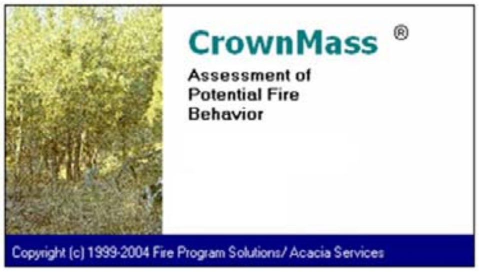
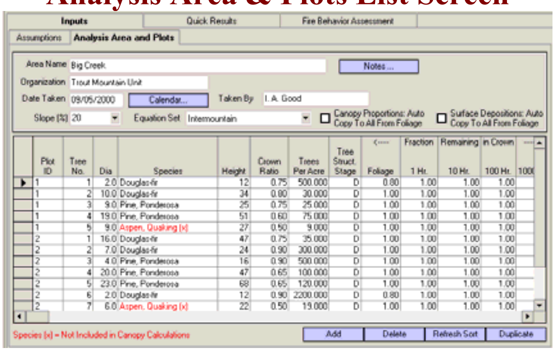
Fuels Management Analyst Suite
FMAPlus®

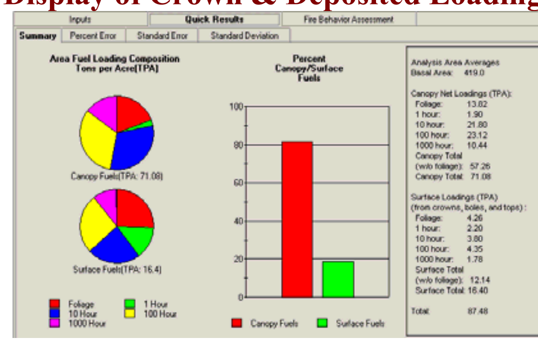
Users' Guide to Using the CrownMass® and Fuel Model Manager Programs



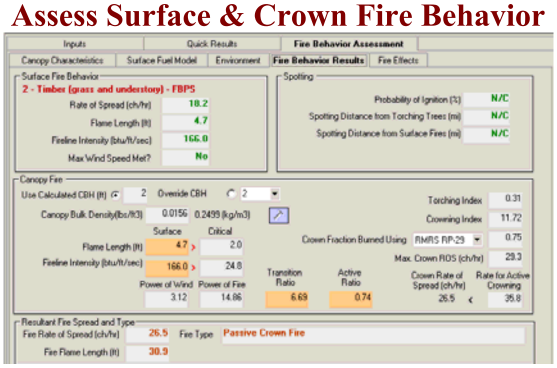
Analysis Area & Plots List Screen



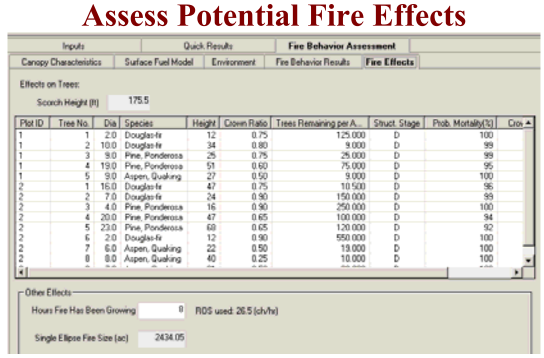
Display of Crown & Deposited Loadings



Assess Surface & Crown Fire Behavior



Assess Potential Fire Effects



Fire Program Solutions, L.L.C.

Acacia Services

07/22/2019

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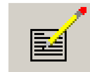
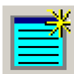
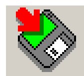
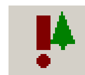
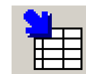
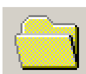
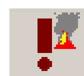
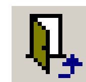
Icon Descriptions		 Notes	 Help
 New CrownMass Inventory	 Save	 Calculate CrownMass	 Log Run
 Open CrownMass Inventory	 Validate Data	 Calculate Fire Behavior	 Exit

Contacting Us

We enjoy hearing from the users of FMAPlus.

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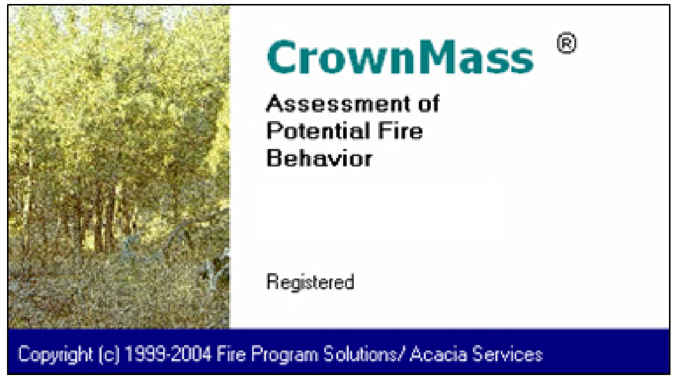
Technical Support

FMAPlus 3 Home Page
http://www.fireps.com/fmanalyst3/

Email Support

dcarlton1@aol.com

Welcome to CrownMass®!



Managers have the need to determine fuel profile objectives for land management projects. The fuel profile consists of aerial fuels as well as surface and ground fuels.

Within the CrownMass (CM3) program, the term "Analysis Area" refers to the total area where an estimate of the crown and surface fuels is desired. Within this area, sample plots are generally established with the inventory of trees based on a fixed radius or variable radius plot sampling methodology. Either sampling method allows for the calculation of the number of trees per acre by species, diameter breast high (dbh), tree height, tree structural stage and tree crown ratio. These values are the native input data needed at each plot for input to CrownMass. The listing of this data for a plot will be referred to as a "tree list." Automated import of tree list data is available in certain defined formats (see the Import option on the CrownMass File Menu).

Surface and ground fuels inventory techniques are available using the DDWoodyPC® and PSExplorer® programs within the FMAPlus®. The CrownMass program facilitates:

- The calculation of the loading of foliage and woody biomass by tree species from plot data consisting of a minimum of tree species, tree diameter breast high, tree height, tree canopy ratio and tree structural stage.

- The calculation and display of the vertical fuel profile within tree crowns by one-foot segments.

- The estimation of crown fire assessment parameters such as canopy ceiling height, canopy base height and canopy bulk density.

- The calculation of potential fire behavior and some first order fire effects.

Loading of Foliage and Woody Biomass in Tree Species

The ability to quantify the loading of needles and woody fuels that are contained in trees can assist in the estimation of the vertical fuel profile. In addition, knowing these values allows for estimation of the amount by size class that might be deposited to the surface fuel profile if these trees were cut or fell to the ground via natural processes. The research documentation for weights of tree crowns and bole components utilized in CrownMass is contained within the following publications:

Brown, James K. 1978. Weight and Density of Crowns of Rocky Mountain Conifers. USDA For. Serv. Res. Pap. INT-197, 56 p.

Brown, James K., J.A. Kendell Snell and David L. Bunnell. 1977. Handbook for Predicting Slash Weight of Western Conifers. USDA For. Serv. GTR INT-37, 35 p.

Freeman, Duane R., Robert M. Lommis and Peter J. Roussopoulos. 1982. Handbook for Predicting Slash Weight in the Northeast. USDA For. Serv. GTR-NC-75, 23p.

Miller, Elwood L., Richard O. Meeuwig and Jerry D. Budy. 1981. Biomass of Singleleaf Pinyon and Utah Juniper. USDA For. Serv. Res. Pap. INT-273, 18p.

Snell, J.A. Kendell and James K. Brown. 1980. Handbook for Predicting Residue Weights of Pacific Northwest Conifers. USDA For. Serv. GTR PNW-103, 44 p.

Snell, J.A. Kendell and Brian F. Anholt. 1981. Predicting Crown Weight of Coast Douglas-fir and Western Hemlock. USDA For. Serv. Res. Pap. PNW-281, 13 p.

Snell, J.A. Kendell and Susan N. Little. 1983. Predicting Crown Weight and Bole Volume of Five Western Hardwoods. USDA For. Serv. GTR PNW-151, 13 p.

Snell, J.A. Kendell and Timothy A. Max. 1985. Estimating the Weight of Crown Segments of Old-Growth Douglas-fir and Western Hemlock. USDA For. Serv. Res. Pap. PNW-329, 22 p.

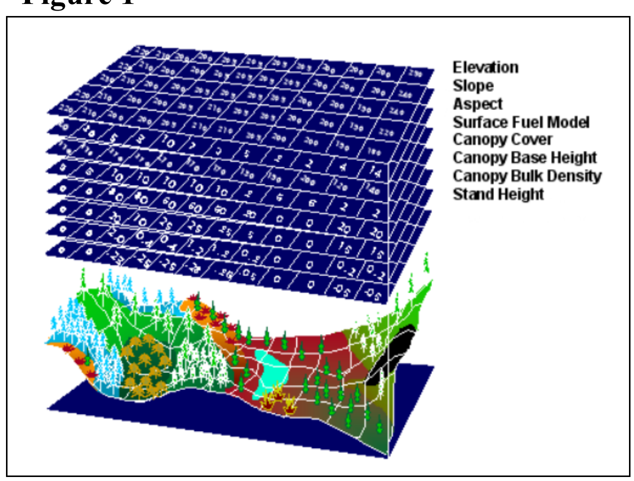
The fuels loadings in and from the crowns of trees can be described by:

- Weights and volumes per tree of foliage and woody material for diameter size classes of 0 to 0.25, 0.26 to 1.00, and 1.01 to 3.00 inches. These correspond, in increasing size, to 1-hour, 10-hour, and 100-hour average moisture timelag classes for many woody materials (Fosberg 1970). These are standard moisture timelags used in the National Fire-Danger Rating System (Deeming and others 1972).

- Weights and volumes per acre of downed woody material for diameters of 3 inches and larger for sound and rotten conditions.

- Depth of fuel or fuel bed depth.

Figure 1



CrownMass accepts tree list data from a tree stand inventory. From this information, predictions can be made of the crown and canopy fuel loading including associated crown profile characteristics. Key crown profile characteristics valuable in assessing crown fire potential are canopy base height and canopy bulk density (Reinhardt et. al. 2000; Van Wagner, 1977, 1993). The current models that allow for assessment of crown fire potential (Van Wagner 1977, 1993) as implemented in the *FARSITE* (Finney 1998) fire behavior prediction model and the FlamMap (Jones and Stokes 1999) utilize estimates of canopy ceiling height, canopy base height and canopy bulk density (Figure 1). Canopy base height and canopy bulk density are both familiar concepts, but are difficult to define or estimate at a stand level. The CrownMass program implements a process described by Reinhardt et. al. (2000) to provide estimates of these characteristics. The basic assumptions of the process are described.

Crown versus Canopy

Within this document, the term crown will be used to refer to the foliage and stem branchwood for an individual tree. The term canopy will be used to refer to the collection of crowns with a stand of trees.

Canopy Base Height

For an individual tree, the measurement of the height to the base of the crown can be made. The averaging of these values for all trees in a stand would give an estimate of the base of the stand canopy base height. Frequently, this is a measure of where the limbs of the canopy start vertically but the number can be skewed by the presence of small trees. A more meaningful value would be the height above the ground of the first canopy layer where the density of the crown mass within the layer is high enough to support vertical movement of a fire.

Canopy Bulk Density

Mathematically, canopy bulk density (CBD) (lbs/ft^3) is canopy biomass divided by the volume occupied by crown fuels. Canopy bulk density is hard to estimate in the field. Initially, it seems attractive to calculate this value by treating the canopy as a box with the depth the stand height minus the canopy base height. Assuming this box covered an acre (43,560 ft^2), dividing the fuel loading in the canopy by the volume of box would provide an estimate of average canopy bulk density. Unfortunately, this estimate has a bias toward underestimation of the canopy bulk density due to the averaging of largely void areas in the top and bottom of the canopy with the more dense layers of foliage. A fire burning vertically within the crowns will most likely propagate through denser canopy layers.

Determination of Canopy Base Height and Canopy Bulk Density

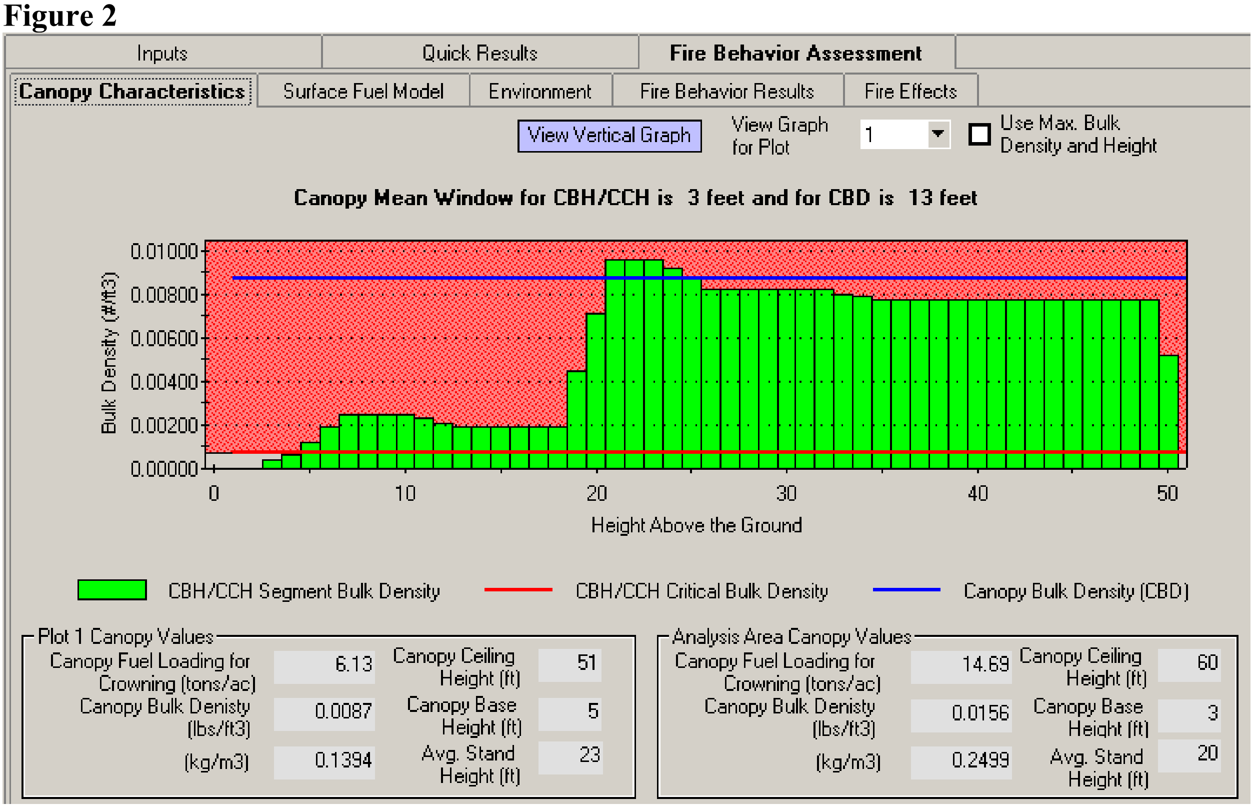
From the tree list data input, the fuel loading is determined for the needle and the 1-hour timelag live and the1-hour timelag dead fuel categories. Current assumptions (Reinhardt et. al. 2000) are that the needle fuel loading and 0.50 of the 1-hour timelag crown fuel loading contribute to the flaming portion of crown fire. On the Assumptions Tab, the proportion of the 1-hour timelag crown fuel loading that contributes to the flaming portion of crown fire can be set with 0.50 the program default. The sum of the needle weight and the assumed proportion of 1-hour timelag weight will be referred to as the crown assessment canopy fuel (CACF).

It is assumed that the crown loading is evenly distributed vertically within the canopy. Of course, this is not true but it still might be acceptable in that trees are conical in shape with light attenuation. For each tree in the tree list, CrownMass distributes the crowning assessment canopy fuel for that tree equally into one-foot vertical segments from the tree's crown base height to the tree's total height. The loading for each one-foot segment is calculated by summing the loading contributions to that segment from all of the trees within the stand.

CrownMass assumes that a fire will spread vertically through the densest portion of the canopy. To use the native segment bulk densities can yield a rather discontinuous distribution of segment bulk densities so a running mean of these values is calculated. The default number of segments used for this running mean is 15 and the user can set this value on the Assumptions Tab. The maximum of this running mean is the value used by CrownMass as *canopy bulk density*.

Sando and Wick (1972) suggest that a minimum bulk density in the canopy to provide vertical propagation of fire is 100 lbs/acre-foot which is 0.0023 #/ft^3 or 0.037 kg/m^3. Experience in use of this value has shown that use of 30 lbs/acre-foot (0.00069 #/ft^3 or 0.0111 kg/m^3) provides a better estimate of the canopy base height (Crookston and Reinhardt 2003). This minimum bulk density can be set by the user on the Assumptions Tab but the recommended value by Sando and Wick is the program default. The *canopy base height* and the *canopy ceiling height* are determined by CrownMass as the lowest and highest segments respectively where the running mean segment bulk density is greater than the minimum canopy bulk density. In CrownMass, a red line is drawn at this canopy bulk density of 0.00069 lbs./ft^3 (Figure 2). Note that the first live limb height is at 3 feet from the ground but the first one foot layer where the running meaning bulk density is 0.00069 lbs./ft^3 is 5 feet. In CM, the canopy bulk density is set as the maximum of the one-foot layer running mean bulk densities. In Figure 2, this value would be 0.0087 lbs./ft^3 (0.1394 kg/m^3) for Plot 1.

Figure 2

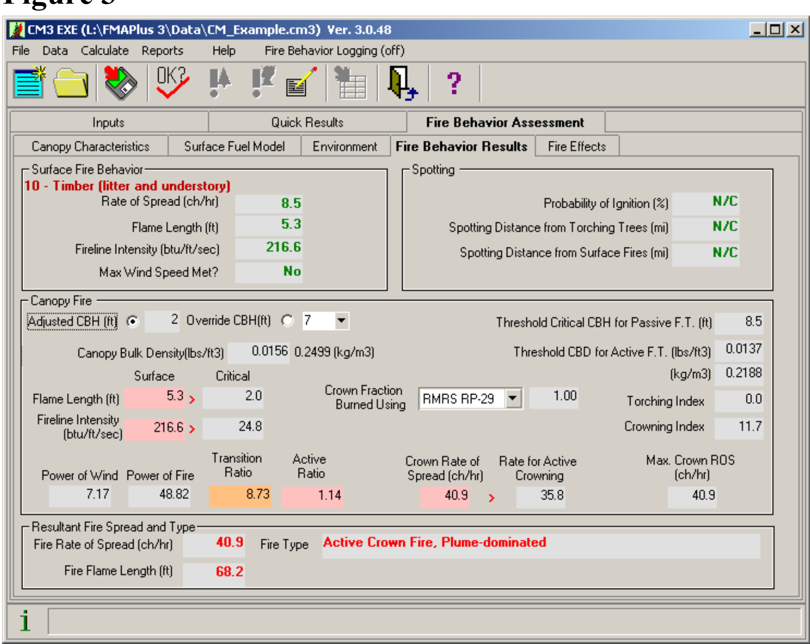


The Calculation of Potential Fire Behavior and Effects.
The canopy bulk density and canopy base height characteristics coupled with identification of the surface fuel profile, topographic and environmental information can allow for the estimation of fire behavior and fire effects. CrownMass contains algorithms to display the following fire behavior and fire effects values based on the work of Alexander (1988), Ryan and Reinhardt (1988), Beukema et al. (1999) Rothermel (1972), Andrews (1986), Andrews (1989), Finney (1998) and Scott and Reinhardt (2001).

- Surface Rate of Spread
- Surface Fireline Intensity
- Surface Flame Length
- Portability of Ignition
- Maximum Spotting Distance from Torching Trees and a Surface Fire
- Crown Fire Initiation Potential based on Methods Described by Finney (1998) and Scott and Reinhardt (2001)
- Torching and Crowning Index
- Resultant Fire Type
- Resultant Fire Rate of Spread
- Resultant Fire Flame Length
- Crown Scorch Height
- Probability of Mortality for each Tree in the Tree List
- Elliptical Fire Size for a Free Burning Fire After a Defined Time Period (Single Ellipse Model)

From this information, effects of varying management strategies of tree density and surface fuel loading can be assessed to estimate the attainment of proposed or defined management objectives.

Figure 3



The CrownMass Program Screen Format and Definitions

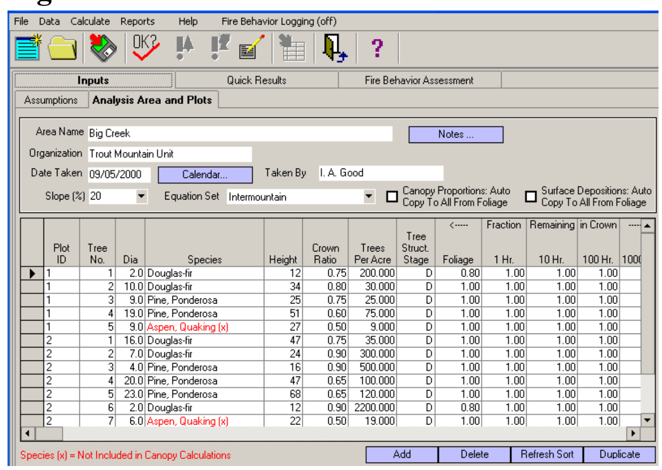
The screen viewed upon initial startup of CrownMass is in Figure 4. The screen is composed of the following sections:

The Main Menu and Toolbar Icons

The Major Process Tabs

The Tabs and Windows to Implement the CrownMass Calculation and Fire Behavior Assessment Processes

Figure 4

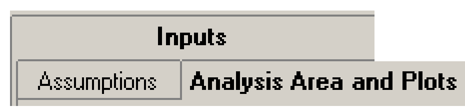


Major Process Tabs

The major process Tabs are Inputs, Quick Results and Fire Behavior Assessment.

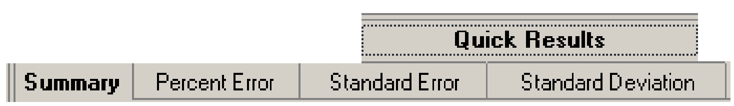
Inputs Tab

CrownMass initiates with the **Inputs Tab** active. There are two tabs here that allow the user to access screens to identify Analysis Area Assumptions and to enter tree list data from an Analysis Area or from Plots (Analysis Area and Plots). The entry of tree list data is not required but the user will need to enter manually the canopy base height, canopy bulk density and canopy ceiling height when calculating fire behavior.



Quick Results Tab

When the user clicks on the **Quick Results Tab**, the CrownMass program implements the "Calculate Crown Weights" action, which computes crown weights, based on analysis assumptions, the tree list values and the settings in the tree list. Results are viewed via the **Summary Tab**. If more than one plot is entered, then statistical data is displayed for canopy fuel loading in the following categories: foliage, 1-hr dead, 10-hr dead, 100-hr dead and 1000-hr dead. In addition, statistical information is given for canopy base height.



The Fire Behavior Assessment Tab

The **<u>Fire Behavior Assessment Tab</u>** assesses the fire behavior and fire affects assessment tools within the CrownMass program.

The **<u>Canopy Characteristics Tab</u>** accesses a display of the vertical canopy profile displaying the bulk density of one foot segments of the canopy. Plot and Analysis Area canopy attributes are displayed.

The **<u>Surface Fuel Model Tab</u>** allows the user to specify a fuel model based on the Fire Behavior Prediction System to represent the surface fuel profile. This process is facilitated by an algorithm, which suggests a fuel model based upon user preferences. The user can manually select a fuel model.

The **<u>Environment Tab</u>** allows the user to specify fuel moisture and wind speed values for use in the assessment of potential fire behavior for a fire burning in the identified surface fuel model and under the defined canopy layer. In addition, calculated canopy attributes are displayed.

Clicking the **<u>Fire Behavior Results Tab</u>** or **<u>Fire Effects Tab</u>** causes CrownMass to calculate surface and crown fire behavior and fire effects. Values displayed include rate of spread, flame length, and fireline intensity for the fire burning in the surface fuel model. If selected, CrownMass calculates the Probability of Ignition and the Spotting Distance from Torching Trees and a Surface Fire. Fire type (surface, passive crown or active crown) is displayed including the resultant calculation of intermediate values used. These include the maximum crown fire rate of spread, crown fraction burned and the rate for active crowning (RAC).

Clicking the **<u>Fire Effects Tab</u>** causes CrownMass to calculate surface fire behavior, crown fire behavior and fire effects. The canopy scorch height for the stand is displayed. For each tree in the tree list, the percent of the crown scorched and the probability of mortality are displayed. In addition, the elliptical fire size is displayed for a free burning fire for a defined time period.

<u>Hot Tip</u>

Caution: The fire behavior calculations are provided for assessment purposes to aid in the comparison of different fuel profiles that might exist naturally or be created via management actions. CrownMass should not be used for “real time” fire behavior calculations and the user is referred to the BEHAVE, *Farsite* or BehavePlus programs for this purpose.

Startup Menu

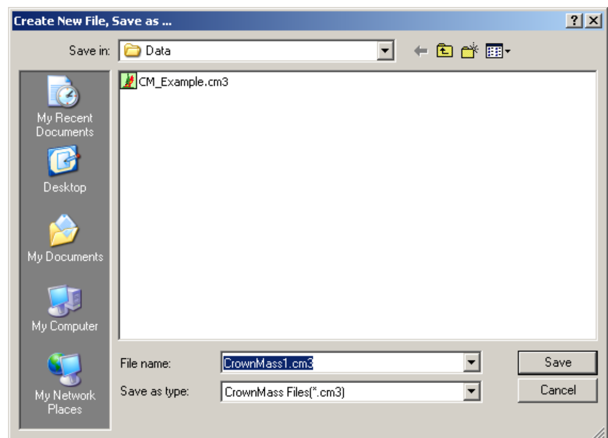
Below are the two possible selections from the initial startup screen in CrownMass.

Start A New Inventory

Open An Existing Inventory

Start a new inventory

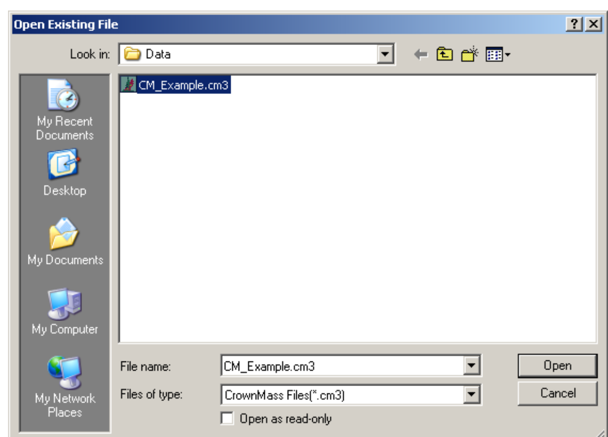
If you want to process plot data from a stand inventory, select Start A New Inventory. The program will request the user to name the file and will by default, place that file in the Data Folder, which is inside the Directory where FMAPlus is installed. In the File Name box, enter the file name. It is not necessary to enter the cm3 extension, as CrownMass will do that automatically. Click the **Save** button.



Open an existing inventory

If the user has already entered the plot data from a stand inventory and saved it in a CrownMass data file, then select Open An Existing Inventory.

By default, all inventories in the Data folder that were created using CrownMass Version 3 will be displayed. If the inventory was created using CrownMass, Version 2, click on the pulldown to the right of the Files of Type: label and select the CrownMass Files v2(*.cmi) option.



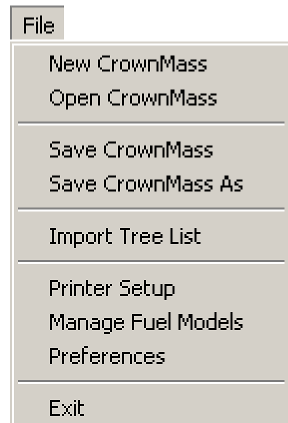
Click on the file name you wish to load and then click the **Open** button.

CrownMass (CM) Main Menu and Toolbar Icon Descriptions

The CrownMass main menu and toolbar are shown in the figure at the right. Below is a description of each main menu item and the tool bar icons.

The FILE Menu

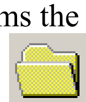
This file menu item allows the user to perform File operations, Data Import, Printer Setup, the ability to Manage Fuel Models, Program Preferences and Exiting program.



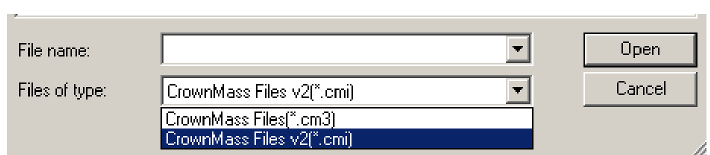
<u>**New CrownMass and Open CrownMass**</u>

A new Crown Mass inventory file is created for each set of plots. Once created, this file can be opened. The inventory file is a Microsoft Access data base file (mdb). To assist in the separation of data base files, CrownMass data base files have a CM3 extension. A CrownMass file name for a sample area Brooke might be named by the user as brooke.cm3. The CrownMass program will automatically attach the cm3 extension. The user is encouraged to use 8 characters or fewer to name files though long file names are supported.

The blue icon  performs the same function as the **File => New CrownMass** menu.

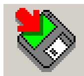
The yellow file folder icon  performs the same function as the **File => Open CrownMass** menu.

When a New CrownMass inventory file is created, the file will be saved in the Data folder, which resides in the parent FMAPlus folder. When the **File => Open CrownMass** menu is used, the program will by default show the data files in the Data folder. If data files have been stored elsewhere, the user will need to navigate to that location to select the file to be opened.



CrownMass, version 3, will open and use CrownMass data files created using CrownMass, Version 2. These files have a CMI file extension. To open a *.cmi data file, use the pulldown in the Files of Type window to highlight and click on this file type. The program will show the *.cmi files that exist in the default Data folder or other target folder.

Save and Save As
These two menu items function as they do in all Windows programs. Selecting the Save menu will save the inventory with the existing file name to the Data folder in the folder where FMAPlus 3 is installed. Selecting the Save As menu will allow the user to define a new file name for the inventory and to save it in any folder.

The Save icon  activates the Save file command.

Hot Tip

It is recommended the user save all inventory data files in the Data folder in the folder where FMAPlus 3 is installed. The user may desire to create folders for projects inside the Data folder.

Import
There are two defined data formats by which the user can Import an existing set of stand inventory data into CrownMass. The DDWoodyPC program supports import of a comma-delimitated ASCII file with field data measurements in a defined format called the CrownMass Standard Import Format. CrownMass also will import a Tree List Report file produced by the Forest Vegetation Simulator (FVS) program.

CrownMass Standard Format
The standard format is a comma-delimitated ASCII file with three sections of information:

- Header Row
- Site Record Row
- Plot Record Row(s)

At the beginning of the next page, there is an example of CrownMass Standard Format comma-delimitated ASCII import file. This import file is from an inventory that has two plots. A description of the rows and their contents follows.

```
CM,STD,03.01
1,Big Creek,Red River RD,3/15/2003,34,Bill Anderson
2,1,1,16.3,PSME,47,0,0.85,2.76,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,2,16.4,PSME,48,0,0.75,2.73,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
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2,1,5,27.5,PIPO,69,0,0.75,0.97,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,6,19.3,PIPO,51,0,0.55,1.97,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,7,7,POTR5,36,0,0.25,14.97,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,8,6,POTR5,35,0,0.25,20.38,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,9,7.5,POTR5,27,0,0.25,13.04,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,10,8.8,POTR5,27,0,0.25,9.47,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,11,8.5,POTR5,40,0,0.25,10.15,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,1,12,7.2,POTR5,21,0,0.25,14.15,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,1,6.9,PSME,24,0,0.75,15.40,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,2,9.9,PSME,34,0,0.55,7.48,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,3,25.4,PIPO,51,0,0.85,1.14,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,4,8.8,PIPO,25,0,0.75,9.47,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,5,20.3,PIPO,47,0,0.65,1.78,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,6,7.2,POTR5,35,0,0.25,14.15,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,7,6.9,POTR5,36,0,0.25,15.40,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,8,6.3,POTR5,22,0,0.25,18.48,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
2,2,9,6.4,POTR5,21,0,0.25,17.90,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
```

Header Row

The first row is the header row. This is always the first line and is formatted as follows:

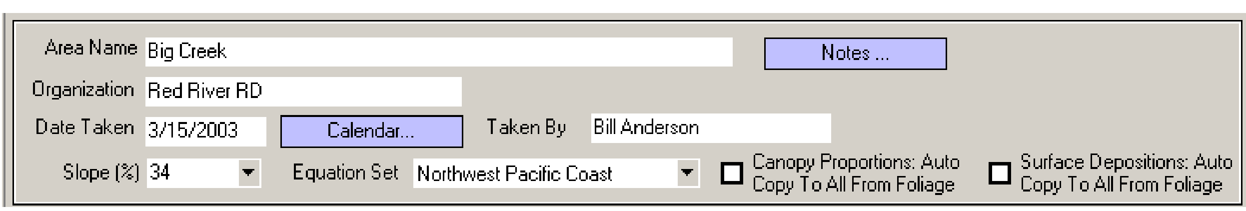
ApplicationID,Format_type,Format_Version,

The first three entries are: CM, STD and 03.01. These are keys to the CrownMass program indicating the formats of the rows that follow. For this version of CrowmMass, use these three entries as shown below:

```
CM,STD,03.01
```

Site Record Row

The site record contains the entries for the upper part of the CrownMass data entry screen.



The data file row that would produce entries shown in the screen above follows:

```
1,Big Creek,Red River RD,3/15/2003,34,Bill Anderson
```

Every import file must have one site record in the following format.

1,AreaName,Organization,Date,Slope%,TakenBy

Hot Tip

- Do not use commas in any field value itself (i.e. Big, Creek)
- Do not enclose text values in quotes (i.e. “Big Creek”)

Table 1 contains the definitions of the fields. Refer to later sections parts of this Users’ Guide where the all cells entries on the Analysis Area and Plot Tab are defined for a description of valid values and formats for the fields.

Table 1 – Site Record Row Field Descriptions

Field	Field ID	Field Description
1	1	Always enter a 1. This is a flag to CrownMass telling the program the format of the data that follows.
2	Area_Name	Area Name
3	Organization	Organization
4	Date_Taken	Date Taken The date must be in xx/yy/zzzz format.
5	% Slope	The average slope of the area entered as a percent.
6	Taken_By	Taken By

Site Record Row(s)

A site record row contains the entries for one sample tree on a plot.

	Plot ID	Tree No.	Dia	Species	Height	Crown Ratio	Trees Per Acre	Tree Struct. Stage	<----- Foliage	Fraction 1 Hr.	Remaining 10 Hr.	in Crown 100 Hr.	------> 1000 Hr.	Proportion Cut	<------ Foliage (Crowns)	Surface 1 Hr. (Crowns)	Deposition 10 Hr. (Crowns)	Remaining 100 Hr. (Crowns)	on the 1000 Hr. (Crowns)	Ground Boles Left Prop.	-----> Rotten Prop.
▶	1	1	16.3	Douglas-fir	47	0.85	2.760	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Each site record has the following format. Due to the page width of this document, the data file row is shown on two rows whereas in the ASCII import file, it would show on one row.

```
2,PlotID,TreeNo,Dia,Species,Height,CrownDia,CrownRatio,TreesPerAcre,TreeClass,TreeStrStge,FRF,
FR1h,FR10h,FR100h,FR1000h,PropCut,SDF,SD1h,SD10,SD100h,SD1000h,BolesPropLeft,PropRotten
```

Below is an example of a data row.

```
2,1,1,16.3,PSME,47,0,0.85,2.76,1,D,1.00,1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
```

If some tree species are selected, a column will appear for entry of the crown diameter. These species are Rocky Mountain Juniper, Utah Juniper, Western Juniper, Singleleaf Pinyon and Twoneedle Pinyon. Be sure to enter a non-zero value for the crown diameter for each data file row, which has one of these species.

Also, use of Tree Class to define the Tree Structural Stage and Fraction Remaining in Crown values is optional. If a Tree Class Scenario will not be used for this purpose, enter a 0 for Tree Class. See page 44 for information on Tree Class scenarios. Note that prior to import, the Tree Class Scenario needs to be defined in CrownMass (see the Assumptions Tab, Tree Class Scenario Manager button).

Table 2 contains a brief field description of each field. Detailed field descriptions and field entry value limitations are provided in the section of this document where the Analysis Area and Plots Tab are described.

Table 2 – Plot Record Row Field Descriptions

Field	Field ID	Field Description
1	2	Always enter a 2. This is a flag to CrownMass telling the program the format of the data that follows.
2	PlotID	This is the number of the plot
3	TreeNo	This is an identifier for the sample tree.
4	Dia	This is the diameter breast height (DBH) in inches.
5	Species	This is the FMA3 species code (see Table 3).
6	Height	This is the tree height in feet.
7	CrownDia	This entry is required only for the Juniper and Pinyon species. It is the crown width in feet.
8	CrownRatio	This is the decimal value attained by dividing the tree's crown length by the tree's height.
9	TreesPerAcre	This is the number of trees per acre.
10	TreeClass	This is a numeric descriptor that collectively defines the Tree Structural Stage and all of the Fraction Remaining in Crown parameters. See the section titled Tree Class Scenarios on the description of entries on the Assumptions Tab.
11	TreeStrStage	This is the Tree Structural Stage. The options are dominant (D), codominent (CD), intermediate (I) or suppressed (S).
12	FRF	This is the fraction remaining in the crown for foliage.
13	FR1h	This is the fraction remaining in the crown for 1-h timelag size class branchwood.
14	FR10h	This is the fraction remaining in the crown for 10-h timelag size class branchwood.
15	FR100h	This is the fraction remaining in the crown for 100-h timelag size class branchwood.
16	FR1000h	This is the fraction remaining in the crown for 1000-h timelag size class branchwood.
17	PropCut	This is the proportion of the trees represented by the sample tree that will be cut.
18	SDF	This is the fraction of the ground-deposited foliage fuel loading that will be remaining on the ground.
19	SD1h	This is the fraction of the ground-deposited 1-h timelag size class fuel loading that will be remaining on the ground. This entry includes loading in this size class from branchwood and the unmerchantible tip.
20	SD10h	This is the fraction of the ground-deposited 10-h timelag size class fuel loading that will be remaining on the ground. This entry includes loading in this size class from branchwood and the unmerchantable tip.
21	SD100h	This is the fraction of the ground-deposited 100-h timelag size class fuel loading that will be remaining on the ground. This entry includes loading in this size class from branchwood and the unmerchantable tip.

Table 2 – Plot Record Row Field Descriptions

Field	Field ID	Field Description
22	SD1000h	This is the fraction of the ground-deposited 1000-h timelag size class fuel loading that will be remaining on the ground. This entry includes loading in this size class from branchwood and the unmerchantable tip.
23	BolesPropLeft	The boles of merchantable trees are assumed to be taken from the site. This entry is the proportion of these boles that will remain on site.
24	PropRotten	This is the proportion of the boles remaining on site that are rotten.

Hot Tip

A field that is blank or has null data is represented as such: 1,,3.
In the example, the second field has no data.

In CrownMass, the species symbols used are based on the plant scientific name. This symbol for a plant was obtained from the Internet (http://plants.usda.gov/). The FMA 3 and the FMA2 symbols for trees are listed in Table 3.

Table 3 – List of Species Symbols

FMA3 Species Symbol	FMA2 Species Symbol	Species Name	Genus	Species
ALRU2	ALD	Alder, Red	Alnus	rubra
ALRH2		Alder, White	Alnus	rhombifolia
FRLA	OA	Ash, Oregon	Fraxinua	latifolia
POTR5	QA	Aspen, Quaking	Populus	tremuloides
FAGR	ABE	Beech, American	Fagus	grandifolia
BEPA	PAB	Birch, Paper	Betula	papyrifera
BEPAC		Birch, Western Paper	Betula	papyrifera
BEAL2		Birch, Yellow	Betula	alleghaniensis
CHNO		Cedar, Alaska (Yellow)	Chamaecyparis	nootkatensis
THOC2	NWC	Cedar, Northern White	Thuja	occidentalis
CHLA	POC	Cedar, Port Orford	Chamaecyparis	lawsoniana
THPL	WC	Cedar, Western Red	Thuja	plicata
PREM		Cherry, Bitter	Prunus	emarginata
PRSE	BCH	Cherry, Black	Prunus	serotina
CACH6	CKP	Chinquapin, Giant	Castanopsis	chrysophylla
POBA	BC	Cottonwood, Black	Populus	balsamifera
CONU4		Dogwood, Pacific	Cornus	nuttallii
PSME	DF	Douglas-fir (East)	Pseudotsuga	menziesii
PSME	DF	Douglas-fir (West)	Pseudotsuga	menziesii

Table 3 – List of Species Symbols

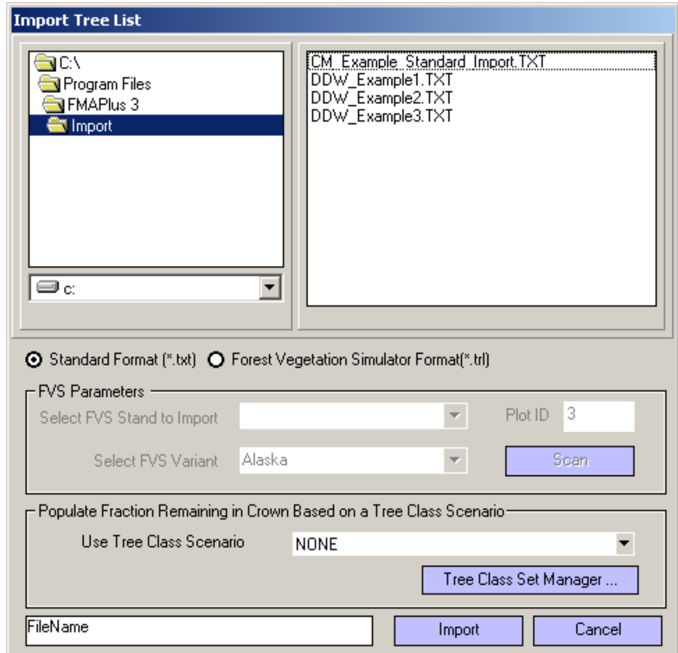
FMA3 Species Symbol	FMA2 Species Symbol	Species Name	Genus	Species
ABBA	BAF	Fir, Balsam	Abies	balsamea
ABMA		Fir, California Red	Abies	magnifica
ABLAA		Fir, Corkbark	Abies	lasiocarpa var. arizonica
ABGR	GF	Fir, Grand	Abies	grandis
ABPR	NF	Fir, Noble	Abies	procera
ABAM	PSF	Fir, Pacific Silver	Abies	amabilis
ABSH	SRF	Fir, Shasta Red	Abies	shastensis
ABLA	AF	Fir, Subalpine	Abies	lasiocarpa
ABCO	WF	Fir, White	Abies	concolor
HWAK		Hardwoods (Alaska)	Hardwood	sp.
CRXX		Hawthorn	Crataegus	sp.
TSCA	EHL	Hemlock, Eastern	Tsuga	canadensis
TSME	MTH	Hemlock, Mountain	Tsuga	mertensiana
TSHE	WH	Hemlock, Western	Tsuga	heterophylla
CAXX	HIC	Hickory	Carya	sp.
CADE27	IC	Incense cedar	Calocedrus	decurrens
JUSC2		Juniper, Rocky Mtn.	Juniperus	scopulorum
JUOS		Juniper, Utah	Juniperus	osteosperma
JUOC		Juniper, Western	Juniperus	monosperma
LALA		Larch, Eastern	Larix	laricina
LALA		Larch, Eastern	Larix	laricina
LALY	SL	Larch, Subalpine	Larix	lyallii
LAOC	WL	Larch, Western	Larix	occidentalis
ARME	MDN	Madrone, Pacific	Artutus	menziesii
ACMA3	MPL	Maple, Bigleaf	Acer	macrophyllum
ACNI5		Maple, Black	Acer	nigrum
ACRU	REM	Maple, Red	Acer	rubrum
ACCI		Maple, Vine	Acer	circinatum
QUXX	OAK	Oak	Quercus	sp.
QUKE		Oak, Black	Quercus	velutina
QURU	REO	Oak, Northern Red	Quercus	rubra
QUGA4	OWO	Oak, Oregon White	Quercus	garryana
QUAL	WHO	Oak, White	Quercus	alba
PIAR		Pine, Bristlecone	Pinus	aristata
PIST	EWP	Pine, Eastern White	Pinus	strobus
PIBA2	JKP	Pine, Jack	Pinus	banksiana
PIJE	JP	Pine, Jeffery	Pinus	jeffreyi
PIAT	KCP	Pine, Knobcone	Pinus	attenuata
PIFL2		Pine, Limber	Pinus	flexilis

Table 3 – List of Species Symbols

FMA3 Species Symbol	FMA2 Species Symbol	Species Name	Genus	Species
PICO	LP	Pine, Lodgepole	Pinus	contorta
PIRI	PIP	Pine, Pitch	Pinus	rigida
PIPO	PP	Pine, Ponderosa	Pinus	ponderosa
PIRE	REP	Pine, Red	Pinus	resinosa
PIST3		Pine, Southwestern White	Pinus	strobiformis
PILA	SP	Pine, Sugar	Pinus	lambertiana
PIMO3	WP	Pine, Western White	Pinus	monticola
PIAL	WBP	Pine, Whitebark	Pinus	albicaulus
PIMO		Pinyon, Singleleaf	Pinus	monophylla
PIED		Pinyon, Twoneedle	Pinus	edulis
LITU	YPO	Poplar, Yellow	Liriodendron	tulipifera
SESE3		Redwood, Coast	Sequoia	sempervirens
SEGI2		Sequoia, Giant	Sequoia	gigantea
PIMA	BLS	Spruce, Black	Picea	mariana
PIPU		Spruce, Blue	Picea	pungens
PIEN	ES	Spruce, Engelmann	Picea	engelmannii
PIRU	RES	Spruce, Red	Picea	rubens
PISI	SS	Spruce, Sitka	Picea	sitchensis
PIGL	WHS	Spruce, White	Picea	glauca
LIDE3	TAN	Tanoak	Lithocarpus	densiflorus
SALUX		Willow, Pacific	Salix	lasiandra
TABR2		Yew, Pacific	Taxus	brevifolia

Importing a ASCII Standard Import Format File

To prepare CrownMass to import an ASCII file in the standard import format, select the **File => New CrownMass** menu item. Provide a name for the new inventory data file and click on the **Save** Button.



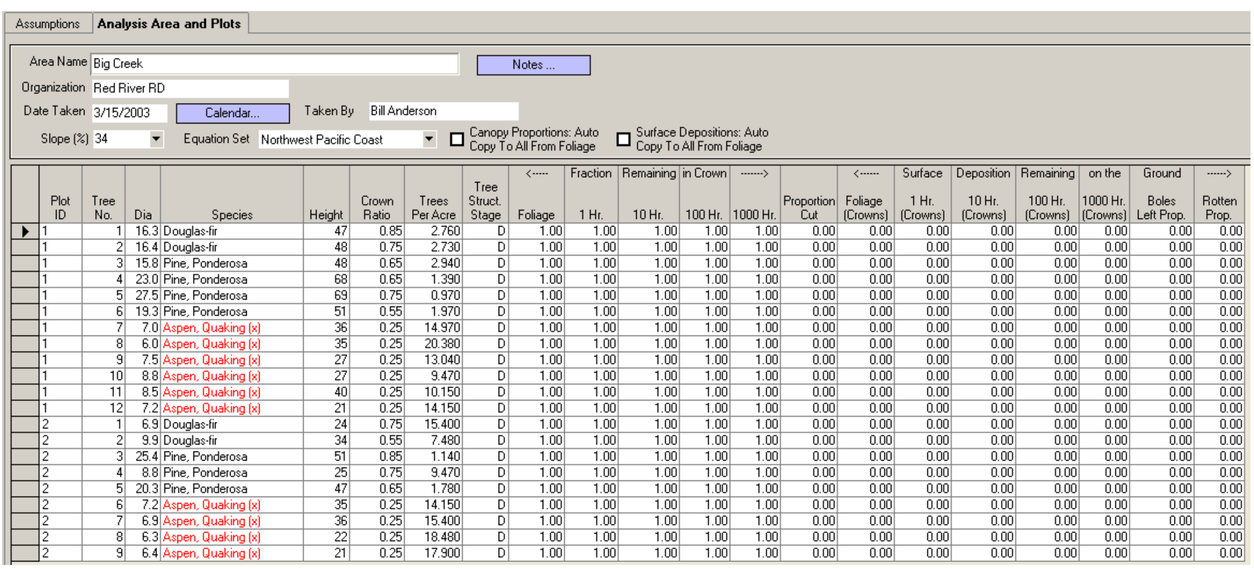
To import the ASCII file in the standard import formatted, select the **File => Import** menu item. The dialog at the right will appear. The default folder for the location of ASCII format import files is the Import folder in the folder where FMAPlus is installed.

Click on the **Standard Format** radio button. By default, this button will be selected when the dialog opens.

Populate Fraction Remaining in Crown Based on a Tree List Scenario Section

If a Tree Class Scenario has been defined that will be used in this import, use the pulldown to select it. For more information on a Tree Class Scenario, see the section titled Tree Class Scenarios on the description of entries on the Assumptions Tab.

Click on the **Import** button. For the ASCII file titled CM_Example_Standard_Import.TXT, the Analysis Area and Assumptions screen will appear as shown below.



								<-----	Fraction	Remaining	in Crown	------->		<------	Surface	Deposition	Remaining	on the	Ground	------>
Plot ID	Tree No.	Dia	Species	Height	Crown Ratio	Trees Per Acre	Tree Struct. Stage	Foliage	1 Hr.	10 Hr.	100 Hr.	1000 Hr.	Proportion Cut	Foliage (Crowns)	1 Hr. (Crowns)	10 Hr. (Crowns)	100 Hr. (Crowns)	1000 Hr. (Crowns)	Boles Left Prop.	Rotten Prop.
1	1	16.3	Douglas-fir	47	0.85	2.760	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	16.4	Douglas-fir	48	0.75	2.730	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	15.8	Pine, Ponderosa	48	0.65	2.940	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	4	23.0	Pine, Ponderosa	68	0.65	1.390	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5	27.5	Pine, Ponderosa	69	0.75	0.970	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	6	19.3	Pine, Ponderosa	51	0.55	1.970	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	7	7.0	Aspen, Quaking (x)	36	0.25	14.970	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	8	6.0	Aspen, Quaking (x)	35	0.25	20.380	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	9	7.5	Aspen, Quaking (x)	27	0.25	13.040	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	10	8.8	Aspen, Quaking (x)	27	0.25	9.470	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	11	8.5	Aspen, Quaking (x)	40	0.25	10.150	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	12	7.2	Aspen, Quaking (x)	21	0.25	14.150	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	6.9	Douglas-fir	24	0.75	15.400	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	9.9	Douglas-fir	34	0.55	7.480	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	3	25.4	Pine, Ponderosa	51	0.85	1.140	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	4	8.8	Pine, Ponderosa	25	0.75	9.470	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5	20.3	Pine, Ponderosa	47	0.65	1.780	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	6	7.2	Aspen, Quaking (x)	35	0.25	14.150	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	7	6.9	Aspen, Quaking (x)	36	0.25	15.400	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	8	6.3	Aspen, Quaking (x)	22	0.25	18.480	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9	6.4	Aspen, Quaking (x)	21	0.25	17.900	D	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Forest Vegetation Simulator Format

The Forest Vegetation Simulator (FVS) (Beukema et. al. 1999) is a popular method used to simulate stand conditions based on modeling and disturbance assumptions. This program has a ASC II output format called a tree list. The file names for these files have a *.trl extension. Below is an example of this report for a stand.

```
0         FOREST VEGETATION SIMULATOR     VERSION 6.31 -- CENTRAL ROCKIES SW MIXED CONIFERS GENGYRV:01.11.2000  01-26-2000  17:03:34

COMPLETE TREE LIST -- STAND: 521.004                         MGMTID: NONE   END CYCLE:  0  CYCLE LENGTH: 10 YRS  YEAR: 1999   PAGE:  1
    1       2   3  4  5  6  7      8          9        10    11    12    13  14  15  16    17      18     19      20      21    22 23 24
  TREE    TREE SP SP TR SS PNT   TREES     MORTAL    CURR  DIAM  CURR   HT      MAX         BA    POINT TOT CU MCH CU  MCH BD MC BF TRC
 NUMBER   INDX CD NO CL CD NUM PER ACRE  PER ACRE    DIAM  INCR   HT   INCR CR  CW   MS %-TILE   BAL  FT VOL FT VOL  FT VOL DF DF  HT
--------  ---- -- -- -- -- --- --------  --------   ----- ----- ----- ---- -- ---- -- ------ ----- ------ ------ ------- -- -- ---
    2004     5 DF  3  1  0   2    2.760     0.000  16.3  1.40  47.0  0.0 85 27.3  0  71.43     0   32.6   26.7   140.0  0  0   0
    5003    15 DF  3  2  0   4    2.726     0.000  16.4  1.40  48.0  0.0 75 27.4  0  76.19     0   33.7   29.2   140.0  0  0   0
    5005    17 DF  3  1  0   4   15.404     0.000   6.9  1.40  24.0  0.0 75 13.9  0  23.81   120    3.1    2.0     0.0  0  0   0
    5008    20 DF  3  1  0   4    7.482     0.000   9.9  0.00  34.0  0.0 55 18.5  0  61.91    20    8.8    6.8    30.0  0  0   0
    1001     1 PP 13  2  0   1    1.136     0.000  25.4  1.20  51.0  0.0 85 35.7  0  95.24     0   74.2   64.7   350.0  0  0   0
    3001     7 PP 13  3  0   3    9.470     0.000   8.8  0.80  25.0  0.0 75 14.2  0  57.15   100    5.4    3.4    10.2  0  0  20
    3002     8 PP 13  1  0   3    1.780     0.000  20.3  1.10  47.0  0.0 65 29.4  0  85.72    40   47.8   40.6   220.0  0  0   0
    3003     9 PP 13  1  0   3    2.938     0.000  15.8  0.00  48.0  0.0 65 23.7  0  66.67    80   31.9   27.3   140.0  0  0   0
    3004    10 PP 13  1  0   3    1.386     0.000  23.0  0.00  68.0  0.0 65 32.7  0  90.48    20   84.5   76.7   420.0  0  0   0
    3005    11 PP 13  2  0   3    0.970     0.000  27.5  0.00  69.0  0.0 75 38.3  0 100.00     0  113.0  102.4   590.0  0  0   0
    3006    12 PP 13  2  0   3    1.968     0.000  19.3  0.00  51.0  0.0 55 28.1  0  80.95    60   47.7   40.9   210.0  0  0   0
    2001     2 AS 20  2  0   2   14.968     0.000   7.0  0.70  36.0  0.0 25 12.6  0  28.57    40    4.8    3.8    10.0  0  0   0
    2002     3 AS 20  2  0   2   20.380     0.000   6.0  0.00  35.0  0.0 25 11.0  0   4.76    80    3.4    2.3     0.0  0  0   0
    2003     4 AS 20  2  0   2   14.148     0.000   7.2  0.00  35.0  0.0 25 12.9  0  33.34    20    4.9    3.8    10.0  0  0   0
    2005     6 AS 20  2  0   2   15.404     0.000   6.9  0.00  36.0  0.0 25 12.4  0  19.05    60    4.6    3.8     0.0  0  0   0
    5001    13 AS 20  2  0   4   18.478     0.000   6.3  0.00  22.0  0.0 25 11.4  0   9.53   160    2.3    1.3     0.0  0  0   0
    5002    14 AS 20  2  0   4   17.904     0.000   6.4  0.00  21.0  0.0 25 11.6  0  14.29   140    2.3    1.7     0.0  0  0   0
    5004    16 AS 20  2  0   4   13.038     0.000   7.5  0.00  27.0  0.0 25 13.4  0  42.86    80    4.1    2.8    10.0  0  0   0
    5006    18 AS 20  2  0   4    9.470     0.000   8.8  0.00  27.0  0.0 25 15.4  0  52.39    40    5.6    4.5    10.0  0  0   0
    5007    19 AS 20  2  0   4   10.150     0.000   8.5  0.00  40.0  0.0 25 14.9  0  47.62    60    7.8    6.4    20.0  0  0   0
    5009    21 AS 20  1  0   4   14.148     0.000   7.2  0.00  21.0  0.0 25 12.9  0  38.10   100    2.9    1.7     0.0  0  0   0
```

FVS Program Variants

There are many variants of the FVS program in use. These variants allow for the use in local areas of specific modeling processes that apply to the local area.

Within a variant, tree species codes are specific to that variant. These tree species code are in a two-letter code and hence CrownMass needs to convert this code to the tree codes (Table 3) used in CrownMass. Table 4 contains a list of FVS variants where a conversion utility exists in CrownMass to make this tree species conversion.

Table 4 – FVS Variants Supported in CrownMass

Variant	Abbreviation
Alaska	AK
Blue Mountains	BM
Central Idaho	CI
East Cascades	EC
East Montana	EM
Klamath Mountains	KM
Northern Idaho	NI
Pacific Northwest	PNW
Rocky Mountains	RM
Southern OR and Northeast CA	OR/CA
Tetons	T
Utah	U
Western Cascades	WC
Western Sierra Nevada	WSN

Table 5 contains the trees species in each FVS variant, the tree species code in each FVS variant and the associated tree species code used in CrownMass. The last column in Table 5 is called STD (Standard) and represents a generic set of species codes that could be used for variants not supported. To use the Standard format, the user will need to assume that the species codes in the Tree List file agree with the Standard format tree codes making edits as necessary prior to import.

Table 5 – FVS Tree Species Codes

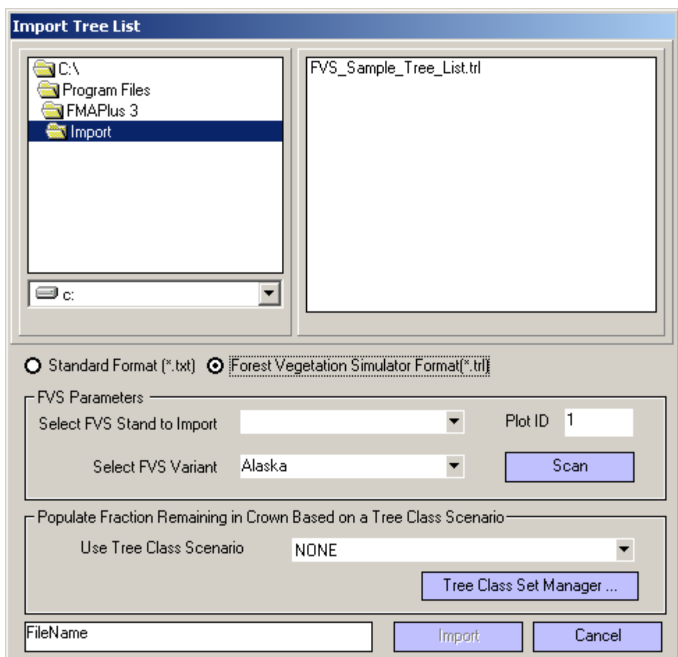
Tree Species	FMA3 Code	FVS Variant															
		BM	AK	CI	CRM	EC	EM	KM	K	NI	PNW	OR/ CA	T	U	WC	WSN	STD
Alder, Red	ALRU2										RA				RA		RA
Alder, White	ALRU2										WA				WA		
Ash, Oregon	FRLA																FL
Aspen, Quaking	POTR5			AS	AS						AS		AS	AS	AS		AS
Beech, American	FAGR																
Birch, Paper	BEPA																
Birch, Western Paper	BEPAC										PB				PB		
Birch, Yellow	BEAL2																
Cedar, Alaska yellow	CHNO										YC				YC		
Cedar, Northern White	THOC2																
Cedar, Port Orford	CHLA																PC
Cedar, Western Red	THPL		RC		RC	RC			C	C	RC				RC		C
Cherry, Bitter	PREM										BC				BC		
Cherry, Black	PRSE																
Chinquapin, Giant	CACH6										GC				GC		GC
Cottonwood, Black	POBA				CO						CO				CO		CW
Dogwood, Pacific	CONU4										DG				DG		
Douglas-fir	PSME	DF		DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF
Fir, Balsam	ABBA																BAF
Fir, California red	ABMA							RF				RF				RF	
Fir, Corkbark	ABLAA				CB												
Fir, Grand	ABGR	GF			GF	GF			GF	GF	GF				GF		GF
Fir, Noble	ABPR										NF				NF		NF
Fir, Pacific Silver	ABAM		SF			SF					SF				SF		SF
Fir, Shasta Red	ABSH										RF				RF		SH
Fir, Subalpine	ABLA	AF	AF	AF	AF	AF	AF		AF	AF	AF		AF	AF	AF		AF
Fir, White	ABCO			WF	WF			WF			WF	WF	WF	WF	WF	WF	WF
Hardwoods (Alaska)	HWAK		HD														
Hawthorn	CRXX										HW				HW		
Hemlock, Eastern	TSCA																
Hemlock, Mountain	TSME	MH	MH		MH						MH				MH		MH
Hemlock, Western	TSHE		WH						WH	WH	WH				WH		
Hickory	CAXX																
Incense cedar	CADE27							IC			IC	IC			IC	IC	IC
Juniper, Rocky Mtn.	JUSC2				JU												
Juniper, Utah	JUOS	OT															
Juniper, Western	JUOC										J			J	J		
Larch, Eastern	LALA																
Larch, Subalpine	LALY										LL				LL		LL
Larch, Western	LAOC	WL			WL	WL	L		L	L							L
Madrone, Pacific	ARME							M									M

Table 5 – FVS Tree Species Codes

Tree Species	FMA3 Code	FVS Variant															
		BM	AK	CI	CRM	EC	EM	KM	K	NI	PNW	OR/ CA	T	U	WC	WSN	STD
Maple, Bigleaf	ACMA3										BM				BM		BM
Maple, Black	ACNI5																
Maple, Red	ACRU																
Maple, Vine	ACCI																
Oak	QUXX				OA									OA			
Oak, Black	QUKE							BO								BO	
Oak, Northern Red	QURU																
Oak, Oregon White	QUGA4										WO				WO		WO
Oak, White	QUAL																
Pine, Bristlecone	PIAR				BC												
Pine, Eastern White	PIST																
Pine, Jack	PIBA2																
Pine, Jeffery	PIJE										JP				JP	JP	JP
Pine, Knobcone	PIAT										KP				KP		KP
Pine, Limber	PIFL2			LM	LM								LM	LM			
Pine, Lodgepole	PICO	LP	LP	LP	LP	LP	LP		LP	LP	LP	LP	LP	LP	LP		LP
Pine, Pinyon	PIED				PI									PI			
Pine, Pitch	PIRI																
Pine, Ponderosa	PIPO	PP		PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP
Pine, Red	PIRE																
Pine, Southwestern White	PIST3				WP												
Pine, Sugar	PILA							SP			SP	SP			SP	SP	SP
Pine, Western White	PIMO3	WP				WP			WP	WP	WP	WP			WP		
Pine, Whitebark	PIAL			WB	WB		WB				WB		WB	WB	WB		WB
Pinyon, Singleleaf	PIMO																
Poplar, Yellow	LITU																
Redwood, Coast	SESE3										RW				RW		
Sequoia, Giant	SEGI2															GS	
Spruce, Black	PIMA																
Spruce, Blue	PIPU				BS									BS			
Spruce, Engelmann	PIEN	ES		ES	ES	ES	S		S	S	ES	ES	ES	ES	ES		S
Spruce, Red	PIRU																
Spruce, Sitka	PISI		SS								SS						
Spruce, White	PIGL		WS		WS												
Tanoak	LIDE3							TO								TO	TO
Willow, Pacific	SALUX										WI				WI		
Yew, Pacific	TABR2										PY				PY		
Other (AK)	OTAK		OT														
Other (BM)	OTBM	OT															
Other (CI)	OTCI			OT													
Other (EC)	OTCA					OT											
Other (EM)	OTEM						OT										

Table 5 – FVS Tree Species Codes																	
Tree Species	**FMA3 Code**	**FVS Variant**															
		BM	AK	CI	CRM	EC	EM	KM	K	NI	PNW	OR/ CA	T	U	WC	WSN	STD
Other (NI)	OTNI										OT						
Other (OR/CA)	OTSCO																
Other (PNW)	OTPNW											OT					
Other (T)	OTTE															OC	
Other (U)	OTUT																
Other (WC)	OTWC																
Other Conifer (KM)	OTSKM							OC									OS
Other Conifers (WSN)	OTSWSN												OT				
Other Hardwoods (KM)	OTHKM							OH								OH	
Other Hardwoods (RM)	OTHRM				OH					OT							
Other Hardwoods (WSN)	OTHWSN													OT			
Other Softwoods (RM)	OTSRM				OS										OT		

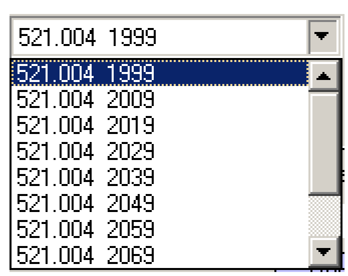
Importing a FVS Tree List File



To prepare CrownMass to import a FVS tree list, select the **File => New CrownMass** menu item. Provide a name for the new inventory data file and click on the **Save** Button.

To import the FVS tree list, select the **File => Import** menu item. The dialog at the right will appear. The default folder for the location of FVS tree list files is the Import folder in the folder where FMAPlus is installed.

Click on the **Forest Vegetation Simulator Format** radio button. Navigate as is necessary to the folder containing the FVS Tree List file desired for import. Select the tree list file desired from the list at the upper right part of the screen and then click on the **Scan** button.



Tree list files can contain more than one stand and for any stand, the expected plot tree data for many years into the future. Use the pulldown on the cell titled Select FVS Stand to Import to select the stand/year combination to import.

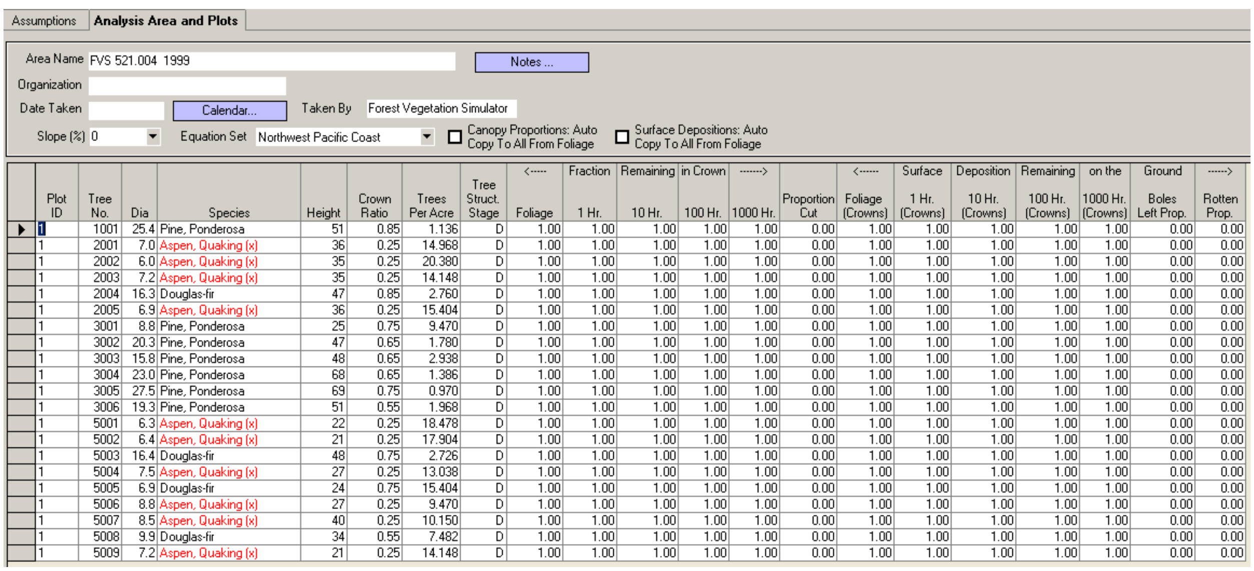
Next, use the pulldown on the cell titled Select FVS Variant to select variant.

Note that since a FVS tree list is a 100% inventory of a modeled "plot," all imported trees are placed in the same plot in CM. Note that the user can designate the Plot Number that the inventory data will be imported to.

If a Tree Class Scenario has been defined that will be used in this import, use the pulldown in the Populate Fraction Remaining in Crown Based on a Tree List Scenario Section to select it. For more information on a Tree Class Scenario, see the section titled Tree Class Scenarios on the description of entries on the Assumptions Tab.

To complete the import, click on the **Import** button. If no Tree Class Scenario is defined, CrownMass will display a dialog box alerting the user to verify that this is the desired situation. The program will next display a dialog box indicating CrownMass is ready to import the number of "records" in the tree list file. The number of records is the same as the number of trees in the tree list. To complete the import, click on the **Yes** button. If there are trees in the Analysis Area and Plots plot entry area prior to importing, the user will be alerted that the imported trees will be appended to the end of the existing tree listing.

For the FVS_tree list file titled FVS_Sample_Tree_List.TXT, the Analysis Area and Assumptions screen will appear as shown below for the stand 521.004 for year 1999. No Tree List Scenario was used in this example.



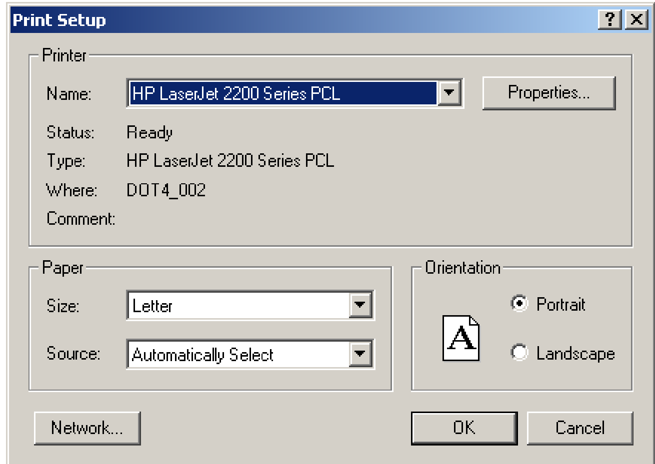
								<---- Fraction Remaining in Crown ---->						<---- Surface Deposition Remaining on the Ground ---->						
Plot ID	Tree No.	Dia	Species	Height	Crown Ratio	Trees Per Acre	Tree Struct. Stage	Foliage	1 Hr.	10 Hr.	100 Hr.	1000 Hr.	Proportion Cut	Foliage (Crowns)	1 Hr. (Crowns)	10 Hr. (Crowns)	100 Hr. (Crowns)	1000 Hr. (Crowns)	Boles Left Prop.	Rotten Prop.
1	1001	25.4	Pine, Ponderosa	51	0.85	1.136	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	2001	7.0	Aspen, Quaking (x)	36	0.25	14.968	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	2002	6.0	Aspen, Quaking (x)	35	0.25	20.380	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	2003	7.2	Aspen, Quaking (x)	35	0.25	14.148	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	2004	16.3	Douglas-fir	47	0.85	2.760	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	2005	6.9	Aspen, Quaking (x)	36	0.25	15.404	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3001	8.8	Pine, Ponderosa	25	0.75	9.470	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3002	20.3	Pine, Ponderosa	47	0.65	1.780	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3003	15.8	Pine, Ponderosa	48	0.65	2.938	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3004	23.0	Pine, Ponderosa	68	0.65	1.386	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3005	27.5	Pine, Ponderosa	69	0.75	0.970	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3006	19.3	Pine, Ponderosa	51	0.55	1.968	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5001	6.3	Aspen, Quaking (x)	22	0.25	18.478	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5002	6.4	Aspen, Quaking (x)	21	0.25	17.904	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5003	16.4	Douglas-fir	48	0.75	2.726	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5004	7.5	Aspen, Quaking (x)	27	0.25	13.038	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5005	6.9	Douglas-fir	24	0.75	15.404	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5006	8.8	Aspen, Quaking (x)	27	0.25	9.470	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5007	8.5	Aspen, Quaking (x)	40	0.25	10.150	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5008	9.9	Douglas-fir	34	0.55	7.482	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5009	7.2	Aspen, Quaking (x)	21	0.25	14.148	D	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00

Hot Tip

Note that placing all ASC II inventory files and FVS tree list files in the Import Folder in the directory where FMAPlus is installed allows the file to be located quickly.

Printer Setup

Selecting the Printer Setup option will display the Print Setup dialog box relative to the default printer defined for your computer.

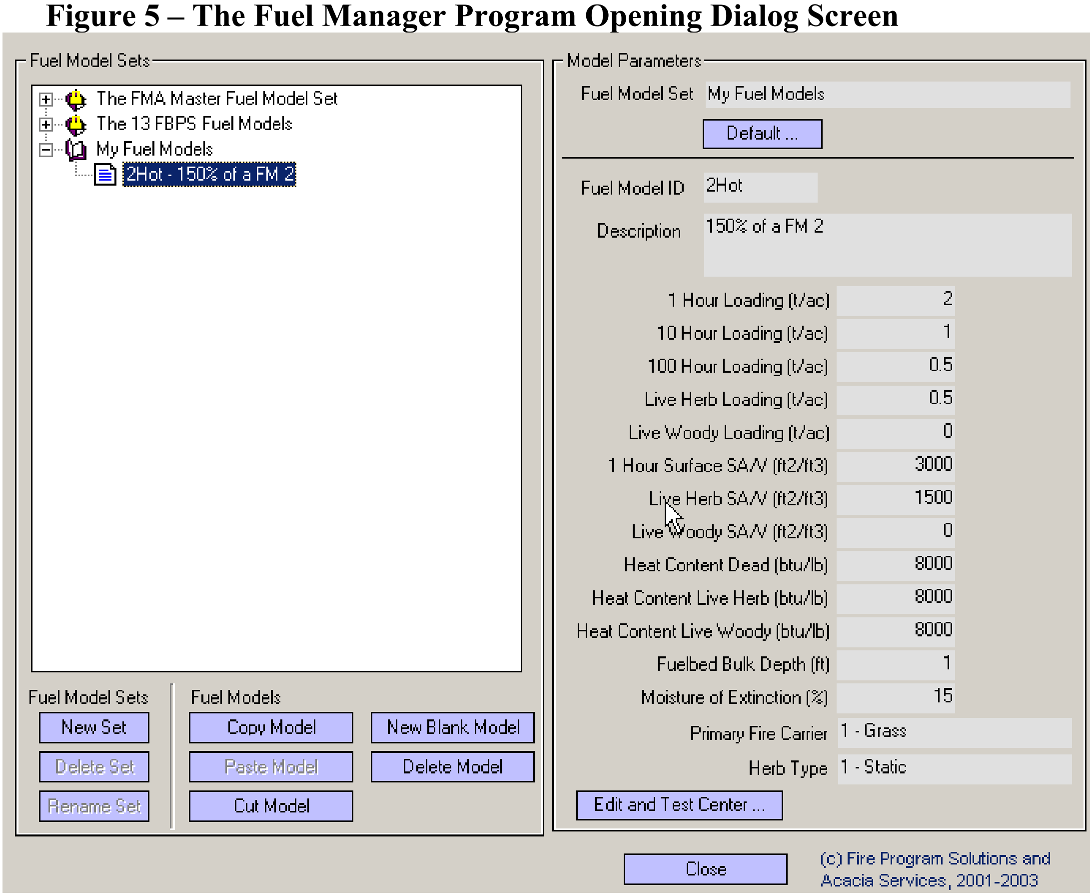


Change the Printer using the pull down to select a different printer. Set the printing properties using the Properties Button.

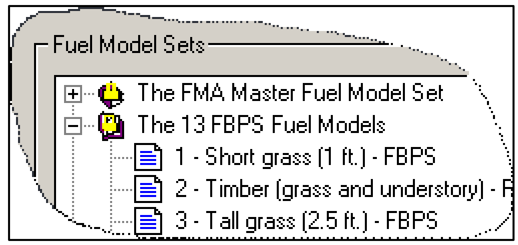
Manage Fuel Models

Clicking on this menu item will invoke the Fuel Model Manager (FMMgr) program. This program can be started via the CrownMass File menu or as a standalone application accessed via the Tools Tab in the Gateway program. The purpose of the FMMgr program is to facilitate the testing and saving of custom fuel models for later use within the Fire Behavior Assessment part of the CrownMass program. In Figure 5, the "active" fuel model, 2Hot, is a custom fuel model located in the user generated Fuel Model Set called My Fuel Models. Its parameters are shown on the right side of the screen.

Figure 5 – The Fuel Manager Program Opening Dialog Screen



Fuel Model Sets
A Fuel Model Set is a group of fuel models. CrownMass contains three groups: the FMA Master Fuel Model Set, the 1982 FBPS Fuel Models (13 models) (Anderson 1972, Albini 1976), the FBPS 2005 Fuel Models (40 models + the 13 models from the 1982 FBPS Fuel Model Set) (Scott and Burgan 2005) and My Fuel Models. The FMA Master Fuel Model Set contains 109 fuel models based on the 1982 FBPS Fuel Models (Rothermel 1972, Anderson 1972, Albini 1976). The core basis for these 109 fuel models are the FBPS fuel models 1-13. A detailed description of the fuel models in the FMA Master Fuel Model Set is contained in the section below titled The FMA Master Fuel Model Set. In addition, seven custom fuel models developed by researchers are included. Fuel models cannot be added to or deleted from this Fuel Model Set.



To access the fuel models in any Fuel Model Set, click on the + to the left of its name in the Fuel Model Sets windows.

To set a Fuel Model Set as the default, select it by clicking on the name in the Fuel Model Sets window followed by clicking on the **Default** button in the upper right part of the screen.

Custom Fuel Model Sets
Additional Fuel Model Sets can be generated by the user. Fuel models contained in the FMA Master Fuel Model Set, FBPS 1982 Fuel Models Set or the FBPS 2005 Fuel Model Set can be copied to a user generated Fuel Model Set like My Fuel Models.

The New Set Button
This button allows the user to create and name a new Fuel Model Set.

The Delete Set Button
This button allows the user to delete a user generated Fuel Model Set.

The Rename Set Button
This button allows the user to rename a user-generated Fuel Model Set.

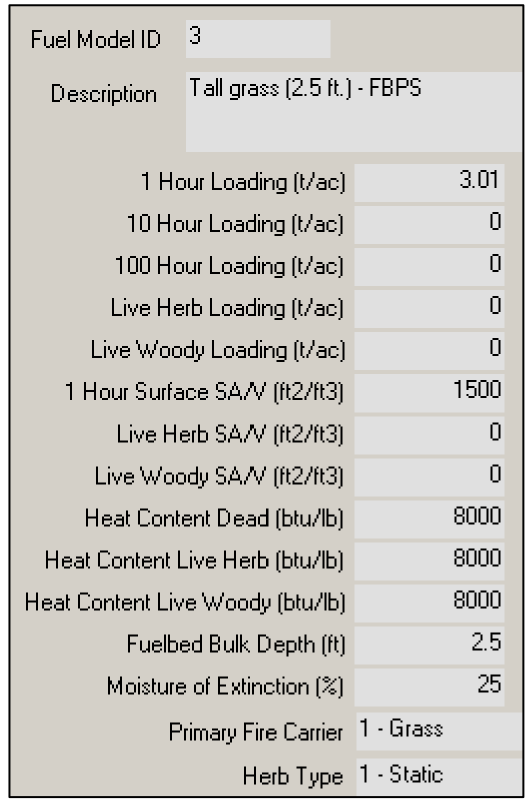
Hot Tip

Placing the cursor on a Fuel Model Set and performing a right mouse click yields a context menu, which the user can use to perform the same operations as the buttons.

Note that some operations are not available when a right mouse click is performed on a fuel model in the FMA Master Fuel Model Set.

Fuel Models

Fuel models within CrownMass are based on the FBPS fuel models (Rothermel 1972, Anderson 1972, Albini 1976). A description of the 109 fuel models provided in the FMA Master Fuel Model Set are contained in the section below titled The FMA Master Fuel Model Set. Highlighting the fuel model with a left mouse click will select the fuel model as the "active fuel model." The fuel model's parameters will be displayed on the right side of the main Fuel Manager screen.



The Copy Button

This button allows the user to copy a fuel model's parameters to the clipboard. To do this, first select the fuel model you wish to copy the parameters from by clicking on it with the left mouse button. This will cause the fuel model to be highlighted on the screen.

The Paste Button

This button allows the user to paste the fuel model parameters on the clipboard into a new custom fuel model, which will be located in a user custom Fuel Model Set. A screen will be displayed requesting the user to provide a fuel model identifier and fuel model description. Once entered, clicking of the **OK** button on this dialog will save the newly created fuel model into the selected custom Fuel Model Set with the name and description provided including the fuel model parameters from the clipboard.

The Cut Button

This button allows the user to remove a fuel model from a custom Fuel Model Set but that fuel model's parameters will be placed on the clipboard. The Cut function within CrownMass works the same way the Cut function works in Windows Explorer.

The New Blank Model Button

This button allows the user to create a new fuel model. Clicking on this button will temporarily create a new fuel model in the active custom Fuel Model Set with a fuel model identifier of New and a description of New Model. CrownMass will then open the Edit and Test Center in the Fuel Model Manager program, which will allow the user to enter fuel model parameters, and save the fuel model with a user specified identifier and description.

Delete Button

This button allows the user to delete a fuel model. Caution is needed in the use of this button, as the result is elimination of the fuel model from the Fuel Model Set permanently. The deleted fuel model does not end up in the Windows Recycle Bin as is the case with the Windows Explorer delete function.

<u>The FMA Master Fuel Model Set</u>

The FMA Master Fuel Model Set contains 109 derivative FBPS fuel models. These include 37 fuel models to represent grass, brush and timber litter and 72 to represent slash. The user cannot modify these 109 derivative FBPS fuel models. The specific fuel model parameters are contained in Appendix A - Parameters Defining Surface Fuel Models.

The Grass, Brush and Timber Litter Fuel Models (1982 FBPS Fuel Models 1-10)

The FBPS fuel models 1-10 are included but their identifiers have been changed to add the letter M following the letter. Hence a 1M designates the FBPS fuel model 1 and its descriptor is Short grass (1 ft.) - FBPS where the FBPS indicates that the fuel model is a standard Fire Behavior Prediction System fuel model.

1A	Short grass (1 ft.) - Low
1M	Short grass (1 ft.) - FBPS
1Z	Short grass (1 ft.) - High
2A	Timber (grass and understory) - Low
2M	Timber (grass and understory) - FBPS
2Z	Timber (grass and understory) - High
3A	Tall grass (2.5 ft.) - Low
3M	Tall grass (2.5 ft.) - FBPS
3Z	Tall grass (2.5 ft.) - High
4A	Chaparral - Low
4M	Chaparral -FBPS
4Z	Chaparral - High
5A	Brush - Low
5M	Brush - FBPS
5Z	Brush - High
6A	Dormant brush, hardwood slash - Low
6M	Dormant brush, hardwood slash - FBPS
6Z	Dormant brush, hardwood slash - High
7A	Southern rough - Low
7M	Southern rough - FBPS
7Z	Southern rough - High
8A	Closed timber litter - Low
8M	Closed timber litter - FBPS
8Z	Closed timber litter - High
9A	Hardwood (long-needle pine) litter - Low
9M	Hardwood (long-needle pine) litter - FBPS
9Z	Hardwood (long-needle pine) litter - High
10A	Timber (litter and understory) - Low
10B	Timber (litter and understory) - FBPS
10C	Timber (litter and understory) - High

Low Derivatives of the 1982 FBPS Fuel Models 1-10

For each FBPS fuel model, a “small” version was developed by reducing the fuel loading in each category by 30% and by reducing the fuelbed bulk depth by 30%. The consistent reduction in depth and loading maintains the fuelbed bulk density and characteristic (average) surface area to volume ratio for the fuelbed. The “low” derivative fuel models are designated with the letter A following the standard fuel model number. For example, a 1A is the low loading version of a 1982 FBPS fuel model 1.

High Derivatives of the 1982 FBPS Fuel Models 1-10

For each 1982 FBPS fuel model, a “high” version was developed by increasing the fuel loading in each category by 30% and by increasing the fuelbed bulk depth by 30%. The “high” derivative fuel models are designated with the letter Z following the standard fuel model number. For example, a 1Z is the high loading version of a 1982 FBPS fuel model 1.

South California and Southeastern Custom Shrub Models

Seven custom fuel models developed to represent Southern California and Southeastern brush fuel type are included. They have fuel models numbers 15 - 21.

15	DBR High Pocosin
16	DBR Low Pocosin
17	Manzanita
18	Chamise 1
19	Ceanothus
20	Chamise 2
21	Sagebrush/buckwheat

1982 FBPS Slash Fuel Models 11-13

For each FBPS slash fuel model, a gradation of fuel models is available with total fuel loading increments of 2-3 tons per acre, each having 3 fuelbed depths.

Derivative Slash Fuel Models Based on Fuel Loading

The three 1982 FBPS slash fuel models 11, 12 and 13 have a total fuel loading of 11.5, 34.5 and 58.1 tons per acre respectively. CrownMass has 24 slash fuel models with total fuel ranging from 2.00 to 66.00 tons per acre.

Model ID and Description	Loading
11AB Light slash - Low-A-Avg Depth	2.00
11BB Light slash - Low-B-Avg Depth	4.00
11CB Light slash - Low-C-Avg Depth	6.50
11DB Light slash - FBPS-D-Avg Depth	9.00
11MB Light slash - FBPS-M-Avg Depth	11.52
11XB Light slash - FBPS-X-Avg Depth	14.00
11YB Light slash - High-Y-Avg Depth	17.00
11ZB Light slash - High-Z-Avg Depth	20.00
12AB Medium slash - Low-A-Avg Depth	23.00
12BB Medium slash - Low-B-Avg Depth	26.00
12CB Medium slash - Low-C-Avg Depth	29.00
12DB Medium slash - FBPS-D-Avg Depth	32.00
12MB Medium slash - FBPS-M-Avg Depth	34.56
12XB Medium slash - FBPS-X-Avg Depth	37.00
12YB Medium slash - High-Y-Avg Depth	40.00
12ZB Medium slash - High-Z-Avg Depth	43.00
13AB Heavy slash - Low-A-Avg Depth	46.00
13BB Heavy slash - Low-B-Avg Depth	49.00
13CB Heavy slash - Low-C-Avg Depth	52.00
13DB Heavy slash - FBPS-D-Avg Depth	55.00
13MB Heavy slash - FBPS-M-Avg Depth	58.11
13XB Heavy slash - FBPS-X-Avg Depth	61.00
13YB Heavy slash - High-Y-Avg Depth	64.00
13ZB Heavy slash - High-Z-Avg Depth	66.00

The 1982 FBPS slash fuel models 11-13 are included but their identifiers have been changed to add the letter M following the number. Hence an 11MB designates the FBPS fuel model 11 and its descriptor is Light slash - FBPS-M-Avg Depth where the FBPS indicates that the fuel model is a standard Fire Behavior Prediction System fuel model. The letters A-D and X-Z indicate different fuel models based on fuel loading changes. The fuel loading is changed in a manner that preserves the characteristic (average) surface area to volume ratio for the fuelbed. The second letter indicates the fuelbed depth assigned to the fuel model. The letter B indicates a depth assignment, which results in a fuel bed bulk density similar to the fuel bed bulk density in the parent FBPS slash fuel model.

Derivative Slash Models Based on Fuelbed Depth

For each derivative slash fuel model developed based on fuel loading, a "low depth" version was developed by reducing the fuelbed bulk depth by 30%. The "low depth" derivative fuel models are designated by the second letter in the fuel model identifier. The "low depth" derivative fuel models have an "A" in this spot. For example, 11MA is the "low depth" fuel model where the 11MB has the average depth that preserves a bulk density similar to the bulk density in a slash fuel model 11.

Model ID and Description	Loading	Depth
11AA Light slash - Low-A-Low Depth	2.00	0.12
11AB Light slash - Low-A-Avg Depth	2.00	0.17
11AC Light slash - Low-A-High Depth	2.00	0.23
11BA Light slash - Low-B-Low Depth	4.00	0.24
11BB Light slash - Low-B-Avg Depth	4.00	0.35
11BC Light slash - Low-B-High Depth	4.00	0.45
11CA Light slash - Low-C-Low Depth	6.50	0.39
11CB Light slash - Low-C-Avg Depth	6.50	0.56
11CC Light slash - Low-C-High Depth	6.50	0.73
11DA Light slash - FBPS-D-Low Depth	9.00	0.55
11DB Light slash - FBPS-D-Avg Depth	9.00	0.78
11DC Light slash - FBPS-D-High Depth	9.00	1.02
11MA Light slash - FBPS-M-Low Depth	11.52	0.70
11MB Light slash - FBPS-M-Avg Depth	11.52	1.00
11MC Light slash - FBPS-M-High Depth	11.52	1.30
11XA Light slash - FBPS-X-Low Depth	14.00	0.85
11XB Light slash - FBPS-X-Avg Depth	14.00	1.22
11XC Light slash - FBPS-X-High Depth	14.00	1.58
11YA Light slash - High-Y-Low Depth	17.00	1.03
11YB Light slash - High-Y-Avg Depth	17.00	1.48
11YC Light slash - High-Y-High Depth	17.00	1.92
11ZA Light slash - High-Z-Low Depth	20.00	1.22
11ZB Light slash - High-Z-Avg Depth	20.00	1.74
11ZC Light slash - High-Z-High Depth	20.00	2.26

For each slash fuel model, a "high depth" version was also developed by increasing the fuelbed bulk depth by 30%. The "high depth" derivative fuel models are designated by the second letter in the fuel model identifier. The "high depth" derivative fuel models have a "C" in this spot. The figure at the right show all 24 derivative slash fuel models developed based on fuel loading and fuelbed depth changes to a 1982 FBPS fuel model 11. See Appendix A for all fuel model parameters.

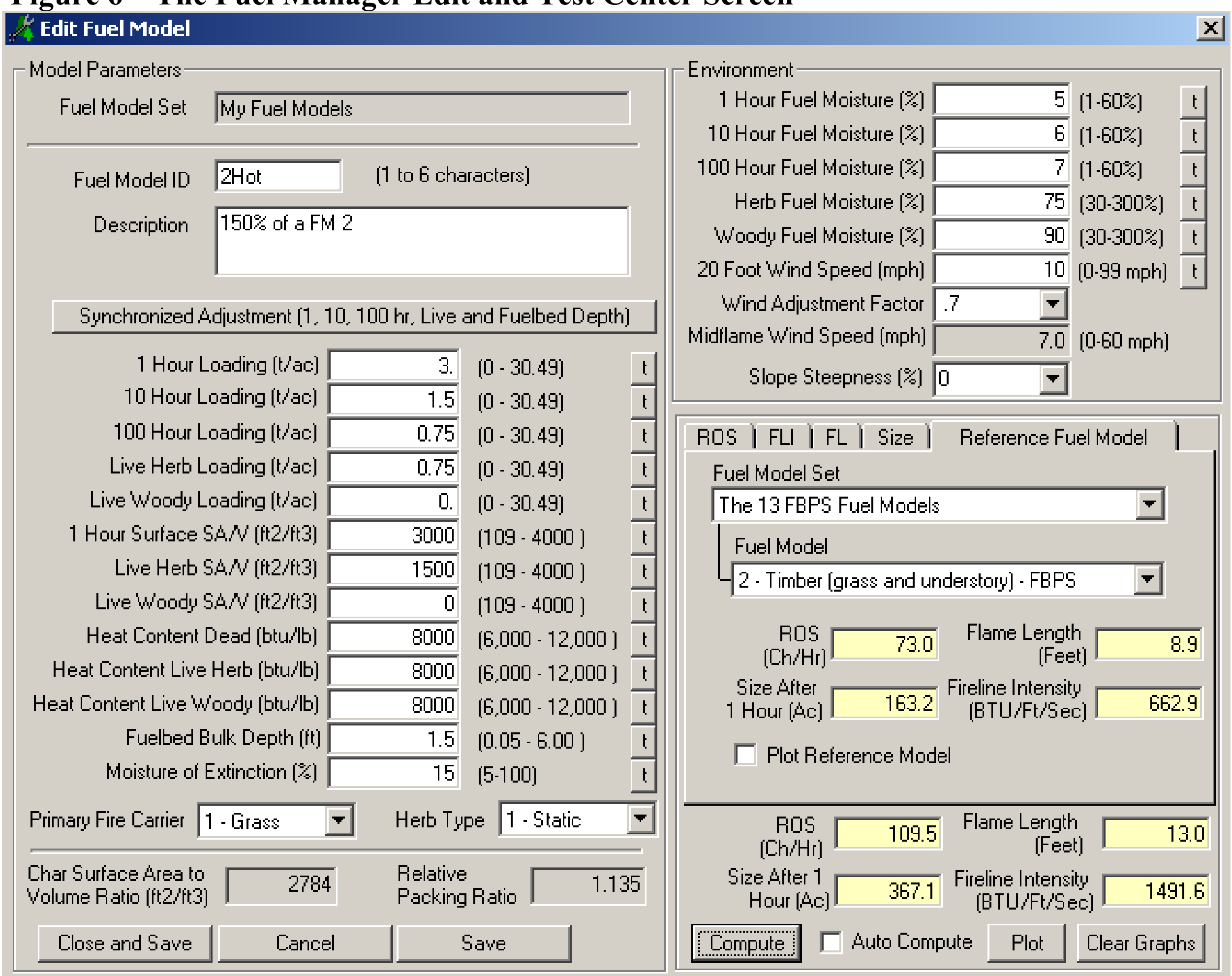
The Edit and Test Center

Clicking on the Edit and Test Center Button will open a screen similar to the example shown in Figure 7 below. Within the Edit and Test Center, the user can edit and save custom fuel models. If the user has previously developed a custom fuel model, this is the place where the fuel model can be saved in a user generated Fuel Model Set, like My Fuel Models, and used in fire behavior assessments within CrownMass.

Once a fuel model's parameters have been defined, the user can calculate the surface rate of spread, the fireline intensity, the flame length and the heat per unit area based on user defined environmental conditions. This feature supports the testing of fuel models and aids in the development of custom fuel models. The Edit and Test Center screen has a field for Model Parameters, for specifying the environmental parameters for the calculation of fire behavior and an outputs display section (lower right part of the screen).

This screen must be closed before the Fuel Model Manager main screen can be accessed again.

Figure 6 – The Fuel Manager Edit and Test Center Screen



Fuel Model Parameters

The parameters for each fuel model are defined in this section. The acceptable range of inputs is shown by each parameter in English and Metric units.

1-h fuel loading (0 - 30.49 tons/ac) (0.0 - 68.35 tonne/ac)

The one-hour (1-h) timelag dead fuel category includes fuels from 0 to 0.25 inches (0.64 cm) in diameter. This includes needles, leaves, cured herbaceous plants and fine dead stems of plants.

10-h fuel loading (0 - 30.49 tons/ac) (0.0 - 68.35 tonne/ac)

The ten-hour (10-h) timelag dead fuel category includes fuels from 0.26 to 1.00 inch (0.64 to 2.54 cm) in diameter.

100-h fuel loading (0 - 30.49 tons/ac) (0.0 - 68.35 tonne/ac)

The hundred-hour (100-h) timelag fuel category includes fuels from 1.1 to 3.0 inches (2.54 to 7.62 cm) in diameter.

Live herbaceous fuel loading (0 - 30.49 tons/ac) (0.0 - 68.35 tonne/ac)

Live herbaceous fuels are grasses and forbs that are living. Herbaceous fuels can be either annual or perennial.

Live woody fuel loading (0 - 30.49 tons/ac) (0.0 - 68.35 tonne/ac)

Live woody fuels are shrubs that are living.

1-h surface area to volume ratio (109 - 4000 ft^2/ft^3) (358-13,123 m^2/m^3)

The 1-h surface-area-to-volume ratio (1-h SA/V) is the amount of area on the outside of the fuel (surface area) divided by the volume of the fuel. A way to visualize the surface-area-to-volume ratio is to imagine the square feet of wrapping paper in would take to wrap a box divided by the volume of the box in cubic feet. The 10-h and 100-h SA/V are set at 109 ft^2/ft^3 (358 m^2/m^3) and 30 ft^2/ft^3 (98 m^2/m^3) for all fire behavior fuel models.

Live herbaceous surface area to volume ratio (109 - 4000 ft^2/ft^3) (358-13,123 m^2/m^3)

This is the total surface area of a herbaceous plant leaf divided by the volume occupied by the plant leaf. Live herbaceous fuels frequently have surface-area-to-volume ratios from 1500 to 3500 (ft^2/ft^3) (4921 to 11,483 m^2/m^3). Some course grass and some conifer needles have a 1-h SA/V of 500 to 1,500 square feet per cubic foot (1640 to 4921 m^2/m^3). Average grasses, broadleaf tree leaves and most conifer needles have a 1-h SA/V of 1,500 to 2,500 square feet per cubic foot (4921 to 8202 m^2/m^3). Fine grasses, most broadleaf tree leaves and some conifer needles have 1-h SA/V of 2,500+ square feet per cubic foot (8202 m^2/m^3).

Live woody surface area to volume ratio (109 - 4000 ft^2/ft^3) (358-13,123 m^2/m^3)

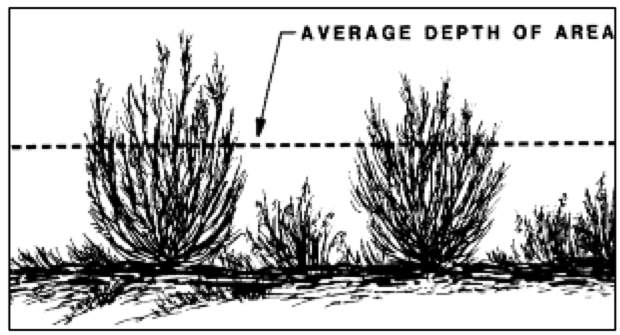
This is the total surface area of a woody plant leaf divided by the volume occupied by the plant leaf. Woody fuels frequently have surface-area-to-volume ratios from 1000 to 2000 ft^2/ft^3 (3281 to 6562 m^2/m^3).

Dead fuel moisture of extinction (5 - 100%)
This is the maximum moisture content of the dead fuels that a predictable steady state rate of fire spread is attainable. If the dead fuel moisture is greater than this value, a predictable steady state rate of fire spread cannot be predicted. Note that although the fire may continue to smolder and spread, its rate cannot be predicted by the spread model.

Dead fuel heat content (6,000 - 12,000 Btu/lb) (13,967-27,934kJ/kg)
This is the amount of heat energy contained in a unit of fuel. The heat content for the 13 FBPS 1982 Fuel Models is 8000 BTUs per pound of fuel (18,622 kJoules/kg).

Herb and Woody fuel heat content (6,000 - 12,000 Btu/lb) (13,967-27,934kJ/kg)
This is the amount of heat energy contained in a unit of fuel. The heat content for the live fuels in the 13 FBPS 1982 Fuel Models fuel models is 8000 BTUs / pound of fuel (18,622 kJoules/kg). Note that this live heat content value applies to both live herbaceous and live woody fuels.

Fuelbed depth (0.05 - 6.00 ft) (0.2-1.83 m)
This is the average depth of the surface fuel. Fuelbed depth is sometimes called fuelbed bulk depth and should not be confused with the average high particle depth. The average high particle depth is an output of the planar intercept dead down woody fuel sampling process (Brown 1974).



Primary Carrier of the Fire
This is the fuel category, which is the primary carrier of the fire. The options are grass, brush, timber litter or slash.

Herb Type
The FBPS 1982 Fuel Model 2 contains a live herbaceous fuel loading and FBPS 1982 Fuel Models 4, 5, 7 and 10 contain a live woody fuel loading. The other FBPS 1982 Fuel Models do not contain any live fuel. Within the fuel models that contain live herbaceous fuel, the fuel loading of the herbaceous has been set to represent mid-summer conditions and remains constant. As such, these fuel models are called "static" fuel models.

The National Fire Danger Rating System (Deeming et al 1972, 1977; Burgan 1979) contains a live fuel moisture model and a dynamic fuel modeling system that transfers herbaceous fuel loading to the 1-hour dead timelag fuel category as herbaceous fuels cure. The loading transfer occurs when the live herbaceous fuel moisture is between 30% and 120%. When the live herbaceous fuel moisture is 30%, all of the live herbaceous loading is transferred to the 1-hour dead timelag fuel category. When the live herbaceous fuel moisture is 120% or greater, none of the live herbaceous loading has been transferred to the 1-hour dead timelag fuel category. The proportion of the live herbaceous loading transferred when the live herbaceous fuel moisture is between 30% and 120% is based on the following formula:

$$\text{Proportion of Live Herb Loading Transferred} = (120 - \text{Live Herb Moisture}) / 90$$

Users are also able to create these "dynamic" fuel models as custom fuel models within the FBPS's NewMdl and TstMdl programs (Burgan 1984). As such, these fuel models are called "dynamic" fuel models.

When building a custom fuel model via the Fuel Model Manager program within CrownMass, the user can specify if the fuel model will be static or dynamic.

Characteristic Surface Area to Volume Ratio (ft2/ft3)
This is the surface area weighted as an "average" surface area to volume ratio for the fuel model. Since the surface area to volume ratio of the fine fuels (1-hr dead and herbaceous) is quite high relative to the other fuel size classes, they dominate this calculation. This is the "one" surface area to volume ratio used by the Rothermel (1972) spread model in its calculations.

Relative Packing Ratio
This is the fuel model's packing ratio divided by the optimum packing ratio for the fuel model. Vertically oriented fuelbeds like grass and brush generally have a relative packing ratio of less than one while horizontally oriented fuel beds such as timber litter and slash have a relative packing ratio greater than one.

Table 6 has the characteristic surface area to volume ratio and the relative packing ratio for the 13 FBPS 1982 Fuel Models.

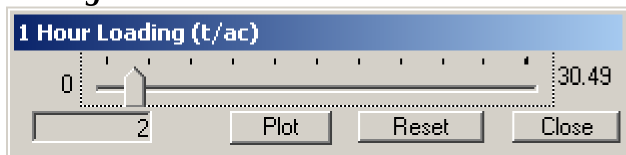
Table 6 - Characteristic Surface Area to Volume Ratio and the Relative Packing Ratios

Fuel Group	FBPS 1982 Fuel Model	Characteristic Surface Area to Volume Ratio (ft^2/ft^3)	Relative Packing Ratio
Grass	1- Short Grass (1 foot)	3500	0.253
	2 - Timber (Grass and understory)	2784	1.135
	3 - Tall Grass (2.5 feet)	1500	0.206
Brush	4 - Chaparral	1739	0.516
	5 - Brush	1683	0.329
	6 - Dormant Brush	1564	0.425
	7 - Southern Rough	1562	0.344
Timber Litter	8 - Closed Timber Litter	1889	5.162
	9 - Hardwood (pine long needle litter)	2484	4.496
	10 - Timber	1765	2.347
Slash	11 - Light Slash	1181	1.619
	12 - Medium Slash	1145	2.059
	13 - Heavy Slash	1159	2.680

Changing the Value of a Fuel Model Parameter Using Manual Entry

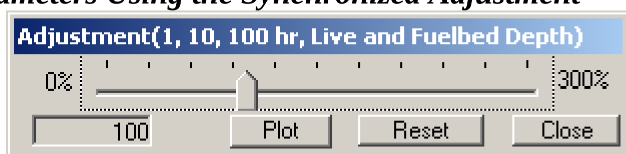
The user may enter a value in the cell desired replacing the existing value with the new value.

Changing the Value of a Fuel Model Parameter Using the Slider Bar



To the right of each fuel parameter is a "toggle" button with the letter "t" on it. Clicking on it will display a screen similar to the one at the right. By clicking on the vertical arrow in the slider and holding down the left mouse button while moving the arrow to the left or right, the user can change the fuel model parameter. The value of the parameter is shown in the box in the lower left of the screen. When the user releases the left mouse button, the value specified by the slider bar is accepted as the value of the parameter to use in the fuel model. Clicking on the **Reset** button changes the value on the slider to the initial parameter value. Clicking on the **Plot** button will initiate the calculation of fire behavior and the plotting of the result on the graphs.

Changing the Values of Some Fuel Model Parameters Using the Synchronized Adjustment



Changing the value of a single fuel model parameter will affect key fuel model attributes such as the fuelbed bulk density and the weighted average (characteristic) surface area to volume ratio of the fuelbed.

By clicking on the **Synchronized Adjustment (1, 10, 100 hr, Live and Fuelbed Depth)** button, the screen at the right will appear. Note the scale is percent. By clicking on the vertical arrow in the slider and holding down the left mouse button while moving the arrow to the left or right, the user can change these four fuel model parameters by the specified percentage. Note the yellow highlight indicating the fuel parameters that will be changed. The value of the percent change is shown in the box in the lower left of the screen. When the user releases the left mouse button, the percent change will be applied to these four fuel model parameter values. Clicking on the **Reset** button changes the value on the slider to the initial 100% setting. Clicking on the ***Plot*** button will initiate the calculation of fire behavior and the plotting of the result on the graphs.

Hot Tip

Changing proportionately the values for the fuel loading in the 1-hour timelag, 10-hour timelag, 100-hour timelag and live fuel categories as well as the fuelbed bulk depth will preserve both the weighted average (characteristic) surface area to volume ratio and the fuelbed bulk density of the fuelbed.

Save Button
Clicking on this button will save the parameter values including those with changes for the fuel model.

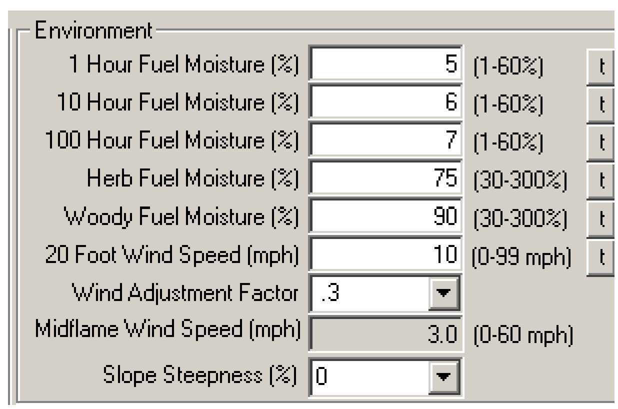
Cancel Button
Clicking on this button will close the Edit and Test Center. Any changes made to the active fuel model will not be saved.

Save and Close Button
Clicking on this button will save the parameter values. The Edit and Test Center will close following the save function.

Environment
To assess potential fire behavior and effects, environmental conditions need to be assumed. These environmental conditions are described by:

- Fuel Moisture Values
- A Midflame Wind Speed Value
- The Slope Steepness

The user may wish to analyze potential fire behavior and effects under some specific environmental conditions that represent a prescribed fire or wildfire burning condition. Examples include assessing potential fire behavior and effects for a proposed prescribed fire prescription window or for a calculated percentile weather situation developed using the FireFamilyPlus program (USDA Forest Service 1999). A description of the environmental parameters can be found in the section of this Users' Guide titled Assigning Environmental Conditions.



Calculating and Graphing Fire Behavior Values
Calculation of fire behavior outputs can be initiated by either clicking on the **Compute** Button or by clicking on a **Plot** Button.

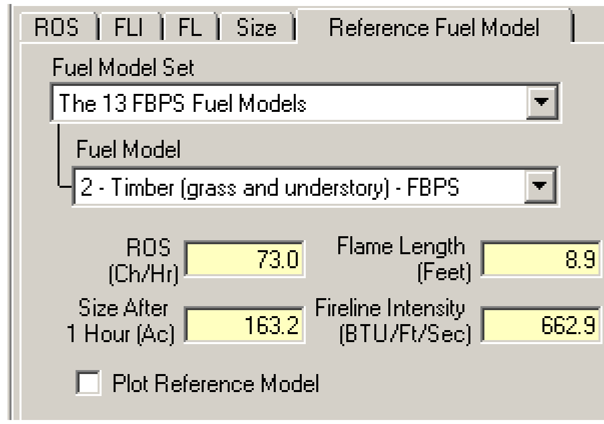
Compute Button
Clicking on the **Compute** button will initiate the calculation of fire behavior. The resultant fire behavior outputs will be displayed in the boxes in the lower right corner of the Edit and Test Center screen.

The Auto-Compute Box

If the Auto-Compute box is checked, then whenever any change is made by any method to a fuel model's parameters will be calculated autoimatically. CrownMass will calculate fire behavior outputs immediately without the need to click the **Compute** Button.

Set Reference Fuel Model

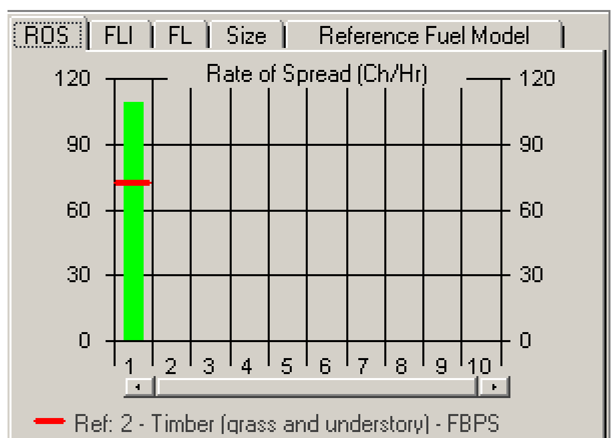
The user may wish to compare the fire behavior outputs from a custom fuel model to the fire behavior outputs from a "reference fuel model." To select the "Reference Fuel Model," click on the **Set Reference Model Tab**. The screen at the right will appear.



Use the pull downs to select the Fuel Model Set and the Reference Fuel Model. Note that the fire behavior output values are provided. If the "Plot Reference Model" box is checked, CrownMass will show the fire behavior outputs on each graph using a red line.

Plotting Fire Behavior Values

CrownMass will plot an unlimited number of values for rate of spread, fireline intensity and flame length. In addition, it will plot the fire size after 1 hour using the single ellipse fire size model (Fons 1946, Anderson 1983).



Note that it will display only 10 values in a manner that can be seen on one screen. The number on the horizontal axis refers to the relative order of the calculations, <u>not fuel model identifiers</u>.

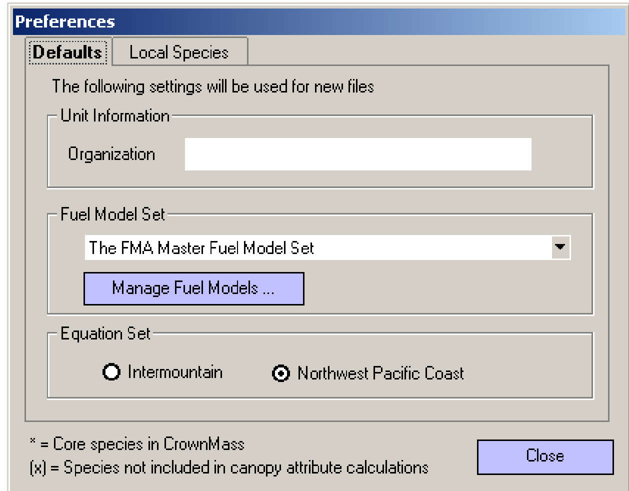
Plot Button

Clicking on the **Plot** button will initiate the calculation of fire behavior and the plotting of the result on the graphs.

Clear Graphs Button

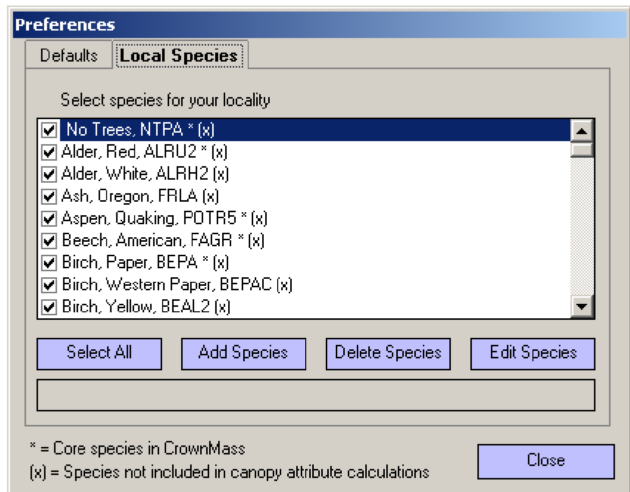
Clicking on this button will cause all graphs to be cleared.

Preferences
All user preferences are defined here.



Defaults Tab
On this screen, the user can enter a name for an Organization that will appear on printouts.

The user can select the default Fuel Model Set that will be used to select fuel models for fire behavior calculations. In addition, the user can select the default crown weight equation set that is to be applied to the inventory.



Species Tab
On the Analysis Area and Plots screen, each tree in the tree list must have a species identified. In a local area, there are generally only a limited number of tree species. The user may wish to limit the number of tree species selections on the pull down menus.

By selecting the **Species Tab**, the screen at the right appears. Select the species that will appear in the inventories in the local area by clicking on the box to the left of the species name. Pull down menus in CrownMass, which specify tree species options will contain the species where the box to the left of the species is checked. When the user is finished selecting the desired species, click on the **Close** button.

Within CrownMass, crown mass prediction equations have been included for species where published relationships are available. These species will be referred to as "core species."

To allow for crown weight predictions for species where these relationships have not been developed, one of the "core species" has been assigned to the "dependent" species. The assignment of a "core species" is based on similar crown component characteristics. For example, no crown weight equations are available for Jeffery pine but its crown is quite similar to Ponderosa pine in structure. Hence, the equations for Ponderosa pine are used to estimate the weight of Jeffery pine, Ponderosa pine is referred to as the "surrogate species" for the dependent species, Jeffery pine. For trees where surrogates are defined, CrownMass calculates the crown weights using the assigned core tree species equations, but then adjusts these values based on the specific gravity (pounds per cubic foot) of the dependent species. A listing of the core and surrogate species including the specific gravity values used in CrownMass is provided in Table 7 that follows on the next pages.

Table 7 – Core and Surrogate Species, Density and Inclusion in Crown Weight Calculations for Canopy Crown Fire Attributes

Species	Species Code	Core / Surrogate*	Density (lbs/ft^2)	Crown Fire Canopy
Alder, Red	ALRU2	Core	25.6	Excluded
Alder, White	ALRH2	Red Alder	25.6	Excluded
Ash, Oregon	FRLA	Red Alder	34.3	Excluded
Aspen, Quaking	POTR5	Core	23.7	Excluded
Beech, American	FAGR	Core	39.9	Excluded
Birch, Paper	BEPA	Core	34.3	Excluded
Birch, Western Paper	BEPAC	Paper Birch	34.3	Excluded
Birch, Yellow	BEAL2	Paper Birch	38.7	Excluded
Cedar, Alaska (Yellow)	CHNO	Western Red Cedar	27.5	Included
Cedar, Northern White	THOC2	Core	19.3	Included
Cedar, Port Orford	CHLA	Western Red Cedar	26.8	Included
Cedar, Western Red	THPL	Core	20.0	Included
Cherry, Bitter	PREM	Black Cherry	31.2	Excluded
Cherry, Black	PRSE	Core	31.2	Excluded
Chinquapin, Giant	CACH6	Core	32.0	Excluded
Cottonwood, Black	POBA	Red Alder	21.8	Excluded
Dogwood, Pacific	CONU4	Red Alder	31.2	Excluded
Douglas-fir	PSME	Core	30.6	Included
Fir, Balsam	ABBA	Core	21.8	Included
Fir, California Red	ABMA	Douglas-fir	23.7	Included
Fir, Corkbark	ABLAA	Subalpine fir	21.8	Included
Fir, Grand	ABGR	Core	23.1	Included
Fir, Noble	ABPR	Douglas-fir	24.3	Included
Fir, Pacific Silver	ABAM	Douglas-fir	26.8	Included
Fir, Shasta Red	ABSH	Douglas-fir	23.7	Included
Fir, Subalpine	ABLA	Core	20.0	Included
Fir, White	ABCO	Subalpine fir	24.3	Included
Hardwoods (Alaska)	AKHD	Red alder	25.6	Excluded
Hawthorn	CRXX	Black cherry	25.6	Excluded
Hemlock, Eastern	TSCA	Core	25.0	Included
Hemlock, Mountain	TSME	Western hemlock	28.1	Excluded
Hemlock, Western	TSHE	Core	28.1	Included
Hickory	CAXX	Core	39.9	Excluded
Incense cedar	CADE27	Western red cedar	23.1	Included
Juniper, Rocky Mtn.	JUSC2	Utah juniper	30.0	Included
Juniper, Utah	JUOS	Core	30.0	Included
Juniper, Western	JUOC	Utah juniper	30.0	Included
Larch, Eastern	LALA	Western larch	32.4	Included

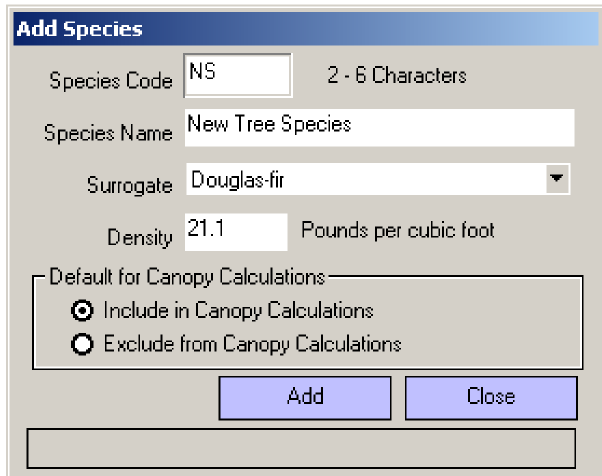
Table 7 – Core and Surrogate Species, Density and Inclusion in Crown Weight Calculations for Canopy Crown Fire Attributes

Species	Species Code	Core / Surrogate*	Density (lbs/ft^2)	Crown Fire Canopy
Larch, Subalpine	LALY	Western larch	32.5	Included
Larch, Western	LAOC	Core	32.4	Included
Madrone, Pacific	ARME	Core	45.0	Excluded
Maple, Bigleaf	ACMA3	Core	30.0	Excluded
Maple, Black	ACNI5	Red maple	35.4	Excluded
Maple, Red	ACRU	Core	33.7	Excluded
Oak	QUXX	Tanoak	32.0	Excluded
Oak, Black	QUKE	Tanoak	38.1	Excluded
Oak, Gamble	QUGA	Tanoak	40.0	Included
Oak, Northern Red	QURU	Core	39.3	Excluded
Oak, Oregon White	QUGA4	Tanoak	42.4	Excluded
Oak, White	QUAL	Core	42.4	Excluded
Pine, Bristlecone	PIAR	Lodgepole pine	25.0	Included
Pine, Eastern White	PIST	Core	21.8	Included
Pine, Jack	PIBA2	Core	26.8	Included
Pine, Jeffery	PIJE	Ponderosa pine	25.0	Included
Pine, Knobcone	PIAT	Lodgepine pine	25.6	Included
Pine, Limber	PIFL2	Ponderosa pine	25.0	Included
Pine, Lodgepole	PICO	Core	25.6	Included
Pine, Pitch	PIRI	Core	32.4	Included
Pine, Ponderosa	PIPO	Core	25.0	Included
Pine, Red	PIRE	Core	28.7	Included
Pine, Southwestern White	PIST3	Western white pine	25.0	Included
Pine, Sugar	PILA	Western white pine	22.5	Included
Pine, Western White	PIMO3	Core	23.7	Included
Pine, Whitebark	PIAL	Core	23.1	Included
Pinyon, Singleleaf	PIMO	Core	30.0	Included
Pinyon, Twoneedle	PIED	Singleleaf pinyon	30.0	Included
Poplar, Yellow	LITU	Core	26.2	Excluded
Redwood, Coast	SESE3	Douglas-fir	23.1	Included
Sequoia, Giant	SEGI2	Douglas-fir	25.0	Included
Spruce, Black	PIMA	Core	28.7	Included
Spruce, Blue	PIPU	Englemann spruce	25.0	Included
Spruce, Engelmann	PIEN	Core	21.8	Included
Spruce, Red	PIRU	Core	25.0	Included
Spruce, Sitka	PISI	Englemann spruce	22.5	Included
Spruce, White	PIGL	Core	25.0	Included
Tanoak	LIDE3	Core	40.5	Included

Table 7 – Core and Surrogate Species, Density and Inclusion in Crown Weight Calculations for Canopy Crown Fire Attributes

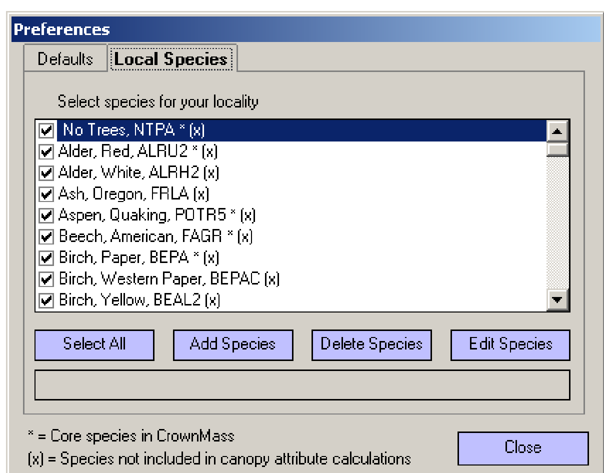
Species	Species Code	Core / Surrogate*	Density (lbs/ft^2)	Crown Fire Canopy
Willow, Pacific	SALUX	Black cottonwood	24.3	Excluded
Yew, Pacific	TABR2	Grand fir	20.0	Included
* - Entry is Core for Core Species and for others, the Entry is the Surrogate Species				

Add, Delete and Edit Species Buttons



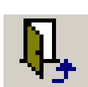
If a species exists in the local area that is not listed in CrownMass, it can be add as a dependent species via the **Add Species** button. The user will be asked to supply a Species Name and to identify a surrogate species from the core species within CrownMass. Also, the user will be asked to enter a weight per cubic foot (wood density) for the species. A good reference for this weight is FPL-GTR-113, The Wood Handbook (1999), Chapter 4, produced by the Forest Products Laboratory. Once the information is entered, click on the **Add** button followed by a click on the **Close** button. Note that only user added species can be edited in CrownMass. (Note: FPL-GTR-113 can be accessed at: http://www.fpl.fs.fed.us)

The Default for Canopy Calculations selection designates if the crown weight for the tree species should be added to the canopy fuel loading for the purpose of calculating the canopy base height, canopy bulk density and canopy ceiling height.



To change the Surrogate or Density assigned to a user-defined_dependent species, click on **Edit Species** button. The user can only delete user-defined dependent species in CrownMass. Program defined core and the user cannot delete surrogate species.

Exit

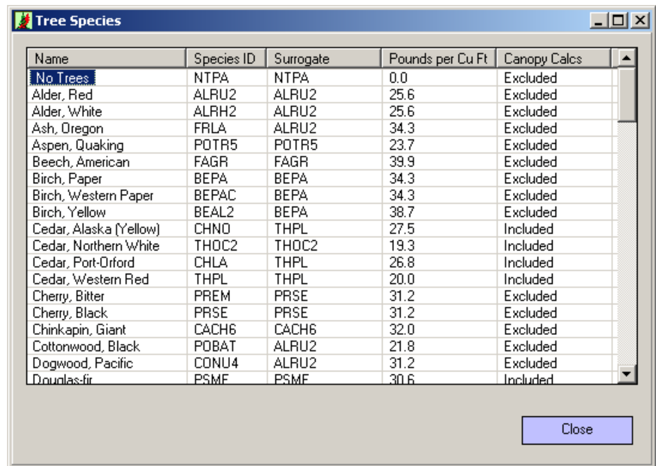
The toolbar icon  is the same as **File => Exit.**

The DATA Menu

This menu allows the user to view a list of the defined species within the program.

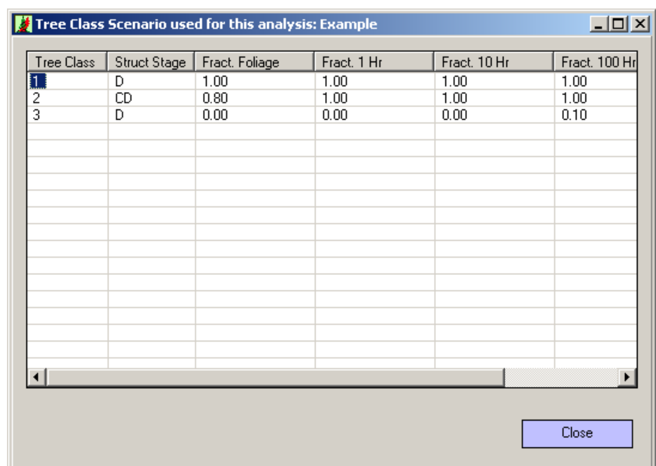
View Tree Species

The View Tree Species menu item allows the user to view the list of each species' name, the species identifier, the surrogate species where appropriate and the species' wood density. If a species surrogate is the same as the species being examined, then that species is a core species within CM.



View Tree Class Scenario

If a Tree Class Scenario has been assigned to the inventory, selecting this menu will result in a screen similar to the one at the right.



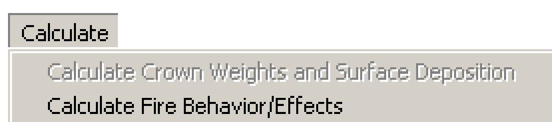
Validate Data

This menu item checks all data for values that are outside legal ranges.

The CALCULATE Menu

There are four ways the user can calculate crown weights, fuel loadings, resultant fire behavior and fire effects.

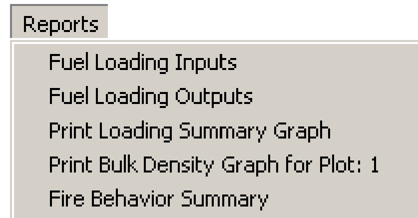
- Select the appropriate choice from the Calculate menu



- Clicking on the icons to Calculate CrownMass or Calculate Fire Behavior
- Clicking on the Quick Results Tab to Calculate CrownMass
- Clicking on the Fire Behavior Results Tab to Calculate Fire Behavior

These calculations are required when any changes are made to the tree inventory information and/or information needed to calculate fire behavior or fire effects.

The REPORTS Menu



The program can produce several printed reports. All reports can be saved in Rich text format for later use within a word processor.

Fuel Loading Inputs Report
This menu item produces a report showing the analysis area assumptions and a summary of stand inventory input values by plot.

Fuel Loading Outputs Report
This menu item produces a report showing the analysis area assumptions and fuel loading outputs for the analysis area. It also shows canopy and surface deposition values by plot.

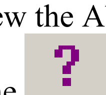
Print Loading Summary Graph
This menu item produces a printout of the fuel loading pie charts and is best produced using a color printer.

Print Bulk Density Graphs by Plot Number
This menu item produces a printout of the canopy bulk density graphs for the last plot for which this graph was viewed. The “currently active plot number” is shown at the end of the menu name.

Fire Behavior Summary Report
This menu item produces a report showing a summary of calculated fire behavior and fire effects.

The HELP Menu

This main menu item allows the user to access the Help Contents system, access the Internet Web Based Support and to view the About screen.

The user can also activate the online Help with the  icon from the Toolbar.

If the user has an active connection to the Internet, clicking on Web Based Support will take the user to the FMAPlus Support Page (www.fireps.com/fmanalyst3/).

The About menu item allows the user to view the CrownMass program version number.

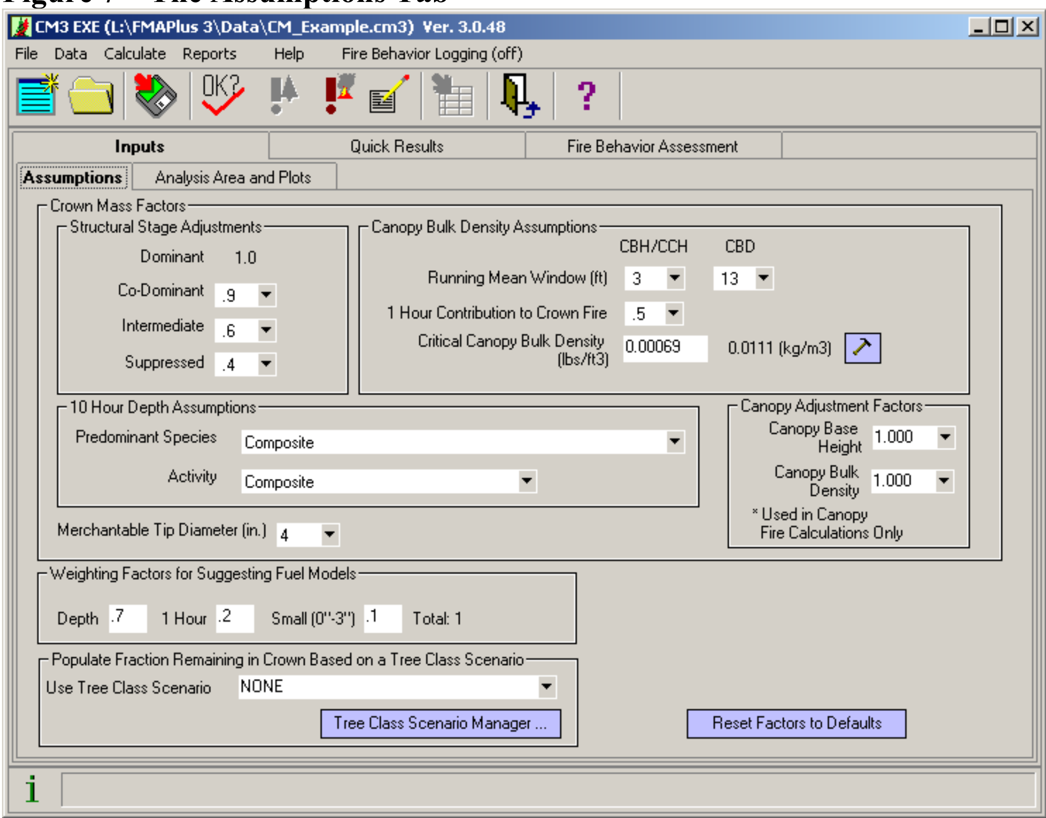
The Fire Behavior Logging Menu

This menu will be described in the section of this guide titled Fire Behavior Assessment.

Analysis Assumptions

For the Analysis, certain general assumptions are necessary. Clicking on the **Inputs Tab** and then the **Assumptions Tab** accesses the screen in Figure 7.

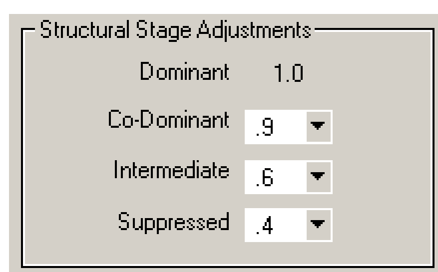
Figure 7 – The Assumptions Tab



CrownMass Factors

The crown mass factors include specification of the structural stage adjustments, the canopy bulk density assumptions, 10-hour depth assumptions, and unmerchantable tip diameter.

Structural Stage Adjustments



On the Analysis Area and Plots screen, the user enters a tree list for each plot in the stand inventory. For each tree sampled, Structural Stage is a required entry. The four possible entries are: Dominant, Co-dominant, Intermediate and Suppressed. Dominant is the default. These four crown classes are defined by the Society of American Foresters (1958) as follows:

Dominant

Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand, and with crowns well-developed but possibly crowded on the sides are dominant.

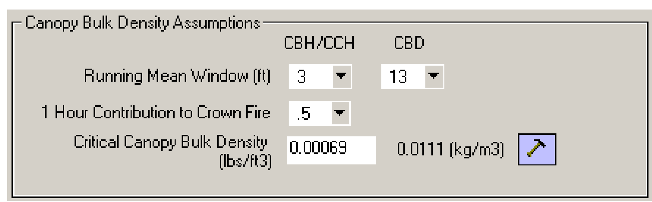
Co-Dominant
Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides; usually with medium-sized crowns more or less crowded on the sides are co-dominant.

Intermediate
Trees shorter than those in the two preceding classes, but with crowns either below or extending into the crown cover formed by co-dominant and dominant trees, receiving little direct light from above, and none from the sides; usually with small crowns considerably crowded on the sides are intermediate.

Suppressed or Overtopped
Trees with crowns entirely below the general level of the crown cover receiving no direct light either from above or from the sides are suppressed or overtopped.

Research documents equations for crown mass based primarily on sampling of dominant trees (Brown, 1978; Snell and Anholt, 1981; Snell and Little, 1983; Snell and Max, 1985). The crown weight equations in the CrownMass program are based on the relationships for trees in the Dominant structural stage. As such, the user needs to supply factors to adjust the crown loading from that predicted for the dominant tree equations to the structural stage of the tree being entered in the tree list.

Canopy Bulk Density Assumptions

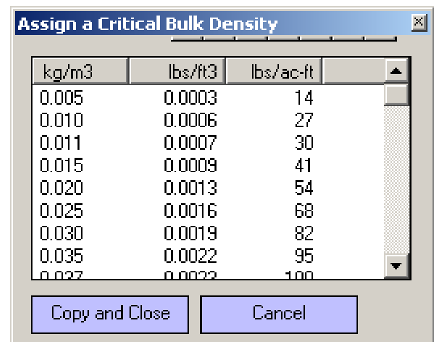


The canopy bulk density is a critical input to the assessment of crown fire potential. The CrownMass program uses a process developed at the Missoula Fire Sciences Laboratory (Reinhardt et. al. 2000) to estimate the canopy base height, the canopy ceiling height and the canopy bulk density. This process requires assignment of the Running Mean Window, 1-hr Contribution to Crown Fire and the Critical Canopy Bulk Density.

Running Mean Window
CrownMass assumes that a fire will spread vertically through the densest portion of the canopy. To use the native segment bulk densities can yield a rather discontinuous distribution of segment bulk densities so a running mean of this value is calculated. The default number of segments used for this running mean is 13 for the canopy bulk density and 3 for the canopy base height and canopy ceiling height calculations. The user can change this value here. The maximum of this running mean is the value used by CrownMass as *canopy bulk density*.

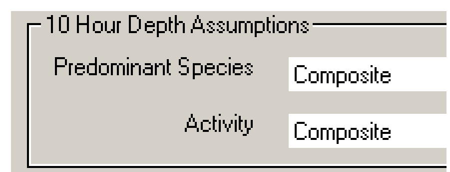
1-hr Contribution to Crown Fire
From the tree list data input, the weight is determined for the needle and the 1-hour timelag live and the1-hour timelag dead fuel categories. Current assumptions (Reinhardt et. al. 2000) are that the needle fuel loading and 50% of the 1-hour timelag crown fuel loading contribute to the flaming portion of crown fire. The proportion of the 1-hour timelag crown fuel loading that contributes to the flaming portion of crown fire can be set here. The program default is 0.50.

Critical Canopy Bulk Density
Sando and Wick (1972) suggest that a minimum crown bulk density of 100 lbs/acre-foot which is 0.0023 lbs/ft^3 is necessary to provide vertical propagation of fire. The Fire and Fuel Extension of the Forest Vegetation Simulator (Reinhardt and Crookston 2003) utilizes a minimum crown bulk density of 30 lbs/acre-foot, which is 0.00069 lbs/ft^3. This minimum canopy bulk density can be set here and the recommended values from Reinhardt and Crookston 2003 are used as the program default. The *canopy base height* and the *canopy ceiling height* are determined by CrownMass as the lowest and highest segments respectively, where the running mean segment bulk density is greater than the minimum crown bulk density to sustain vertical propagation of fire. Note the entry is in English units but the equivalent value in Metric units is shown to the right of the box.



Clicking on the **Hammer** icon will display the screen at the right. This screen provides equivalent values for bulk density in kg/m^3, lbs/ft^3 and lbs/ac-foot. The cell entry for the critical canopy bulk density value is entered in lbs/ft^3 and the equivalent values provide support to the entry of a value other than the default (0.00069).

10-hr Depth Assumptions



The estimation of the fuelbed depth has been determined for slash fuelbeds by Albini and Brown (1978). The equations used in CrownMass to estimate the fuelbed depth need an assignment of the predominant species and type of management activity, if any. The algorithms from this research essentially use the10-hr timelag fuel loading, the predominant species and the type of management activity to estimate the fuel bed depth referred to as the *fuelbed bulk depth*.

Predominant Species
The options available are. The Composite assigns values based on an average of species values.

- Ponderosa pine
- Western Redcedar
- Douglas-fir, Grand Fir, Lodgepole Pine, Western Larch and Engelmann Spruce
- Composite

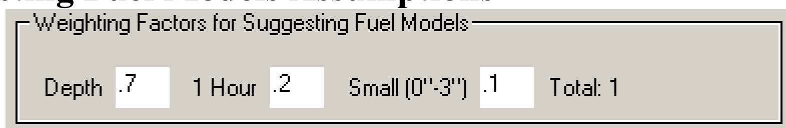
Activity
The activities are as follows. The Composite assigns values based on an average of species values.

- High Lead Harvest - All Species
- Pre-commercial Thinning, Pines
- Pre-commercial Thinning, Others
- Ground Lead Harvest, Pines
- Ground Lead Harvest, Others
- Composite (Suggested for use in natural stands)

Unmerchantable Tip Diameter Assumptions

The unmerchantable tip diameter is the diameter on the main stem of a tree the separates the bole from the unmerchantable tip. The weight of the unmerchantable tip is calculated by CrownMass and included with the fuel loading that may be deposited to the surface if a tree was felled to the ground or fell naturally. The allowable values are 4, 5 or 6 inches with 4 inches being the program default.

Weighting Factors for Suggesting Fuel Models Assumptions



The program contains a process for the suggestion of a derivative FBPS fuel model that best fits created surface fuel characteristics (Fire Behavior Assessment, Surface Fuel Model Tab). This process calculates the percent difference between certain fuelbed characteristics for the created fuelbed and all candidate derivative FBPS fuel models. These fuelbed characteristics are:

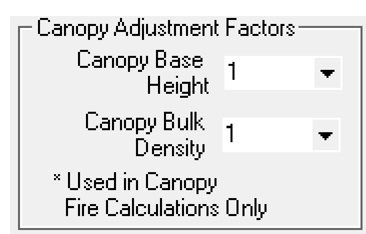
- Fuelbed Bulk Depth
- 1-hr Timelag Fuel Loading
- 0-3" Total Fuel Loading

After the percent difference has been calculated for each of these fuelbed characteristics, a weighted percent difference is calculated for each FBPS fuel model. The weighting factors are assigned here. The program defaults are: Fuelbed Bulk Depth, 0.7; 1-hr Timelag Fuel Loading, 0.2; and 0-3" Total Fuel Loading. 0.1. These are assigned to reflect the high sensitivity of the surface fire spread model (Rothermel, 1972) to fuelbed depth followed by a lesser sensitivity to 1-hr timelag and total 0-3" fuel loading.

Hot Tip

The ten-hour depth assumptions are based on data from slash fuelbeds.
The Suggest Fuel Model option in CrownMass is used most appropriately for the timber litter and slash fuel categories.

Canopy Adjustment Factors



Canopy Base Height and Canopy Bulk Density

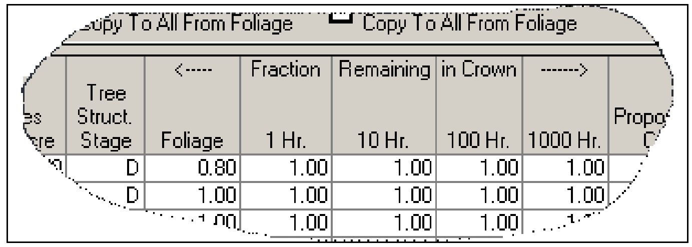
These factors are multiplied times the calculated canopy base height and canopy bulk density values. This allows the user to make adjustments based on professional judgment that the calculated values may be systematically too high or too low.

Populate Fraction Remaining in Crown Based on a Tree Class Scenario

Figure 8 displays six columns from the tree inventory section of the Analysis Area and Plots Tab. The six columns are:

- Tree Structural Stage
- Fraction Remaining in Crown for
  - Foliage
  - 1-hr timelag branchwood
  - 10-hr timelag branchwood
  - 100-hr timelag branchwood
  - 1000-hr timelag branchwood

Figure 8



Forest inventories will frequently classify each tree based on the crown characteristics of the tree. The tree structural stages of dominant, co-dominant, intermediate and suppressed (Society of American Foresters 1958) are frequently used. Dead trees may also be classified into categories such as recent dead and older dead. Tree inventory systems define a classification system to use in the field to describe the crown characteristics of a sample tree. Inventory systems have called Tree History, Tree Class or another name. For example, the Forest Vegetation System Tree List Report has a column called Tree Class, which is user-defined. The user of CrownMass needs to understand the assumptions behind the classification system.

For the purposes of crown weight calculation, CrownMass uses crown weight equations based on the relationships of trees in the dominant structural stage. Adjustment factors to calculate the crown weight for non-dominant trees are assigned in the Structural Stage Adjustment section on the Assumptions Tab. In addition, the user can further adjust the crown weight for foliage or a timelag branchwood size class by assigning factors in the Fraction Remaining in Crown columns in the Plot Entry Section on the Analysis Area and Plots Tab (Figure 8). Table 8 shows an example calculation for a co-dominant sample tree with additional adjustments for fraction remaining in crown by fuel size class.

Table 8 – Example of Crown Weight Calculation

Fuel Size Class	Weight for a Dominant Tree (tons/acre)	Structural Stage Adjustment Factor	Fraction Remaining in Crown Adjustment Factor	Final Weight (tons/acre)
Foliage	3.00	0.90	0.75	2.03
1-h timelag	4.00		0.90	3.24
10-h timelag	6.00		1.00	5.40
100-h timelag	8.00		1.00	7.20
1000-h timelag	10.00		1.00	9.00
Total	31.00			26.87

Tree Class Scenario

Within CrownMass, a Tree Class Scenario is a unique combination of assignment for the tree structural stage and the fraction remaining in crown factors. Assigning a Tree Class Scenario to an inventory in CrownMass facilitates the entry of values in the Tree Structural Stage and Fraction Remaining in Crown columns. By entering a Tree Class for a sample tree, CrownMass automatically enters values for the Tree Class in the Tree Structural Stage and Fraction Remaining in Crown columns.

This feature is particularly valuable when importing a Forest Vegetation Simulator tree list into CrownMass. In the figure below, the Tree Class column (5) has a title TR CL.

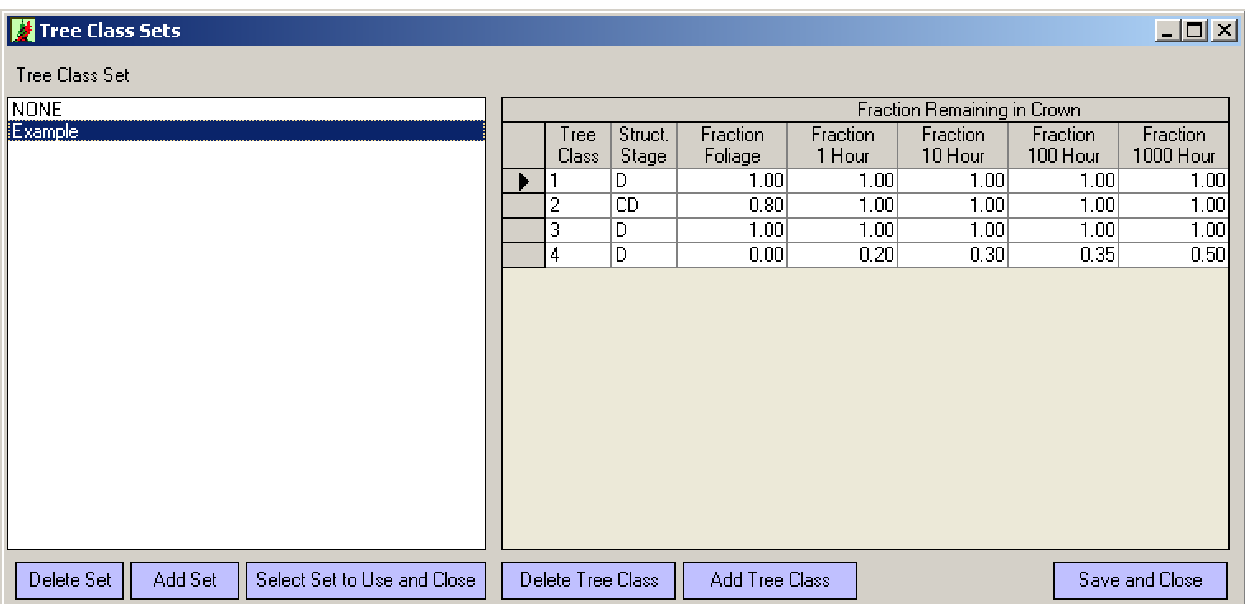
```
0        FOREST VEGETATION SIMULATOR     VERSION 6.31 -- CENTRAL ROCKIES SW MIXED CONIFERS GENGYRV:01.11.2000  01-26-2000  17:03:34

COMPLETE TREE LIST -- STAND: 521.004                MGMTID: NONE  END CYCLE:  0  CYCLE LENGTH: 10 YRS  YEAR: 1999  PAGE:  1
   1        2   3  4  5  6  7      8          9      10    11    12    13  14   15  16    17     18     19      20      21   22 23 24
  TREE    TREE SP SP TR SS PNT  TREES      MORTAL   CURR  DIAM  CURR   HT        MAX          BA  POINT TOT CU MCH CU  MCH BD MC BF TRC
 NUMBER   INDX CD NO CL CD NUM PER ACRE  PER ACRE  DIAM  INCR   HT   INCR CR   CW  MS %-TILE  BAL  FT VOL FT VOL  FT VOL DF DF  HT
-------- ---- -- -- -- -- --- --------- --------- ----- ----- ----- ---- -- ---- -- ------ ----- ------ ------ ------- -- -- ---
    2004    5 DF  3  1  0   2     2.760     0.000  16.3  1.40  47.0  0.0 85 27.3  0  71.43     0   32.6   26.7   140.0  0  0   0
    5003   15 DF  3  2  0   4     2.726     0.000  16.4  1.40  48.0  0.0 75 27.4  0  76.19     0   33.7   29.2   140.0  0  0   0
    5005   17 DF  3  1  0   4    15.404     0.000   6.9  1.40  24.0  0.0 75 13.9  0  23.81   120    3.1    2.0     0.0  0  0   0
```

Figure 9 provides an example of a Tree Class Scenario. To create and save a Tree Class Scenario, click on the **Tree Class Scenario Manager** button on the Assumptions Tab. A screen similar to the one below will appear.

Figure 9 – Example of a Tree Class Scenario

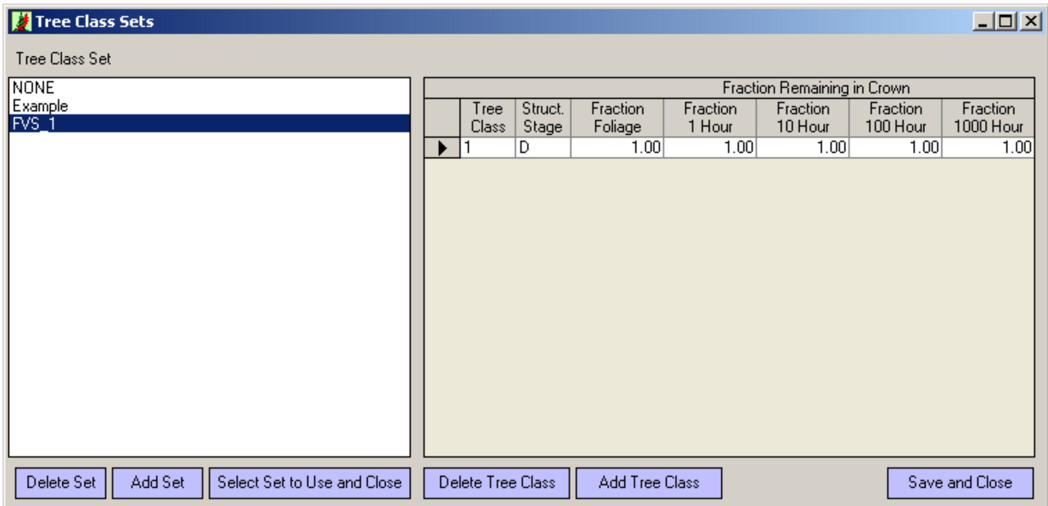
			Fraction Remaining in Crown				
	Tree Class	Struct. Stage	Fraction Foliage	Fraction 1 Hour	Fraction 10 Hour	Fraction 100 Hour	Fraction 1000 Hour
▶	1	D	1.00	1.00	1.00	1.00	1.00
	2	CD	0.80	1.00	1.00	1.00	1.00
	3	D	1.00	1.00	1.00	1.00	1.00
	4	D	0.00	0.20	0.30	0.35	0.50



The three buttons in the lower left allow the user to Delete a Scenario, to Add (Create) a Scenario or to Select a Scenario as the active scenario for assignment and use with an inventory.

Create a Tree Class Scenario

To create a Tree Class Scenario, click on the **Add Scenario** button. A dialog will appear where the user can enter a name for the Tree Class Scenario. After the **OK** button is clicked on the naming dialog, a screen similar to the following one will appear.



In the example, the new Tree Class Scenario was named FVS_1. By default, the right side of the screen will display a row with Tree Class 1 defined using the default values for the Tree Structural Stage and Fraction Remaining in Crown columns. To add additional tree classes, click on the **Add Tree Class** button. Each click on the button will add a tree class and they will be initially numbered consecutively. The screen at the right has four tree classes created with the default column entries.

		Fraction Remaining in Crown				
Tree Class	Struct. Stage	Fraction Foliage	Fraction 1 Hour	Fraction 10 Hour	Fraction 100 Hour	Fraction 1000 Hour
1	D	1.00	1.00	1.00	1.00	1.00
2	D	1.00	1.00	1.00	1.00	1.00
3	D	1.00	1.00	1.00	1.00	1.00
4	D	1.00	1.00	1.00	1.00	1.00

Use the pulldown for cells in the Tree Structural Stage column to make assignments. For entries in the Fraction Remaining in Crown columns, the user can use the pulldowns or can manually enter a value in a cell. An edited Tree List Scenario might look like the screen shown. Tree classes 1 and 2 might be representing live trees but where insects have been impacting Tree Class 2 hence there is 20% less foliage than expected on a co-dominant tree. Tree Class 3 might be representing a recently dead tree where 50% of the needles still remain on the tree. Tree Class 4 might be representing an older dead tree where all of the foliage, 1-h timelag branchwood and 10-h timelag branchwood are gone but 35% and 50% of the 100-h timelag branchwood and 1000-h timelag branchwood loading respectively remain.

		Fraction Remaining in Crown				
Tree Class	Struct. Stage	Fraction Foliage	Fraction 1 Hour	Fraction 10 Hour	Fraction 100 Hour	Fraction 1000 Hour
1	D	1.00	1.00	1.00	1.00	1.00
2	CD	0.80	1.00	1.00	1.00	1.00
3	D	0.50	1.00	1.00	1.00	1.00
4	D	0.00	0.00	0.00	0.35	0.50

The Reset Default Factors Button

Clicking on this button resets all values on the Assumptions screen to their default program values.

Crown Weight Prediction

To perform a crown weight prediction, the steps include the assignment of Analysis Assumptions, Analysis Area Assumptions, the entry of Analysis Area values and the entry of tree inventory data from plots (Analysis Area and Plots Tab). The determination of crown weights and surface deposition loadings is obtained by clicking on the Quick Results Tab, by clicking on the Calculate Crown Mass icon or via the Calculate, Calculate Crown Mass menu item.

For the purposes of crown weight calculation, CrownMass uses crown weight equations in the based on the relationships for trees in the dominant structural stage. Adjustment factors to calculate the crown weight for non-dominant trees are assigned in the Structural Stage Adjustment section on the Assumptions Tab. In addition, the user can further adjust the crown weight for foliage or a timelag branchwood size class by assigning factors in the Fraction Remaining in Crown columns in the Plot Entry Section on the Analysis Area and Plots Tab (Figure 10). Table 9 shows an example calculation for a co-dominant sample tree with additional adjustments for fraction remaining in crown by fuel size class.

Figure 10

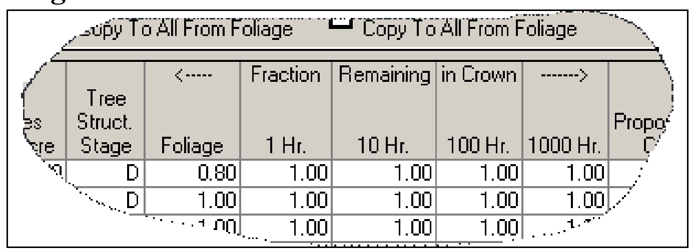
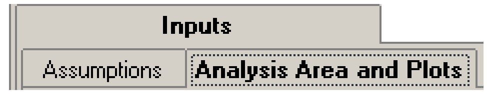


Table 9 – Example of Crown Weight Calculation

Fuel Size Class	Weight for a Dominant Tree (tons/acre)	Structural Stage Adjustment Factor	Fraction Remaining in Crown Adjustment Factor	Final Weight (tons/acre)
Foliage	3.00	0.90	0.75	2.03
1-h timelag	4.00		0.90	3.24
10-h timelag	6.00		1.00	5.40
100-h timelag	8.00		1.00	7.20
1000-h timelag	10.00		1.00	9.00
Total	31.00			26.87

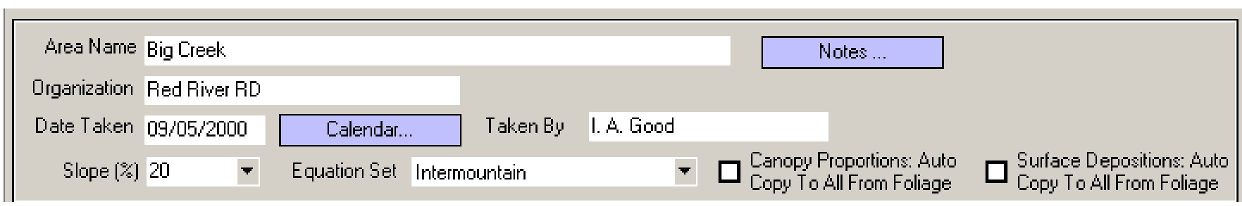
Analysis Area and Plots Tab



Entry of Analysis Area values and the entry of tree inventory data from plots is done on the Analysis Area and Plots Tab.

<u>Analysis Area Definition</u>

Within CM, the term "Analysis Area" refers to the total area where an estimate of the crown weights and surface fuels is desired. Within this area, sample plots are generally established from an inventory of trees based on a fixed radius or a variable plot radius sampling methodology. Either sampling method allows for the calculation of the number of tree per acre by species, diameter breast high (dbh), tree height and tree crown ratio. These values are the native input data needed at each plot for input to CrownMass via the Analysis Area and Plots Tab. The listing of this data for a plot will be referred to as a "tree list." Automated import of tree list data in available is certain defined formats (see the Import option on the CrownMass File Menu).



<u>Area Name</u>

Enter the name of the Analysis Area. This is an optional data entry but tracking of printouts and data files may be difficult if this entry is left blank.

<u>Organization</u>

Enter the name of your organization. This is an optional data entry.

<u>Date Taken</u>

Enter the date the stand inventory was performed. Use of the calendar icon is a method that can be used to enter the date. This is an optional data entry.

Calendar Button

Selecting the calendar icon will cause the screen at the right to be displayed. The < and > buttons will display the month (September) before and after (November) the displayed month. The << and >> buttons will display month for the preceding year (October 1997) and following year (October 1999).

Slope

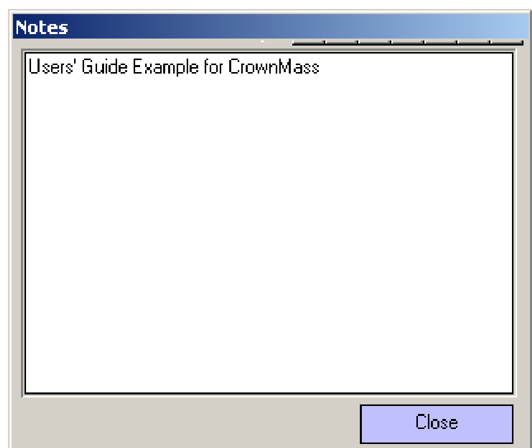
Use the pulldown to enter the average slope in percent for the Analysis Area being sampled.

Taken By

Enter names or initials of those taking the stand inventory data. This is an optional data entry.

Equation Set

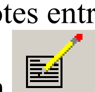
Research in some geographic areas has resulted in the publishing of more than one crown weight equation for a tree species. To assure the correct equations are being used for a species, the user needs to select an Equation Set. The Analysis Area being sampled should fall into the applicable geographic area which is represented by one of the programmed equation sets within CrownMass. Select the appropriate equation set from the pull down menu. The two current equation sets in CrownMass are Intermountain and Northwest Pacific Coast. The Northwest Pacific Coast equation set should be used for areas west of the Cascade Mountains in the states of Washington and Oregon. Other areas should select the Intermountain equation set.



Notes Button

The **Notes** button activates a dialog box that allows the user to enter information about the area sampled. The information in the Notes box is printed on the Inputs Report.

You can also activate the Notes entry window by

clicking on the **Notes** Button  on the toolbar.

Tree List Data and Surface Deposition

The lower part of the Analysis Area and Plots screen contains the Tree List Input Area. In this area, the user enters the data from the stand inventory as well as defining what proportion of the crown weight will be deposited to the surface. The columns that make up this area are divided in two categories: Basic Tree List Information and Surface Deposition Information.

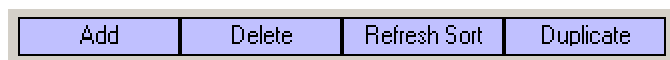
Basic Tree List Information

Plot ID	Tree No.	Dia	Species	Height	Crown Ratio	Trees Per Acre	Tree Class	Tree Struct. Stage	<---- Foliage	Fraction 1 Hr.	Remaining 10 Hr.	in Crown 100 Hr.	----> 1000 Hr.
1	1	2.0	Douglas-fir	12	0.75	500.000	0	D	0.80	1.00	1.00	1.00	1.00
1	2	10.0	Douglas-fir	34	0.80	30.000	0	D	1.00	1.00	1.00	1.00	1.00
1	3	9.0	Pine, Ponderosa	25	0.75	25.000	0	D	1.00	1.00	1.00	1.00	1.00
1	4	19.0	Pine, Ponderosa	51	0.60	75.000	0	D	1.00	1.00	1.00	1.00	1.00
1	5	9.0	Aspen, Quaking (x)	27	0.50	9.000	0	D	1.00	1.00	1.00	1.00	1.00
2	1	16.0	Douglas-fir	47	0.75	35.000	0	D	1.00	1.00	1.00	1.00	1.00
2	2	7.0	Douglas-fir	24	0.90	300.000	0	D	1.00	1.00	1.00	1.00	1.00
2	3	4.0	Pine, Ponderosa	16	0.90	500.000	0	D	1.00	1.00	1.00	1.00	1.00
2	4	20.0	Pine, Ponderosa	47	0.65	100.000	0	D	1.00	1.00	1.00	1.00	1.00
2	5	23.0	Pine, Ponderosa	68	0.65	120.000	0	D	1.00	1.00	1.00	1.00	1.00
2	6	2.0	Douglas-fir	12	0.90	2200.000	0	D	0.80	1.00	1.00	1.00	1.00
2	7	6.0	Aspen, Quaking (x)	22	0.50	19.000	0	D	1.00	1.00	1.00	1.00	1.00
2	8	8.0	Aspen, Quaking (x)	40	0.25	10.000	0	D	1.00	1.00	1.00	1.00	1.00
2	9	7.0	Aspen, Quaking (x)	21	0.50	28.000	0	D	1.00	1.00	1.00	1.00	1.00

Surface Deposition Information

Plot ID	Tree No.	Proportion Cut	<---- Foliage (Crowns)	Surface 1 Hr. (Crowns)	Deposition 10 Hr. (Crowns)	Remaining 100 Hr. (Crowns)	on the 1000 Hr. (Crowns)	Ground Boles Left Prop.	----> Rotten Prop.
1	1	0.75	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	2	0.70	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	3	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	4	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
1	5	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	1	0.70	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	2	0.50	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	3	0.50	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	4	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	5	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	6	0.75	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	7	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	8	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
2	9	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00

Plot control buttons are in the lower right part of the screen.



Basic Tree List Information

The Basic Tree List information includes Plot No., Tree No., DBH, Species, Height, Crown Ratio, Trees per Acre, Tree Structural Stage and Proportion in Crown by foliage and size class.

Sorting Capability

Clicking on the column heading will cause the tree list to be sorted either numerically or alphabetically based on the information in the selected column: Plot ID., Tree No., DBH, Species, Height, Crown Ratio, Trees per Acre and Tree Structural Stage.

Plot ID.

Any number of plots can be entered in CrownMass. For each plot, enter the number of the plot and the tree list data for each tree sampled in the survey. This information is entered via direct cell input.

Data Entry

Entry of the Tree Species and Tree Structural Stage is only allowed by selecting the entry from the pull down list. All other entries can be entered directly or by using the pull down list. To use the pull down list, first do a left mouse click on the cell and a down arrow will appear. Do a left mouse click on the down arrow to see the selections available. To select an item or value from the pull down list, do a left mouse click on the value.

Tree No.

Enter a numeric tree identifier. This information is entered via direct cell input.

DBH
Enter the diameter breast high (DBH in inches) of the sample tree. This information is entered via direct cell input.

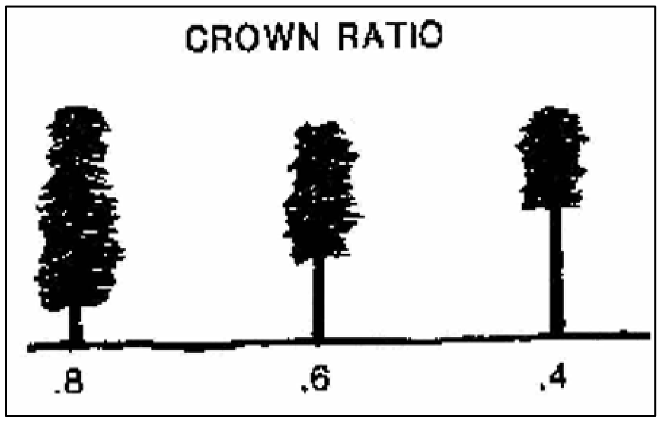
Species
Enter the species of the sample tree. This information is entered via a selection from a pull down list of available species. A species is available if it is defined and made active via the File, Preferences menu item.

Height
Enter the total tree height (feet) of the sample tree. This information is entered via direct cell input.

Crown Ratio
Enter the proportion of the total vertical tree height that is occupied by the vertical length of the tree crown.

$$\text{Crown Ratio} = \frac{\text{Live Crown Length}}{\text{Tree Height}}$$

For example, if the length of the crown is 10 feet and the total tree height is 20 feet, the crown ratio would be 0.50. This information is entered via a selection from a pull down list.



Trees per Acre
Enter the number of trees per acre that the sampled tree represents. This information is entered via direct cell input.

Tree Structural Stage
Enter the Structural Stage from the following options: Dominant, Co-dominant, Intermediate and Suppressed. Dominant is the default. This information is entered via a selection from a pull down list. These four crown classes are defined by the Society of American Foresters (1958) as follows:

Dominant
Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand, and with crowns well-developed but possibly crowded on the sides.

Co-Dominant

Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides; usually with medium-sized crowns more or less crowded on the sides.

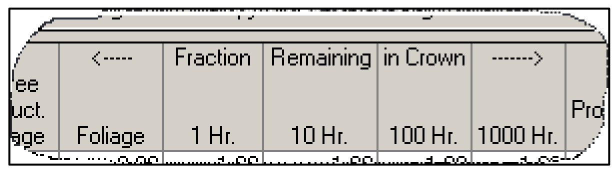
Intermediate

Trees shorter than those in the two preceding classes, but with crowns either below or extending into the crown cover formed by co-dominant and dominant trees, receiving little direct light from above, and none from the sides; usually with small crowns considerably crowded on the sides.

Suppressed or Overtopped

Trees with crowns entirely below the general level of the crown cover receiving no direct light either from above or from the sides.

Fraction Remaining in Crown (for foliage and branchwood size class)



The user has the option for each tree in the tree list to specify if all of the predicted crown component weight for the structural stage assigned is present in the crowns. For example, if insects have been eating tree foliage, then the user may wish to specify the fraction remaining in the Foliage box under the Proportion in Crown columns. The values can range from 0.0 to 2.0 with 1.0 as the default value. This information is entered via a selection from a pull down list.

- Foliage

  Enter the proportion of foliage in the crown with 1.00 indicating no loading change from the calculated value.

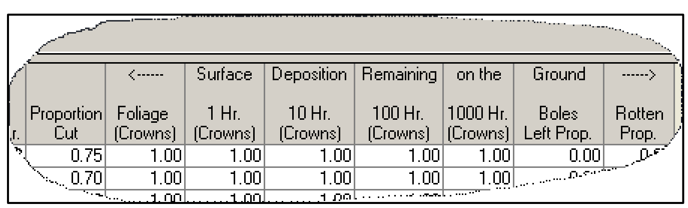
  

  If the "Crown Proportions: Auto Copy To All From Foliage" box is checked, then the fractional change specified in the Foliage box will be copied automatically to the 1-hr, 10-hr, 100-hr and 1000-hr boxes under this heading.

- 1-hr, 10-hr, 100-hr and 1000-hr timelag fuels

  Enter the proportion of 1-hr, 10-hr, 100-hr and 1000-hr timelag fuels in the crown with 1.00 indicating no loading change from the calculated value.

<u>Surface Deposition Information</u>

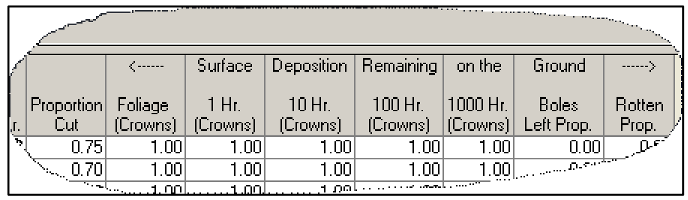


The Basic Tree List information includes Proportion Cut, Surface Deposition (by foliage and branchwood size class), Boles Left Proportion and Rotten Proportion.

Proportion Cut (for foliage and by branchwood size class)

A portion of the trees represented by a sample tree can be cut or deposited to the ground. This allows for estimating of the additional needle and woody fuel loading that would be added to the existing surface fuel profile if trees were cut or fell by natural processes. (See the Fire Behavior Assessment Tab, Surface Fuel Model Tab). The default proportion cut is 0.0. The program “cuts” and removed the proportion of the trees and hence the tree's crown weight from the canopy. By default, 100% of this crown material is deposited to the surface. This includes needles, 1-h, 10-h, 1000-h and 1000-h live and dead branchwood as well as the unmerchantable tip. By default, the program assumes all boles for cut trees with a DBH 7 inches and greater are removed from the site. For trees with a DBH of 6 inches or less, the bole is left on the site since these are considered unmerchantable (small trees). Enter a proportion between 0.00 and 1.00 via a selection from a pull down list.

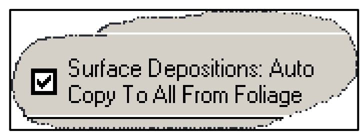
Surface Deposition (for foliage and by branchwood size class)



The user has the option for each tree in the tree list to specify if all of the predicted crown component weight deposited to the surface will remain on the surface or be removed by some process. For example, if whole tree yarding will occur, the majority of the deposited foliage and branchwood would be removed but some may also remain. The values can range from 0.0 to 1.0 with 1.0 as the default value. This information is entered via a selection from a pull down list.

- Foliage
  Enter the proportion of the deposited foliage remaining on site.

  If the “Surface Deposition: Auto Copy To All From Foliage” box is checked, then the fractional change specified in the Foliage box will be automatically copied to the 1-hr, 10-hr, 100-hr and 1000-hr boxes under this heading.



- 1-hr, 10-hr, 100-hr and 1000-hr timelag fuels
  Enter the proportion of deposited 1-hr, 10-hr, 100-hr and 1000-hr timelag fuels that will remain on site.

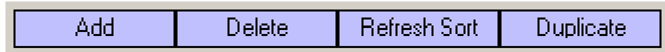
Boles Left Prop.

By default, the program assumes all boles for cut trees with a DBH 7 inches and greater are removed from the site. Boles that are deposited to the surface may be removed or may remain. This entry specifies the proportion of the boles that are left on site. Enter a proportion between 0.00 and 1.00 via a selection from a pull down list. The default value for the cell is 0.0.

Rotten Prop.

The boles left on site may not be all sound material. Rotten or partially decayed boles weigh less. In CrownMass, the specific gravity of rotten boles is assumed to be 0.30 or 18.7 pounds per cubic foot. This entry specifies the proportion of the boles that are left on site that are rotten. Enter a proportion between 0.00 and 1.00 via a selection from a pull down list. The default value for the cell is 0.0.

Tree Control Buttons



At the bottom right of the Analysis Area and Plots Tab, there are tree control buttons that allow the user to **Add** a tree to the tree list, to **Delete** a tree from the tree list, to **Duplicate** a tree (row) or to **Refresh (a) Sort**.

Add Button

The **Add** button is used to add a tree (row) to the tree list described in the Data Input Screen.

Delete Button

The **Delete** button is used to delete a tree (row) from the tree list described in the Data Input Screen. Identify the row to be deleted by first clicking on it.

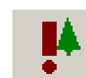
Refresh Sort Button

When the user enters data into the tree list, Sorting of rows based on the Plot ID and Tree Number does not occur. Use this button to order the rows by Plot ID and Tree Number.

Duplicate Plot Button

The **Duplicate** plot button will copy the tree (row) that the target arrow is pointing to (left side of the plot window) adding it to the end of the tree listing.

Determining Crown Weights, Canopy Weights and Surface Deposition Fuel Loadings



When changes have occurred in tree list information, the Calculate Crown Mass icon will be colored (versus dimmed) to alert the user that the canopy loadings and surface deposition loadings need to be calculated or re-calculated. The user has three options to invoke the calculation of the canopy weights and surface deposition fuel loadings based on the tree list information and assumptions:

- Clicking on the **Calculate => Calculate CrownMass** menu item
- Clicking on the **Calculate Crown Mass** icon
- Clicking on the **Quick Results** tab

Viewing Canopy and Surface Deposition Fuel Loadings

To calculate and view canopy and surface deposition loadings, click on the **Quick Results** Tab.

Summary Tab

Selecting the Summary Tab will display both numerical and graphical information on the crown weights and surface fuel loadings.

Numerical Summary of Canopy and Surface Deposition Loadings

On the right side of the screen is a summary of the Canopy Net and the Surface Deposition Fuel Loadings subdivided into the foliage and the 1-hr, 10-hr, 100-hr and 1000-hr timelag fuel categories. The loadings are all expressed in tons per acre. Totals are provided both with and without foliage. The average basal area (sq. ft. / ac.) for trees left standing on the site is shown at the top.

Analysis Area Averages
Basal Area: 419.0

Canopy Net Loadings (TPA):

Foliage:	13.82
1 hour:	1.90
10 hour:	21.80
100 hour:	23.12
1000 hour:	10.44
Canopy Total (w/o foliage):	57.26
Canopy Total:	71.08

Surface Loadings (TPA) (from crowns, boles, and tops):

Foliage:	4.26
1 hour:	2.20
10 hour:	3.80
100 hour:	4.35
1000 hour:	1.78
Surface Total (w/o foliage):	12.14
Surface Total:	16.40

Hot Tip

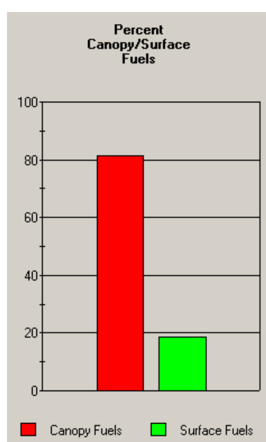
Canopy fuel loadings include the unmerchantable tip but no bole weight.

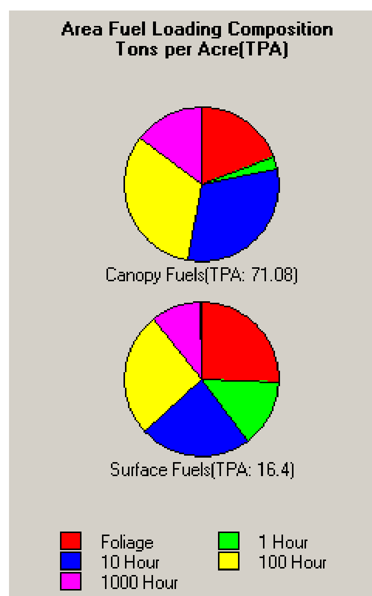
The surface loadings include the unmerchantable tip weight, the bole weight for all trees with a DBH less than or equal to 6 inches and the bole weight for all trees with a DBH 7 inches or greater that are left on site.

Graphical Display of Crown and Surface Deposition Loadings

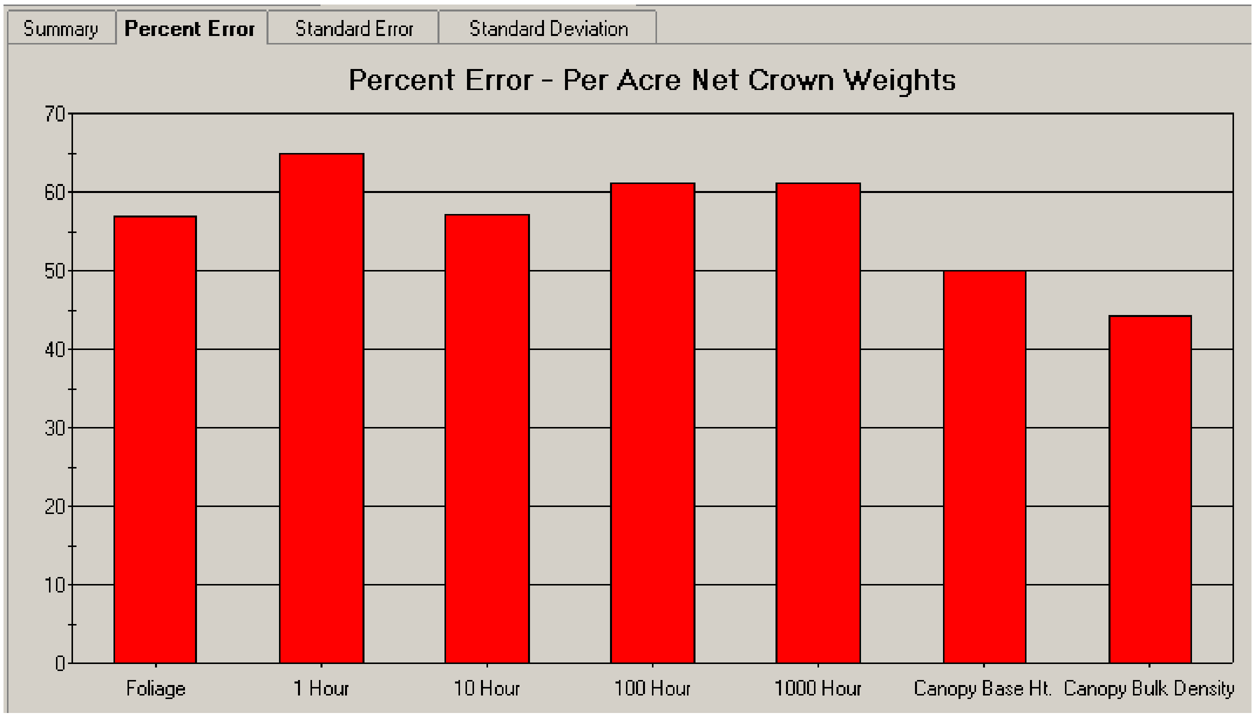
To aid the user in understanding the distribution of fuel loadings for foliage and the 1-hr, 10-hr, 100-hr and 1000-hr timelag fuel categories, pie charts are provided.

To aid the user in understanding the proportional split of the total tree list canopy fuel loading, a bar graph shows the proportion of the total tree list canopy fuel loading deposited to the surface and that remaining.





Percent Error Tab
The percent error for the foliage and 1-hr, 10-hr, 100-hr and 1000-hr timelag fuel categories as well as the canopy base height is displayed via a bar graph. The percent error is calculated as the standard error of the mean divided by the mean value of each category. If only one plot is entered, no statistics are available or necessary. Percent error values less than 20% are considered acceptable and adequate when assessing fuel loadings and associated fire behavior/effects.



Standard Error Tab
The standard error of the mean for the foliage and the 1-hr, 10-hr, 100-hr and 1000-hr timelag fuel categories as well as the canopy base height is displayed via bar graph. The standard error of the mean is calculated as the standard deviation divided by the square root of the number of plots. The standard error of the mean can be viewed as the expected standard deviation of the category estimates based on repeated sampling of the analysis area. If only one plot is entered, no statistics are available or necessary.

Standard Deviation Tab
The standard deviation for the foliage and the 1-hr, 10-hr, 100-hr and 1000-hr timelag fuel categories as well as the canopy base height is displayed via bar graph. The standard deviation is calculated based on the individual values for these categories in the plots. If only one plot is entered, no statistics are available or necessary.

Fire Behavior Assessment

The *canopy bulk density* and *canopy base height* characteristics in treed stands coupled with identification of the *surface fuel profile*, *topographic* and *environmental* information facilitate the estimation of surface fire behavior, potential crown fire involvement and first order fire effects. CrownMass contains algorithms to display the following fire behavior and fire effects values based on the work of Alexander (1988), Ryan and Reinhardt (1988), Beukema et al. (1999) Rothermel (1972), Andrews (1986), Andrews (1989), Finney (1998) and Scott and Reinhardt (2001).

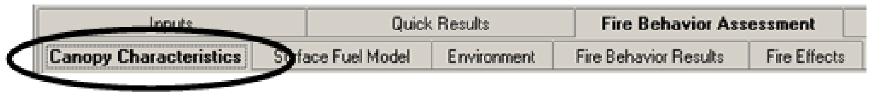
- Surface Rate of Spread
- Surface Fireline Intensity
- Surface Flame Length
- Portability of Ignition
- Maximum Spotting Distance from Torching Trees and a Surface Fire
- Crown Fire Initiation Potential based on Methods Described by Finney (1998) and Scott and Reinhardt (2001)
- Torching and Crowning Index
- Resultant Fire Type
- Resultant Fire Rate of Spread
- Resultant Fire Flame Length
- Crown Scorch Height
- Probability of Mortality for each Tree in the Tree List
- Elliptical Fire Size for a Free Burning Fire After a Defined Time Period (Single Ellipse Model)

From this information, effects of varying management strategies of tree density and surface fuel loading can be assessed to estimate the attainment of proposed or defined management objectives.

Hot Tip

Caution: The fire behavior calculations are provided for assessment purposes to aid in the comparison of different fuel profiles that might exist naturally or be created via management actions. CrownMass should not be used for "real time" fire behavior calculations and the user is referred to the BEHAVE, Farsite or BehavePlus programs for this purpose.

Canopy Characteristics



From the tree list information, CrownMass predicts the crown weight, canopy base height and canopy bulk density (Reinhardt et. al. 2000; Van Wagner, 1977, 1993). Canopy base height and canopy bulk density are both familiar concepts, but are difficult to define or estimate at the stand level. The CrownMass program implements a process described by Reinhardt et. al. (2000) to provide estimates of these characteristics. In addition to fuel loading, canopy characteristics that are estimated by CrownMass are:

- Canopy Bulk Density
- Canopy Base Height
- Canopy Ceiling Height

Crown versus Canopy

Within this document, the term crown will be used to refer to the foliage and stem branchwood for an individual tree. The term canopy will be used to refer to the collection of crowns with a stand of trees.

Canopy Bulk Density

Mathematically, canopy bulk density (CBD) (lbs/ft^3) is canopy biomass divided by the volume occupied by crown fuels. Canopy bulk density is hard to estimate in the field. Initially, it seems attractive to calculate this value by treating the canopy as a box with the depth the stand height minus the canopy base height. Assuming this box covered an acre (43,560 ft^2), dividing the fuel loading in the canopy by the volume of the box would provide an estimate of the average canopy bulk density. Unfortunately, this estimate has a bias toward underestimation of the canopy bulk density due to the averaging of largely void areas in the top and bottom of the canopy with the more dense layers of foliage. A fire burning vertically within the crowns will most likely propagate through more dense canopy layers.

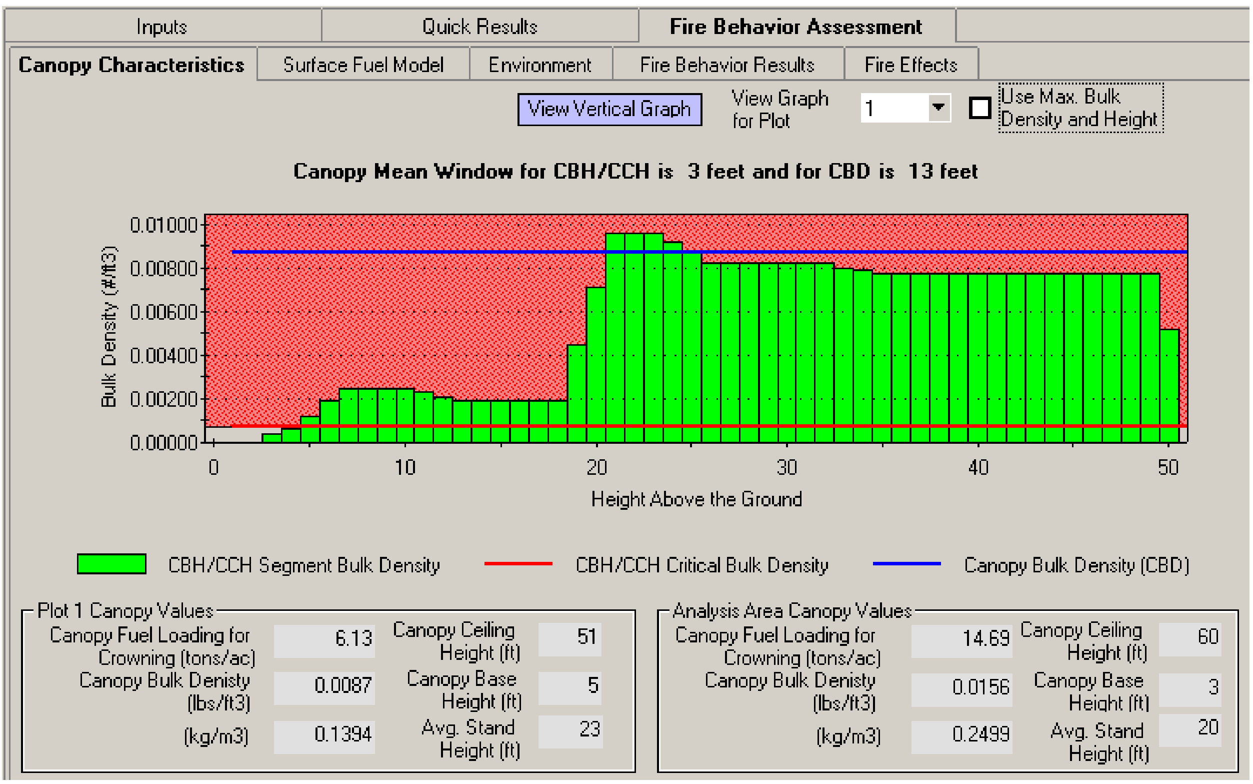
Canopy Base Height

For an individual tree, the measurement of the height to the base of the crown can be made. The averaging of these values for all trees in a stand would give an estimate of the level of the stand canopy base height. Frequently, this is a measure of where the limbs of the canopy start vertically but the number can be skewed by the presence of small trees or occasional live limbs. A more meaningful value would be the height above the ground of the first canopy layer where the density of the crown mass within the layer is high enough to support vertical movement of a fire.

Determination of Canopy Base Height and Canopy Bulk Density

From the tree list data input, the crown weight is determined for the needle and the 1-hour timelag live and the1-hour timelag dead fuel categories. Current assumptions (Reinhardt et. al. 2000) are that the needle fuel loading and 0.50 of the 1-hour timelag crown fuel loading contribute to the flaming portion of crown fire. With the Assumptions Tab, the proportion of the 1-hour timelag crown fuel loading that contributes to the flaming portion of crown fire can be set with 0.50 the program default.

It is assumed that the canopy loading is evenly distributed vertically within the canopy. Of course, this is not true but it still might be acceptable in that trees are conical in shape with light attenuation. For each tree in the tree list, CrownMass distributes the crowning assessment canopy fuel for that tree equally into one-foot vertical segments from the tree's crown base height to the tree's total height. The loading for each one-foot segment is calculated by summing the loading contributions to that segment from all of the trees within the stand.

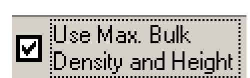


CrownMass displays the calculated bulk density for each one-foot segment of the canopy for each plot via the Canopy Characteristics Tab.

View Graph for Plot

Use the pull-down to select the plot to be viewed.

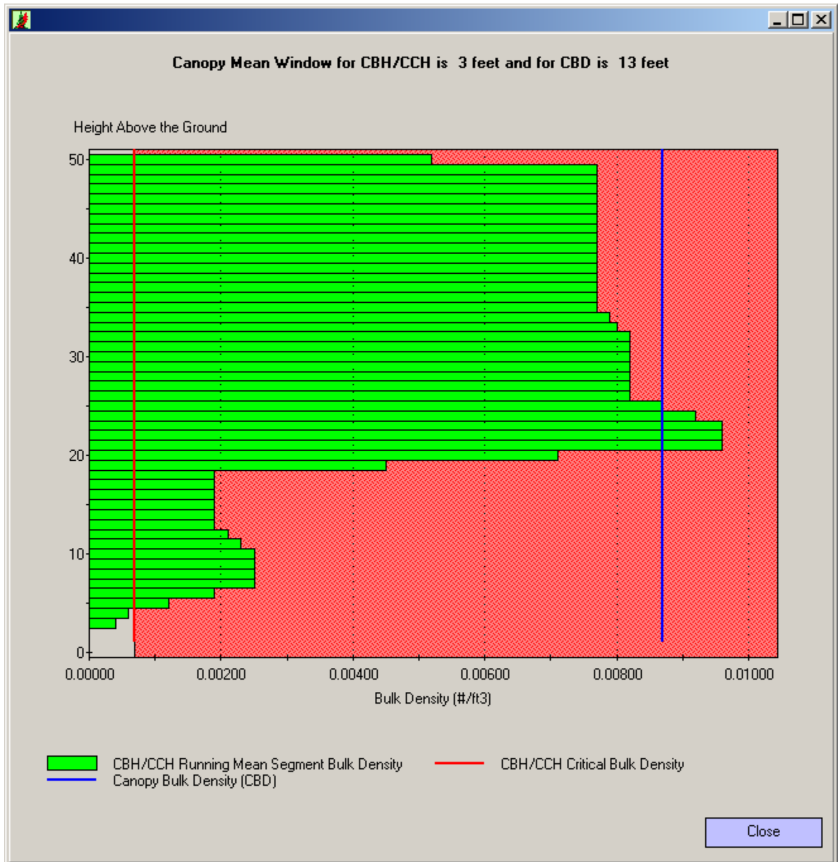
Use Site Max. Bulk Density on Y Axis



Clicking in the box implements the setting of the maximum value on the Y-axis to be the maximum running mean segment bulk density from all segments on all plots. This will cause the Y-axis on each plot graph to be the same. This can aid in the ocular comparison of plot values.

View Canopy Profile Graph Vertically

By clicking on the **View Vertical Graph** button, the canopy profile graph will be displayed with the height above the ground on the Y-axis and the bulk density on the x-axis.

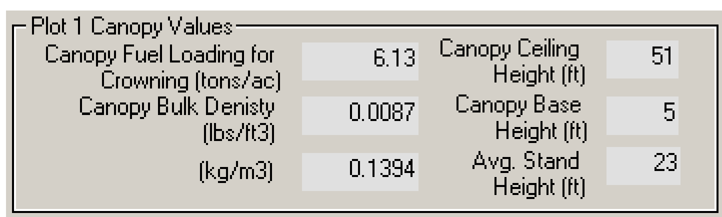


Running Mean Segment Bulk Density

This value is graphed showing the segment running mean bulk density for each one-foot canopy segment. The number of segments, X, used to determine this value is set on the Inputs, Assumptions screen. The calculation uses the segment bulk density value at the specified height, the segments X/2 below the segment and the segments X/2 above the specified height. If there are not X/2 segments below the specified height, the running mean is calculated based on the number of segments that do exist. This value is used to determine the number of segments above the segment, which the running mean is being calculated for.

Plot X Canopy Values

The following items are displayed for the plot selected.

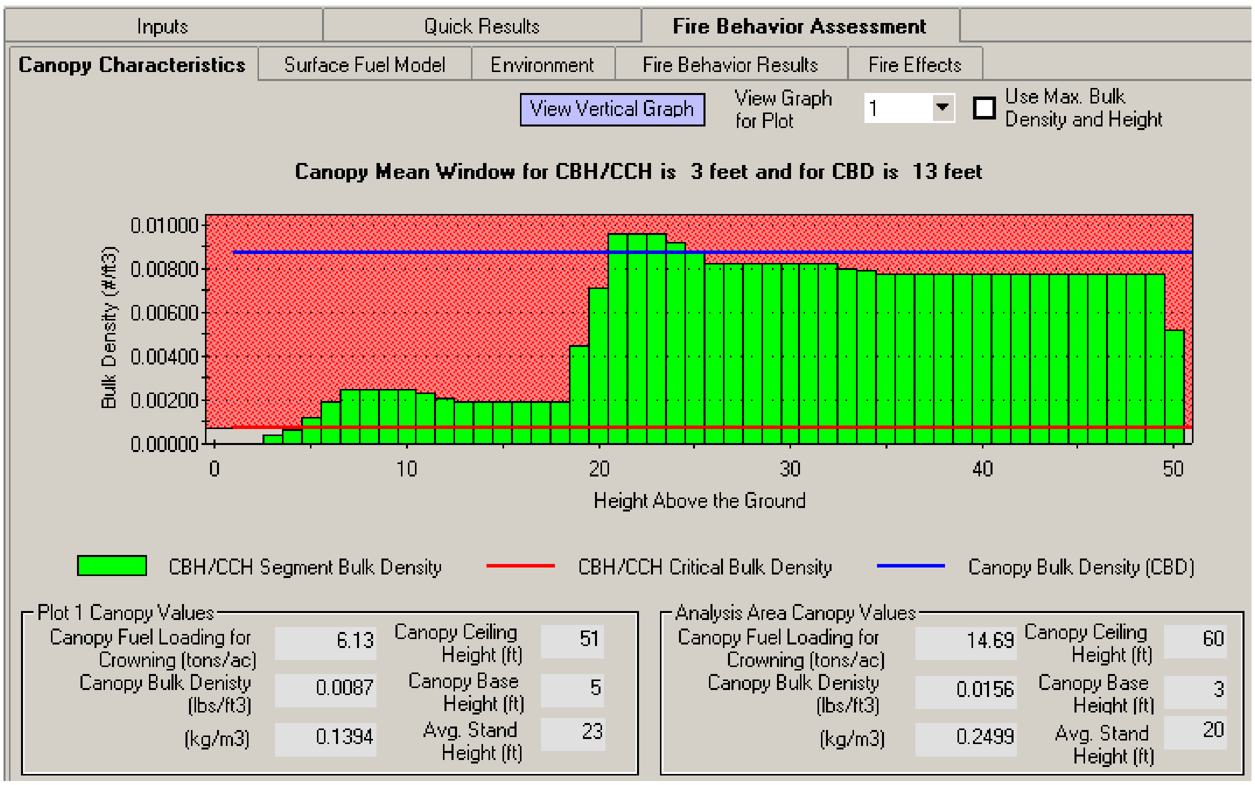


Canopy Fuel Loading for Crowning

From the tree list data input, the weight is determined for the needle and the 1-hour timelag live and the1-hour timelag dead fuel categories. Current assumptions (Reinhardt et. al. 2000) are that the needle fuel loading and 0.50 of the 1-hour timelag crown fuel loading contribute to the flaming portion of crown fire. With the Assumptions Tab, the proportion of the 1-hour timelag crown fuel loading that contributes to the flaming portion of crown fire can be set with 0.50 the program default. This value is the sum of the canopy needle weight and the assumed proportion of 1-hour timelag weight.

Canopy Base Height and Canopy Ceiling Height

Sando and Wick (1972) suggest that a minimum bulk density in the canopy to provide vertical propagation of fire is 100 lbs/acre-foot which is 0.0023 #/ft^3 or 0.037 kg/m^3. Experience in use of this value has shown that use of 30 lbs/acre-foot (0.00069 #/ft^3 or 0.0111 kg/m^3) provides a better estimate of the canopy base height (Crookston and Reinhardt 2003). This minimum bulk density can be set by the user on the Assumptions Tab but the recommended value by Sando and Wick is the program default. The *canopy base height* and the *canopy ceiling height* are determined by CrownMass as the lowest and highest segments respectively where the running mean segment bulk density is greater than the minimum canopy bulk density. In CrownMass, a red line is drawn at the canopy bulk density of 0.00069 lbs./ft^3. Note that the first live limb height is at 3 feet from the ground but the first one foot layer where the running meaning bulk density is 0.00069 lbs./ft^3 is 5 feet.

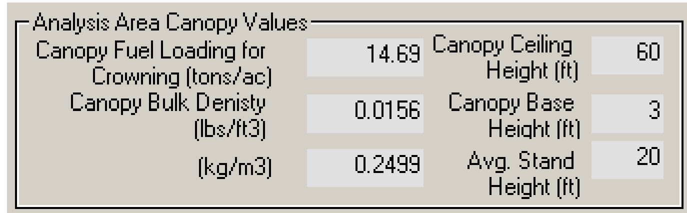


Canopy Bulk Density

The plot canopy bulk density is the largest of the one-foot segment bulk densities on the plot. In CrownMass, the canopy bulk density is set as the maximum of the one-foot layer running meaning bulk densities. In the figure above, this value would be 0.0087 lbs./ft^3 (0.1394 kg/m^3) for Plot 1. The blue line in the figure represents the plot's canopy bulk density. The Analysis Area's canopy bulk density is the average of the plot canopy bulk density values and is shown in the table in the lower right.

Analysis Area Canopy Values

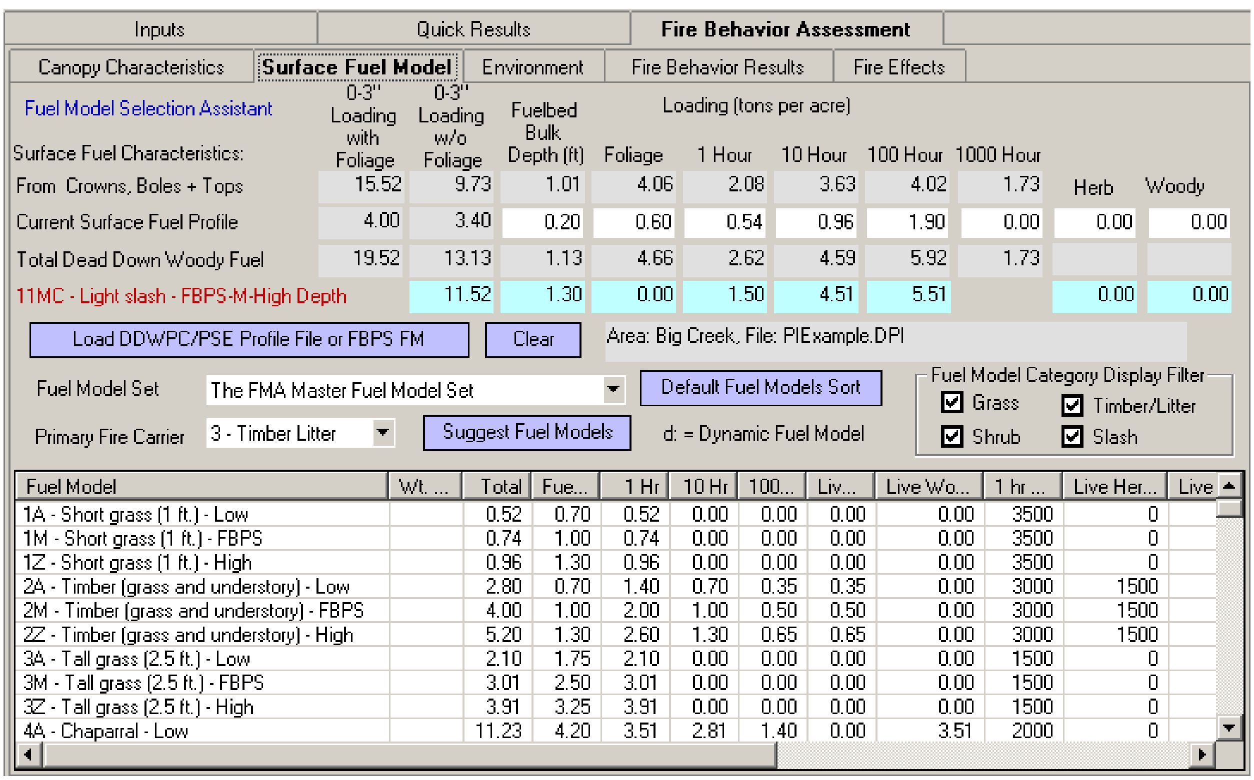
The following items are displayed for the Analysis Area and are calculated as an <u>average of plot values</u> for each.



- Canopy Fuel Loading for Crowning
- Canopy Base Height
- Canopy Ceiling Height
- Canopy Bulk Density

Determining the Surface Fuel Model

The DDWoodyPC and PSExplorer programs in FMAPlus allow the user to estimate surface dead and down woody fuel loadings. These loadings together with the knowledge of herbaceous and shrub loadings provides the information necessary to assign a Fire Behavior Prediction System (FBPS) (Rothermel 1983; Anderson 1982) fuel model. The Fuel Model Selection Assistant in CrownMass program facilitates integration of this information and provides aids to the user in the assignment of a derivative FBPS fuel model to the analysis area.



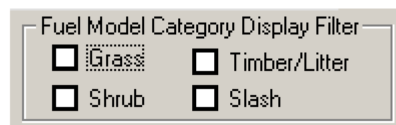
Fuel Models

A fuel model is a set of numerical values that describe the fuel inputs for a mathematical model that predicts spread rate and intensity. Fuel models are prepackaged sets of fuel parameters representing stylized fuel situations. Fuel models within CrownMass are based on the FBPS 1982 fuel models (Rothermel 1972, Anderson 1972, Albini 1976).

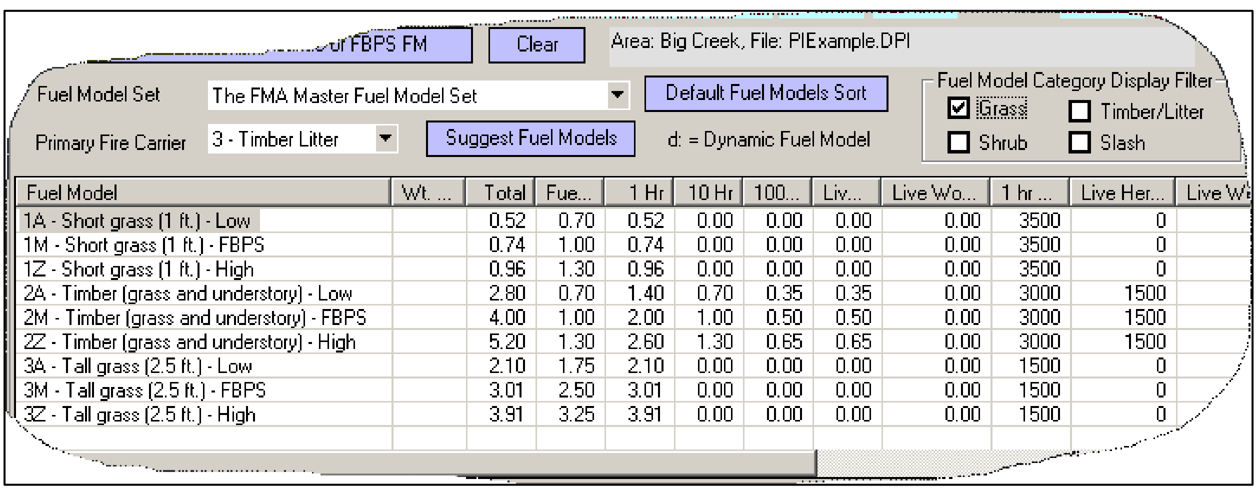
Fuel Model Sets

A Fuel Model Set is a group of fuel models. CrownMass contains three groups: the FMA Master Fuel Model Set, the FBPS 1982 Fuel Models (13 models), the FBPS 2005 Fuel Models (53 models) and My Fuel Models. The FMA Master Fuel Model Set contains 109 fuel models based on the FBPS 1982 Fuel Models (Rothermel 1972, Anderson 1972, Albini 1976). The core basis for these 109 fuel models is the FBPS 1982 fuel models 1-13. A detailed description of the fuel models in the FMA Master Fuel Model Set is contained in the section titled The FMA Master Fuel Model Set earlier in this guide. In addition, seven custom fuel models developed by researchers are included.

To select Fuel Model Set, click on the pulldown in the Fuel Model Set window. The fuel models in the selected fuel model set will appear in the display area in the low part of the screen.



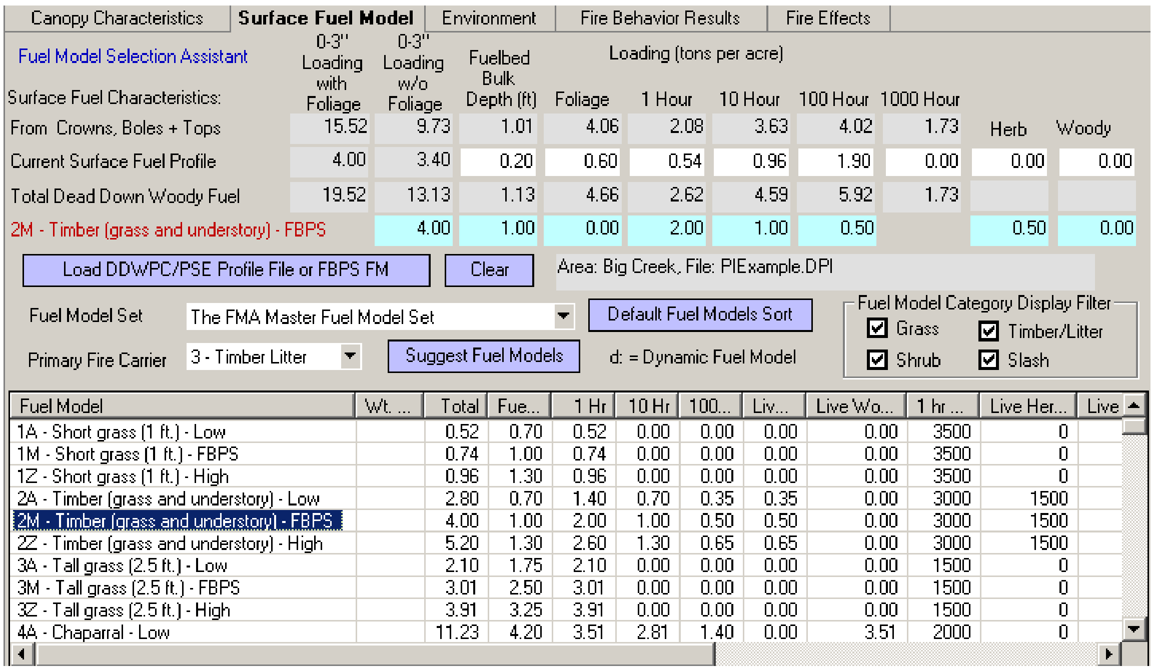
Fuel model in the selected Fuel Model Set can be displayed by Fuel Category: Grass, Brush, Timber Litter or Slash. By checking duel categories in the Fuel Model Display Filter box, the user can display in the fuel model display area a fuel model from the selected fuel categories. In the screen capture below, only the fuel models in the grass fuel category in the FMA Master Fuel Model Set are displayed.



Fuel Model	Wt. ...	Total	Fue...	1 Hr	10 Hr	100...	Liv...	Live Wo...	1 hr ...	Live Her...	Live W
1A - Short grass (1 ft.) - Low		0.52	0.70	0.52	0.00	0.00	0.00	0.00	3500	0	
1M - Short grass (1 ft.) - FBPS		0.74	1.00	0.74	0.00	0.00	0.00	0.00	3500	0	
1Z - Short grass (1 ft.) - High		0.96	1.30	0.96	0.00	0.00	0.00	0.00	3500	0	
2A - Timber (grass and understory) - Low		2.80	0.70	1.40	0.70	0.35	0.35	0.00	3000	1500	
2M - Timber (grass and understory) - FBPS		4.00	1.00	2.00	1.00	0.50	0.50	0.00	3000	1500	
2Z - Timber (grass and understory) - High		5.20	1.30	2.60	1.30	0.65	0.65	0.00	3000	1500	
3A - Tall grass (2.5 ft.) - Low		2.10	1.75	2.10	0.00	0.00	0.00	0.00	1500	0	
3M - Tall grass (2.5 ft.) - FBPS		3.01	2.50	3.01	0.00	0.00	0.00	0.00	1500	0	
3Z - Tall grass (2.5 ft.) - High		3.91	3.25	3.91	0.00	0.00	0.00	0.00	1500	0	

Selecting a Fuel Model to Use in Fire Behavior Prediction

To manually select a fuel model to use in fire behavior prediction, click on the fuel model name. The selected fuel model's name and identifier will appear in red above the **Load DDWPC/PSE Profile or FBPS FM** button and the fuel model parameters will be displayed in the cyan colored cells to the right of the fuel model's name and identifier. In the screen below, a file; model 2M – Timber (grass and understory) – FBPS has been selected.



Selecting a Fuel Model To Use in Assessing Fire Behavior Potential from Management Activities for Natural Events

The fuel model selection process follows the following steps:

1. Determine the Deposited Surface Fuel Loading from the Crowns, Boles and Tops of Trees
2. Determine the Current Surface Fuel Profile
3. Determine a Suggested Fuel Model
   a. Timber Litter or Slash Fuel Categories
   b. Grass and Brush (Shrub) Fuel Categories
4. Select Fuel Model to Use in Fire Behavior Assessment

Step 1: Determining the Deposited Surface Fuel Loading from the Crowns, Boles and Tops of Trees

This fuel loading is the surface deposition fuel loading displayed on the **Quick Results** tab. The estimation of the fuelbed depth has been determined for slash fuelbeds using the process described by Albini and Brown (1978). The algorithms from this research essentially use the10-hr timelag fuel loading, the predominant species and the type of management activity to estimate the *fuelbed bulk depth*. The predominant species and management activity used for this calculation are specified on the **Inputs => Assumptions Tab**.

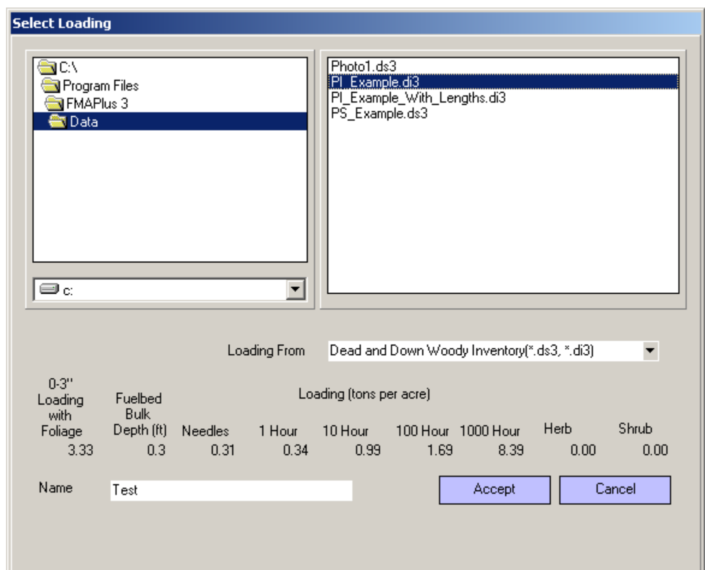
Step 2: Determine the Current Surface Fuel Profile

The current surface fuel profile allows for the entry of 1-hr, 10-hr, 100-hr and 1000-hr timelag fuel loadings as well as the fuelbed bulk depth. Direct entry values in these cells is permitted. If the user has done a planar intercept inventory and reduced the data using the DDWoodyPC program or has saved a fuel profile via the PSExplorer program, the fuels information from these inventories can be input automatically.

The Load DDWPC/PSE Profile or FBPS FM Button

If the user has used the planar intercept method or photo series method to do a fuel inventory and if the data was reduced via the DDWoodyPC program, then the inputs and results of that inventory are saved in a file (FileName.dpi, FileName.dp3, FileName.dps or FileName.ds3). If the user has developed and saved a fuels profile in the PSExplorer program, then the profile (FileName.pro or FileName.pr3) file should also exist. If the default file locations were used, these files should reside in the Data folder, which is inside the Directory where the FMAPlus program has been installed.

Clicking on the **Load DDWPC/PSE Profile or FBPS FM** Button will cause the screen at the right to appear. In the upper left window, the user can navigate to the folder where data files are located. Note that the default folder is the Data folder where FMAPlus software is installed. The "Loading From" pull-down allows the user to select the type of file desired. The files of the selected type that are in the Data Folder (or user selected folder) will appear in the upper right window. By clicking on a file name, the fuels information and the area sampled name will appear in the lower area of the screen. Click on the **Accept** button to accept the identified inventory.



The Clear Button

Clicking on the **Clear** button to the right of the **Load DDWPC/PSE Profile or FBPS FM** button will clear all values in the Current Surface Fuel Profile row and set them to 0.0.

The Total Dead Down Woody Fuel Row

For fuel loadings, this value is the sum of the loading from Crowns, Boles and Tops row and from the Current Surface Fuel Profile row. The estimation of the fuelbed depth is determined using the process described by Albini and Brown (1978) based on the total 10-hour timelag fuel loading.

Step 3a: Determine a Suggested Timber Litter or Slash Fuel Model

CrownMass contains a process for the suggestion of a derivative FBPS timber litter or slash fuel model that best fits created surface fuel characteristics. The following sections describe the process used by CrownMass to suggest a timber litter or slash FBPS fuel model that best fits created surface fuel characteristics.

Select The Fuel Model Set

Use the pull down to select the Fuel Model Set needed to select the surface fuel model. Custom fuel models can be developed and saved in additional Fuel Model Sets (see the File, Manage Fuel Models menu).

Primary Carrier of the Fire

To aid in the suggestion of the most appropriate surface fuel model for Timber Litter and Slash fuelbeds that best matches the Total Dead Down Woody Fuel, select the fuel group that is the primary carrier of the fire: Timber Litter or Slash.

Hot Tip

The ten-hour depth assumptions are based on data from slash fuelbeds. The Suggest Fuel Model option in CrownMass is used most appropriately for the timber litter and slash fuel categories.

Suggest Fuel Model Button

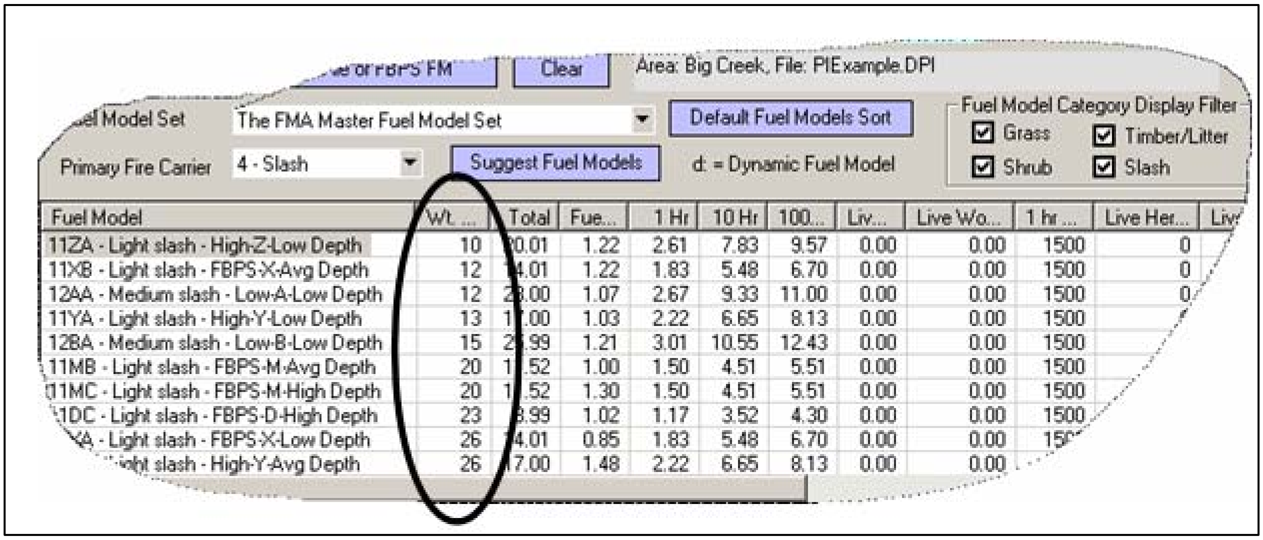
Click this button to see the suggested fuel model displayed in red text below the Total Surface Fuel label. The fuel model list will be sorted so that the best-fit fuel model is displayed on the first row of the fuel model listing.

The process CrownMass uses to determine the best-fit fuel model starts by calculating the percent difference between certain fuelbed characteristics for the created fuelbed and all candidate derivative fuel models. These fuelbed characteristics are:

- Fuelbed Bulk Depth
- 1-hr Timelag Dead and Down Fuel Loading
- 0-3" Total Fuel Loading

After the percent difference has been calculated for each of these fuelbed characteristics, a weighted percent difference is calculated for each candidate derivative fuel model. The program default weighting factors are assigned on the Inputs, Assumptions Tab and are: Fuelbed Bulk Depth, 0.7; 1-hr Timelag Fuel Loading, 0.2; and 0-3" Total Fuel Loading. 0.1. These weighting factors are assigned to reflect the high sensitivity of the surface fire spread model (Rothermel, 1972) to fuelbed depth followed by a lesser sensitivity to 1-hr timelag and total 0-3" fuel loading.

The Wt. % Diff column in the fuel model display window displays the weighted percent difference for each fuel model.



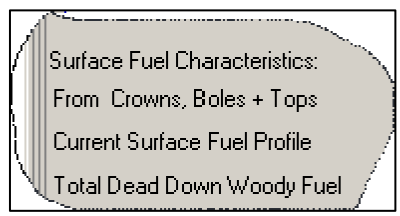
Sorting Capability of Columns

Clicking on any column heading will cause the fuel model list to be sorted either numerically or alphabetically based on the information in the selected column.

Default Fuel Model Sort Button

Clicking on this button will return the display of the fuel model in the selected Fuel Model Set to the default display.

Step 3b: Determine a Suggested Grass or Brush Fuel Model



The Surface Fuel Characteristics section only documents the presence of dead down woody material in the surface fuel profile. Grasses and shrubs may be present. At this time, the automated fuel model selection process in CrownMass does not consider live fuel. A future upgrade of CrownMass is planned which will include the grass and shrub loading in the automated fuel model selection process. The consideration of the presence of these is critical and must be part of the decision when the user makes a final fuel model selection for the fire behavior assessment.

Grass and brush fuelbeds have significantly different characteristics than timber litter and slash fuelbeds. Grass and brush fuelbeds are "vertically oriented" where as timber litter and slash fuelbeds are "horizontally oriented." This orientation affects the fuelbed depth and associated characteristics such as the fuelbed bulk density and the relative packing ratio. To aid in the suggestion of the most appropriate surface fuel model for Timber Litter and Slash fuelbeds that best matches the Total Dead Down Woody Fuel, select the fuel group that is the primary carrier of the fire from the Fuel Model Category Display Filter: Grass or Shrub. Select a best-fit fuel model using the total dead down woody fuels loadings, the estimated grass and shrub fuel loading and professional judgment.

Step 4: Select a Fuel Model to Use in the Fire Behavior Assessment

The user can accept the suggested fuel model assignment from CrownMass or can select a different fuel model. To select a different fuel model, scroll to the fuel model and click on it’s name. The selected fuel model’s identifier and name will appear in red below the Total Surface Fuel title.

Assigning Environmental Conditions

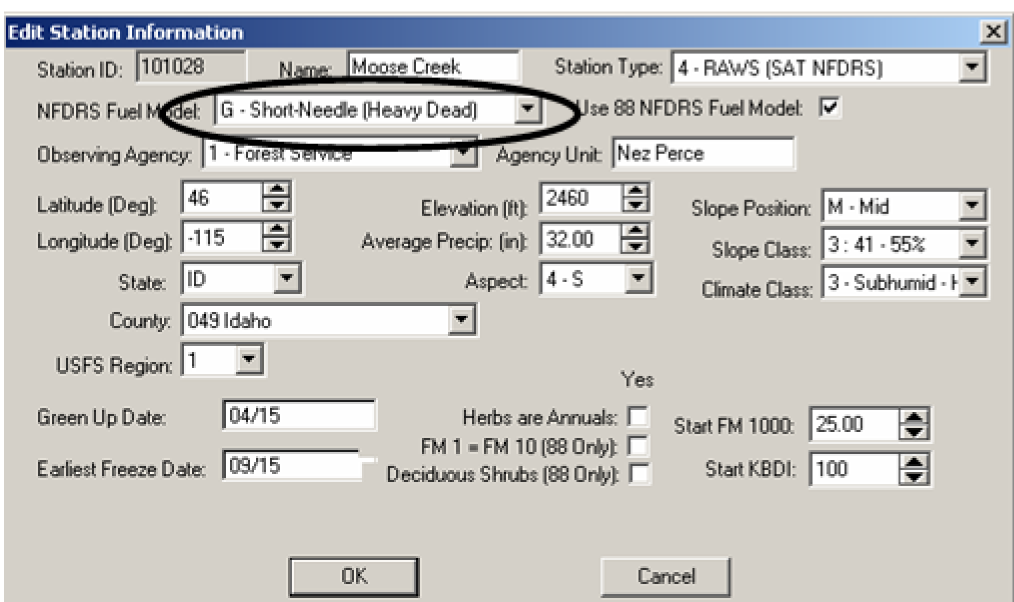
To assess potential fire behavior and effects, environmental conditions need to be assumed. These environmental conditions are described by:

- Fuel Moisture Values
- A Midflame Wind Speed Value
- The Slope Steepness
- The Air Temperature
- The Foliar Moisture Content

The user may wish to assess potential fire behavior and effects under some specific environmental conditions that represent a prescribed fire or wildfire burning condition. Examples include assessing potential fire behavior and effects for a proposed prescribed fire prescription window or for a calculated percentile weather situation developed using the FireFamily Plus program (USDA Forest Service 1999).

Determining Percentile Weather

The first task in determining percentile weather is defining a weather station(s), which is representative of the analysis area. This includes defining the Fuel Model-Slope Class-Veg Type-Climate Class. It is recommended that an NFDRS fuel model G be used for this process since it contains fuel loading in all of the dead and live fuel classes.

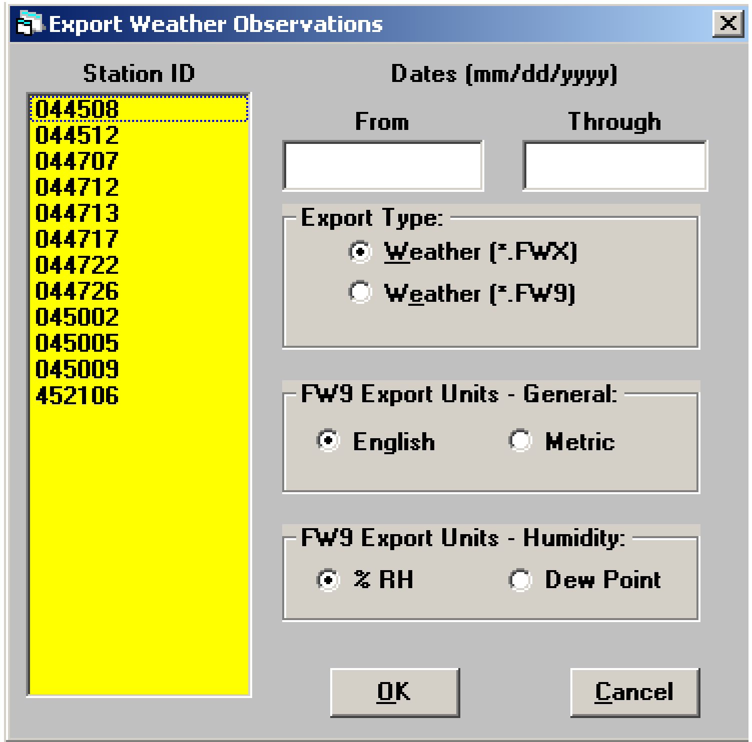


Obtain Weather Data in *.raw file format

Weather data is used in many planning processes on a unit. The same weather data from a specific weather station should be used. Obtain the weather data desired by contacting the local agency's unit fire protection planning specialist. For agencies that use the National Fire Management Analysis System (NFMAS), this weather data is contained in the unit's PCHA database. Using the unit's corporate weather data set for a weather station insures consistency and should also insure that the weather data set has been screened for incorrect or invalid weather observations.

Export weather from PCHA

Weather data can be exported from the PCHA data base. Choose the station number, date range, and file type for each export.



Station ID

PCHA will list the stations defined in the *Weather Station* screen. Choose a station for export.

Dates

Enter the beginning and ending dates to export in the From and Through boxes. Enter the dates in mm/dd/yy format. PCHA will export only the weather observations for the requested station whose observation date falls between the two dates.

Export Type

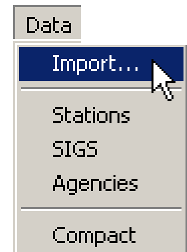
There are two possible export types.

- FWX Format - This file contains one observation per date and is formatted in the 1972 National Interagency Fire Management Information Database (NIFMID) format.

- FW9 Format - This file contains hourly observation data and is formatted in the 1998 NIFMID format.

FireFamily Plus accepts either type.

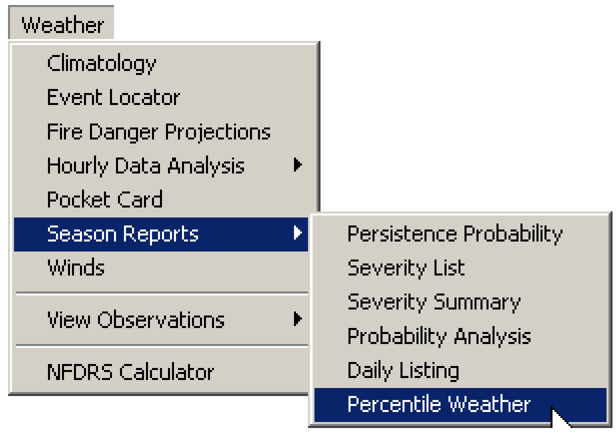
Importing Weather to FireFamilyPlus



Import the weather station data into FireFamilyPlus using the **Data => Import** menu. Refer to the FireFamilyPlus Users Guide, which can be found on the FMAPlus installation CD-ROM.

Determine Percentile Weather

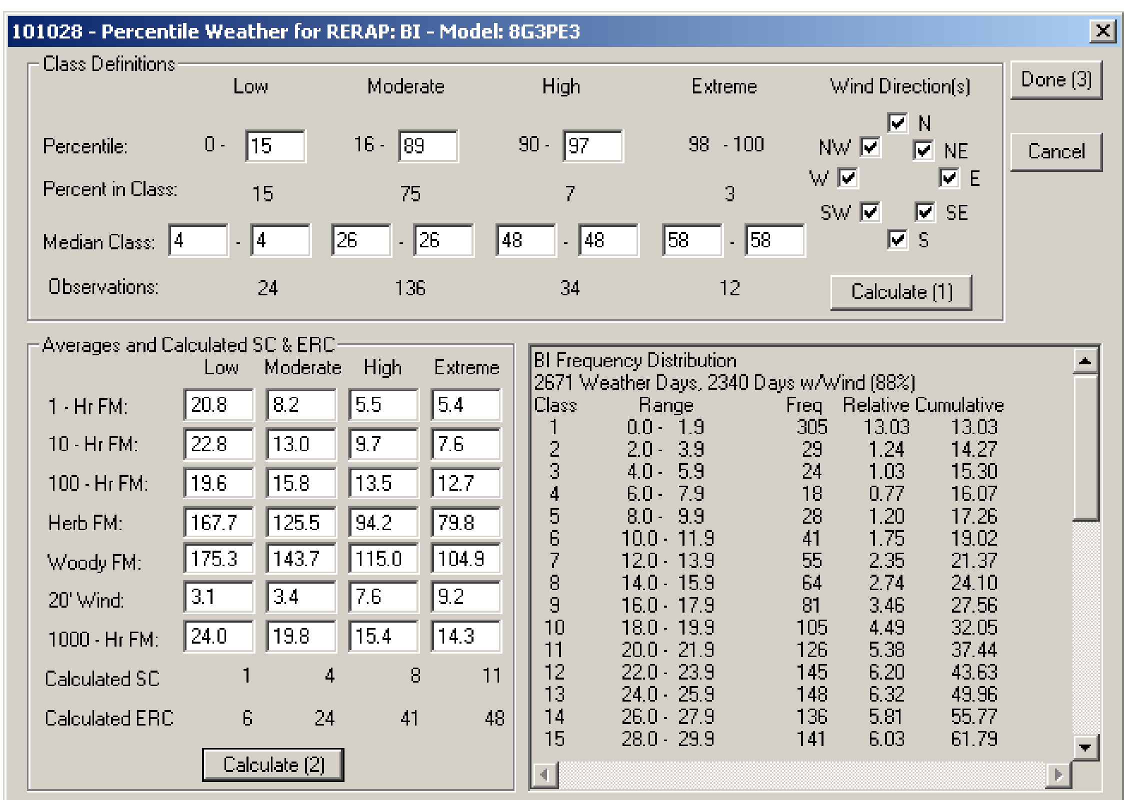
Go to the **Weather => Season Reports => Percentile Weather** menu.



Select a NFDRS index to use. Click **OK**.

The screen at the below appears. Note that all wind directions have been selected. Calculate (1) and Calculate (2) have been clicked. The highest BI can be found by scrolling down in the window in the lower right hand corner. It is about 66, which is in the lower FIL 4 range.

The 99th percentile is listed in the Extreme column and occurs on 3% of the days. The 93rd percentile weather is listed in the High column and occurs on the next 7% of the days. The purpose of determining these percentile weather sets is to have weather values to enter into the Fire Behavior Assessment Environment Tab.



Clicking on the **Done** (3) button results in a screen displaying the report below. If the entire test area in the windows that is displayed is highlighted using the left mouse button, then the text can be copied to the Windows clipboard by holding the CTRL key down and then clicking on the C key on the keyboard. Once copied to the Windows clipboard, the report text can be pasted into any word processor program for printing or inclusion in a report.

```
FireFamily Plus Percentile Weather Report for RERAP

 Station: 101028: Moose Creek            Variable: BI
 Model: 8G3PE3
         Data Years: 1980 - 1995
         Date Range: May 1 - October 30
Wind Directions: N, NE, E, SE, S, SW, W, NW

Percentiles, Probabilities, and Mid-Points
    Variable/Component Range      Low       Mod       High      Ext
            Percentile Range     0 - 15    16 - 89    90 - 97    98 - 100
       Climatol. Probability       15        75         7          3
          Mid-Point     BI       4 -   4   26 -  26   48 -  48   58 -  58
            Num Observations       24       136        34         12
     Calculated Spread Comp.        1         4         8         11
              Calculated ERC        6        24        41         48

Fuel Moistures
        1 Hour Fuel Moisture      20.80      8.20      5.50      5.40
       10 Hour Fuel Moisture      22.80     13.00      9.70      7.60
      100 Hour Fuel Moisture      19.60     15.80     13.50     12.70
    Herbaceous Fuel Moisture     167.70    125.50     94.20     79.80
         Woody Fuel Moisture     175.30    143.70    115.00    104.90
              20' Wind Speed       3.10      3.40      7.60      9.20
     1000 Hour Fuel Moisture      24.00     19.80     15.40     14.30

 2671 Weather Records Used, 2340 Days With Wind (87.61%)
```

Hot Tip

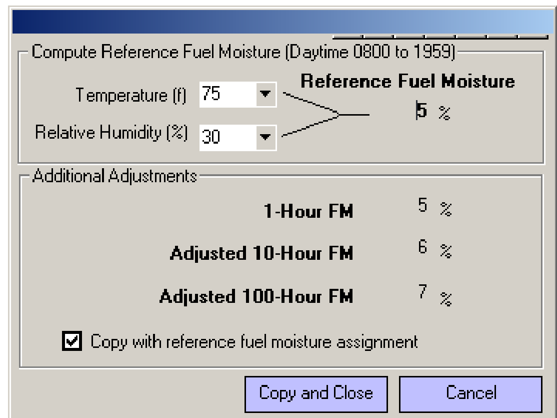
The frequency of the weather conditions that occur under a given percentile weather category MUST be displayed when doing a fire behavior and effects assessment. This frequency is shown as Percent in Class on the FireFamilyPlus percentile weather screen.

Fuel Moisture Values

The fuel moisture for a fuel size class or category is the ratio of the oven dry weight to the wet weight converted to a percentage. Acceptable values are noted in parenthesis following each title.

1- Hour Reference Fuel Moisture (1-60%)

The user needs to calculate the1-hour timelag reference fuel moisture using the air temperature and the relative humidity. Tables are available in Appendix B, reproduced from Rothermel (1983), the Field Reference Guides to the S-390 and S-490 courses and the NWCG Fireline Handbook, Appendix B.



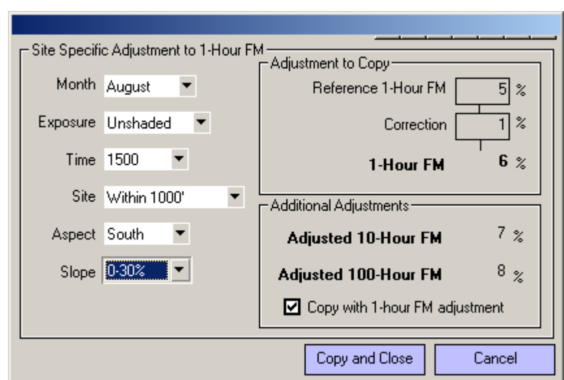
In addition, clicking on the icon will enable the Reference Fuel Moisture Wizard and the screen at the right will be displayed. By selecting the (dry bulb) temperature and relative humidity, the reference fuel moisture is displayed. By default, the program will assign the 1-h fuel moisture to be the same as the reference fuel moisture, the 10-hour fuel moisture to be 1% more than the 1-h fuel moisture and the 100-hour fuel moisture to be 1% more than the 10-h fuel moisture.

These default assignments will not be used if the “Copy with reference fuel moisture assignment” box is not checked.

Clicking on the **Copy and Close** button will copy fuel moisture values to the Environment Tab. The user can change this value manually on the Environment Tab.

1-Hour Fuel Moisture (1-60%)

The user needs to calculate the 1-hour timelag fuel moisture by adding an appropriate correction factor to the 1-hour reference fuel moisture. Correction factors are located in tables in Appendix B.



In addition, clicking on the icon will enable the Fuel Moisture Adjustment Wizard and the screen at the right will be displayed. By selecting the month, exposure (to the sun), time of day (0800-1800), site of weather observation to the projection location (Site), aspect and the slope percent range, the 1-hour fuel moisture correction is displayed. Note that the adjusted 1-hour fuel moisture is shown as the sum of the reference 1-hour fuel moisture and this correction. By default, the program will assign the 1-h fuel moisture. Also by default, the program will assign the 10-hour fuel moisture to be 1% more than the 1-h fuel moisture and the 100-hour fuel moisture to be 1% more than the 10-h fuel moisture.

These default assignments will not be used if the “Copy with 1-hour adjustment” box is not checked.

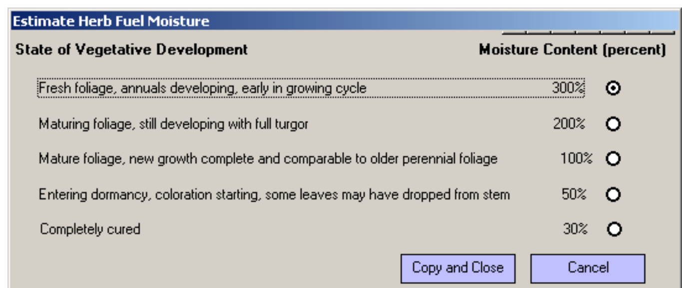
Clicking on the **Copy and Close** button will copy fuel moisture values to the Environment Tab. The user can change this value manually on the Environment Tab.

10-Hour Fuel Moisture (1-60%)
The user needs to either enter the 10-hour timelag fuel moisture or accept the assigned value from the Wizard assist process.

100-Hour Fuel Moisture (1-60%)
The user needs to either enter the 100-hour timelag fuel moisture or accept the assigned value from the Wizard assist process.

Herb Fuel Moisture and Woody Fuel Moisture (30-300%)
The user can enter the herbaceous fuel moisture.

In addition, clicking on the icon  will enable the Live Fuel Moisture Wizard and the screen at the right will be displayed. Select the value desired and click on the **Copy and Close** button. The program will assign the live fuel moisture, either the Herbaceous or Woody based on which selected for assignment.



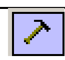
Midflame Wind Speed Value
The midflame wind speed is the wind speed that exists at midflame height above the fuel bed. Midflame is often called eye-level. Technically, midflame wind speed is the average wind speed measured from the top of the fuel bed to the height of the flame above the fuel (Albini and Baughman, 1979). Complete the following entries so the midflame wind speed can be calculated.

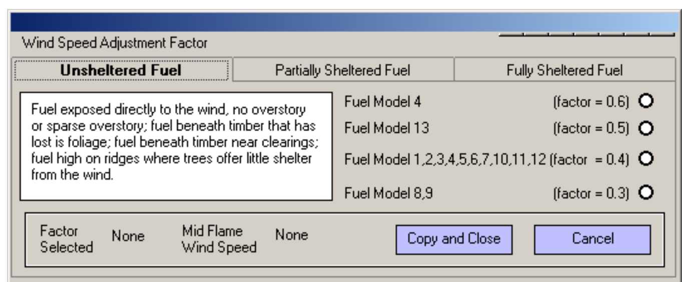
20 Foot Wind Speed (0-99 mph)
The wind speed is frequently taken at a National Fire Danger Rating System weather station. The National Fire Weathers Observers Handbook provides the standards for the gathering of weather at stations designated to provide data for the National Fire Danger Rating System (Deeming et. al, 1972). The wind speed measurement is taken at 20 feet above the vegetation and is measured based on a 10-minute average. Wind speed values used should be the average expected values for the projection period. Enter the 20-foot wind speed in the cell.

Wind Adjustment Factor (0-1)
To reduce the 20-foot wind speed to midflame, a wind adjustment factor needs to be assigned. This factor is multiplied times the 20-foot wind speed by CrownMass to calculate the midflame wind speed. The following table documents the wind adjustment factors based on fuel (Albini and Baughman, 1979).

Table 9 - Wind Speed Adjustment Factors

<table>
<tr><th>Fuel
Sheltering</th><th colspan="2">Fuel
Model</th><th>Adj.
Factor</th></tr>
<tr><td rowspan="4">Unsheltered Fuel
Fuel exposed directly to the wind, no overstory or sparse overstory; fuel beneath timber that has lost is foliage; fuel beneath timber near clearings; fuel high on ridges where trees offer little shelter from the wind.</td><td colspan="2">4</td><td>0.6</td></tr>
<tr><td colspan="2">13</td><td>0.5</td></tr>
<tr><td colspan="2">1,2,3,5,6,7,10,11,12</td><td>0.4</td></tr>
<tr><td colspan="2">8, 9</td><td>0.3</td></tr>
<tr><td>Partially Sheltered Fuel
Fuel beneath patchy timber where it is not well sheltered; fuel beneath standing timber at midslope or higher on a mountain with wind blowing directly at the slope.</td><td colspan="2">All
Fuel
Models</td><td>0.3</td></tr>
<tr><td rowspan="2">Fully Sheltered Fuel
Fuel sheltered beneath standing timber on flat or gentle slope or near the base of a mountain with steep slopes.</td><td rowspan="2">All
Fuel
Models</td><td>Open
Stands</td><td>0.2</td></tr>
<tr><td>Dense
Stands</td><td>0.1</td></tr>
</table>

In addition, clicking on the icon  will enable the Wind Adjustment Wizard and the screen at the right will be displayed. By selecting the appropriate tab, the user can select the wind reduction factor by clicking on the radio button next to the fuel model used in the assessment.



Clicking on the **Copy and Close** button will copy the wind reduction factor to the Environment Tab. The user can change this value manually on the Environment Tab.

Midflame Wind Speed (0-60 mph)

This value is calculated by CrownMass. If the user has a specific midflame wind speed value desired, then the user should set the 20-foot wind speed and the wind adjustment factor so that the desired midflame wind speed value is calculated and displayed.

The Slope Steepness (0 - 100%)

The slope steepness is displayed by default to be the same as that specified for the Analysis Area. A different value can be entered. The value is the steepness of the slope “straight uphill.” The fire behavior values within CrownMass assume the wind is blowing “upslope.”

Analysis Area Slope Steepness

This is the slope steepness for the analysis area entered in the Inputs, Analysis Area and Plots screen.

The Air Temperature (-40 to 120 degrees F)

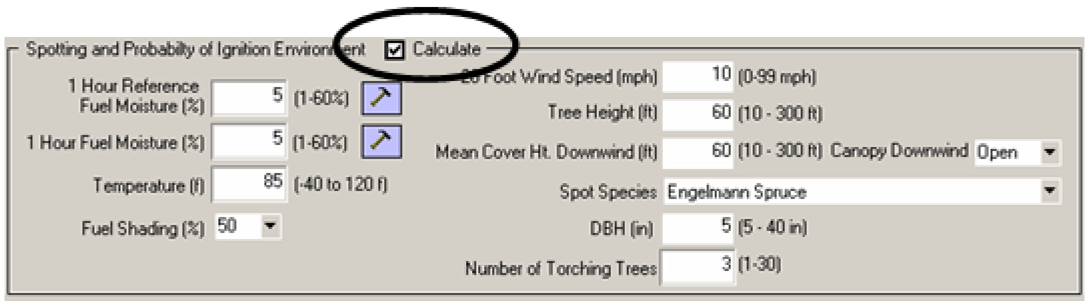
Enter the air temperature. This value is used in the scorch height and probability of mortality calculations.

The Foliar Moisture Content (30 - 200%)

Enter the foliar moisture content. The foliar moisture content is the percent of moisture in the live needles of trees.

Spotting and Probability of Ignition Environment Inputs

In the lower part of the Environment Tab screen, clicking on the **Calculate** check box with result in CrownMass calculating values for the maximum spotting distance from torching trees and a spreading surface fire as well as the probability of ignition.



Probability of Ignition Inputs

The probability of ignition is an indication of the chance that a firebrand will cause an ignition. The number of firebrands, their size, and the fuel on which they land is unknown. Probability of Ignition should not be confused with Ignition Component from the National Fire Danger Rating System (Deeming et al. 1977).

The inputs to the calculation of the Probability of Ignition are:

- 1-h Moisture (1 - 60%)
- Air Temperature (-40 to 120 degrees F) (-40 - 40 deg C)
- Fuel Shading from the Sun (0 - 100%)

The default values for these inputs are the values displayed in the upper part of the Environment Tab and are used for fire spread and intensity calculations.

Hot Tip

The input values for the calculation of the Probability of Ignition should reflect the site attributes where fire brands are expected to land.

Spotting Distance Inputs

Inputs to the calculation of the maximum spotting distance from torching trees fire are as follows:

- 20-ft Wind Speed (0 - 99 mph) (0.0 - 159 km/h)
  This is the wind speed 20 feet above the vegetation. The default entry in CrownMass is the 20-foot windspeed value in the upper part of the Environment Tab, which is used for fire spread and intensity calculations.

- Tree Height (0 - 300 ft) (0 - 91 m)
  The tree height is the distance from the ground to the top of a tree. The default entry in CrownMass is the Analysis Area Canopy Ceiling Height.

- Mean Cover Height Downwind (0 - 300 ft) (0 - 91 m)
  The mean cover height is the average height of the vegetation in the downwind direction from the spotting source location. The default entry in CrownMass is the Analysis Area Canopy Ceiling Height.

- Canopy Downwind (Open or Closed)
  If the area downwind is open, the maximum spotting distance calculation from torching trees assumes divides by two the Mean Cover Height Downwind value. The user needs to only use the pulldown to assign a value of Open or Closed. The default value is Open.

- Spot Tree Species
  The user must use the pulldown to select from the following tree species: Balsam fir, Douglas-fir, Engelmann Spruce, Grand Fir, Longleaf Pine, Loblolly Pine, Lodgepole Pine, Pond Pine, Ponderosa Pine, Subalpine Fir, Shortleaf Pine, Slash Pine, Western Hemlock, Western Larch, Western Red Cedar and Western White Pine. The selection should consider the tree species in the tree inventory entered on the Analysis Area and Plots Tab. If the tree species of interest is not listed, the user should select a surrogate. The default is Englemann spruce.

- D.B.H. (Diameter Breast Height) (5 - 40 in) (13 -102 cm)
  DBH is the abbreviation for diameter breast high. It is the measurement of the diameter of a tree measured at about 4.5 feet (1.4 meters) from the ground level. The default value in CrownMass is the trees per acre-weighted average DBH for the tree inventory entered on the Analysis Area and Plots Tab.

- Number of Torching Trees (0 - 30)
  This is the number of trees that torch simultaneously. It is used to calculate the height at which firebrands are lofted. The default is 1 tree.

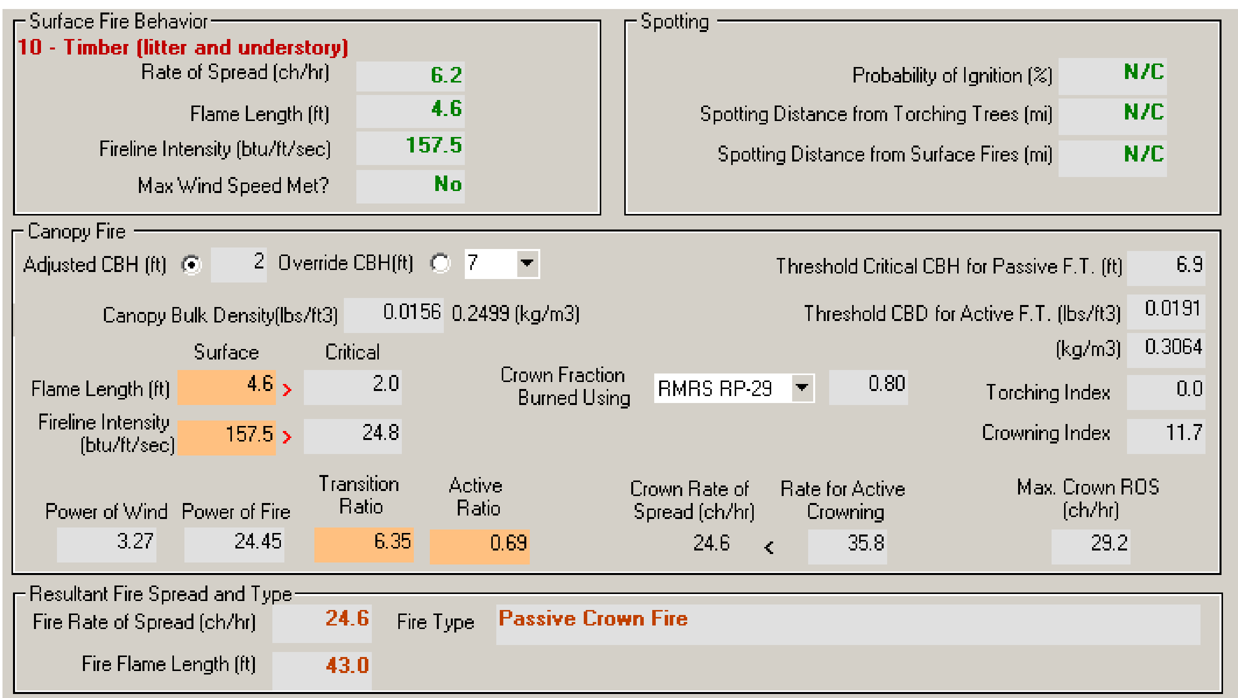
Inputs to the calculation of a spreading surface fire are:

- Canopy Height Downwind
- 20-ft Wind Speed
- Flame Length

The first two inputs are defined above and the flame length is calculated by CrownMass.

Predicted Surface and Crown Fire Behavior With a Tree Inventory

Clicking on the **Fire Behavior Results Tab**, clicking on the **Calculate Fire Behavior** icon or selecting the **Calculate => Calculate Fire Behavior/Effects** will results in the display of fire behavior and fire effects outputs.



Hot Tip

Caution: The fire behavior calculations are provided for assessment purposes to aid in the comparison of different fuel profiles that might exist naturally or be created via management actions. CrownMass should not be used for "real time" fire behavior calculations. The user is referred to the BEHAVE, Farsite or BehavePlus programs for this purpose.

Surface Fire Behavior

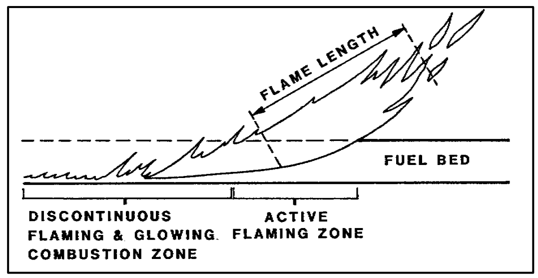
CrownMass uses the same equations and processes as BEHAVE (Andrews 1986, 1989; Rothermel 1972; Albini 1976) and BehavePlus to calculate rate of spread, flame length and fireline intensity. A maximum limit for the wind speed is calculated as part of this process and if it is exceeded, the user is advised of this.

Rate of Spread (ch/hr)

Rate of spread is the "speed" the fire travels through the surface fuels. The rate of spread is the spread rate of the head fire spreading uphill with the wind blowing straight uphill. The rate of spread prediction uses the Rothermel (1972) surface fire spread model, which assumes the weather, topography and fuels remain uniform for the elapsed time of the projection.

Flame Length (ft)

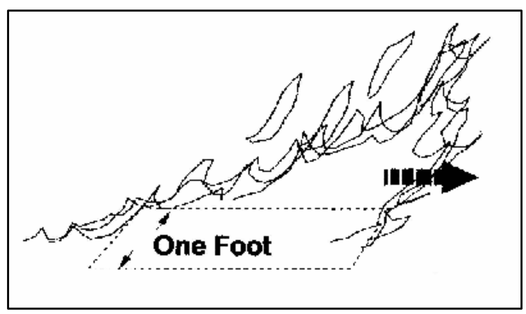
This is the length of the flame in a spreading surface fire within the flaming front. Flame length is measured from midway in the combustion zone to the average tip of the flames). The flame length for a surface fire is calculated from observations using the following formula (Byram's 1959):



Flame Length (feet) = $0.45 * (FLI_{Surface})^{0.46}$

Fireline Intensity (BTU/ft/sec)

This is the heat energy release per unit of time from a one-foot (one-meter) wide section of the fuelbed extending from the front to the rear of the flaming front. Fireline intensity is a function of rate of spread and heat per unit area, and is directly related to flame length. Fireline intensity and the flame length are related to the heat felt by a person standing next to the flames.



Maximum Wind Speed Met? (Yes/No)

This is the maximum midflame wind speed used in the surface fire spread model calculations. It is a function of reaction intensity. Mathematically, the following is calculated within CrownMass:

Maximum Reliable Wind Speed (mph) = 0.01 * Reaction Intensity (Btu/ft2/min)

At high wind speeds, fire spread rate can become difficult to predict. In fact, studies have shown that at high wind speeds, the spread rate can actually decrease when the wind speed increases. The wind speed at which predictions of rate of spread by the Rothermel spread model become unreliable is called the windspeed limit. If the user enters a windspeed, which is higher than this wind speed limit, the model uses the maximum reliable wind speed limit value in the fire spread rate calculation.

Crown Fire

A crown fire is a fire that involves the crowns of trees or shrubs.

Canopy Base Height (CBH) - Adjusted CBH

This is the canopy base height for the Analysis Area that is calculated as an average of plot canopy base heights adjusted by the factor on the Assumptions Tab. For more information on CBH, refer to the section in this document describing the Canopy Characteristics Tab.

Canopy Base Height (CBH) - Override CBH

By selecting this option, the user can set the canopy base height manually to allow for the testing the effect of changing the canopy base height. Be aware that this change does not affect the canopy bulk density. It remains at its calculated value.

Canopy Bulk Density

The canopy bulk density for the Analysis Area is calculated as an average of plot canopy bulk density adjusted by the factor on the Assumptions Tab. For more information on Canopy Bulk Density, refer to the section in this document describing the Canopy Characteristics Tab. English units are shown but the equivalent value in Metric units is shown to the right of the box.

Passive Crown Fire Initiation Criteria

For trees to torch, the intensity of the surface fire must be high enough to ignite tree crowns. Alexander (1988) provided tables and graphs of the relationship developed by Van Wagner (1977, 1993) between the critical fireline intensity to ignite tree crowns given the distance from the tree crowns to the ground (Canopy Base Height).

Fireline Intensity and Flame Length

The fireline intensity is the same as that noted in the Surface Fire Behavior section of the Fire Behavior Results screen. It is repeated on the screen so that a side-by-side comparison can occur with the critical fireline intensity. The flame length is calculated from surface fireline intensity.

Critical Fireline Intensity and Flame Length

The critical fireline intensity for crown fire initiation is a threshold for transition from a surface fire to a crown fire (Van Wagner 1977, 1993). This threshold is defined as the critical fireline intensity, $I_{Critical}$, based on the crown base height (CBH) and the crown foliar moisture content (M). The critical flame length is calculated from critical fireline intensity. A side-by-side comparison of the calculated flame length and the critical flame length for crown fire initiation is provided.

Alexander (1988) described the relationship as:

$$FLI_{Critical} = (0.003096 * CBH * (197.50 + 11.186*M))^{1.5}$$

Where: $FLI_{Critical}$ is in BTU/foot of fire front/second,
CBH in feet and
M is in percent (oven dry weight).

Threshold Critical CBH for Passive (F.T.)
If the canopy base height is below this value, a passive fire type as a minimum will occur under defined fuels and weather that a passive fire type will begin.

Torching Index
The Torching Index (TI) is the 20-foot wind speed at which crown fire is expected to initiate based on Rothermel's (1972) surface fire spread model and Van Wagner's (1977) crown fire initiation criteria (Scott and Reinhardt 2001).

Transition Ratio
The ratio of the surface fireline intensity to the critical surface fireline intensity. If the transition ratio is greater than or equal to one, then the surface fireline intensity is sufficient for a transition to crown fire.

<u>Active Crown Fire Initiation and Propagation Criteria</u>
Van Wagner (1993) developed criteria to predict when a fire would propagate through a forest canopy. This criterion is based on a rate for active crowning "criteria."

Rate for Active Crowning
The type of crown fire (Passive or Active) depends on the threshold for the "active fire spread rate" RAC (Van Wagner, 1993):

$$RAC = 0.55861 / CBD \text{ with}$$

RAC is in chains per hour and CBD is in pounds per ft^3.

Crown Rate of Spread
Van Wagner (1993) indicates that the actual active crown fire spread rate ROS_{Crown} is:

$$ROS_{Crown} = R_{Surface} + CFB * (ROS_{Max\ Crown} - R_{Surface})$$

where $R_{Surface}$ = the surface fire spread rate;

<u>Hot Tip</u>

If the Crown Rate of Spread is less than RAC, a Passive Fire is predicted.

If the Crown Rate of Spread is greater than RAC, an Active Fire is predicted.

Crowning Index

The Crowning Index (CI) is the 20-foot windspeed at which active crown fire is possible, based on Rothermel's (1991) crown fire spread rate model and Van Wagner's (1977) criterion for active crown spread (Scott and Reinhardt 2001).

Active Ratio

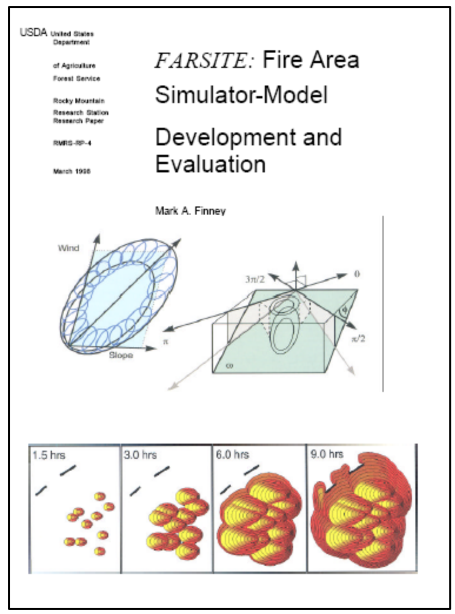
The ratio of the crown fire rate of spread to the critical crown fire rate of spread. If the active ratio is greater than or equal to one, then the fire may be an active crown fire.

Crown Fraction Burned

The crown fraction burned is an input to the crown fire rate of spread. Crown fraction burned is calculated by two methods. The user selects the crown fraction burned method using the pulldown to the right of the title Crown Fraction Method Using. The two selections are the RP-4 and the RP-29 methods. The RP stands for Research Paper.

The RP-4 Method

This method is documented by Finney (1998):



Finney, Mark A. 1998. *FARSITE*: Fire Area Simulator -- model development and evaluation. USDA Forest Service, Research Paper RMRS-4, Rocky Mountain Research Station, Ft. Collins, CO. 45p.

Van Wagner (1993) indicated that the crown fraction burned (CFB) is equal to:

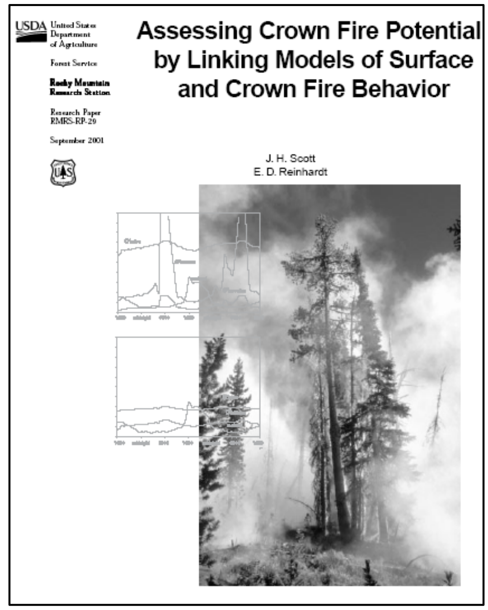
CFB = the crown fraction burned, $CFB=1-e^{-a * x}$

Where: $a = \dfrac{-\ln(0.1)}{0.9\,(RAC - ROS_{Critical})}$

and $x = (ROS_{Surface} - ROS_{Critical})$

$ROS_{Surface}$ = Surface rate of spread
$ROS_{Critical}$ = Critical crown fire spread rate associated with $I_{Critical}$; $[ROS_{Critical} = FLI_{Critical} * (ROS_{Surface} / FLI_{Surface})]$
$FLI_{Surface}$ = Surface fireline intensity
RAC = Rate for Active Crowning
ln = Logarithm Base e

The RP-29 Method



This method is documented by Scott and Reinhardt (2001):

Scott, Joe H. and Elizabeth D. Reinhardt. 2001. Assessing the Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior. USDA Forest Service, Research Paper RMRS-29, Rocky Mountain Research Station, Ft. Collins, CO. 59p.

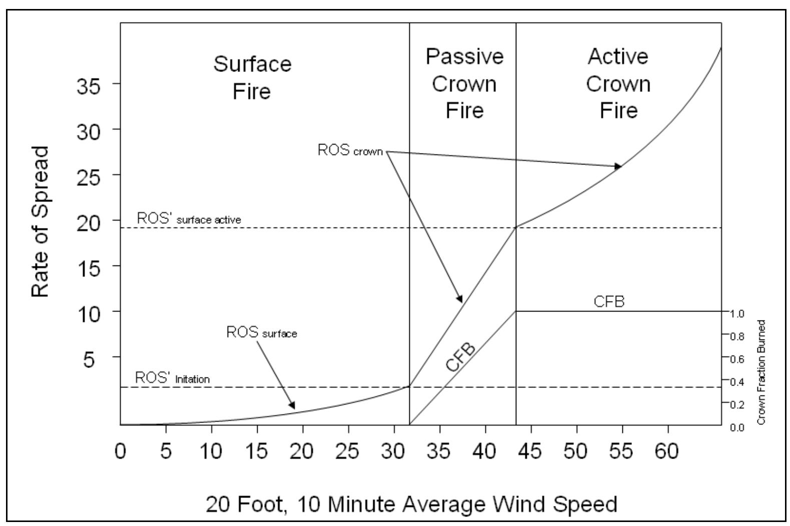
Crown fraction burned (CFB) is calculated as follows:

$$CFB = \frac{ROS_{Surface} - ROS'_{Initiation}}{ROS'_{Surface\ Active} - ROS'_{Initiation}}$$

Where: $ROS_{Surface}$ = the surface fire spread rate
$ROS'_{Initiation}$ = the surface fire spread rate that occurs at $FIL_{Critical}$
$ROS'_{Surface\ Active}$ = the surface fire spread rate that occurs when ROS_{Crown} = RAC

The equation for $ROS'_{Initiation}$ follows:

$ROS'_{Initiation}$ = [($FIL_{Critical}$ * (3600/66))] / (Heat per Unit Area)



To determine $ROS'_{Surface\ Active}$, the 20 foot, 10 minute average wind speed at which a ROS_{Crown} = RAC with all other environmental assumptions remaining constant needs to be determined. The process to determine that wind speed value is documented by Scott and Reinhardt (2001). It is called the Crowning Index (CI).

$ROS'_{Surface\ Active}$ = the surface rate of spread where all environmental assumptions are held constant except for the 20 foot, 10 minute average wind speed which is used in the calculation together with a wind reduction factor or 0.40.

The resulting CFB is hence scaled from 0 to 1 as the $ROS_{Surface}$ moved from $ROS'_{Initiation}$ to $ROS'_{Surface\ Active}$.

Maximum Crown Fire Rate of Spread

The maximum rate of spread for a crown fire ($ROS_{Max\ Crown}$) has been estimated by Rothermel (1991) as:

$$ROS_{Max\ Crown} = 3.34 * ROS_{FBPS\ FM10}$$

Where: $ROS_{FBPS\ FM10}$ is the rate of spread in a FBPS 1982 fuel model 10 under an unshaded condition and with a midflame calculated from the 20-ft wind speed and a wind adjustment factor of 0.4.

Hot Tip

Caution: The crown fire rate of spread calculation developed by Rothermel (1991) was done using data from fires that burned in the Northern Rocky Mountains.

Care should be used when applying this value to other areas.

Threshold Critical CBD for Active F.T.

This value only applies to the RP-29 crown fraction burned method. This is the canopy bulk density that which based on the defined fuels and weather that an active fire type will begin once a passive fire type has occurred.

Resultant Fire Spread, Flame Length and Fire Type

Fire Type

There are three types of fires predicted in CrownMass:

- Surface Fire
- Passive Crown Fire
- Active Crown Fire

Surface Fire

A surface fire is one that burns only in the surface fuelbed.

- Occurs when $FLI_{Surface} < FLI_{Critical}$ and $ROS_{Crown} < RAC$

Passive Crown Fire

A passive crown fire is traditionally called "torching." It is small scale, consuming single or small groups of trees or bushes. This stage of a crown fire reinforces the spread of the fire, but the main fire spread is still dependent upon surface fire behavior.

- Occurs when $FLI_{Surface} > FLI_{Critical}$ and $ROS_{Crown} < RAC$

Active Crown Fire
An active crown fire is associated with a "pulsing" spread. The surface fire ignites crowns and the fire spread is able to propagate through the canopy. After a distance, the crown fire weakens due to a lack of reinforcing surface fire heat. When the surface fire catches up to where the crown fire died, the surface fire intensity again initiates a crown fire "pulse."

- Occurs when $FLI_{Surface} > FLI_{Critical}$ and $ROS_{Crown} > RAC$

<u>Fire Rate of Spread</u>
This is the final estimated fire spread rate. If the RP_4 crown fraction method is selected and the fire type is either surface or passive, then the estimated fire spread rate is the same as the surface fire behavior rate of spread ($ROS_{Surface}$). . If the RP_4 crown fraction method is selected and the fire type is active, then the estimated as the crown rate of spread (ROS_{Crown}) (Rothermel 1991).

If the RP_29 crown fraction method is selected and the fire type is surface, then the estimated fire spread rate is the same as the surface fire behavior rate of spread ($ROS_{Surface}$).

$$ROS_{Resultant} = ROS_{Surface}$$

If the RP_29 crown fraction method is selected and fire type is passive, then the estimated fire spread rate based on the process described in the RP-29 method section and is displayed in the Crown Rate of Spread and Resultant Fire Rate of Spread cell. This is a scaled value between the surface rate of spread when passive fire starts and Rate for Active Crowning (RAC) value.

$$ROS_{Resultant} = R_{Surface} + CFB * (ROS_{Max\ Crown} - R_{Surface})$$

If the fire type is active, then this value is estimated as the crown rate of spread (ROS_{Crown}) (Rothermel 1991).

$$ROS_{Resultant} = ROS_{Max\ Crown}$$

<u>Flame Length</u>
The flame length for a surface fire is calculated from observations using the following formula (Byram's 1959):

$$\text{Flame Length (feet)} = 0.45 * (FLI_{Surface})^{0.46}$$

Thomas' (1963) developed a formula for the flame length of a crown fire based on convection theory. This flame length is calculated using the following formula:

$$\text{Flame Length (feet)} = 0.20 * (FIL_{Surface\ and\ Aerial})^{0.67}$$

Where: $FIL_{Surface\ and\ Aerial}$ is the fireline intensity calculated from the consumption of both surface and aerial fuels.

The value for $FIL_{\text{Surface and Aerial}}$ is calculated using the following formula:

$$FIL_{\text{Surface and Aerial}} = \frac{(HPA_{\text{surface}} + (7744.8 * (CBD * CFB * (SH - CBH)))) * (ROS_{\text{final}} * 1.1)}{60}$$

Where: HPA_{surface} the heat per unit area of the surface fire (BTU/ft^2)
CBD is the canopy bulk density ($\# / ft^3$)
CFB is the crown fraction burned
SH is the stand height (feet)
CBH is the canopy base height (feet)
ROS_{final} is the resultant rate of spread based on the fire type (feet/minute)

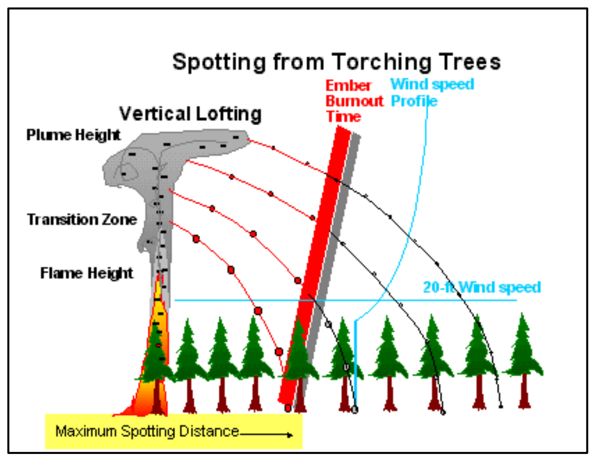
Probability or Ignition and Maximum Spotting Distances

Probability of Ignition from a Firebrand (Percent)

The probability of ignition is an indication of the chance that a firebrand will cause an ignition. The number of firebrands, their size, and the fuel on which they land is unknown. Probability of Ignition should not be confused with Ignition Component from the National Fire Danger Rating System (Deeming et al. 1977).

Spotting Distance from Torching Trees(in miles)

This is the maximum distance that one can expect potential spot fires resulting from firebrands from torching trees. The spotting model is applicable under conditions of intermediate fire severity in which spotting distance up to a mile or two might be expected. This model does not apply to those extreme conditions where spotting may occur up to tens of miles from the fire front. The model is for spotting from torching trees, not from a spreading crown fire.



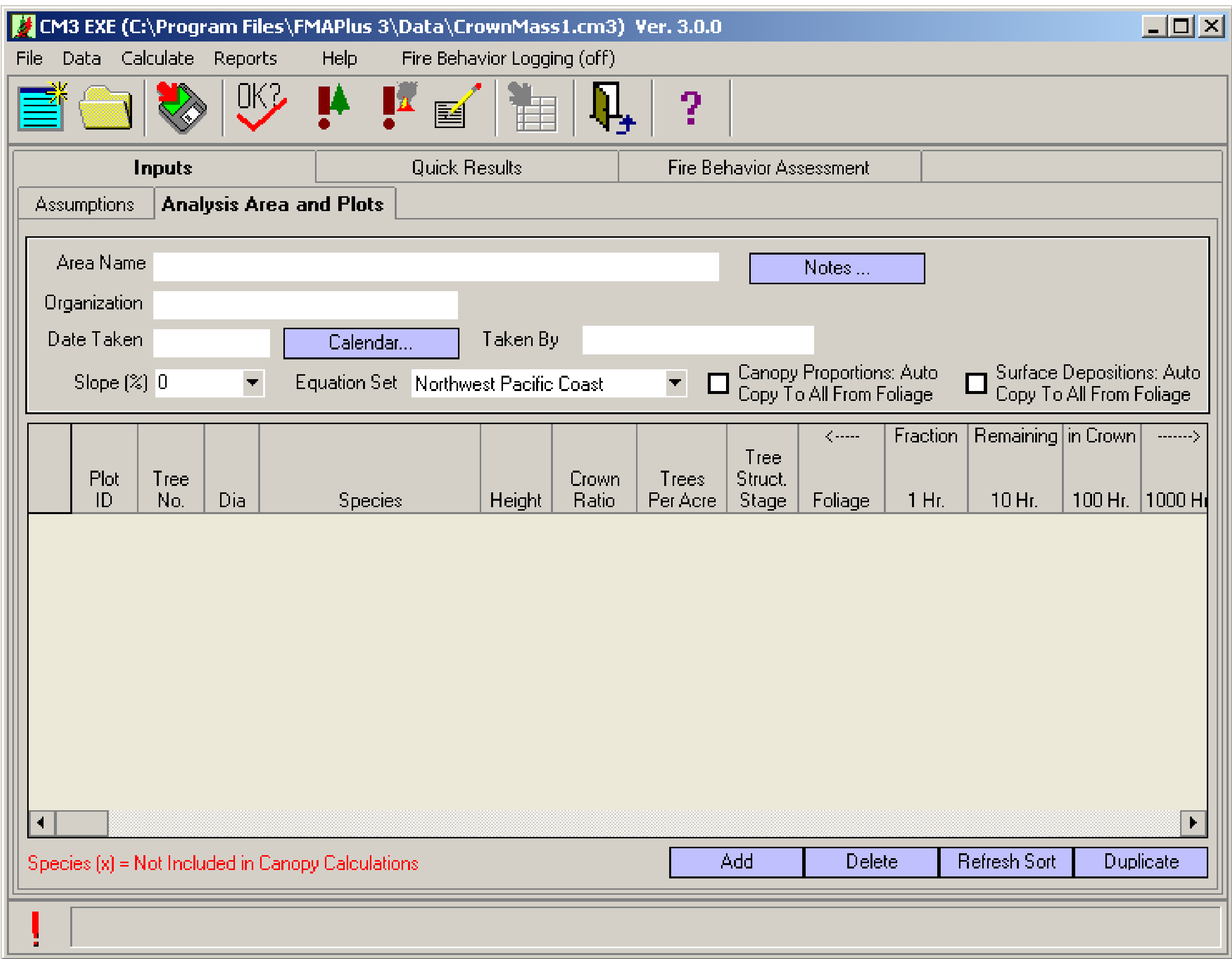
Spotting Distance from a Wind Driven Surface Fire (in miles)

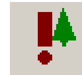
The maximum distance that one can expect potential spot fires based on firebrands from the spreading surface fire. The model is applicable only if the fire is truly wind-driven through surface fuels that are not sheltered from the wind by overstory.

Predicted Surface and Crown Fire Behavior Without a Stand Inventory

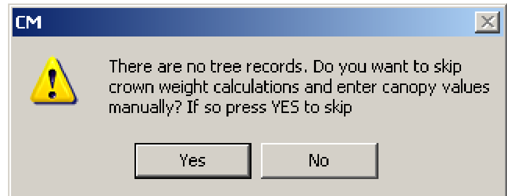
The purpose of using stand inventory inputs on the Analysis Area and Plots Tab is to utilize the crown weight calculation ability of CrownMass to generate estimates of canopy base height, canopy bulk density and canopy ceiling height. If the user has estimates of these values, the fire behavior and effects part of the CrownMass program will generate the same fire behavior and effects outputs.

To predict surface and crown fire behavior without a stand inventory, start CrownMass and Start a New Inventory. After naming the database (*.cm3) file, a blank Analysis Area and Plots screen will appear (see screen below). Complete entries for the Area name, Organization, Date Taken, Slope (%) and Taken By as desired. Select the Equation Set that is appropriate.



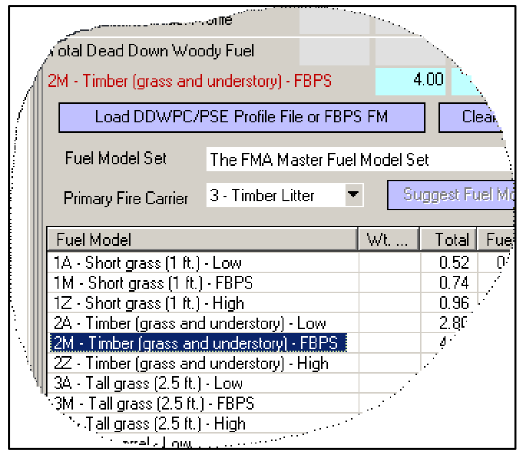
Click on the **Quick Results** Tab, on the **Calculate CrownMass** icon  or select the **Calculate => Calculate Crown Weights and Surface Deposition** menu.

Crown Mass with display the dialog and message at the right. Click on the **Yes** button.



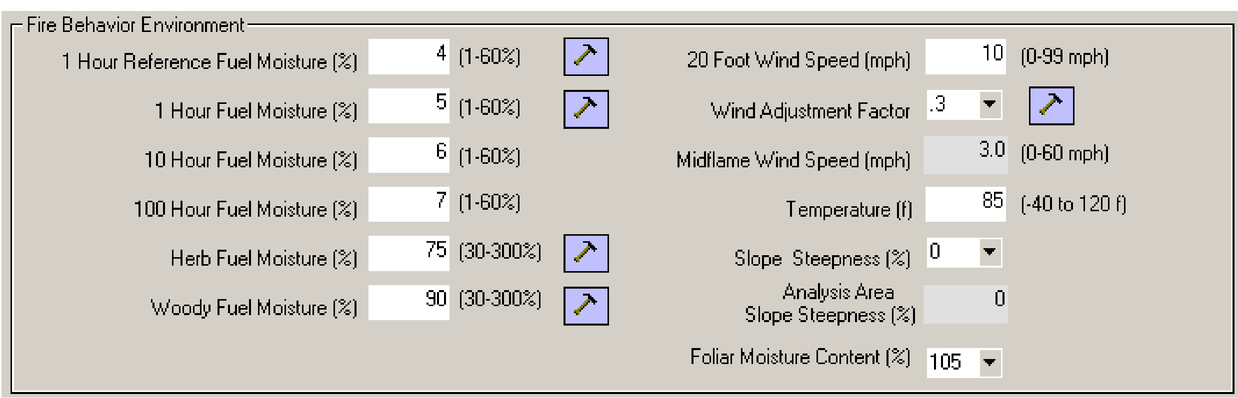
Select a Surface Fuel Model

CrownMass will open to the **Fire Behavior => Surface Fuel Model** Tab. Select a Fuel Model Set and the desired fuel model.



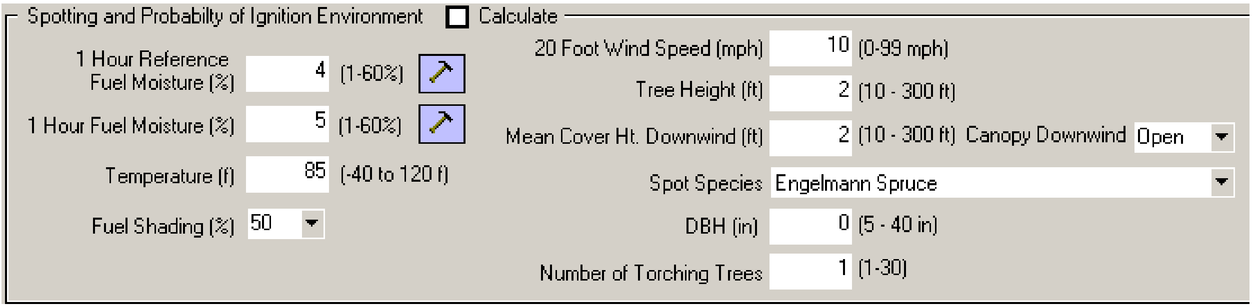
Define Environmental Parameters

Click on the Environment Tab and define the fuel moisture values, wind speed values and other required inputs.



Define Probability of Ignition and Maximum Spotting Distance Inputs (If Desired)

Enter values for the inputs to the probability of ignition and maximum spotting distance calculations.

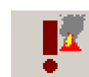


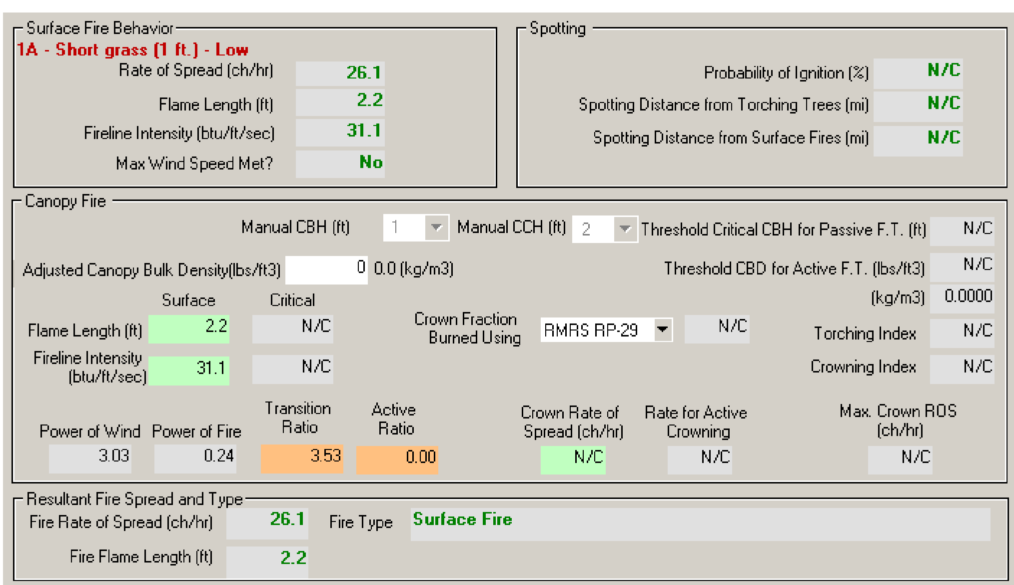
Hot Tip

Caution: The default inputs for Tree Height, Mean Cover Height Downwind, and DBH are not the same as if a stand inventory was entered.

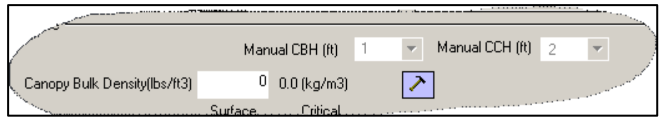
Be sure to edit these input values!

Calculate Fire Behavior and Effects Assuming No Tree Canopy Exists That Would Support Crowning

Click on the Fire Behavior Tab, click on the **Calculate Fire Behavior**  icon select the **Calculate => Calculate Fire Behavior/Effects** menu. A screen similar to the one below will appear.



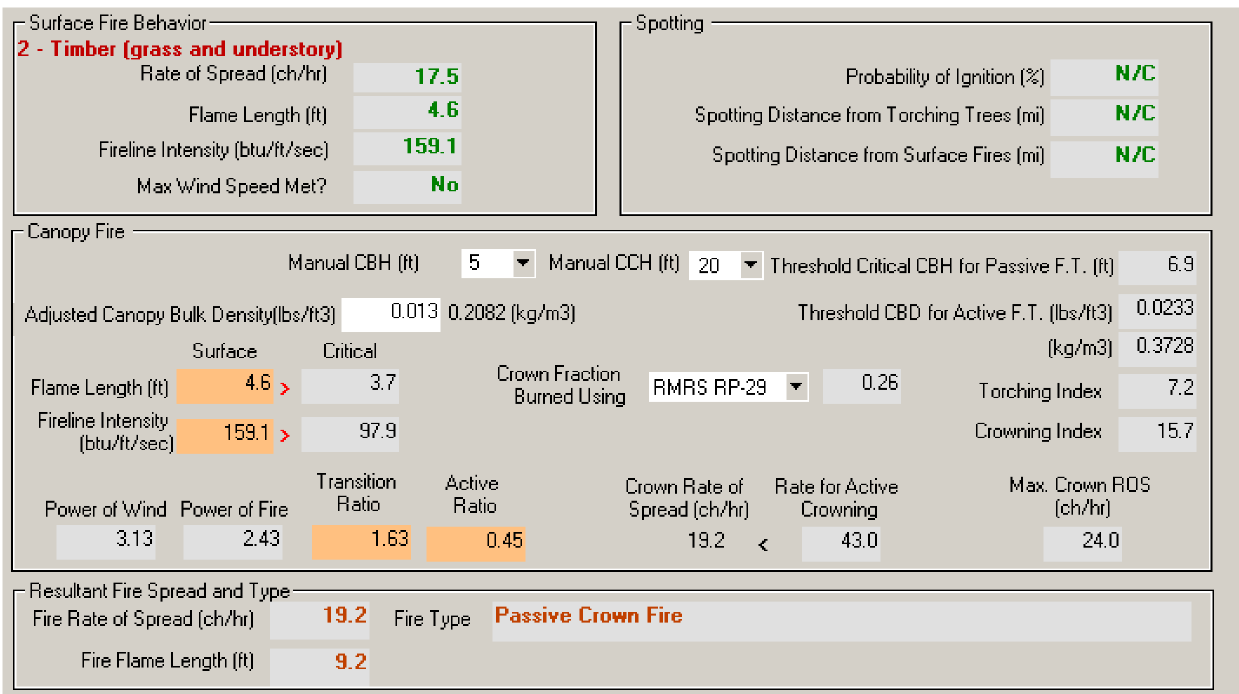
Notice that the Manual CBH and Manual CCH cells are dimmed and that the Canopy Bulk Density input value is 0. The 0 value for the Canopy Bulk Density is consistent with the assumption that there is no canopy which would support crowning.



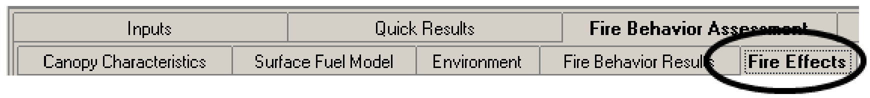
Calculate Fire Behavior and Effects Assuming
A Tree Canopy Exists That Could Support Crowning

To define a canopy that would support crowning in CrownMass, enter a non-zero value in the Canopy Bulk Density cell. Once this is done, the Manual CBH and Manual CCH cells will no longer be dimmed. The default Manual CBH will be 1 foot and the default CCH will be 2 feet. Use the pulldowns to set the CBH and CCH values as desired.

Below is a screen where the Canopy Bulk Density has been set to 0.013 lbs/ft^3, CBH has been set to 5 feet and the CCH has been set to 20 feet. Each time any of these three values is changed, CrownMass will automatically recalculate fire behavior and effects.



Predicted Fire Effects



Effects on Trees

Several effects on trees are provided.

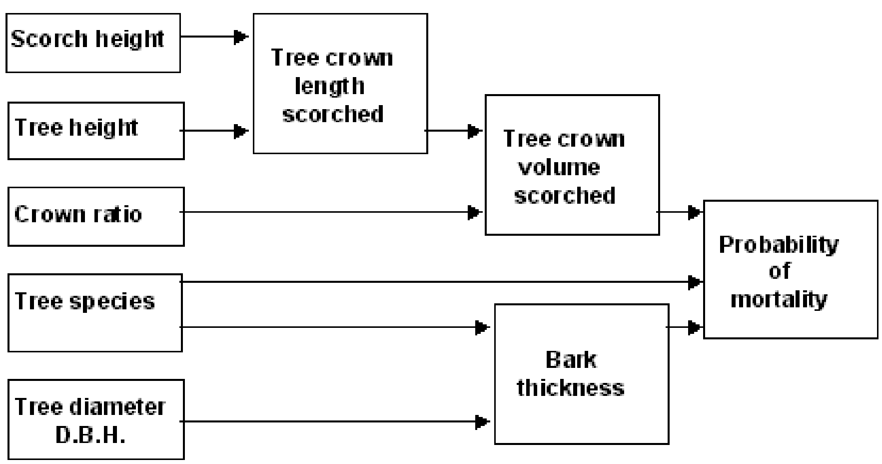
Scorch Height

The scorch height is the height above the ground that the temperature in the convection column reaches the lethal temperature to kill live crown foliage. This temperature is assumed to be 140 degrees Fahrenheit (60 Celsius).

Probability of Mortality

For each tree listed in the Inputs, Analysis Area and Plots Tab input section, the Plot No., the Tree No., the DBH, the Species, the Height, the Crown Ratio, the Number of Trees per Acre and the Structural Stage are shown. Refer to the section in this Users' Guide on the Inputs, Analysis Area and Plots Tab input section for information on these inputs.

The probability of mortality is the likelihood that a tree will be killed by a fire. Probability of mortality is based on bark thickness and percent crown volume scorched, which are derived from scorch height, tree height, crown ratio, species, and tree diameter (Figure 15). The mortality calculation in CrownMass parallels the calculation methods in FOFEM (Reinhardt et al. 1997).



Crown Volume Scorched

This is the percentage of the tree crown volume that is scorched It is calculated from the length of tree crown scorched and the total crown length and is used to calculate tree mortality.

Other Effects

At this time, the only additional effects calculations displayed in the CrownMass program is the expected size of a fire after a defined number of hours of burning. Also needed for this calculation is the effective midflame windspeed. CrownMass calculates the effective midflame windspeed based on the slope percent and midflame windspeed shown on the Environment Tab.

Hours Fire Has Been Growing

This is the time a fire begins spreading until a time that the user wants to know the fire's size. The fire is assumed to be spreading at a constant rate during this time period. Elapsed time can also be referred to as projection time. The fuel model, fuel moisture, wind speed and direction, and slope steepness (and thus the rate of spread) are assumed to be constant for the entire elapsed time. Because wildland fires almost always burn under non-uniform conditions, the elapsed time and choice of input values must be considered carefully to achieve useful projections.

Single Ellipse Fire Size

This is the size of a fire based on the single ellipse fire area model (Anderson 1983, Fons 1946, USDA-FS 2000).

Sorting Capability

Clicking on any column heading will cause the fuel model list to be sorted either numerically or alphabetically based on the information in the selected column.

The Fire Behavior Logging Menu

This menu item allows the user to save fire behavior and fire effects outputs to a Microsoft Access database file (mdb). This feature has been added to CrownMass at the request of several users. At this time, the only feature supported is the saving of the outputs to the database log file. In future releases of CrownMass, it is anticipated that custom reports displaying the results of multiple fire behavior runs will be available on the **Reports** main menu.

The following assumptions are recorded to the FBAreaResults table in the log file database:

- Run Identifier
- Area Name
- Organization
- Date
- Basal Area
- Fuel Model
- Canopy Fuel Loading
- Canopy Base Height Override ID
- Canopy Base Height
- Canopy Ceiling Height
- Critical Bulk Density Used
- Canopy Bulk Density (lbs/ft^3)
- Canopy Bulk Density (kg/m^3)
- Slope
- CFB Method (RP-4 or RP-29)

The following fire behavior outputs are recorded to the FBAreaResults table in the log file database:

- Surface Rate of Spread
- Surface Flame Length
- Fire Type
- Resultant Rate of Spread
- Resultant Flame Length
- RAC
- Crown Fraction Burned
- Maximum Crown Rate of Spread
- Probability of Ignition
- Torching Tree Spotting Distance
- Surface Fire Spotting Distance
- Torching Index
- Crowning Index

The following fire size values are recorded to the FBAreaResults table in the log file database:

- Spread Hours (Assumption)
- Elliptical Fire Size (Acres)

The following tree inventory assumptions are recorded to the FBTreeEffects table in the log file database:

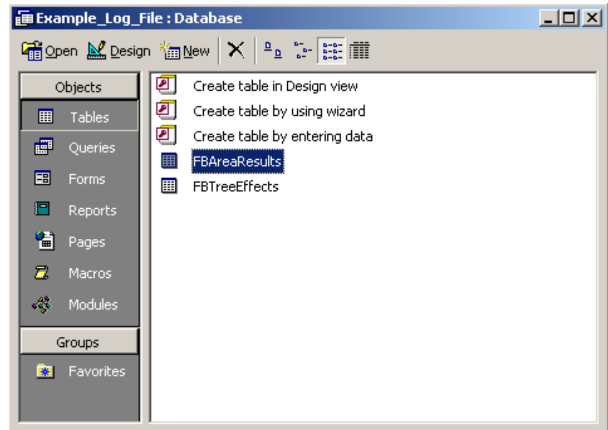
- Run Identifier
- Area Name
- Organization
- Date
- Plot
- Tree
- Diameter Breast Height (DBH)
- Tree Species Code
- Tree Species Name
- Tree Height
- Tree Crown Ratio
- Number of Trees per Acre Remaining
- Tree Structural Stage

The following fire effects outputs are recorded to the FBTreeEffects table in the log file database:

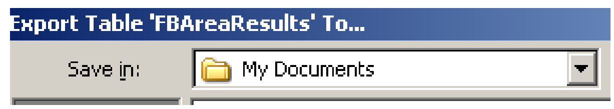
- Tree Percent Crown Scorch
- Tree Probability of Mortality

Working With Fire Behavior Log Files

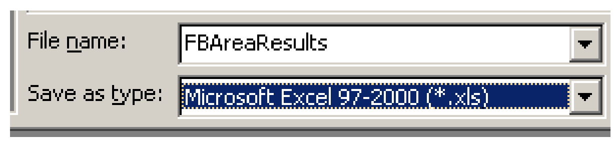
At this time, no formal reports are available using the CrownMass program. Users who are knowledgeable in the use of a database program can develop reports using that program. Opening a database log file in Microsoft Access will result in the display screen shown at the right once the **Tables** icon in the left side column is clicked.



It is possible to export an Access data table into a spreadsheet file. To do this, select the **File => Export** menu in Access. Use the Save in dialog to navigate to the folder where the exported file will be saved.

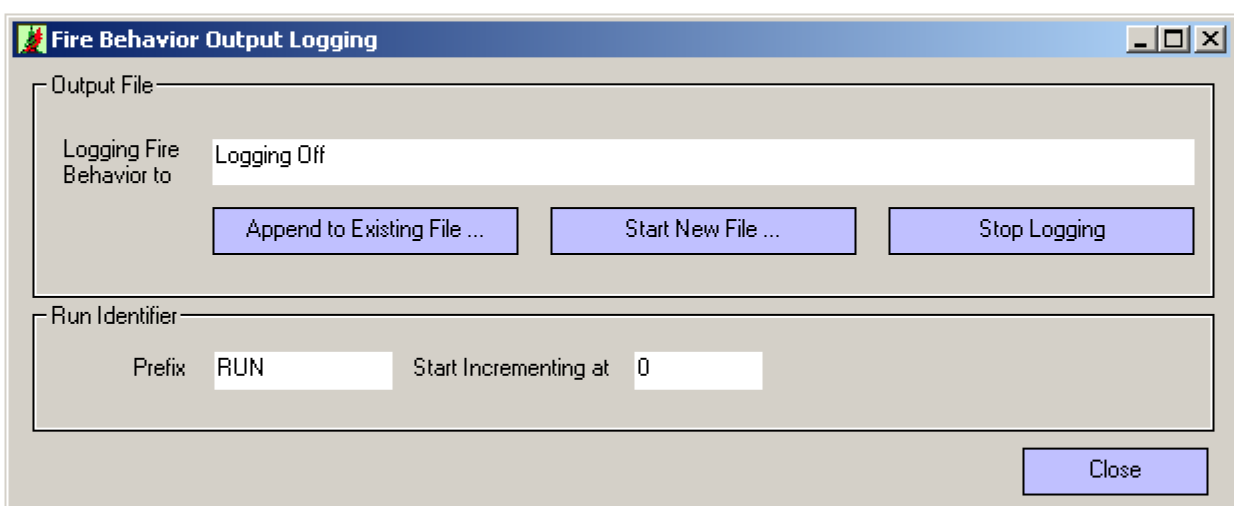


In the Windows File dialog screen, enter a File name and select the Save as type as the desired type. In the example at the right, the file type is selected to be a Microsoft Excel 97-2000 (*.xls). Then click on the **Save** button.



Start Logging Fire Behavior

To start logging fire behavior outputs, click on the main item titled **Fire Behavior Logging (Off)**. The program will display the screen below.

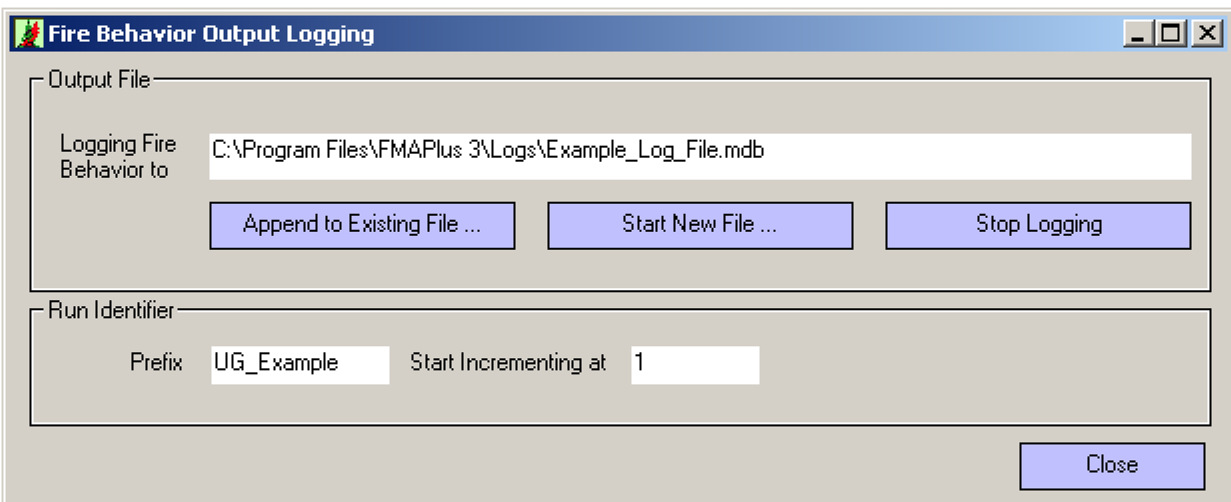


Log Output File
To store fire behavior outputs, the user needs to either create a new output file or append fire behavior outputs to an existing log file.

Start New (Log) File
To create a new log output file, click on the **Start New File** button. Provide a name for the log file and click on the **Save** button on the Windows dialog. The default folder for log file storage is the Logs folder that resides in the folder where FMAPlus 3 was installed. Click on the **Close** button and the Fire Behavior Logging on the main menu will now read **Fire Behavior Logging (On)**.

Append to Existing (Log) File
If a log file already exists, the user can append fire behavior output runs to it. To do this, click on the **Append to Existing File** button. The Windows file selection dialog will automatically open showing existing log files in the Logs folder. If the desired log file is not there, navigate to the file's location. Click on the file to select it and the click on the **Open** button.

Run Identifier
Each fire behavior run identifier will have a user defined prefix and a numerical identifier. The default run prefix is RUN and the default starting numerical identifier is 0. The user may find value in entering a prefix that is related to the project or analysis area being analyzed. CrownMass will increment the numerical identifier by 1 each time a run is logged.



In the sample screen above, the prefix has been defined as UG_Example and the numerical identifier will start at 1. The first fire behavior logged output run will have a run identifier of UG_Example-0001. The next fire behavior logged output run will have a run identifier of UG_Example-0002.

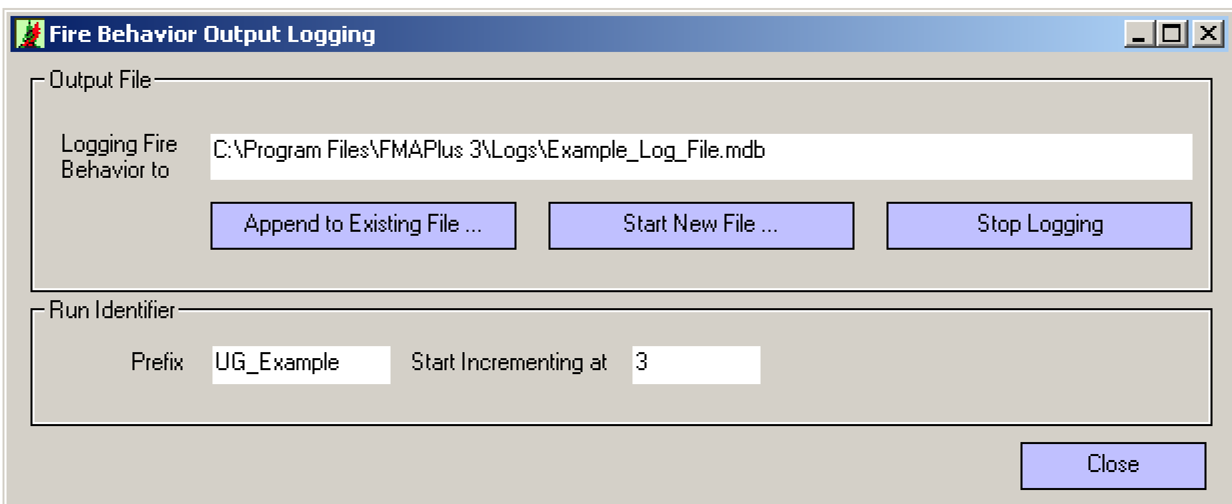
Recording Fire Behavior Runs to the Active Log File

Each time CrownMass calculates fire behavior outputs, the Log Fire Behavior Results icon will appear. The figure at the right displays an active the Log Fire Behavior Results icon. To record the fire behavior run outputs just completed to the active log file, click on the **Log Fire Behavior Results** icon.

In the CrownMass screen lower tray, a message will be displayed indicating the run has been recorded to the active output log file.

Stop Logging Fire Behavior

To discontinue logging, click on the main menu **Fire Behavior Logging (On)**. A dialog similar to the one below will appear.



Click on the **Stop Logging** button and then the **Close** button. The main menu will now read **Fire Behavior Logging (Off)**.

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Appendix A

Fuel Model Parameters for the

FMA Master Fuel Model Set

Appendix A – Fuel Model Parameters for the FMA Master Fuel Model Set

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
1A Short grass (1 ft.) - Low	0.52	0.70	0.52	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
1M Short grass (1 ft.) - FBPS	0.74	1.00	0.74	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
1Z Short grass (1 ft.) - High	0.96	1.30	0.96	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
2A Timber (grass and understory) - Low	2.81	0.70	1.40	0.70	0.35	0.35	0.00	3000	1500	N/A	0.15	8000
2M Timber (grass and understory) - FBPS	4.01	1.00	2.00	1.00	0.50	0.50	0.00	3000	1500	N/A	0.15	8000
2Z Timber (grass and understory) - High	5.21	1.30	2.60	1.30	0.65	0.65	0.00	3000	1500	N/A	0.15	8000
3A Tall grass (2.5 ft.) - Low	2.10	1.75	2.10	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
3M Tall grass (2.5 ft.) - FBPS	3.01	2.50	3.01	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
3Z Tall grass (2.5 ft.) - High	3.91	3.25	3.91	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
4A Chaparral - Low	11.22	4.20	3.51	2.81	1.40	0.00	3.51	2000	N/A	1500	0.20	8000
4M Chaparral -FBPS	16.03	6.00	5.01	4.01	2.00	0.00	5.01	2000	N/A	1500	0.20	8000
4Z Chaparral - High	20.84	7.80	6.51	5.21	2.60	0.00	6.51	2000	N/A	1500	0.20	8000
5A Brush - Low	2.45	1.40	0.70	0.35	0.00	0.00	1.40	2000	N/A	1500	0.20	8000
5M Brush - FBPS	3.50	2.00	1.00	0.50	0.00	0.00	2.00	2000	N/A	1500	0.20	8000
5Z Brush - High	4.55	2.60	1.30	0.65	0.00	0.00	2.60	2000	N/A	1500	0.20	8000
6A Dormant brush, hardwood slash - Low	4.21	1.75	1.05	1.75	1.40	0.00	0.00	1750	N/A	N/A	0.25	8000
6M Dormant brush, hardwood slash - FBPS	6.01	2.50	1.50	2.50	2.00	0.00	0.00	1750	N/A	N/A	0.25	8000
6Z Dormant brush, hardwood slash - High	7.81	3.25	1.95	3.26	2.60	0.00	0.00	1750	N/A	N/A	0.25	8000
7A Southern rough - Low	3.42	1.75	0.79	1.31	1.05	0.00	0.26	1750	N/A	1550	0.40	8000
7M Southern rough - FBPS	4.88	2.50	1.13	1.87	1.50	0.00	0.37	1750	N/A	1550	0.40	8000
7Z Southern rough - High	6.34	3.25	1.47	2.44	1.95	0.00	0.48	1750	N/A	1550	0.40	8000
8A Closed timber litter - Low	3.51	0.14	1.05	0.70	1.75	0.00	0.00	2000	N/A	N/A	0.30	8000
8M Closed timber litter - FBPS	5.01	0.20	1.50	1.00	2.50	0.00	0.00	2000	N/A	N/A	0.30	8000
8Z Closed timber litter - High	6.51	0.26	1.95	1.30	3.26	0.00	0.00	2000	N/A	N/A	0.30	8000
9A Hardwood (long-needle pine) litter - Low	2.44	0.14	2.04	0.29	0.11	0.00	0.00	2500	N/A	N/A	0.25	8000
9M Hardwood (long-needle pine) litter - FBPS	3.48	0.20	2.92	0.41	0.15	0.00	0.00	2500	N/A	N/A	0.25	8000
9Z Hardwood (long-needle pine) litter - High	4.53	0.26	3.79	0.54	0.20	0.00	0.00	2500	N/A	N/A	0.25	8000
10A Timber (litter and understory) - Low	8.41	0.70	2.10	1.40	3.51	0.00	1.40	2000	N/A	1500	0.25	8000
10B Timber (litter and understory) - FBPS	12.02	1.00	3.01	2.00	5.01	0.00	2.00	2000	N/A	1500	0.25	8000
10C Timber (litter and understory) - High	15.62	1.30	3.91	2.60	6.51	0.00	2.60	2000	N/A	1500	0.25	8000
11AA Light slash - Low-A-Low Depth	2.00	0.12	0.26	0.78	0.96	0.00	0.00	1500	N/A	N/A	0.15	8000
11AB Light slash - Low-A-Avg Depth	2.00	0.17	0.26	0.78	0.96	0.00	0.00	1500	N/A	N/A	0.15	8000
11AC Light slash - Low-A-High Depth	2.00	0.23	0.26	0.78	0.96	0.00	0.00	1500	N/A	N/A	0.15	8000
11BA Light slash - Low-B-Low Depth	4.00	0.24	0.52	1.57	1.91	0.00	0.00	1500	N/A	N/A	0.15	8000
11BB Light slash - Low-B-Avg Depth	4.00	0.35	0.52	1.57	1.91	0.00	0.00	1500	N/A	N/A	0.15	8000
11BC Light slash - Low-B-High Depth	4.00	0.45	0.52	1.57	1.91	0.00	0.00	1500	N/A	N/A	0.15	8000
11CA Light slash - Low-C-Low Depth	6.50	0.39	0.85	2.54	3.11	0.00	0.00	1500	N/A	N/A	0.15	8000
11CB Light slash - Low-C-Avg Depth	6.50	0.56	0.85	2.54	3.11	0.00	0.00	1500	N/A	N/A	0.15	8000
11CC Light slash - Low-C-High Depth	6.50	0.73	0.85	2.54	3.11	0.00	0.00	1500	N/A	N/A	0.15	8000
11DA Light slash - FBPS-D-Low Depth	9.00	0.55	1.17	3.52	4.30	0.00	0.00	1500	N/A	N/A	0.15	8000
11DB Light slash - FBPS-D-Avg Depth	9.00	0.78	1.17	3.52	4.30	0.00	0.00	1500	N/A	N/A	0.15	8000
11DC Light slash - FBPS-D-High Depth	9.00	1.02	1.17	3.52	4.30	0.00	0.00	1500	N/A	N/A	0.15	8000
11MA Light slash - FBPS-M-Low Depth	11.52	0.70	1.50	4.51	5.51	0.00	0.00	1500	N/A	N/A	0.15	8000
11MB Light slash - FBPS-M-Avg Depth	11.52	1.00	1.50	4.51	5.51	0.00	0.00	1500	N/A	N/A	0.15	8000
11MC Light slash - FBPS-M-High Depth	11.52	1.30	1.50	4.51	5.51	0.00	0.00	1500	N/A	N/A	0.15	8000
11XA Light slash - FBPS-X-Low Depth	14.00	0.85	1.83	5.48	6.70	0.00	0.00	1500	N/A	N/A	0.15	8000
11XB Light slash - FBPS-X-Avg Depth	14.00	1.22	1.83	5.48	6.70	0.00	0.00	1500	N/A	N/A	0.15	8000
11XC Light slash - FBPS-X-High Depth	14.00	1.58	1.83	5.48	6.70	0.00	0.00	1500	N/A	N/A	0.15	8000
11YA Light slash - High-Y-Low Depth	17.00	1.03	2.22	6.65	8.13	0.00	0.00	1500	N/A	N/A	0.15	8000

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
11YB Light slash - High-Y-Avg Depth	17.00	1.48	2.22	6.65	8.13	0.00	0.00	1500	N/A	N/A	0.15	8000
11YC Light slash - High-Y-High Depth	17.00	1.92	2.22	6.65	8.13	0.00	0.00	1500	N/A	N/A	0.15	8000
11ZA Light slash - High-Z-Low Depth	20.00	1.22	2.61	7.83	9.57	0.00	0.00	1500	N/A	N/A	0.15	8000
11ZB Light slash - High-Z-Avg Depth	20.00	1.74	2.61	7.83	9.57	0.00	0.00	1500	N/A	N/A	0.15	8000
11ZC Light slash - High-Z-High Depth	20.00	2.26	2.61	7.83	9.57	0.00	0.00	1500	N/A	N/A	0.15	8000
12AA Medium slash - Low-A-Low Depth	23.00	1.07	2.67	9.33	11.00	0.00	0.00	1500	N/A	N/A	0.20	8000
12AB Medium slash - Low-A-Avg Depth	23.00	1.53	2.67	9.33	11.00	0.00	0.00	1500	N/A	N/A	0.20	8000
12AC Medium slash - Low-A-High Depth	23.00	1.99	2.67	9.33	11.00	0.00	0.00	1500	N/A	N/A	0.20	8000
12BA Medium slash - Low-B-Low Depth	26.00	1.21	3.01	10.55	12.43	0.00	0.00	1500	N/A	N/A	0.20	8000
12BB Medium slash - Low-B-Avg Depth	26.00	1.73	3.01	10.55	12.43	0.00	0.00	1500	N/A	N/A	0.20	8000
12BC Medium slash - Low-B-High Depth	26.00	2.25	3.01	10.55	12.43	0.00	0.00	1500	N/A	N/A	0.20	8000
12CA Medium slash - Low-C-Low Depth	29.00	1.35	3.36	11.77	13.87	0.00	0.00	1500	N/A	N/A	0.20	8000
12CB Medium slash - Low-C-Avg Depth	29.00	1.93	3.36	11.77	13.87	0.00	0.00	1500	N/A	N/A	0.20	8000
12CC Medium slash - Low-C-High Depth	29.00	2.51	3.36	11.77	13.87	0.00	0.00	1500	N/A	N/A	0.20	8000
12DA Medium slash - FBPS-D-Low Depth	32.00	1.49	3.71	12.99	15.30	0.00	0.00	1500	N/A	N/A	0.20	8000
12DB Medium slash - FBPS-D-Avg Depth	32.00	2.13	3.71	12.99	15.30	0.00	0.00	1500	N/A	N/A	0.20	8000
12DC Medium slash - FBPS-D-High Depth	32.00	2.77	3.71	12.99	15.30	0.00	0.00	1500	N/A	N/A	0.20	8000
12MA Medium slash - FBPS-M-Low Depth	34.56	1.61	4.01	14.03	16.53	0.00	0.00	1500	N/A	N/A	0.20	8000
12MB Medium slash - FBPS-M-Avg Depth	34.56	2.30	4.01	14.03	16.53	0.00	0.00	1500	N/A	N/A	0.20	8000
12MC Medium slash - FBPS-M-High Depth	34.56	2.99	4.01	14.03	16.53	0.00	0.00	1500	N/A	N/A	0.20	8000
12XA Medium slash - FBPS-X-Low Depth	37.00	1.72	4.29	15.01	17.70	0.00	0.00	1500	N/A	N/A	0.20	8000
12XB Medium slash - FBPS-X-Avg Depth	37.00	2.46	4.29	15.01	17.70	0.00	0.00	1500	N/A	N/A	0.20	8000
12XC Medium slash - FBPS-X-High Depth	37.00	3.20	4.29	15.01	17.70	0.00	0.00	1500	N/A	N/A	0.20	8000
12YA Medium slash - High-Y-Low Depth	40.00	1.86	4.64	16.23	19.13	0.00	0.00	1500	N/A	N/A	0.20	8000
12YB Medium slash - High-Y-Avg Depth	40.00	2.66	4.64	16.23	19.13	0.00	0.00	1500	N/A	N/A	0.20	8000
12YC Medium slash - High-Y-High Depth	40.00	3.46	4.64	16.23	19.13	0.00	0.00	1500	N/A	N/A	0.20	8000
12ZA Medium slash - High-Z-Low Depth	43.00	2.00	4.99	17.45	20.57	0.00	0.00	1500	N/A	N/A	0.20	8000
12ZB Medium slash - High-Z-Avg Depth	43.00	2.86	4.99	17.45	20.57	0.00	0.00	1500	N/A	N/A	0.20	8000
12ZC Medium slash - High-Z-High Depth	43.00	3.72	4.99	17.45	20.57	0.00	0.00	1500	N/A	N/A	0.20	8000
13AA Heavy slash - Low-A-Low Depth	46.00	1.66	5.55	18.24	22.21	0.00	0.00	1500	N/A	N/A	0.25	8000
13AB Heavy slash - Low-A-Avg Depth	46.00	2.37	5.55	18.24	22.21	0.00	0.00	1500	N/A	N/A	0.25	8000
13AC Heavy slash - Low-A-High Depth	46.00	3.09	5.55	18.24	22.21	0.00	0.00	1500	N/A	N/A	0.25	8000
13BA Heavy slash - Low-B-Low Depth	49.00	1.77	5.91	19.43	23.66	0.00	0.00	1500	N/A	N/A	0.25	8000
13BB Heavy slash - Low-B-Avg Depth	49.00	2.53	5.91	19.43	23.66	0.00	0.00	1500	N/A	N/A	0.25	8000
13BC Heavy slash - Low-B-High Depth	49.00	3.29	5.91	19.43	23.66	0.00	0.00	1500	N/A	N/A	0.25	8000
13CA Heavy slash - Low-C-Low Depth	52.00	1.88	6.28	20.62	25.10	0.00	0.00	1500	N/A	N/A	0.25	8000
13CB Heavy slash - Low-C-Avg Depth	52.00	2.68	6.28	20.62	25.10	0.00	0.00	1500	N/A	N/A	0.25	8000
13CC Heavy slash - Low-C-High Depth	52.00	3.49	6.28	20.62	25.10	0.00	0.00	1500	N/A	N/A	0.25	8000
13DA Heavy slash - FBPS-D-Low Depth	55.00	1.99	6.64	21.81	26.55	0.00	0.00	1500	N/A	N/A	0.25	8000
13DB Heavy slash - FBPS-D-Avg Depth	55.00	2.84	6.64	21.81	26.55	0.00	0.00	1500	N/A	N/A	0.25	8000
13DC Heavy slash - FBPS-D-High Depth	55.00	3.69	6.64	21.81	26.55	0.00	0.00	1500	N/A	N/A	0.25	8000
13MA Heavy slash - FBPS-M-Low Depth	58.11	2.10	7.01	23.04	28.05	0.00	0.00	1500	N/A	N/A	0.25	8000
13MB Heavy slash - FBPS-M-Avg Depth	58.11	3.00	7.01	23.04	28.05	0.00	0.00	1500	N/A	N/A	0.25	8000
13MC Heavy slash - FBPS-M-High Depth	58.11	3.90	7.01	23.04	28.05	0.00	0.00	1500	N/A	N/A	0.25	8000
13XA Heavy slash - FBPS-X-Low Depth	61.00	2.20	7.36	24.19	29.45	0.00	0.00	1500	N/A	N/A	0.25	8000
13XB Heavy slash - FBPS-X-Avg Depth	61.00	3.15	7.36	24.19	29.45	0.00	0.00	1500	N/A	N/A	0.25	8000
13XC Heavy slash - FBPS-X-High Depth	61.00	4.09	7.36	24.19	29.45	0.00	0.00	1500	N/A	N/A	0.25	8000
13YA Heavy slash - High-Y-Low Depth	64.00	2.31	7.72	25.38	30.90	0.00	0.00	1500	N/A	N/A	0.25	8000
13YB Heavy slash - High-Y-Avg Depth	64.00	3.30	7.72	25.38	30.90	0.00	0.00	1500	N/A	N/A	0.25	8000
13YC Heavy slash - High-Y-High Depth	64.00	4.30	7.72	25.38	30.90	0.00	0.00	1500	N/A	N/A	0.25	8000
13ZA Heavy slash - High-Z-Low Depth	66.00	2.39	7.97	26.17	31.86	0.00	0.00	1500	N/A	N/A	0.25	8000
13ZB Heavy slash - High-Z-Avg Depth	66.00	3.41	7.97	26.17	31.86	0.00	0.00	1500	N/A	N/A	0.25	8000
13ZC Heavy slash - High-Z-High Depth	66.00	4.43	7.97	26.17	31.86	0.00	0.00	1500	N/A	N/A	0.25	8000

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
15 DBR High Pocosin	11.70	6.70	4.20	2.50	0.00	0.00	5.00	2000	N/A	1500	0.30	9000
16 DBR Low Pocosin	12.90	3.10	6.10	2.00	0.00	0.00	4.80	2000	N/A	1500	0.30	9000
17 Manzanita	15.00	3.00	3.00	4.50	1.05	1.45	5.00	350	1500	250	0.15	9211
18 Chamise 1	8.50	3.00	2.00	3.00	1.00	0.50	2.00	640	2200	640	0.15	10000
19 Ceanothus	14.65	6.00	2.25	4.80	1.80	3.00	2.80	500	1500	500	0.15	8000
20 Chamise 2	7.30	4.00	1.30	1.00	1.00	2.00	2.00	640	2200	640	0.20	8000
21 Sagebrush/buckwheat	9.65	3.00	5.50	0.80	0.10	0.75	2.50	640	1500	640	0.25	9200

Appendix B

Fuel Moisture Tables
from
How to Predict the Spread and Intensity of Forest and Range Fires (Rothermel 1983)

Appendix B – Fuel Moisture Tables

Table A - Reference Fuel Moisture
Day Time - 0800 to 1959

Dry Bulb Temperature (°F)	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89	90 to 94	95 to 99	100
10 - 29	1	2	2	3	4	5	5	6	7	8	8	8	9	9	10	11	12	12	13	13	14
30 - 49	1	2	2	3	4	5	5	6	7	7	7	8	9	9	10	10	11	12	13	13	13
50 - 69	1	2	2	3	4	5	5	6	6	7	7	8	8	9	9	10	11	12	12	12	13
70 -89	1	1	2	2	3	4	5	5	6	7	7	8	8	8	9	10	10	11	12	12	13
90 - 109	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	13
109+	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	12

Table E - Reference Fuel Moisture
Night Time - 2000 to 0759

Dry Bulb Temperature (°F)	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89	90 to 94	95 to 99	100
10 - 29	1	2	4	5	5	6	7	8	9	10	11	12	12	14	15	17	19	22	25	**25**	**25**
30 - 49	1	2	3	4	5	6	7	8	9	9	11	11	12	13	14	16	18	21	24	**25**	**25**
50 - 69	1	2	3	4	5	6	6	8	8	9	10	11	11	12	14	16	17	20	23	**25**	**25**
70 -89	1	2	3	4	4	5	6	7	8	9	10	10	11	12	13	15	17	20	23	**25**	**25**
90 - 109	1	2	3	3	4	5	6	7	8	9	9	10	10	11	13	14	16	19	22	25	**25**
109+	1	2	2	3	4	5	6	6	8	9	9	9	10	11	12	14	16	19	21	24	**25**

Note: Numbers in Bold are 25+.

Table F - All Year
Dead Fuel Moisture Content Corrections
Night Time - 2000 to 0759

	2000--->			2200--->			0000--->			0200--->			0400--->			0600--->		
	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N + E	9	1	1	13	1	2	16	2	2	17	1	1	18	1	1	16	2	1
S + W	9	0	1	14	0	1	16	0	2	17	0	1	18	0	0	9	0	1

Table B - May, June, July Dead Fuel Moisture Content Corrections Day Time - 0800 to 1959																			
Unshaded - Less Than 50% Shading of Surface Fuels																			
		0800--->			1000--->			1200--->			1400--->			1600--->			1800--->		
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N	0-30%	2	3	4	1	1	1	0	0	1	0	0	1	1	1	1	2	3	4
	31%+	3	4	4	1	2	2	1	1	2	1	1	2	1	2	2	3	4	4
E	0-30%	2	2	3	1	1	1	0	0	1	0	0	1	1	1	2	3	4	4
	31%+	1	2	2	0	0	1	0	0	1	1	1	2	2	3	4	4	5	6
S	0-30%	2	3	3	1	1	1	0	0	1	0	0	1	1	1	1	2	3	3
	31%+	2	3	3	1	1	2	0	1	1	0	1	1	1	1	2	2	3	3
W	0-30%	2	3	4	1	1	2	0	0	1	0	0	1	0	1	1	2	3	3
	31%+	4	5	6	2	3	4	1	1	2	0	0	1	0	0	1	1	2	2
Shaded - Greater Than or Equal to 50% Shading of Surface Fuels																			
N	0%+	4	5	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5
E	0%+	4	4	5	3	4	5	3	3	4	3	4	4	3	4	5	4	5	6
S	0%+	4	4	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5
W	0%+	4	5	6	3	4	5	3	3	4	3	3	4	3	4	5	4	4	5

Table C - February, March, April / August, September, October
Dead Fuel Moisture Content Corrections
Day Time - 0800 to 1959

Unshaded - Less Than 50% Shading of Surface Fuels																			
		0800--->			1000--->			1200--->			1400--->			1600--->			1800--->		
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N	0-30%	3	4	5	1	2	3	1	1	2	1	1	2	1	2	3	3	4	5
	31%+	3	4	5	3	3	4	2	3	4	2	3	4	3	3	4	3	4	5
E	0-30%	3	4	5	1	2	3	1	1	1	1	1	2	1	2	3	3	4	5
	31%+	3	3	4	1	1	1	1	1	1	1	2	3	3	4	5	4	5	6
S	0-30%	3	4	5	1	2	2	1	1	1	1	1	1	1	2	3	3	4	5
	31%+	3	4	5	1	2	2	0	1	1	0	1	1	1	2	2	3	4	5
W	0-30%	3	4	5	1	2	3	1	1	1	1	1	1	1	2	3	3	4	5
	31%+	4	5	6	3	4	5	1	2	3	1	1	1	1	1	1	3	3	4
Shaded - Greater Than or Equal to 50% Shading of Surface Fuels																			
N	0%+	4	5	6	4	5	5	3	4	5	3	4	5	4	5	5	4	5	6
E	0%+	4	5	6	3	4	5	3	4	5	3	4	5	4	5	6	4	5	6
S	0%+	4	5	6	3	4	5	3	4	5	3	4	5	3	4	5	4	5	6
W	0%+	4	5	6	4	5	5	3	4	5	3	4	5	3	4	5	4	5	6

Table D - November, December, January
Dead Fuel Moisture Content Corrections
Day Time - 0800 to 1959

		0800--->			1000--->			1200--->			1400--->			1600--->			1800--->		
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
Unshaded - Less Than 50% Shading of Surface Fuels																			
N	0-30%	4	5	6	3	4	5	2	3	4	2	3	4	3	4	5	4	5	6
	31%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
E	0-30%	4	5	6	3	4	4	2	3	3	2	3	3	3	4	5	4	5	6
	31%+	4	5	6	2	3	4	2	2	3	3	4	4	4	5	6	4	5	6
S	0-30%	4	5	6	3	4	5	2	3	3	2	2	3	3	4	4	4	5	6
	31%+	4	5	6	2	3	3	1	1	2	1	1	2	2	3	3	4	5	6
W	0-30%	4	5	6	3	4	5	2	3	3	2	3	3	3	4	4	4	5	6
	31%+	4	5	6	4	5	6	3	4	4	2	2	3	2	3	4	4	5	6
Shaded - Greater Than or Equal to 50% Shading of Surface Fuels																			
N	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
E	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
S	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
W	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6