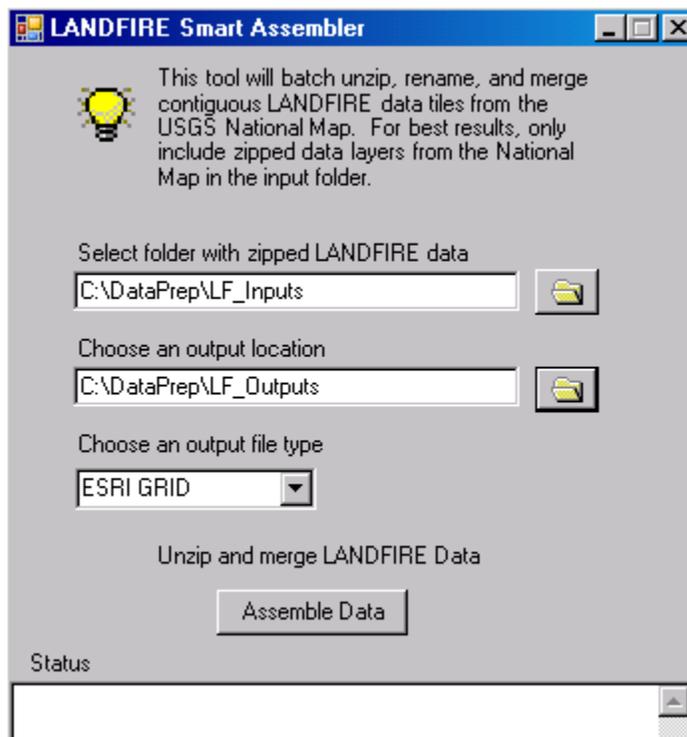


Figure C-4. The *LANDFIRE Smart Assembler* dialog box.

14. Click on the **Assemble Data** button. A progress bar displays at the bottom of the dialog box. Close the Smart Assembler when the process completes.
15. Add the layer from *LF_Outputs* folder to the map. Notice that the LFDAT Smart Assembler appropriately renames the downloaded data layers.
16. At this point, the data should be ready for further processing as input for one of the NIFTT tools.