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BehavePlus fire modeling system

Version 4.0

User's Guide

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Abstract

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This publication has been revised to reflect updates made to version 3 of the BehavePlus software, it was originally published as the BehavePlus fire modeling system, version 2.0 User's Guide in June, 2003

The BehavePlus fire modeling system is a program for personal computers that is a collection of mathematical models that describe fire and the fire environment. It is a flexible system that produces tables, graphs, and simple diagrams. It can be used for a multitude of fire management applications including projecting the behavior of an ongoing fire, planning prescribed fire, and training. BehavePlus is the successor to the BEHAVE fire behavior prediction and fuel modeling system. Primary modeling capabilities include surface fire spread and intensity, crown fire spread and intensity, safety zone size, size of point source fire, fire containment, spotting distance, crown scorch height, tree mortality, wind adjustment, and probability of ignition. The User's Guide describes operation of the program. Other papers describe the models and application of the system.

Keywords

Fire behavior, fire spread, fire intensity, computer program

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The following SEM people contributed to the project: Collin Bevins (program design and development), Deb Tirmenstein (program testing, document review and editing), Faith Ann Heinsch (tutorial development), Don Carlton (version 1 User's Guide and online help system), Joe Scott (online help and supporting material for the fire models added in versions 2 & 3), Mark Finney (supporting material for the fire models added in version 3) and Miguel Cruz (Portuguese translation for the 'language' option in version 3).

Other contributors include Rob Seli (tutorial development, editing, online help, and program testing), and Pat Andrews (project manager, system design, program testing, and tutorial development), Tobin Kelly (tutorial development), and Dave Custer (version 2 tutorial editing and formatting).

Software technical support is provided by US Forest Service, Fire and Aviation Management, National Systems Support Group, Boise, ID.

Cover Art

"WILDFIRE" (C) 1992, an original acrylic painting by Monte Dolack. Trumpeter swans take refuge in the air as a threatening wildfire rages through the forest habitat. This image is from a 29" x 24" poster commissioned by the National Wildfire Foundation and used here by permission of the artist.

All images used in BehavePlus and its associated manuals and training materials are from original works by Monte Dolack and appear by permission of the artist.

Preface

This User's Guide explains how to use the BehavePlus fire modeling system software. Other papers will describe the models incorporated into the system and application of the predictions.

This is an RMRS online publication. It can be downloaded from the Rocky Mountain Research Station publications web page, http://www.fs.fed.us/rm/main/pubs/electronic.html

You can download this User's Guide and the BehavePlus program from the BehavePlus web site, http://firemodels.org

This User's Guide is also an integral part of the BehavePlus system, serving as online help.

This publication has been revised from its original June, 2003 release. It will continue to be updated as features and modeling capabilities are added to the program.

The BehavePlus system is supported by

US Forest Service
National Fire and Aviation Management Information Systems Team
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Boise, ID 83705

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fire_help@fs.fed.us

What's New

Version 4.0 adds modeling capabilities and features to version 3. A summary of changes can be found in the Appendix.

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Table of Contents

1. Introduction

The BehavePlus fire modeling system is a PC-based program that is a collection of models that describe fire and the fire environment. It is a flexible system that produces tables and graphs and can be used for a multitude of fire management applications. BehavePlus is the successor to the BEHAVE fire behavior prediction and fuel modeling system (Andrews 1986, Andrews and Chase 1989, Burgan and Rothermel 1984, Andrews and Bradshaw 1990). It is called the BehavePlus fire modeling system to reflect its expanded scope (Andrews 2007, Andrews and Bevins 1999).

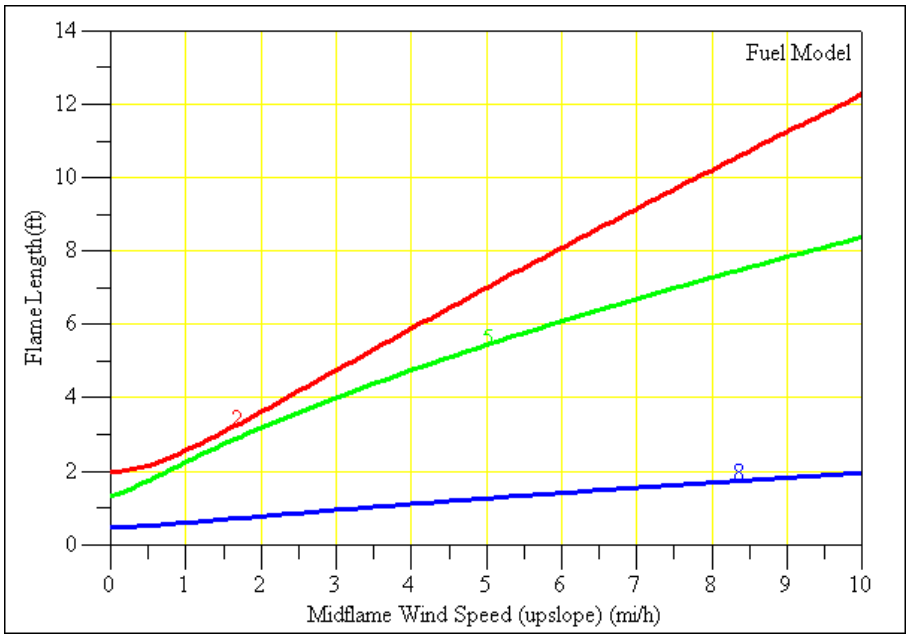
This document describes only the operation of the BehavePlus program. The fire models and their application are described elsewhere.

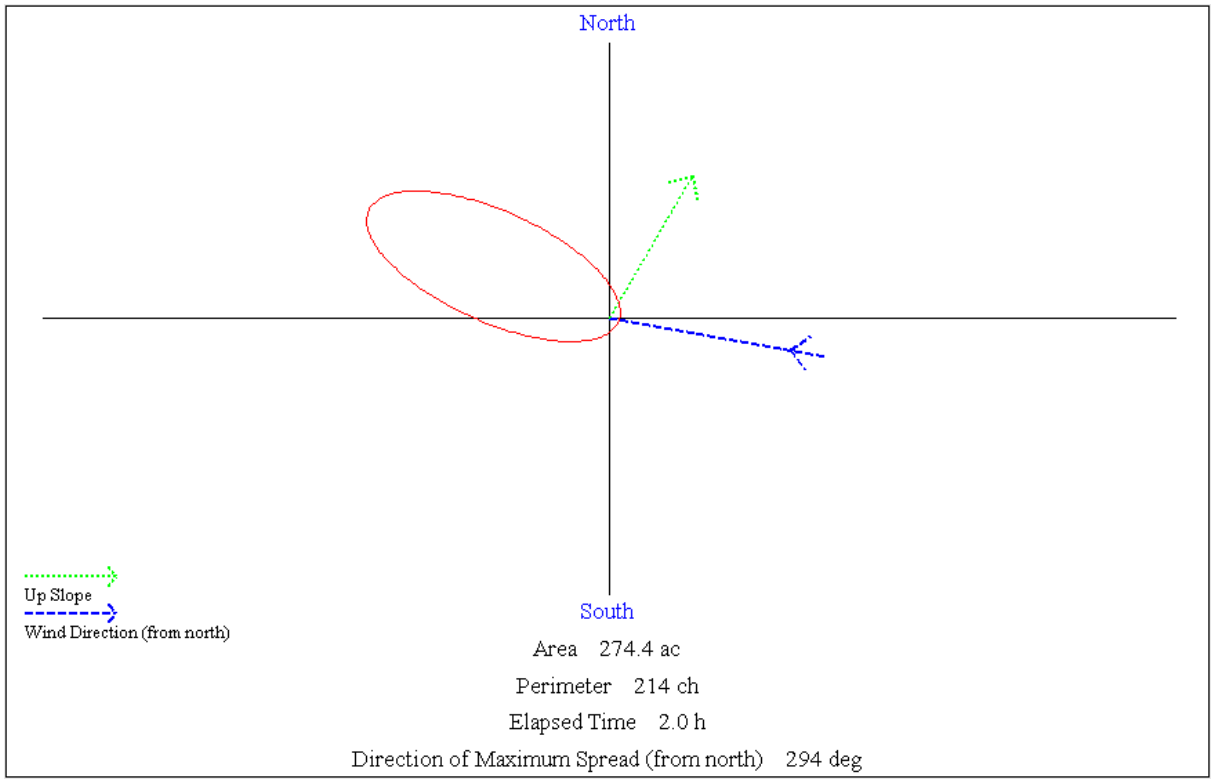
Many of the fire models in BehavePlus are the same as those in the *FARSITE* fire area simulator (Finney 1998) and the FlamMap fire behavior mapping and analysis system (Finney 2006). Each system meets a different need. Shown below are example outputs from each.

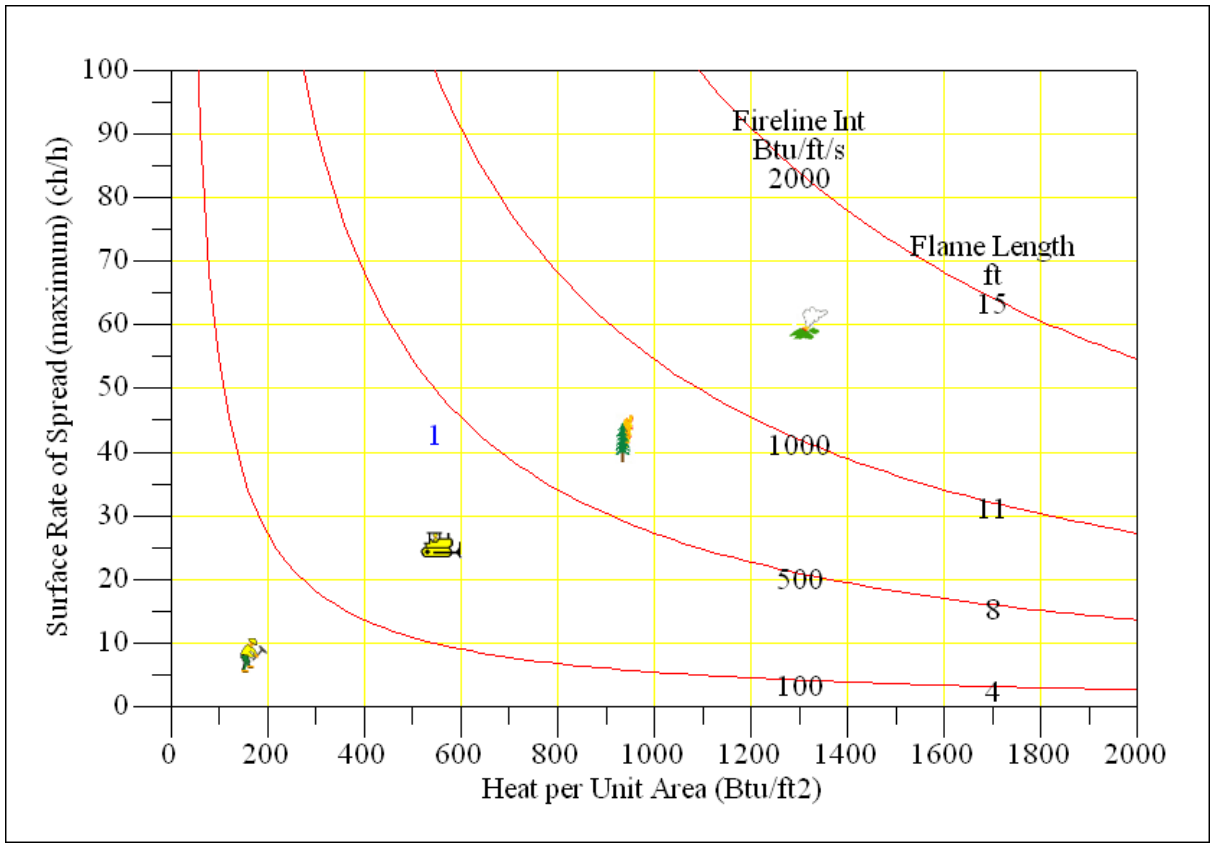
Sample table, graph, and diagram output from BehavePlus:

Flame Length (ft)

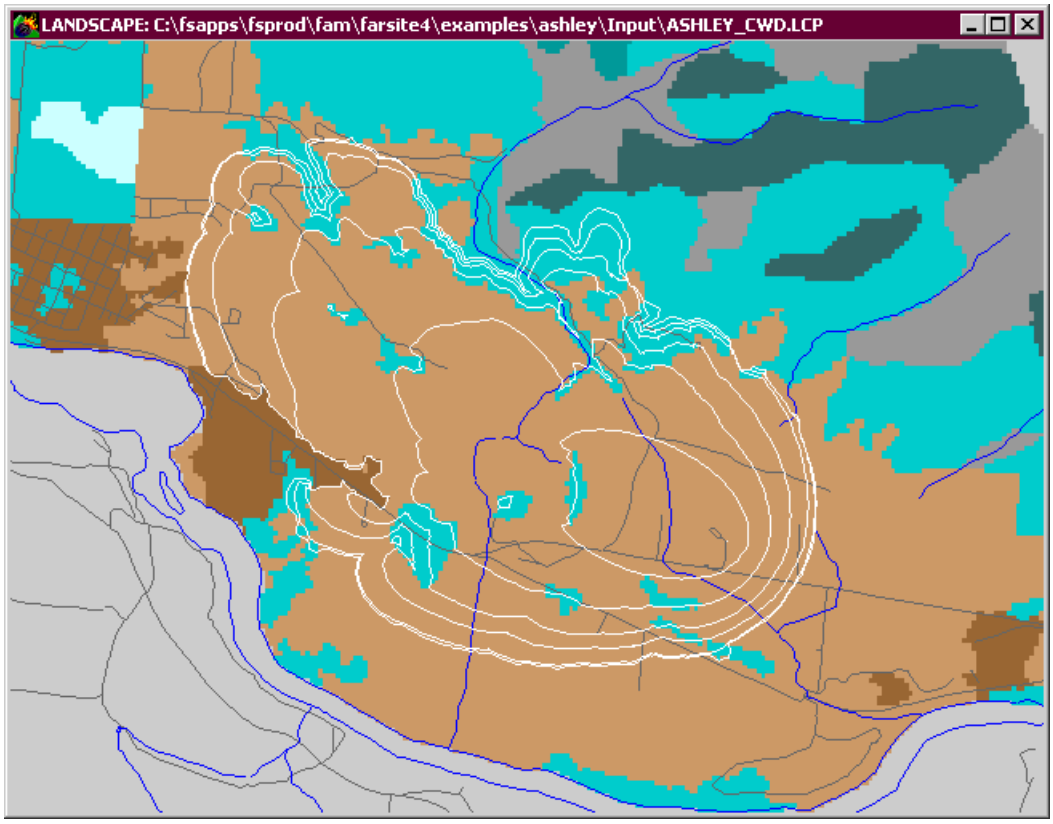
Fuel Model	Midflame Wind Speed (upslope) mi/h		
	0.0	5.0	10.0
2	2.0	7.0	12.3
5	1.3	5.4	8.4
8	0.5	1.3	2.0



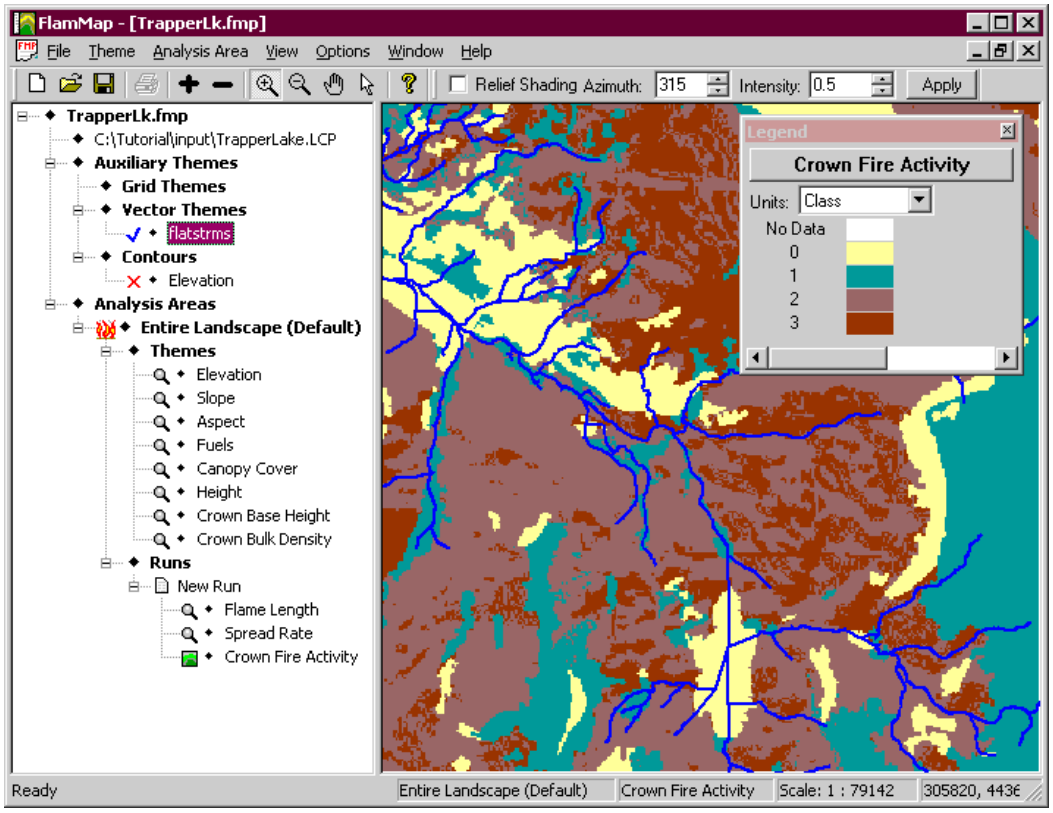

North
South
Up Slope
Wind Direction (from north)
Area 274.4 ac
Perimeter 214 ch
Elapsed Time 2.0 h
Direction of Maximum Spread (from north) 294 deg


Surface Rate of Spread (maximum) (ch/h)
Heat per Unit Area (Btu/ft2)
Fireline Int
Btu/ft/s
2000
1000
500
100
Flame Length
ft
15
11
8
4
1
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000

Sample fire perimeter output from *FARSITE*:



Sample landscape fire potential output from FlamMap:



Version 1.0 of BehavePlus was based primarily on the same fire models that composed the old BEHAVE system. Development focus was initially on a new look and feel for the program. This paper describes version 4.0, which provides additional models and features. A summary of changes to version 3.0 is given in the Appendix.

The primary modeling capabilities of BehavePlus, version 4.0, include

- Surface fire spread and intensity
- Safety zone size
- Size of a point source fire
- Fire containment
- Spotting distance
- Crown scorch height
- Tree mortality
- Probability of ignition from fire brands or from lightning
- Transition from surface to crown fire
- Crown fire spread

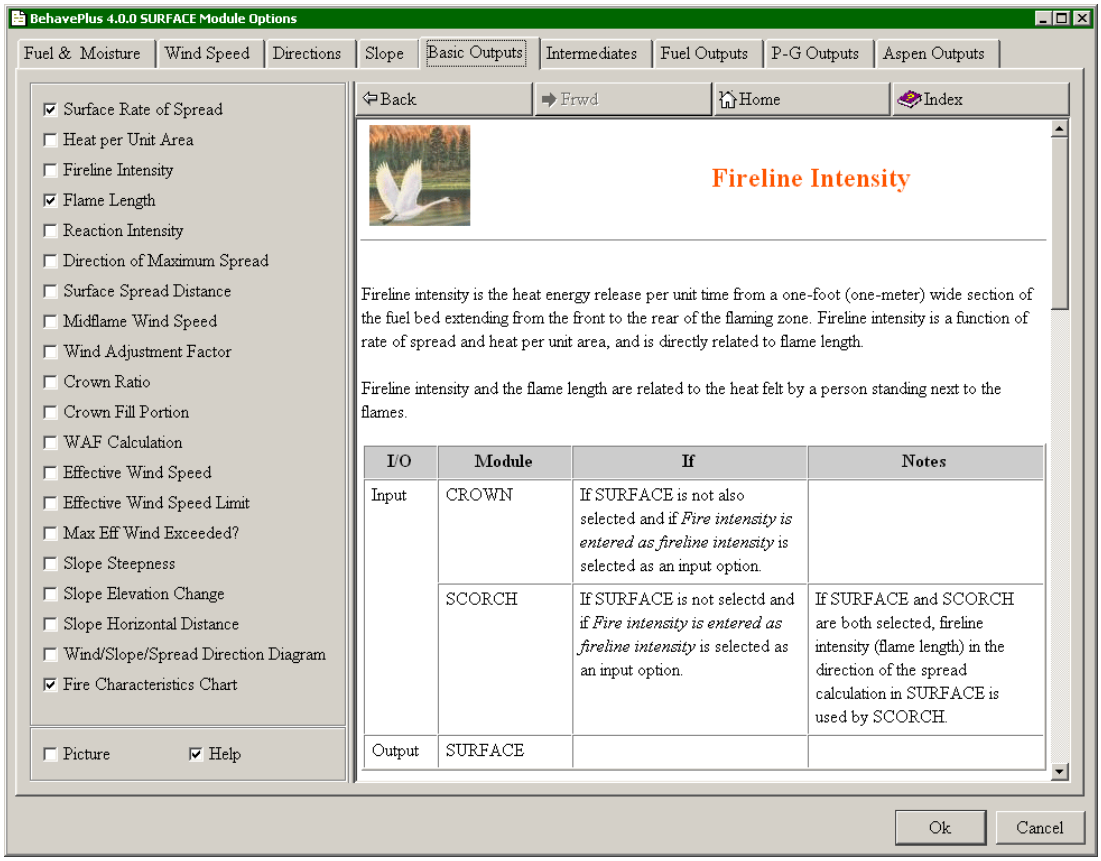
Other modeling capabilities include

- Tables for fine dead fuel moisture
- Tables for relative humidity or dew point
- Standard and custom fuel models
- Three methods for weighting two fuel models: two-dimensional expected spread, harmonic mean, area weighted

Key features include

- Diagrams for point source fire shape, shape of a contained fire, fire characteristics chart, wind / slope / fire directions
- Shading of table output for acceptable fire conditions
- Distances in map units
- User control of input options and output variables
- Description of each input and output variable
- User control of units and number decimal places displayed
- Multiple values can be entered for almost any input variable

The help system is an important part of the BehavePlus system. This User's Guide is available with the program for help on operation of the program. In addition, a help browser is available in the dialog boxes providing immediate information on specific operations and definition of input and output variables as shown below.



Variable descriptions and input/output tables are also available in a Adobe Acrobat document that is part of the help system. That paper (Andrews, 2008) is referred to as the "Variables paper" in this User's Guide.

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2. Operation

This User's Guide addresses only operation of the program. The fire models, associated variables, and application are described elsewhere.

2.1. Organization

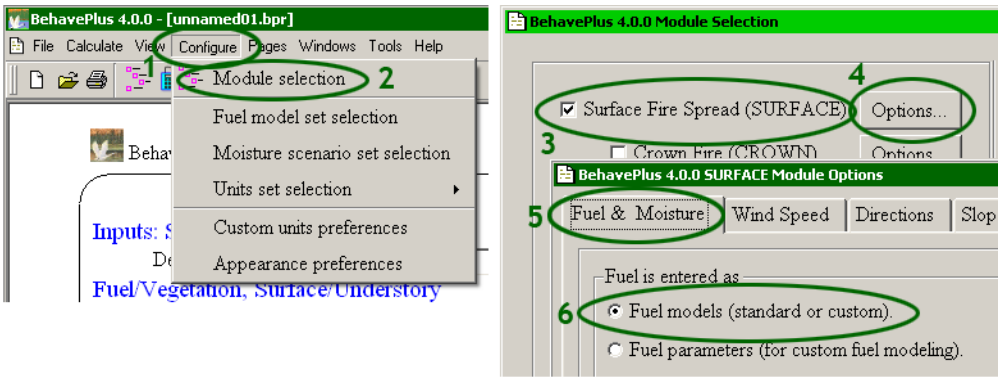
Organization of material on Operation of the BehavePlus program is different from the organization of the program itself. It is designed to help you find the answer to a question. Most users are comfortable with looking at menus and dialog boxes and associated information in the program without use of a User's Guide.

This is not a step-by-step operation manual, but a reference guide. The tutorials provide step-by-step instructions.

In describing operation of the program, we use the following font and/or conventions in describing menus, commands, buttons, tabs, and check boxes:

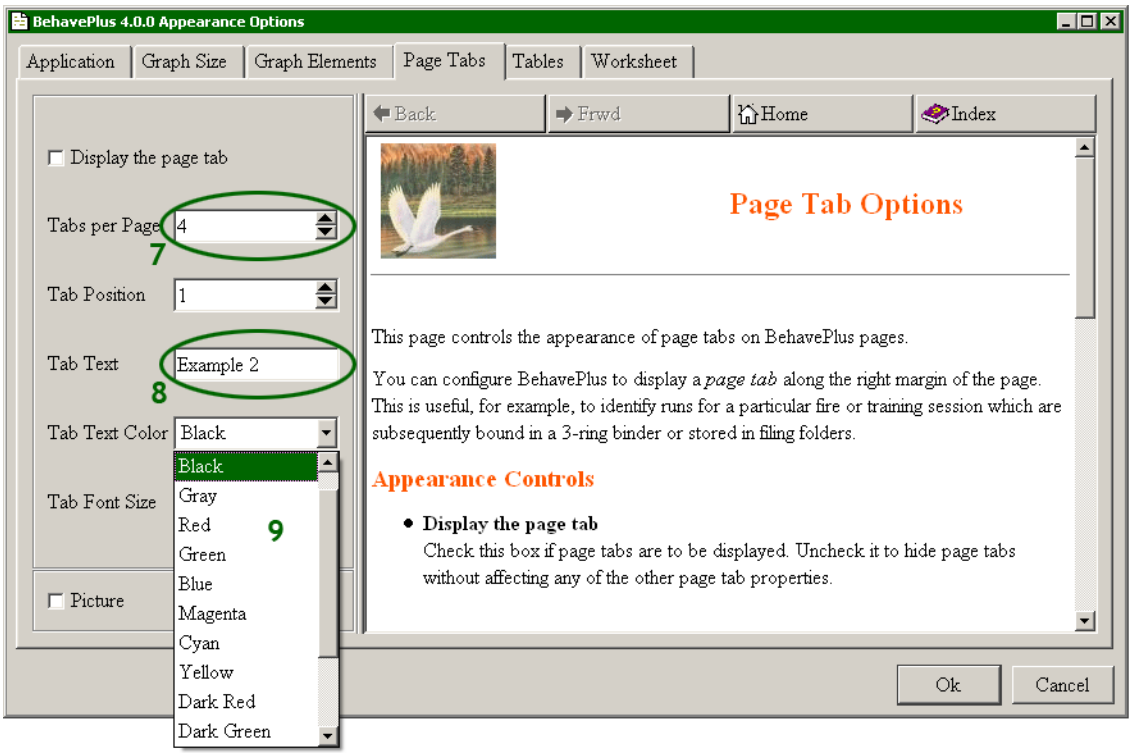
Configure > Module selection > SURFACE > Options... > Fuel & Moisture > fuel models radio button.

For example the sequence of menus, commands, check boxes, buttons, and tabs shown above refers to the following actions in BehavePlus:



Each of the above elements would be described in this User's Guide as

1. Configure menu
2. Module selection command
3. SURFACE check box
4. Options... button
5. Fuel & Moisture tab
6. fuel models radio button



Other elements used in BehavePlus include

7. Spin box - select the value using the buttons or enter a value from the keyboard,
8. Text box - click inside the box to enter values from the keyboard,
9. Drop-down list - Choose the value from the list displayed with the button.

In the interest of saving space and improving readability, we include screen captures of only the portion of concern.

2.2. Design

2.2.1. Page Oriented

BehavePlus is meant to be more than just a fire modeling tool. It is meant to be a lesson book with a built-in training manual, and a planning tool whose results may be incorporated into management reports. It is meant to be a fire behavior assessment aid whose tables and graphs can be shared with others in briefings and in written documentation.

Because of these expectations, the BehavePlus user interface is designed around the concept of the standard 8.5 x 11 printed page.

Given input information BehavePlus can generate documentation, diagrams, tables, and graphs. Fortunately, BehavePlus has a variety of methods for saving and displaying your work. Six months later when you need to review the work, the What, How, and Why of each Run is considerably less obscure than it would have been otherwise.

The page on which you enter input information appears first (page 1) and is called the Worksheet. A complex Worksheet may span several pages. Once the Calculate button is pressed, BehavePlus generates additional pages containing output tables, graphs, and diagrams. These too are deigned to fit neatly on the printed page. Navigation buttons on the Tool Bar let you move to the first page, last page, next page, or previous page. The

Pages menu lets you jump directly to any diagram, table, or graph. The "Print" dialog box lets you print selected pages.

2.2.2. Highly Configurable

BehavePlus is a repository of many mathematical models related to fire behavior and effects. These models may have alternate input sets and can produce many output variables. Individual models may be linked together so that outputs from one module automatically become inputs for another module. Input and output variables may have user-specified units of measure. Outputs may be in the form of diagrams, tables, and/or graphs.

BehavePlus may be used for fire behavior training, for fire planning, or for real-time fire behavior assessment. It may be used to assess fire behavior, fire effects, and the link between them.

2.2.3. Self Documenting

Configurability must be balanced with complexity. The input Worksheet automatically documents all Modules in use, all input variables and units of measure, all output variables and units of measure, and pertinent notes on the current configuration. The Worksheet also allows you to enter a Run description (and possibly additional training or fire incident information) and offers a notes field for free-field entry of expository text.

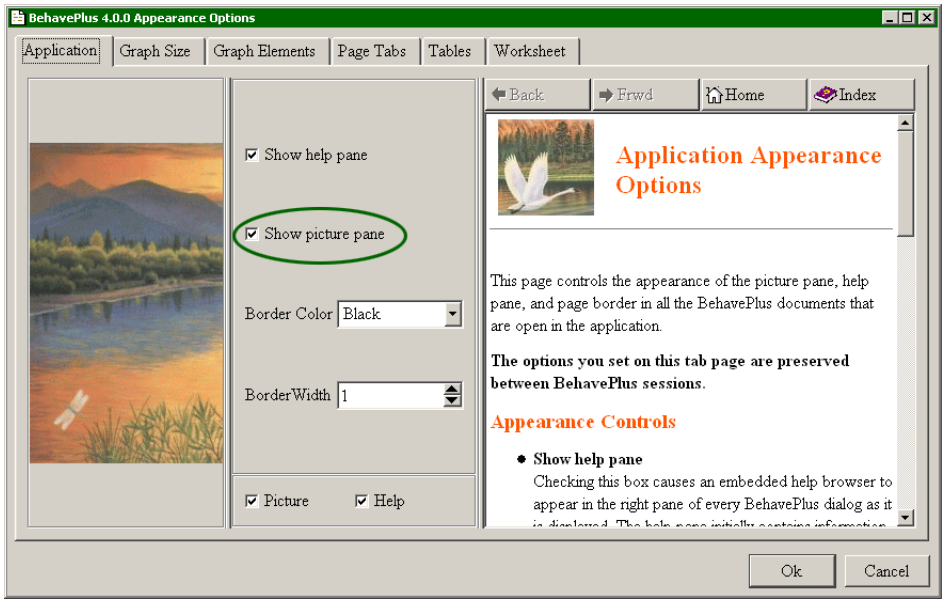
2.2.4. User Manual and Help

The Guide Button next to each entry field opens a dialog box containing a help browser pane with valid inputs. The help browser pane describes input and output variables and program operation with tables, photographs, and figures to help you select inputs. Variable descriptions with input and output tables are also available in a Adobe Acrobat document by selecting the Help > Variable Help command.

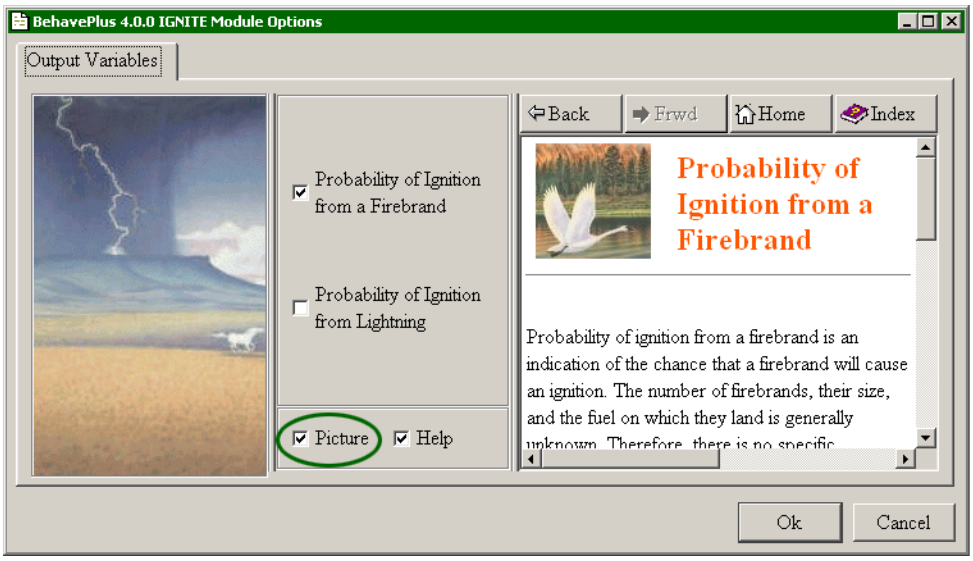
In addition, this User's Guide is available as part of BehavePlus with the Help > User's Guide command.

2.2.5. Not Boring

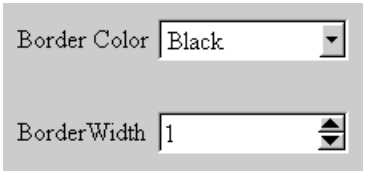
Finally, every attempt has been made to keep BehavePlus from becoming yet another boring program with a gray personality. If you prefer you can eliminate the pictures for the entire session by clearing the Show picture pane check box on the Configure > Appearance preferences > Application tab.



You can also choose to show the art work or not in the dialog boxes with the Picture check box



2.2.6. Borders



The border color and thickness on the Worksheet and output pages can be changed on the Configure > Appearance preferences > Application tab using the Border Color drop-down list and the Border Width spin box. The border can be eliminated by entering a Border Width of 0.

2.3. Features

2.3.1. Fire Models

A listing of the fire models in BehavePlus, with citations, is given in Andrews (2007) and in the Variables paper (Andrews 2008), which is available by selecting the Help > Variable Help command.

BehavePlus contains models to estimate

- Surface fire rate of spread, intensity, and flame length
- Direction of maximum spread
- Wind adjustment factor
- Rate of spread through two fuel models
- Crown fire spread rate, critical thresholds, and fire type
- Safety zone size
- Point source fire shape, area, and perimeter
- Success or failure of suppression resources to build line around a fire
- Spotting distance from a burning pile, from torching trees, or a wind-driven surface fire
- Crown scorch height
- Fire-induced tree mortality
- Probability of fire ignition from firebrands or from lightning

2.3.2. Operation

BehavePlus has the following operational features:

- Multiple Worksheets may be open at one time.
- Worksheets may be overlaid, tiled, cascaded, and resized.
- Modules (collections of related fire models) may be individually toggled on/off.
- Modules may have alternate input options available through the Configure > Module selection > Options... > Input Options tab.
- Module output variables can be selected via the Configure > Module selection > Options... > Output Variables tab.
- Modules may be linked so the outputs from one module are automatically input into another module.
- Distance outputs may be scaled to map units.
- Input and output units of measure may be modified by the user.
- Custom Worksheet configurations may be saved and re-used.
- Custom sets of units of measure may be saved and re-used.
- The Guide Button next to each Worksheet entry field displays a help browser pane with context-specific text and either a list of valid choices (for discrete variables) or fields for generating a range of input values.
- Zero, one, or two input variables may have multiple entry values, producing either a simple result list, a single one-way table, or a multi-page two-way table, respectively.
- If one input variable has multiple entry values, a separate graph can be generated for each output variable. If two input variables have multiple entry values each output variable graph contains a family of curves.
- The SURFACE, SIZE, and CONTAIN Modules can produce diagrams of their results.
- Help commands make this manual and all associated documentation available in Adobe Acrobat format for reading, web browsing, and printing.
- Completed Runs may be saved and re-used.

2.4. Installation

2.4.1. Download

BehavePlus is available for download from www.firemodels.org.

2.4.2. System Requirements

BehavePlus has modest system requirements.

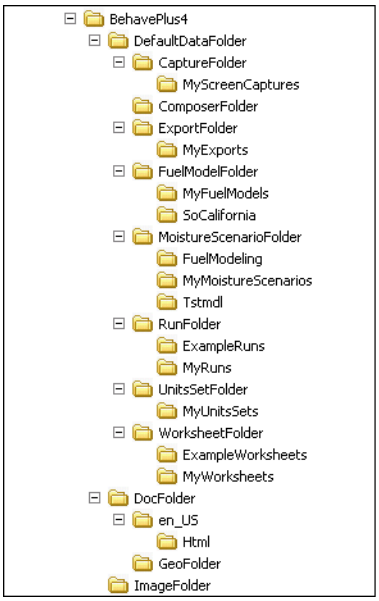
- Windows 95, 98, ME, NT, 2000, XP, or Vista
- Minimum 800 x 600 video resolution with 256 (8-bit) colors (recommend 1024 x 768 video resolution with 64K (16-bit) colors)
- 16 megabytes of available RAM
- 20 megabytes of disk storage

2.4.3. Windows Installation

BehavePlus for Windows is packaged using the Wise Installation System. Simply type the name of the package (e.g., bp_4_0_0.exe) at a command prompt (or click on its name in Windows Explorer) and the installation wizard will guide you through the process. This mostly consists of pressing the OK button.

2.4.4. File Structure

BehavePlus has a proscribed file system structure; all files must be located in specific subdirectories. The parent directory of this file structure and all its subdirectories and files are collectively known as a Workspace. When BehavePlus is first installed it has a single Workspace called "DefaultDataFolder" as shown below.



This is the default current Workspace every time BehavePlus is started.

Workspaces aid file management as you apply BehavePlus to several projects. See the section 17.1, Workspaces, for more information.

A list of three letter file extensions used by BehavePlus is shown in the following table. These extensions are automatically attached to the files you create in BehavePlus.

File extension	File Type	Folder
.bpf	Custom fuel models	FuelModelFolder
.bpm	Moisture scenarios	MoistureScenarioFolder
.bpr	Runs	RunFolder
.bpu	Custom Unit Sets	UnitsSetFolder
.bpw	Worksheets	WorksheetFolder

2.5. Definitions

A Worksheet is the first page or two containing the input Entry Fields. The content of a Worksheet depends upon the specific BehavePlus configuration including module selections, input options, output variables, and units of measure. Some Example Worksheets are supplied with the BehavePlus distribution and are included in every Workspace. You may develop your own Worksheets and save them for later reuse. A Worksheet does not have input values associated with it.

A Run is a Worksheet that has a complete set of valid input values, but no outputs are saved in a Run. You must calculate a saved Run to obtain outputs. Runs may be saved for documentation and later use. The BehavePlus installation includes Example Runs.

A Model is a set of equations that estimate one or more output variables from one or more input variables. BehavePlus contains many mathematical models which are grouped into Modules.

A Fuel Model is a set of numbers describing a fuel bed used by the surface fire spread model.

A Module is a collection of one or more mathematical models. The IGNITE Module, for example, includes both the firebrand ignition model and the lightning strike ignition model.

A Continuous Variable is an input or output variable that has a continuous range of numerical values. Continuous variables have a minimum and maximum valid value. Examples include fuel moisture content and wind speed.

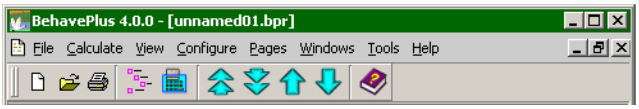
A Discrete Variable has a finite set of valid values. Examples include Fuel Model and Spotting Source Location.

A Guide Button is the button with the arrow icon next to each Worksheet entry field. Pressing the Guide Button activates an "Input Guide" dialog box containing a help browser pane and input assistance. For continuous variables, the dialog facilitates entry of inputs by specifying the minimum input value, maximum input value, and increment value. For discrete variables the "Input Guide" dialog box contains a list of all valid inputs from which the user may select values.

A Workspace is a complete subdirectory tree containing all required BehavePlus files plus any additional Worksheet, Run, Fuel Model, Moisture Scenario, Units Set, or capture files saved by the user. A Workspace can be used for a project. Workspaces are created by the File > Workspaces > New workspace and the Files > Workspaces > Clone current workspace commands.

2.6. Menus and Toolbar

BehavePlus operations are available from the menu bar.



The more common operations, such as Module Selection or Calculate, may also be invoked from Toolbar buttons. Toolbar buttons and their equivalent Menu commands are shown below:

Toolbar Buttons	Definitions	Equivalent menu operation
	Open a new Worksheet	File > Open Worksheet
	Open a saved Run	File > Open Run
	Print this Run	File > Print
	Module selection	Configure > Module selection
	Calculate this Run	File > Calculate
	Display first page	Pages > then select page #
	Display last page	Pages > then select page #
	Display previous page	Pages > then select page #
	Display next page	Pages > then select page #
	Access User's Guide	Help > User's Guide

3. Worksheets

A Worksheet is a form on which you enter input. Module selection, input options, and output variable selections determine the Worksheet.

BehavePlus initially starts with the BasicStart.bpw example Worksheet. This gives the option of doing a quick basic fire behavior Run without having to load or configure a Worksheet.

You also have the option of setting your own startup worksheet as described in section 3.8

3.1. Worksheet layout

A BehavePlus Worksheet is more than just an input form; it is the primary source of documentation about the Run. Worksheets include the following components:

Header - The Worksheet header shows the BehavePlus version number, useful for reporting bugs and determining if you have the most recent update. The header also includes the date and time of the last calculation and the page number, which lets you collate the correct pages after printing and spreading them out for further study.

Border - The line surrounding the Worksheet body may be modified with the Configure > Appearance preferences > Worksheet tab.

Tabs - Zero, one, or more page tabs with labels along the right-hand margin of the Worksheet may be activated with the Configure > Appearance preferences > Page Tabs tab.

Documentation - This section lists all the currently selected modules and contains an entry field for the Run description. Additional documentation entry fields are optionally activated on the Configure > Appearance preferences > Worksheet tab.

Input - This section contains the required input data entry fields identified by a short phrase and their units of measure. Each entry text box also has a Guide button that may be pressed for input assistance. Entry text boxes are grouped under headings such as "Fuel/Vegetation, Surface/Understory", "Fuel/Vegetation, Overstory", "Fuel Moisture", "Weather", "Terrain", and "Fire".

Acceptable Fire Conditions - Used to enter ranges of acceptable fire behavior when using the table shading option. Table shading is enabled by selecting the Configure > Table shading for acceptable fire conditions check box.

Run Option Notes - This section documents pertinent configuration settings that are selected for the Worksheet.

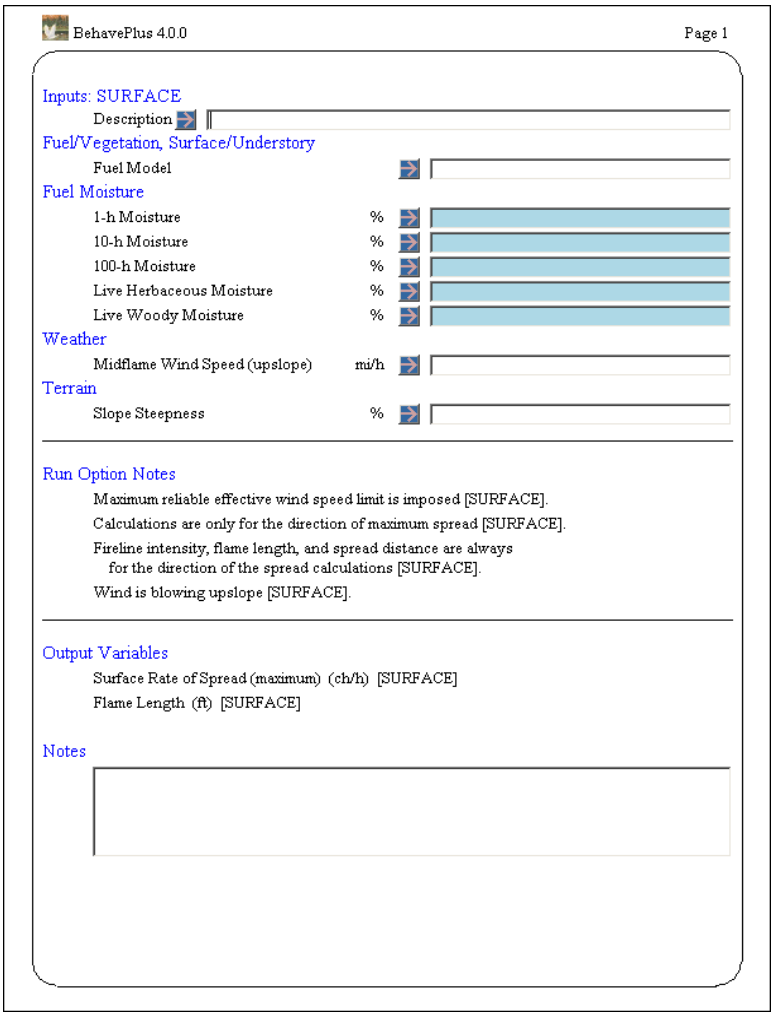
Output Variables - This section lists all the selected output variables and their units of measure. This section may be toggled on/off in the Configure > Appearance preferences > Worksheet tab.

Notes - This section permits the user to enter free-field expository text. The user has control of the size of this section or whether it is displayed using the Configure > Appearance preferences > Worksheet tab.

3.2. Example Worksheets

A number of predefined example Worksheets are included with the BehavePlus installation in the ExampleWorksheets folder. You may use these Worksheets as provided, or use them as starting points for your own configuration. Use the File > Open worksheet command to open an example Worksheet and proceed to change your module selection, input options, and/or output variables as needed. Once the Worksheet is configured the way you want, you may name and save it as a new Worksheet. During subsequent BehavePlus sessions you may load your custom Worksheet.

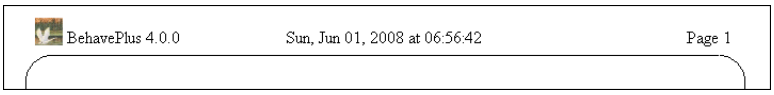
Shown below is the BasicStart.bpw example Worksheet:



3.3. Worksheet Sections

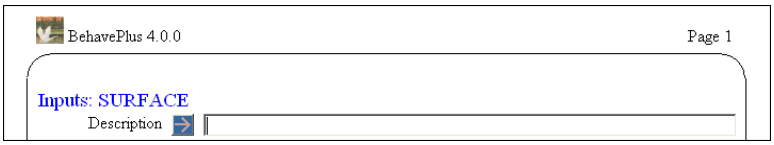
3.3.1. Page Header

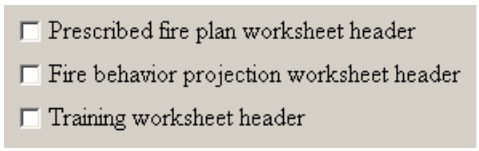
The header of each page includes the version number of the BehavePlus program and the page number. Once a Run is calculated the date and time of the calculation is added. The date and time and page number can be used to correctly collate printed documents.



3.3.2. Documentation

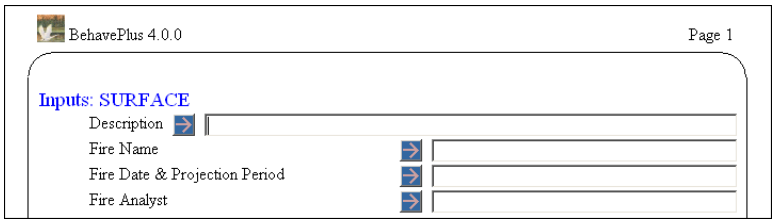
Documentation is the header information on the Worksheet. The calculation modules that have been selected are listed. There is always a Description field.



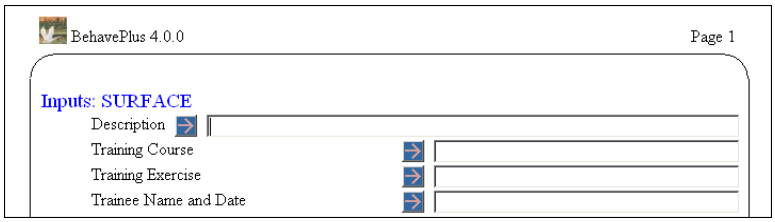


Additional documentation lines can be added by selecting the Fire behavior projection worksheet header, Training worksheet header, and/or Prescribed fire plan worksheet header check boxes from the Configure > Appearance preferences > Worksheet tab.

Selecting the Fire projection documentation check box adds the following input fields to the Worksheet:



Selecting the Training documentation check box adds the following input fields to the Worksheet:

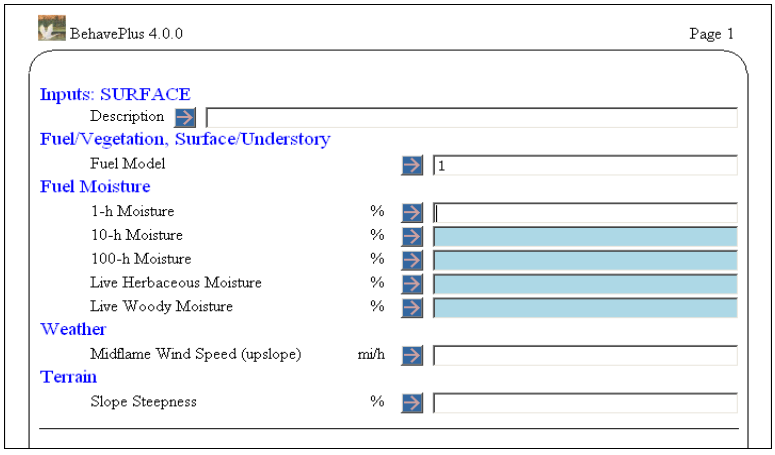


More than one option can be selected at the same time.

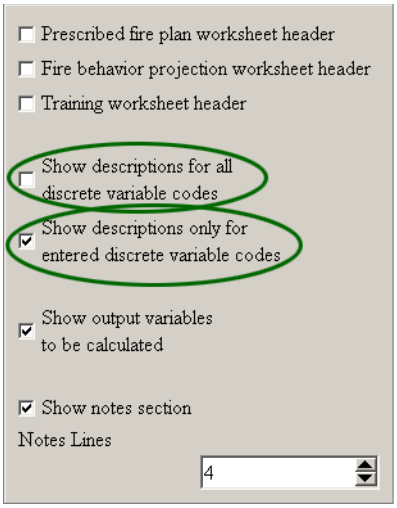
3.3.3. Input section

The required input variables and their units are displayed next to their text boxes. Fuel moisture variables that are not required have the text box shaded. In the example below, only 1-h fuel moisture is required for fuel model 1, because the other fuel categories are not included in that fuel model.

The Guide button for each input variable provides access to definitions and input assistance. Input variables are organized by logical association (rather than by calculation module). A table of all possible input variables by category is given in the Variables paper.

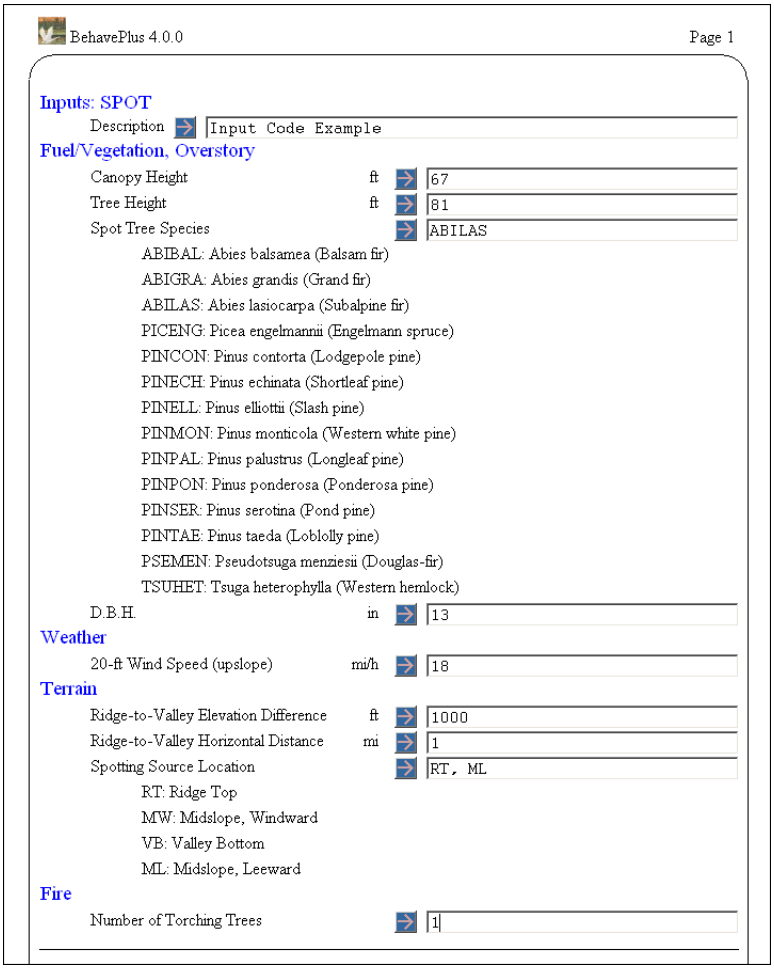


3.3.4. Input codes

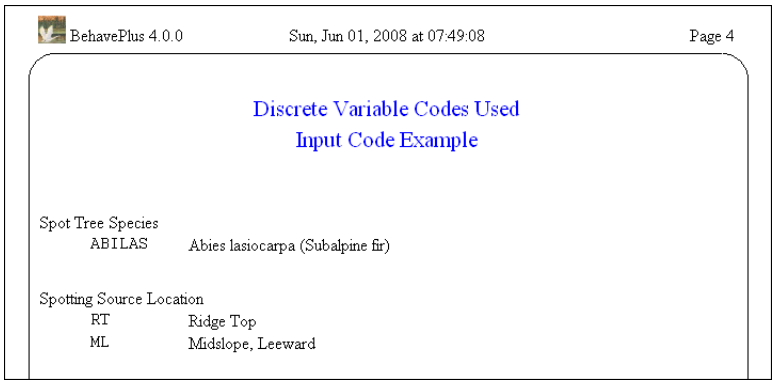


The definition of discrete variable input codes can be displayed by selecting two options on the Configure > Appearance > Worksheet tab. Selecting the Show description for all discrete variable codes check box displays the codes on the Worksheet beneath the variable. The Show descriptions only for entered discrete variable codes check box displays the codes used in the Run on a separate output page when selected.

For example, on the SPOT module with the Show descriptions for all discrete variable codes check box selected, all tree species and spotting source location codes are shown.



With the Show descriptions only for entered discrete variable codes check box selected a page is generated at the end of outputs listing the codes and descriptions used in the Run.


BehavePlus 4.0.0 Sun, Jun 01, 2008 at 07:49:08 Page 4

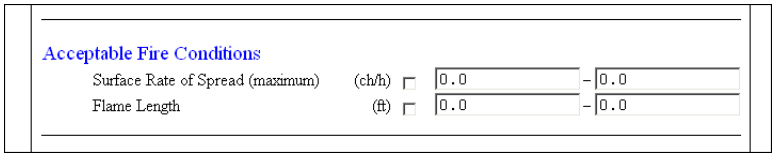
Discrete Variable Codes Used
Input Code Example

Spot Tree Species
ABILAS Abies lasiocarpa (Subalpine fir)

Spotting Source Location
RT Ridge Top
ML Midslope, Leeward

3.3.5. Acceptable Fire Conditions

This section is displayed on the Worksheet when the Table shading for acceptable fire conditions check box in the "Module Selection" dialog box is selected.

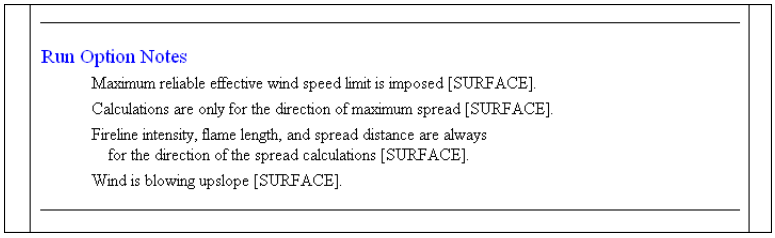

Acceptable Fire Conditions

Surface Rate of Spread (maximum)	(ch/h)	☐	0.0 –	0.0
Flame Length	(ft)	☐	0.0 –	0.0

Acceptable Fire Conditions are fully explained in Chapter 7, Table Shading.

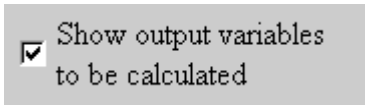
3.3.6. Run Option Notes

For clarification, Run options are given after the input variables. The user does not have the option of suppressing this information. The module using the option is also listed in brackets.


Run Option Notes

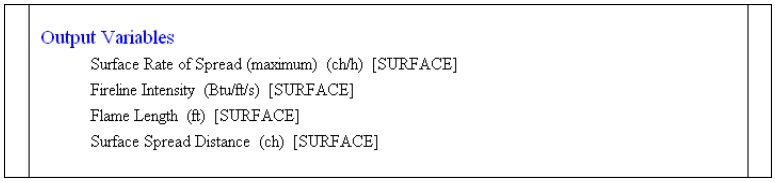
Maximum reliable effective wind speed limit is imposed [SURFACE].
Calculations are only for the direction of maximum spread [SURFACE].
Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].
Wind is blowing upslope [SURFACE].

3.3.7. Output variables



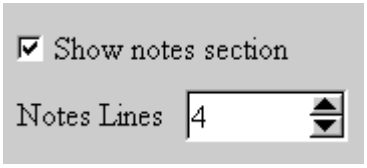
Selected output variables and their units can be displayed at the end of the input Worksheet using the Configure > Appearance preferences > Worksheet tab. The module calculating the output variable is also listed in brackets.

For example:


Output Variables

Surface Rate of Spread (maximum) (ch/h) [SURFACE]
Fireline Intensity (Btu/ft/s) [SURFACE]
Flame Length (ft) [SURFACE]
Surface Spread Distance (ch) [SURFACE]

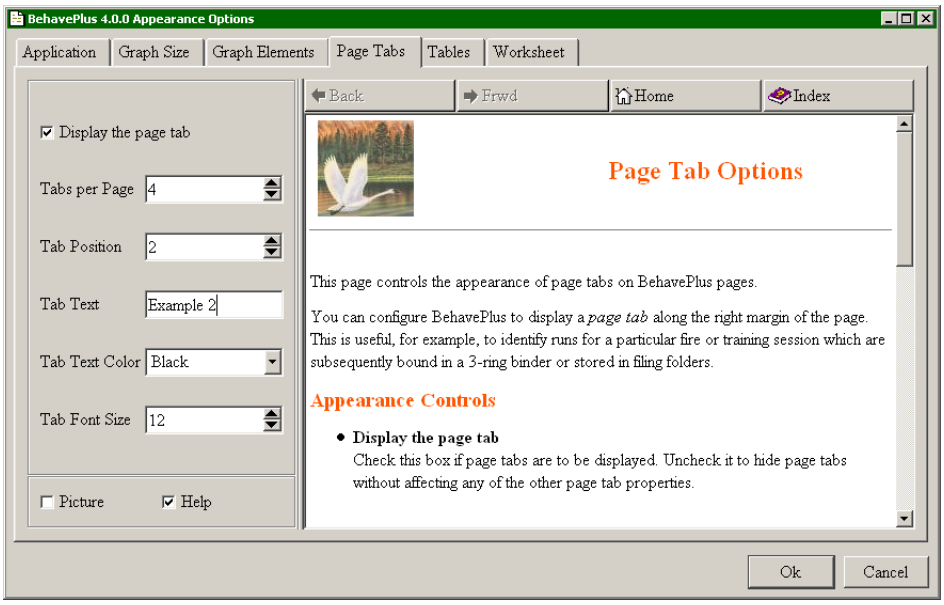
3.3.8. Notes



The Notes section of the Worksheet allows the user to enter text to describe a Run. The user has the option of changing the number of lines provided for notes or even eliminating the notes section on the Configure > Appearance preferences > Worksheet tab with the Show notes section check box and the Notes Lines spin box.

3.3.9. Page Tabs

Page tabs can be displayed along the right margin of the page. This is useful, for example, to identify Runs for a particular fire or training session that are subsequently bound in a three-ring binder or stored in filing folders. Page tabs can be added and defined with the Configure > Appearance preferences > Page Tabs tab.



Tabs per page - The size of the tab depends upon the value selected in this spin box. Only one tab is actually displayed per page. If tabs per page is 4, the displayed tab occupies one-fourth the page height. If it is 10, the displayed tab occupies one-tenth the page height. As this number increases, the displayed tab size decreases.

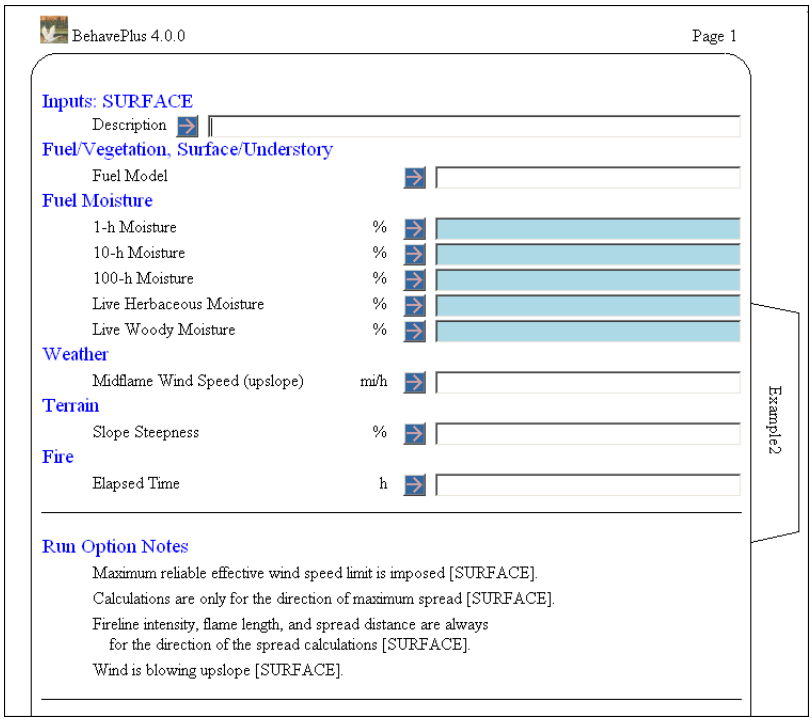
Tab position - Determines the position of the displayed tab. Tab position 1 is always at the upper edge of the right margin.

Tab text - The text to appear on the tab. The text is centered within the tab and will therefore be truncated at both ends if it is too long.

Tab text color - A color is selected from the drop-down list.

Tab font size - Font point size is selected using this spin box.

The above settings create the tab on the Worksheet below:



3.4. Loading a previously saved Worksheet

A previously saved Worksheet can be loaded using

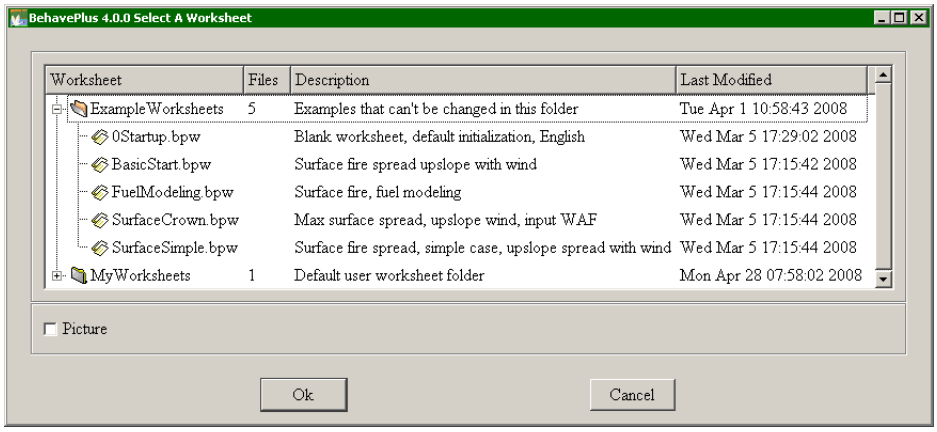
- the File > Open worksheet command,
- or the toolbar button.

To see the Worksheets in the folder click on the button to the left of the folder.

To select a Worksheet either

- double click on it,
- or select and click the OK button.

A set of Worksheets is supplied with the program in the "ExampleWorksheets" folder.



3.5. The 0Startup Worksheet

The 0Startup.bpw Worksheet is used as the starting place for selecting calculation modules and options. It shows no input or output variables, but it sets defaults for all settings. The 0Startup.bpw Worksheet was used to initialize all of the example Worksheets.

A Worksheet can be designed to meet specific needs by starting with the 0Startup.bpw Example Worksheet, selecting the desired modules, and changing options as needed. The startup Worksheet is named 0Startup.bpw to assure that it is the first selection of the Example Worksheets folder.

3.6. Changing a Worksheet

A Worksheet can be changed at any time by changing the selected modules and associated options. The changes are in effect only for the current session unless the revised Worksheet is saved. If a Worksheet that came with the program in the ExampleWorksheets folder is changed, the revised version must be saved in another Worksheet folder.

3.7. Saving a Worksheet or a Run

A Worksheet can be saved for later use with the File > saveAs > Worksheet command. The values entered onto the Worksheet are not saved.

Save the Run, which is a Worksheet with the defined input values, with the File > saveAs > Run command.

See the Section 17.4, Save As, for more specific information.

3.8. Setting a Startup Worksheet

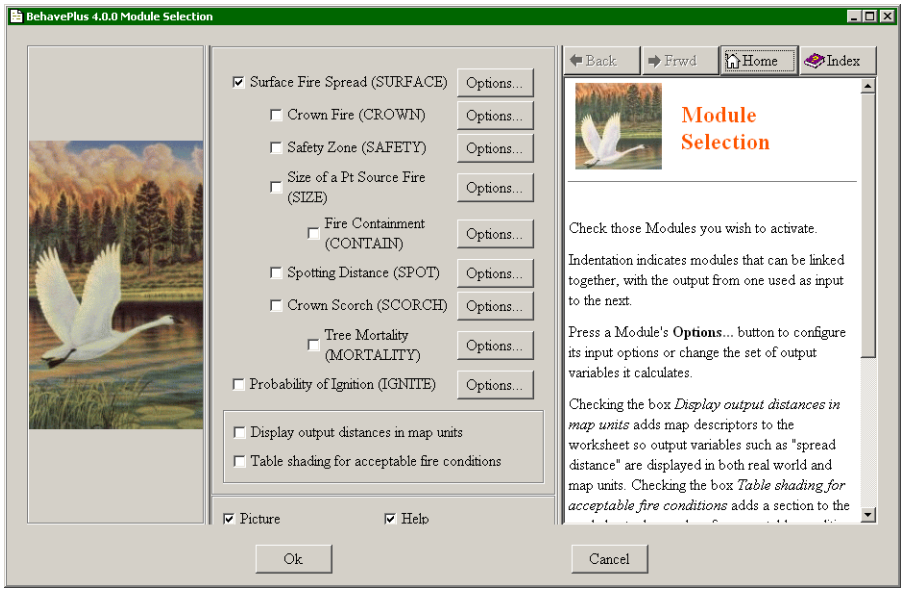
BehavePlus initially starts with the BasicStart.bpw Worksheet.You have the option of changing the startup Worksheet to one that better meets your needs.

The File > Set startup worksheet command opens a dialog box where you can select any Worksheet from the WorksheetFolder. It can be one of the ExampleWorksheets that come with the application or one that you have developed and saved.

4. Modules

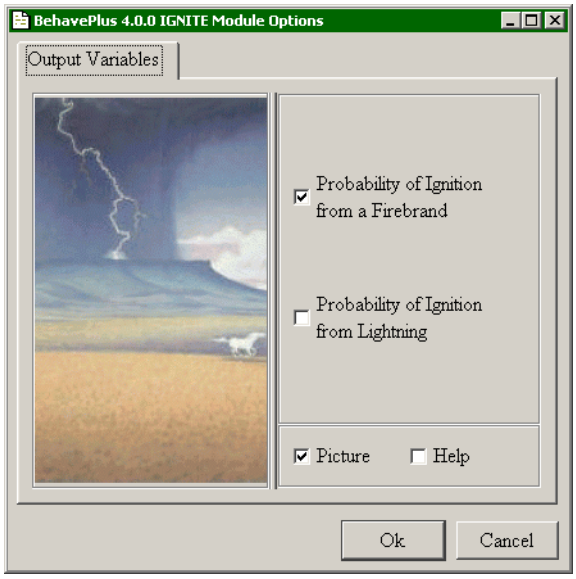
Modules are a grouping of mathematical fire models for a Worksheet.
Selection of modules is made with the Configure > Module command.

The output variables that can be calculated by each module are given in the Variables paper.



Indentation of modules indicates which can be linked, which means that output from one module is used as input to the other. For example, if both SURFACE and SAFETY are selected, the modules are linked. Output from SURFACE is used as input to SAFETY. If only SAFETY is selected, the Flame Length input appears on the Worksheet and must entered by the user. A table of input variables and associated modules is given in the Variables paper.

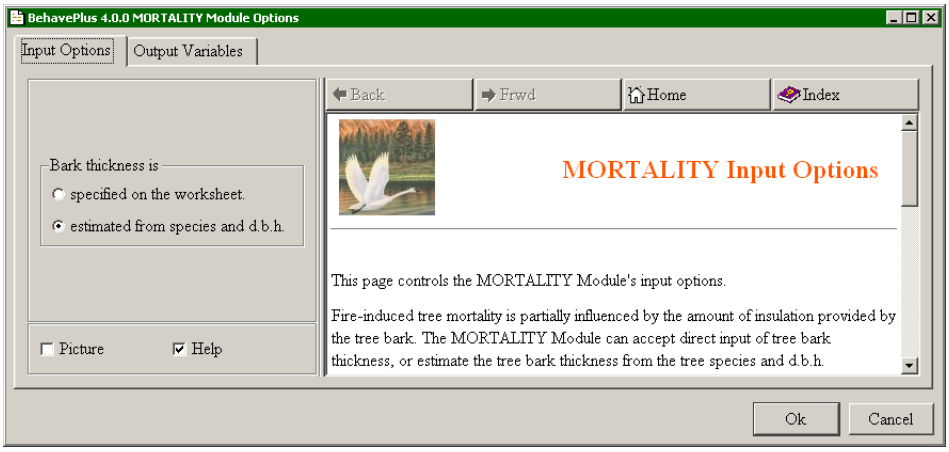
Selection of modules, options, and output variables determines the required input variables shown on the Worksheet. The Options... button is used to configure a module's input options or change the output variables calculated. Some module options are very simple, IGNITE for example, has no input options.



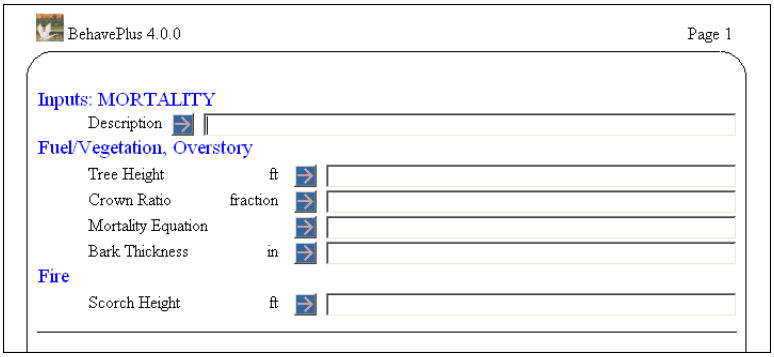
The "SURFACE Module Options" dialog box offers the most options, with multiple tabs for both input options and output variables.

4.1. Input options

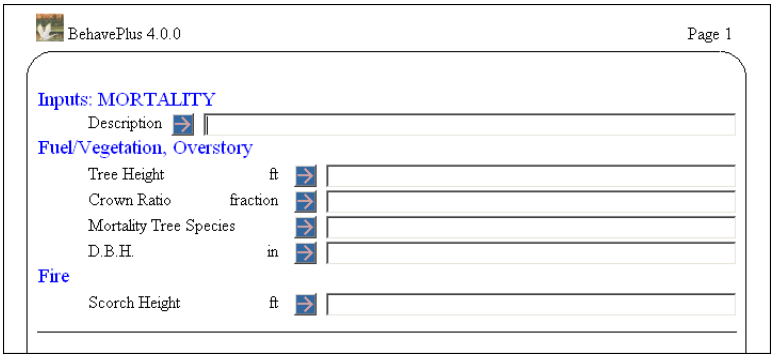
Some modules offer options on alternate ways of specifying input. For example, clicking the MORTALITY Options... button displays the "MORTALITY Module Options" dialog box with the Bark thickness is input option:



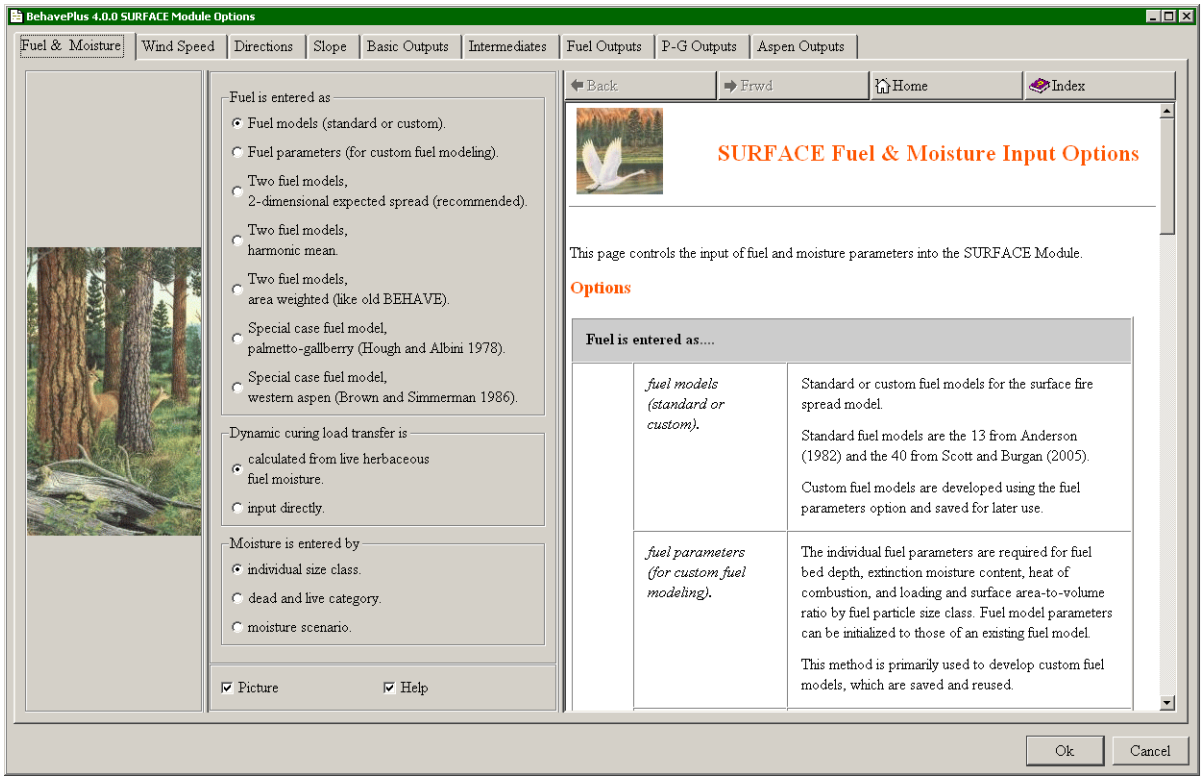
The bark thickness option affects the input variables included on the Worksheet. If Bark thickness is specified on the worksheet is selected, the resulting Worksheet is as follows:



If Bark thickness is estimated from species and d.b.h. is selected, the Worksheet is as follows:



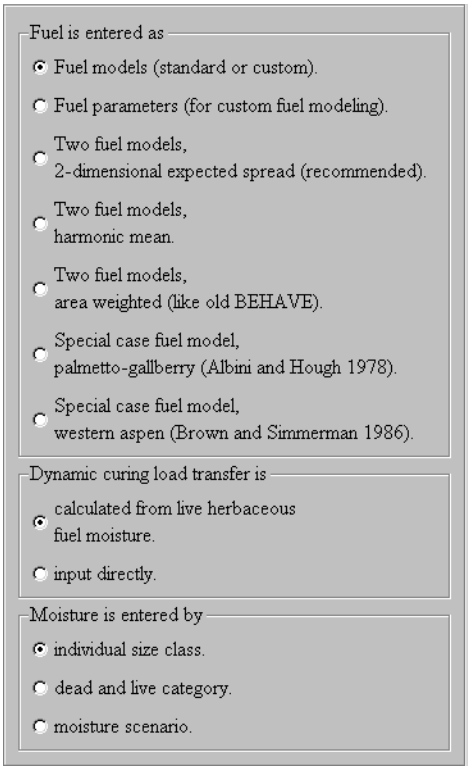
The SURFACE module has many input options, which are available on several tabs:



For the "SURFACE Module Options" dialog box the following tabs offer input options;

- Fuel & Moisture
- Wind Speed
- Directions
- Slope

4.1.1. Fuel & Moisture Tab



Fuel models are prepackaged sets of fuel parameters representing stylized fuel situations. Using this input option allows you to simply enter fuel model codes rather than a dozen fuel model parameters. This is the most common way of running BehavePlus as it greatly simplifies input. If you have special fuel situations, create a custom fuel model and use it.

The individual fuel parameters are required for fuel bed depth, extinction moisture content, heat of combustion, and loading and surface area-to-volume ratio by fuel particle size class. Fuel model parameters can be initialized to an existing fuel model. This method is primarily used to develop custom fuel models which are saved and reused.

The two-fuel model options are useful for areas that clearly consist of two different fuel models rather than a single, homogenous fuel model. The two fuel models are designated as "first" and "second". The coverage is entered for the "first" fuel model only. The coverage of the "second" fuel model is the remainder, with the total being 100%. The two fuel model options work with standard or custom fuel models, but not with the special case or fuel parameters options. The primary purpose of the two fuel option is weighted rate of spread. It is not appropriate to weight fire intensity values or their derivatives such as flame length or scorch height.

A special case palmetto-gallberry fuel model was developed by Hough and Albini (1978). It requires input of the age of palmetto-gallberry rough, palmetto coverage, understory height, and overstory basal area.

A special case western aspen fuel model was developed by Brown and Simmerman (1986). It requires selection of one of four aspen fuel types and aspen curing level (which is different from the curing level for the dynamic standard fuel models).

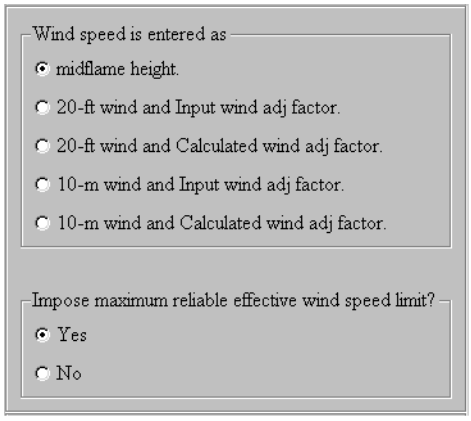
Dynamic curing load transfer is applicable to dynamic standard or custom fuel models. Seventeen of the 40 fuel models developed by Scott and Burgan (2005) are dynamic. Selecting the calculated from live herbaceous fuel moisture radio button uses the fuel load transfer model described in that paper. Selecting input directly radio button allows the user to specify the curing (fuel load transfer portion) directly.

Selecting the Moisture is entered by individual size class radio button requires you enter the moisture content for each fuel size class with fuel present in the fuel models used (1-h, 10-h, and 100-h dead fuels and herbaceous and woody live fuels).

The dead and live category option for moisture content is the simplest as you enter just two moisture contents; one is applied to all the dead fuels, and the second is applied to all the live fuels.

A moisture scenario is a predefined set of fuel moistures for 1-h, 10-h, and 100-h dead fuel and herbaceous and woody live fuel. It is analogous to the fuel model concept in that a single code represents an entire moisture situation. Fuel moisture scenarios may be developed, for example, to represent local 90-, 95-, and 97-percentile weather situations. More information on moisture scenarios is found in Chapter 13 of the User's Guide.

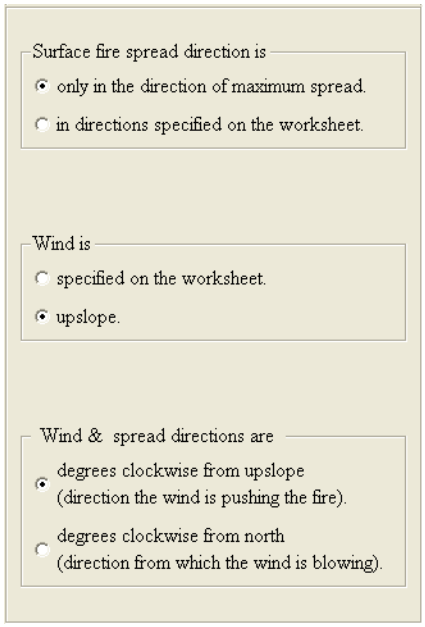
4.1.2. Wind Speed Tab



Wind speed can be entered at three different heights; midflame (eye-level), 20-ft. or 10-m. When using a 20-ft. or 10-m windspeed you also have the option of entering a wind adjustment factor or having BehavePlus calculate one based on tree characteristics of the site.

Low intensity fires may not continue to spread faster with increasing wind speeds. When the Impose maximum reliable effective wind speed limit? Yes radio button is selected the maximum wind speed used to calculate rate of spread is based on the reaction intensity. If the No radio button is selected, the limit is not imposed.

4.1.3. Directions Tab

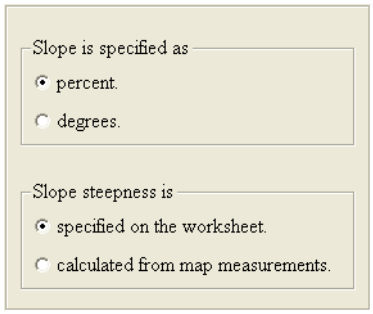


The simplest direction option is using upslope wind and upslope spread. To use this method select the Surface fire spread direction is only in the direction of maximum spread radio button and the Wind is upslope radio button.

Alternatively the non-head fire spread direction and/or direction of the wind can be specified. To more easily examine the relative effect of wind and slope on fire spread, select the Wind & slope directions are degrees clockwise from upslope radio button. Using this option, the wind direction is the direction the wind is pushing the fire.

When fire projection are being done for a specific location on a map and weather observations or forecasts are being used, select the Wind & slope directions are degrees clockwise from north radio button. With this option, the wind direction is the direction from which the wind is blowing.

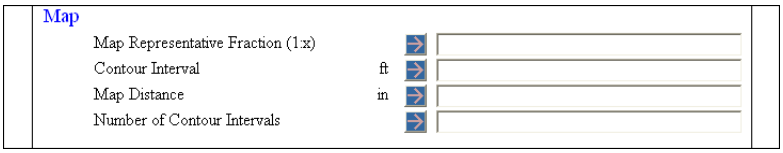
4.1.4. Slope Tab



Slope is specified as either percent or degrees by selecting the appropriate radio button.

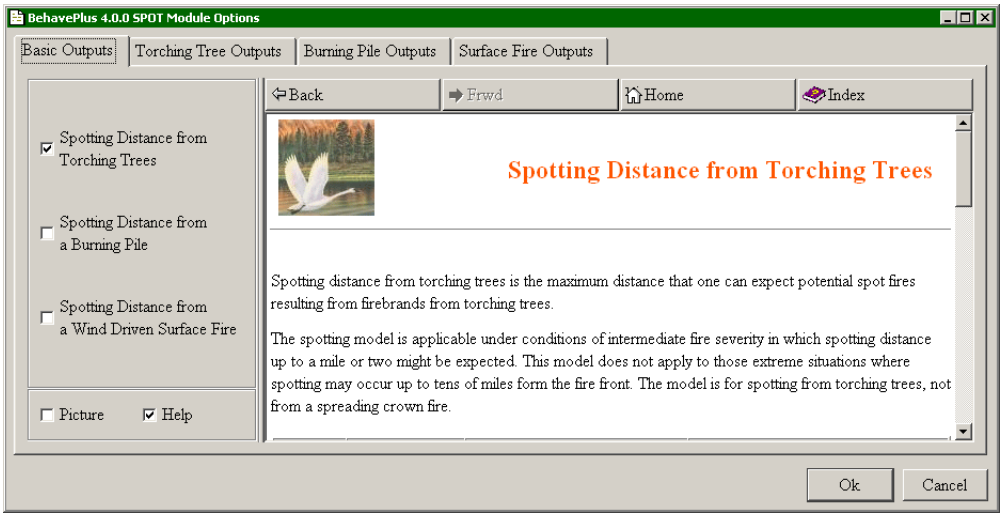
Selecting the Slope steepness is specified on the worksheet radio button allows the user to enter the slope values directly on the Worksheet.

Selecting the Slope steepness is calculated from map measurements radio button allows the slope to be calculated from map measurements and additional inputs are required on the Worksheet.



4.2. Output Variables

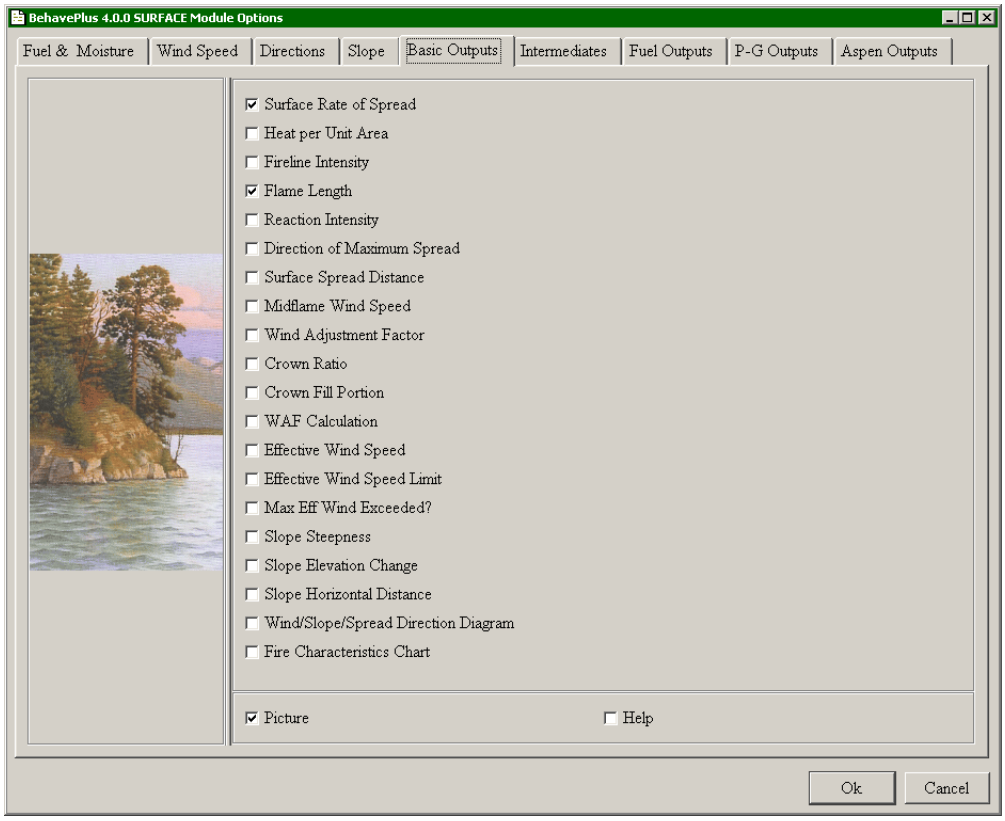
Every module has choices for which output variables are calculated. The desired output variables are selected through the Options... button associated with each module.The selected output determines the input requirements on the Worksheet. For example, input variables on the Worksheet when using the SPOT Module will be different for each spotting source.



Most of the modules have just one output tab named Output Variables. The SURFACE module has several output tabs.

- Basic Outputs
- Intermediate Outputs
- Fuel Outputs
- P-G Outputs
- Aspen Outputs

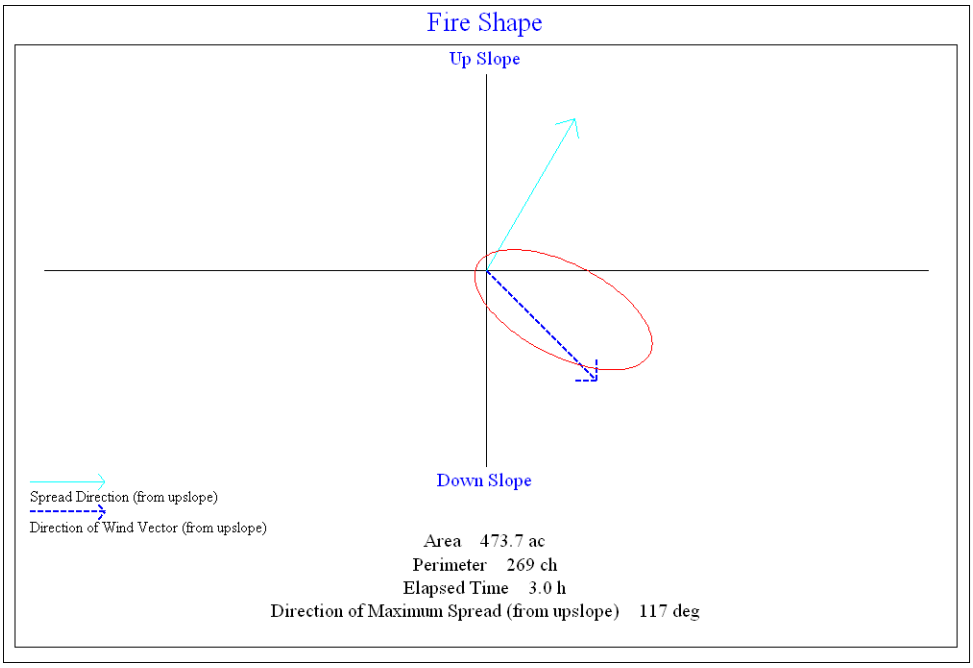
Outputs can be displayed as tables, graphs, or diagrams and charts. Variable outputs are those most typically displayed by the SURFACE module. The top section of output variables can be displayed in tables or graphs. Details on each output variable are found in the Variables paper.



In addition to the table and graph variables, charts and diagrams are also available for some modules.

For example, for the SIZE Module, a simple Fire Shape Diagram for the calculated values is available.

When you select this output a diagram of the relative directions of slope, wind, and fire spread is produced for each calculation result. These diagrams are useful for clarifying the selected input options and their resulting output values.



5. Entering input

There are several ways to enter input to the BehavePlus program. Values can be typed directly into the input field, choices can be made from a list of valid input values, a range of values can be specified, and for some variables, a selection can be made from a list of common choices.

5.1. Shaded text boxes

In some cases, input variables depend on values entered elsewhere on the Worksheet. When an input variable is not required, its text box is shaded. If a value is entered for a shaded text box, it is not used.

5.2. Direct entry

Values can be typed directly into the variable text boxes and the Enter or Tab keys moves the cursor to the next field. The cursor can also be moved to any text box with a mouse click. More than one value can be entered for an input variable. Multiple values are separated by a space or comma delimiter. You do not need to always specify equal steps. You can enter several independent values separated by delimiters.

For table output a separate row and/or column will be created for each value from the input variable text box. For graphs of continuous input variables the curve is drawn between the smallest and largest value entered. Graphs of discrete variables will display a separate bar for each input value. See chapter 6, Table output, for more on how multiple values affect outputs.

5.3. Input Guide

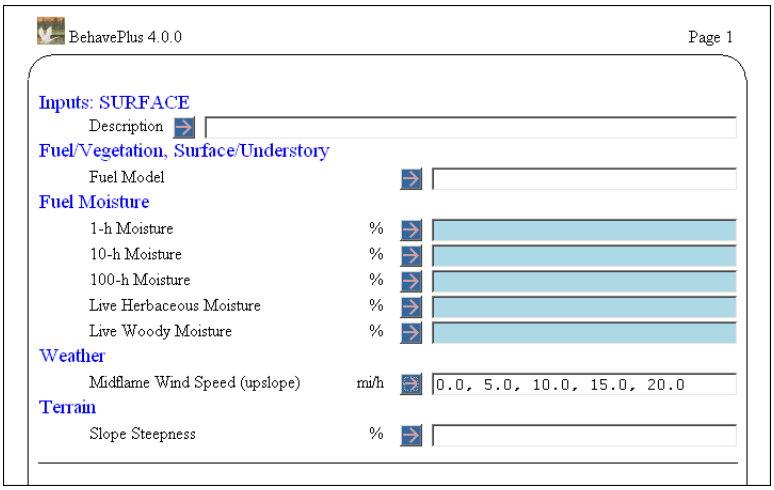
The "Input Guide" dialog box is opened by clicking the Guide button to the left of each input variable text box.

5.3.1. Continuous variables

Valid input ranges can be viewed in the "Input Guide" dialog box.

Single values are entered in just the From text box; a second value can be entered in the Thru text box.

For continuous variables the "Input Guide" dialog box allows definition of a range of values by a constant increment. For example, midflame wind speed from 0 to 20 mi/h in steps of 5 enters 0, 5, 10, 15, 20 on the Worksheet as shown below.

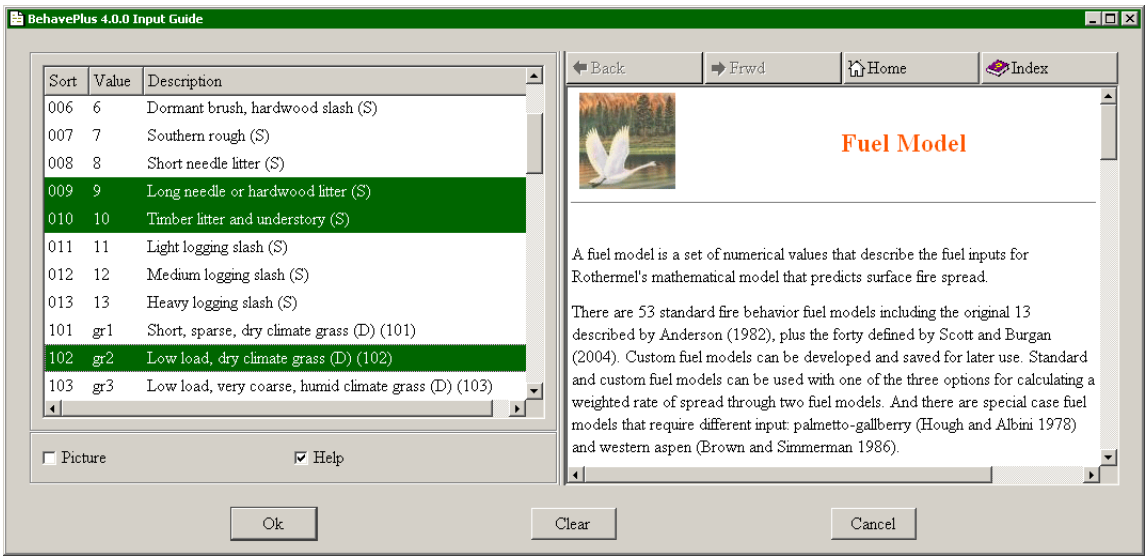


You can also enter a decreasing range with a negative step. This is useful when you have two input variables, such as wind and fuel moisture, that have opposite effect on fire behavior

5.3.2. Discrete variables

When the Guide button is clicked for a discrete variable, the allowed selections are given in the center pane of the "Input Guide" dialog box.

Clicking the values selects them; you can select several values. This example shows the fuel model "Input Guide" dialog box. The Ok button enters the selected fuel models on the Worksheet.

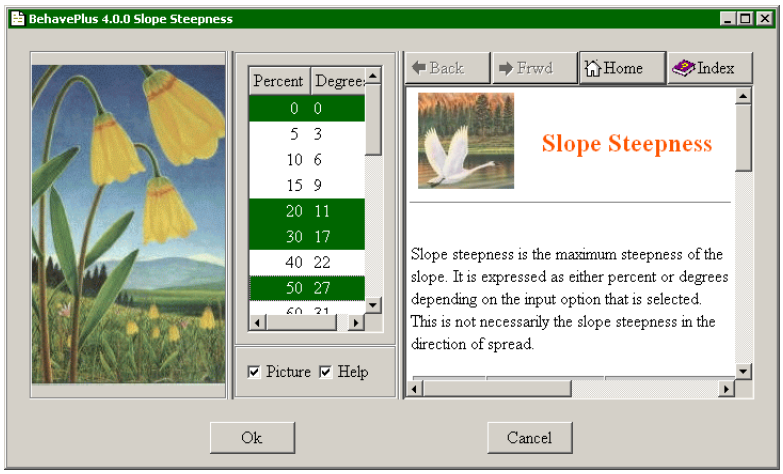


5.3.3. Choices button

Although any value in the valid range can be entered for a continuous variable, in some cases common values can be entered with the Choices button.

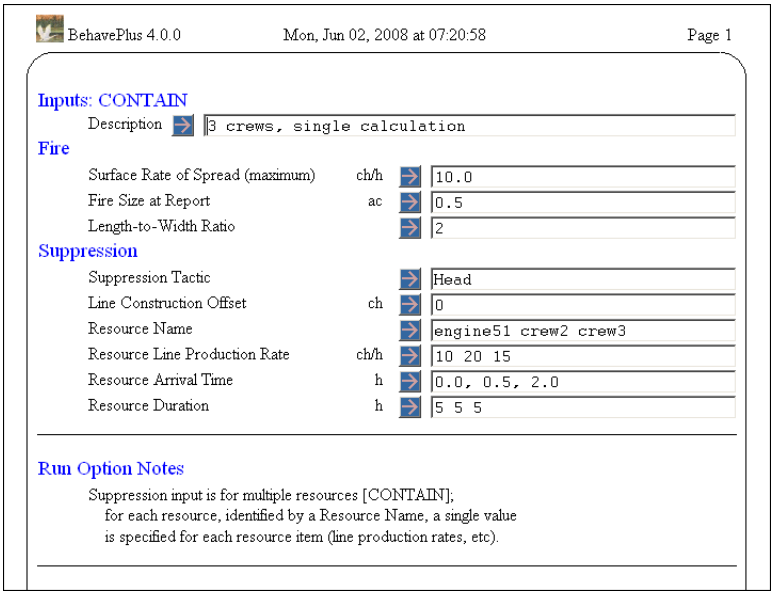
When available on the "Input Guide" dialog box, clicking the Choices button displays commonly used values.

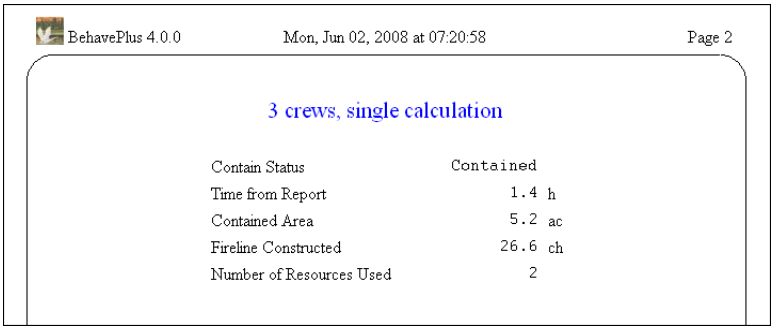
After selecting values in the "Slope Steepness" dialog box, clicking Ok enters them on the Worksheet.



5.4. Linked input variables

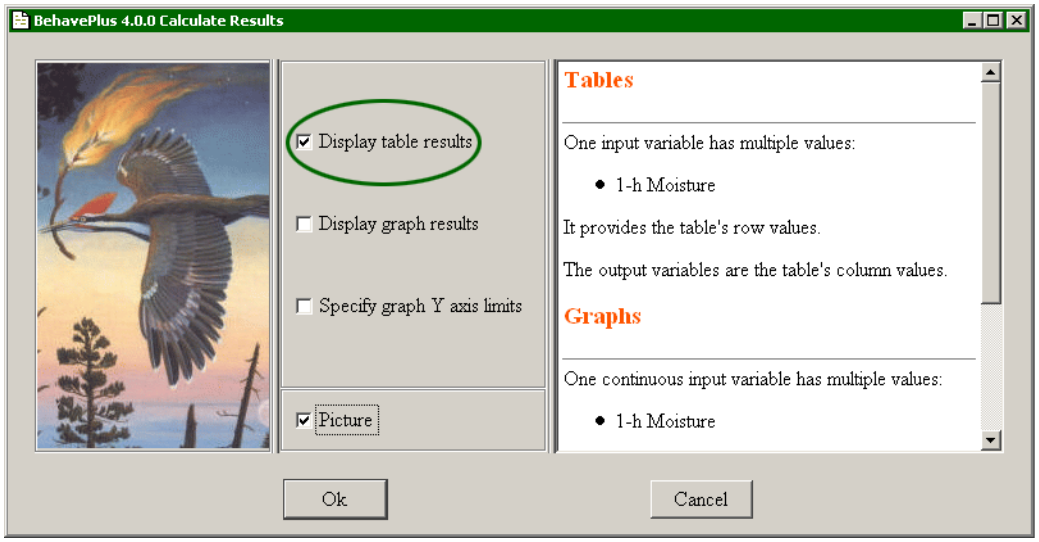
When using the CONTAIN module, with the multiple resources input option selected, some input variables are directly associated with each other. This is an exception to the general BehavePlus rule. For example, a line production rate, arrival time, and duration are assigned to each resource. Linked input variables also allow you to enter multiple values for more than two input variables. In the following example, although multiple values are assigned to several input variables, those variables are linked together, so only a single calculation is done.





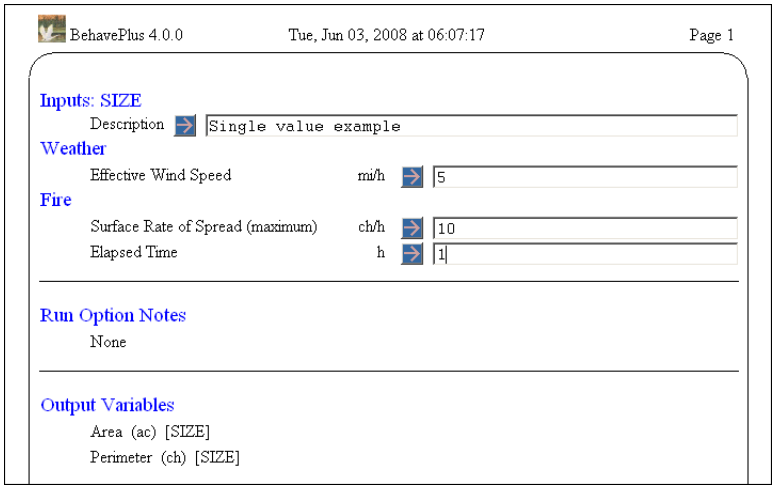
6. Table output

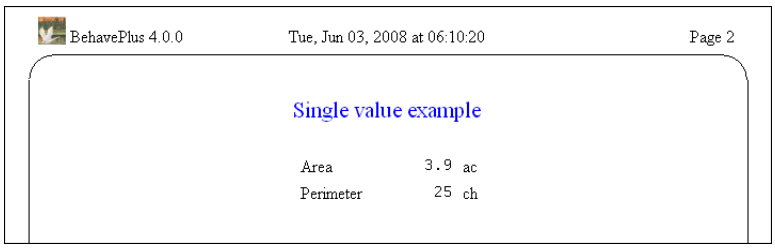
When more than one value is assigned to one or two input variables, table output is produced. Tables are produced by selecting the Display table results check box in the "Calculate Results" dialog box that displays after selecting a File > Calculate command.



6.1. Single value calculation

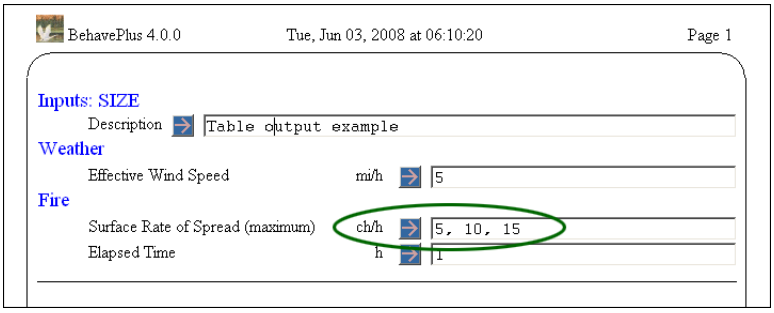
When each variable is assigned only one value, a simple list of output is given. No table or graph is possible. For example:

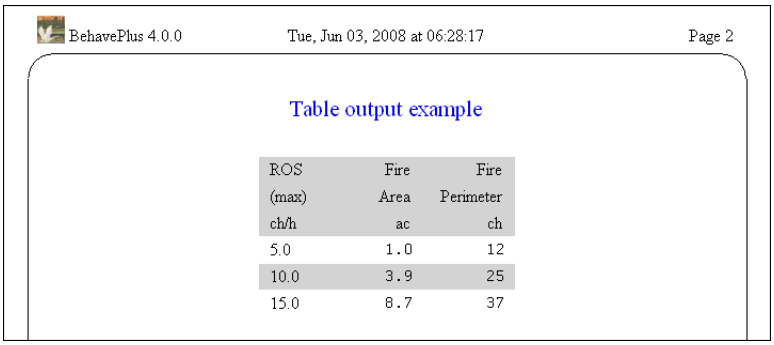




6.2. Table output

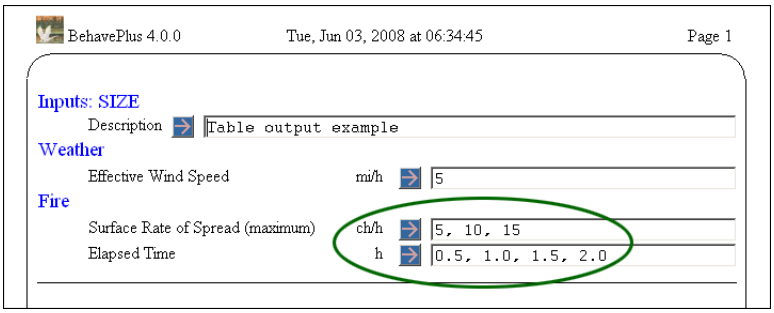
When more than one value is assigned to a variable, table output is produced. Each output variable is a specified column. For example, these multiple Rate of Spread inputs produce the page 2 table below:

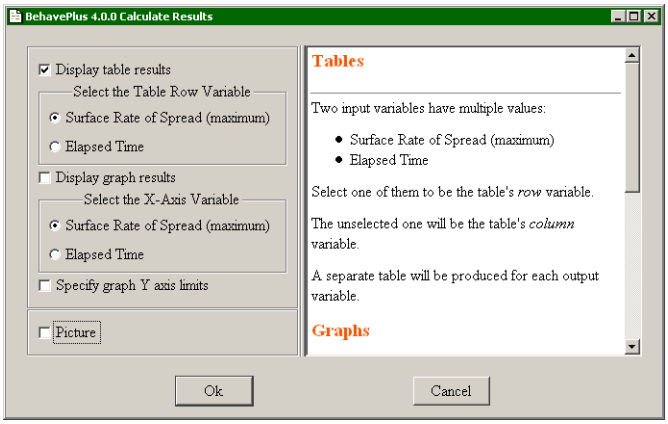




6.3. Two way tables

When more than one value is assigned to two variables, a two way table is produced. A table is produced for each selected output variable. Either variable can be specified as the row variable in the "Calculate Results" dialog box.





For example, with the above inputs this dialog box appears when you Calculate the Run.

After selecting the Rate of Spread (maximum) option button and clicking the Ok button, the following tables are produced:

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Table output example

Area (ac)

ROS (max)	Elapsed Time h			
ch/h	0.5	1.0	1.5	2.0
5.0	0.2	1.0	2.2	3.9
10.0	1.0	3.9	8.7	15.5
15.0	2.2	8.7	19.7	35.0

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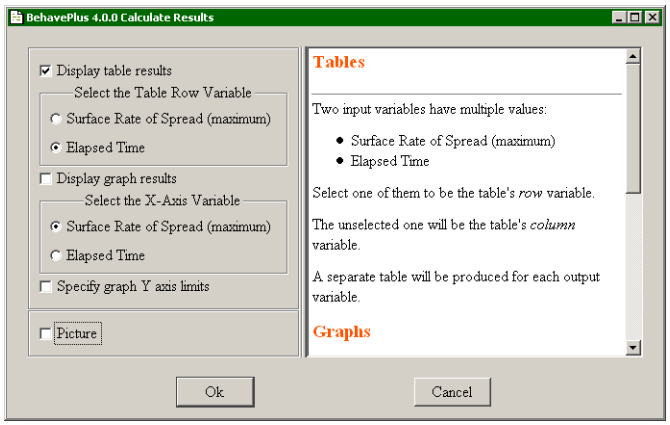
Table output example

Perimeter (ch)

ROS (max)	Elapsed Time h			
ch/h	0.5	1.0	1.5	2.0
5.0	6	12	19	25
10.0	12	25	37	50
15.0	19	37	56	74



Changing the Table Row Variable to the Elapsed Time radio button swaps the table columns and rows produces the following Area table:

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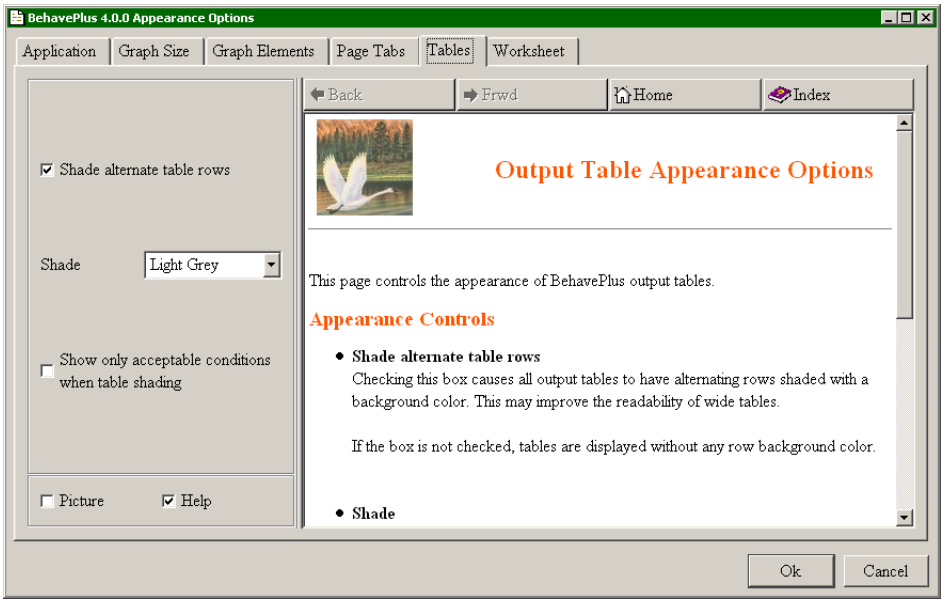
Table output example

Area (ac)

Elapsed Time h	Surface Rate of Spread (maximum) ch/h		
	5.0	10.0	15.0
0.5	0.2	1.0	2.2
1.0	1.0	3.9	8.7
1.5	2.2	8.7	19.7
2.0	3.9	15.5	35.0

6.4. Table appearance

Table row shading can be enabled with the Configure > Appearance > Tables tab.



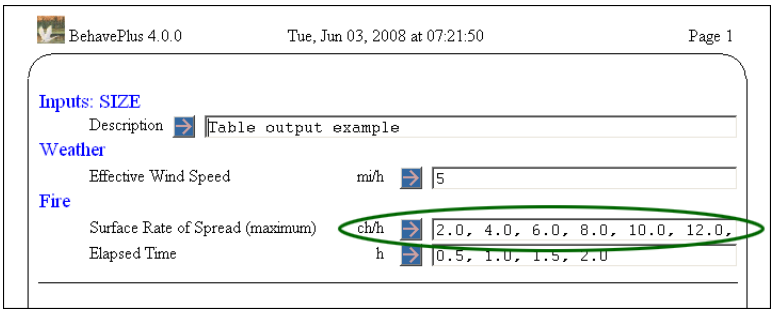
Selecting the Shade alternate table rows check box causes all output tables to have alternating rows shaded with a background color. This may improve the readability of wide tables. If the check box is cleared, tables are displayed without any row background color. This table appearance option is used to improve table readability, don't confuse it with the Table shading for acceptable fire conditions output option. See chapter 7, Table shading, for more information.

The table row background color is selected from the Shade drop-down list.

Selecting the Show only acceptable conditions when table shading check box replaces crossed off output values with blank cells in the output tables produced with the Table shading for acceptable fire conditions option as described in chapter 7.

6.5. Multiple pages

There is essentially no limit on the number of values that can be assigned to an input variable. But the resulting table might not fit on a single page. For example, if rate of spread is calculated for values from 2 to 30 in steps of 2, and elapsed time is specified as the row variable, the table overlaps onto 3 pages.



The > or < symbols lined to the right and/or left of the table heading indicates that there are additional results for those variables in the indicated direction.

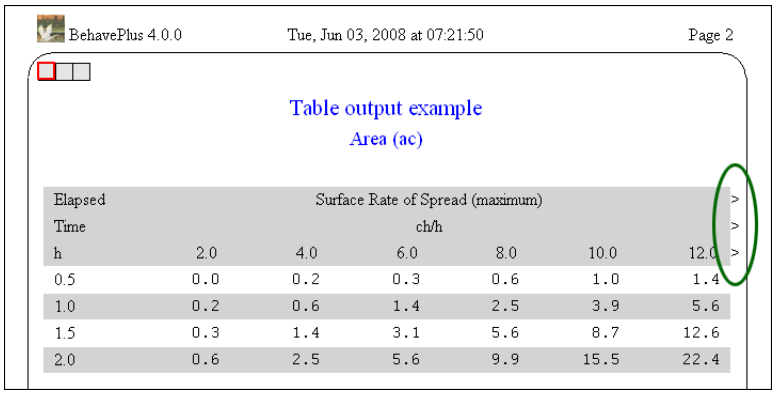


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Table output example

Area (ac)

Elapsed Time	Surface Rate of Spread (maximum) ch/h					
h	2.0	4.0	6.0	8.0	10.0	12.0 >
0.5	0.0	0.2	0.3	0.6	1.0	1.4
1.0	0.2	0.6	1.4	2.5	3.9	5.6
1.5	0.3	1.4	3.1	5.6	8.7	12.6
2.0	0.6	2.5	5.6	9.9	15.5	22.4

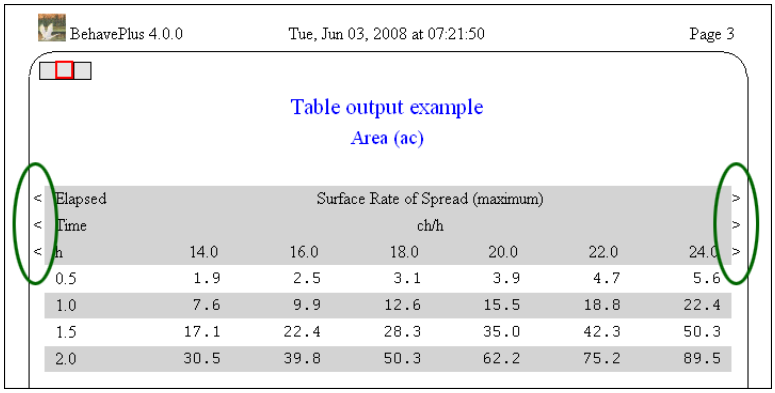

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Table output example

Area (ac)

< Elapsed Time	Surface Rate of Spread (maximum) ch/h					
< h	14.0	16.0	18.0	20.0	22.0	24.0 >
0.5	1.9	2.5	3.1	3.9	4.7	5.6
1.0	7.6	9.9	12.6	15.5	18.8	22.4
1.5	17.1	22.4	28.3	35.0	42.3	50.3
2.0	30.5	39.8	50.3	62.2	75.2	89.5

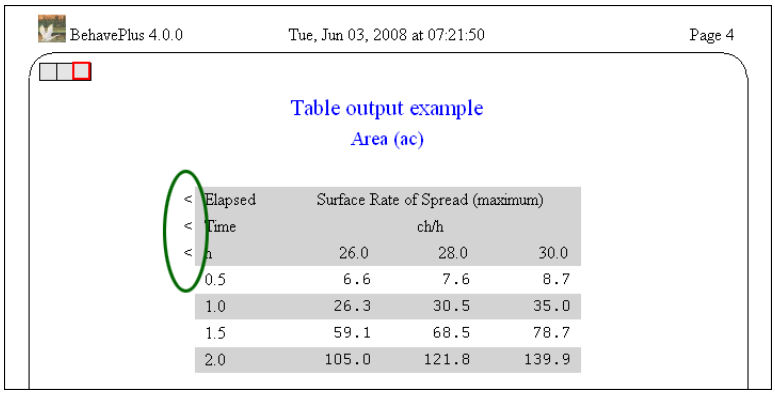

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Table output example

Area (ac)

< Elapsed Time	Surface Rate of Spread (maximum) ch/h		
< h	26.0	28.0	30.0
0.5	6.6	7.6	8.7
1.0	26.3	30.5	35.0
1.5	59.1	68.5	78.7
2.0	105.0	121.8	139.9

The box diagram at the upper left of the pages shows the relative position of the currently viewed page in the multi-page table.

In this example, however, it would make more sense to specify rate of spread as the row variable since it produces a table that fits on a single page as shown below:

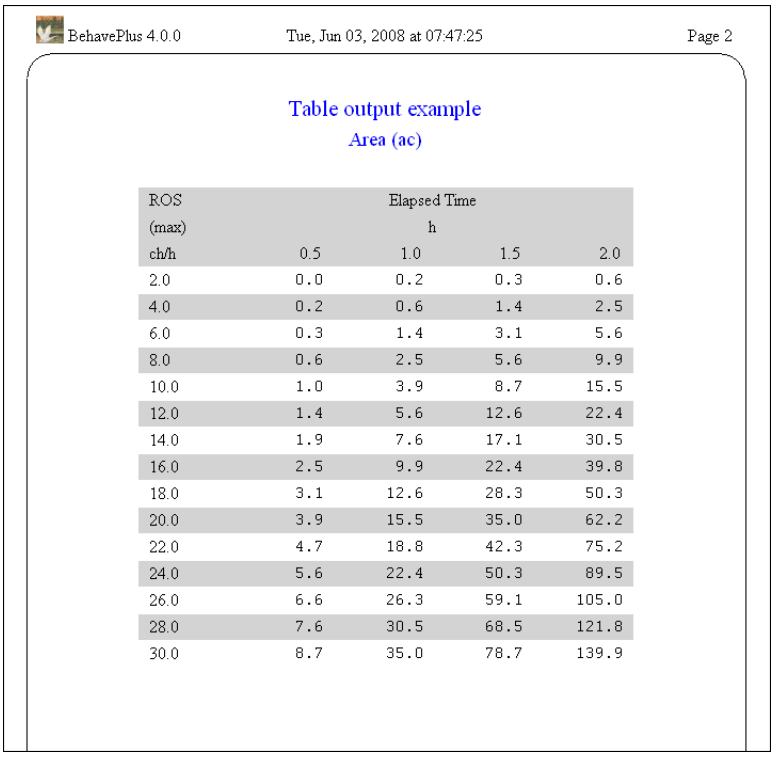

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Table output example

Area (ac)

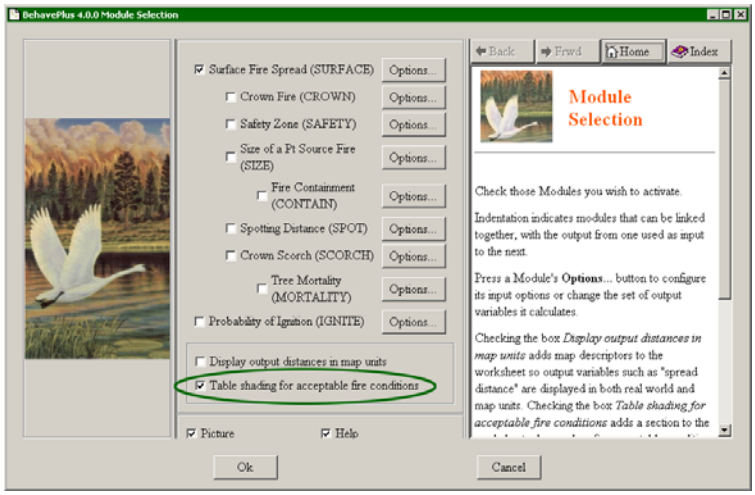
ROS (max)	Elapsed Time h			
ch/h	0.5	1.0	1.5	2.0
2.0	0.0	0.2	0.3	0.6
4.0	0.2	0.6	1.4	2.5
6.0	0.3	1.4	3.1	5.6
8.0	0.6	2.5	5.6	9.9
10.0	1.0	3.9	8.7	15.5
12.0	1.4	5.6	12.6	22.4
14.0	1.9	7.6	17.1	30.5
16.0	2.5	9.9	22.4	39.8
18.0	3.1	12.6	28.3	50.3
20.0	3.9	15.5	35.0	62.2
22.0	4.7	18.8	42.3	75.2
24.0	5.6	22.4	50.3	89.5
26.0	6.6	26.3	59.1	105.0
28.0	7.6	30.5	68.5	121.8
30.0	8.7	35.0	78.7	139.9

7. Table Shading

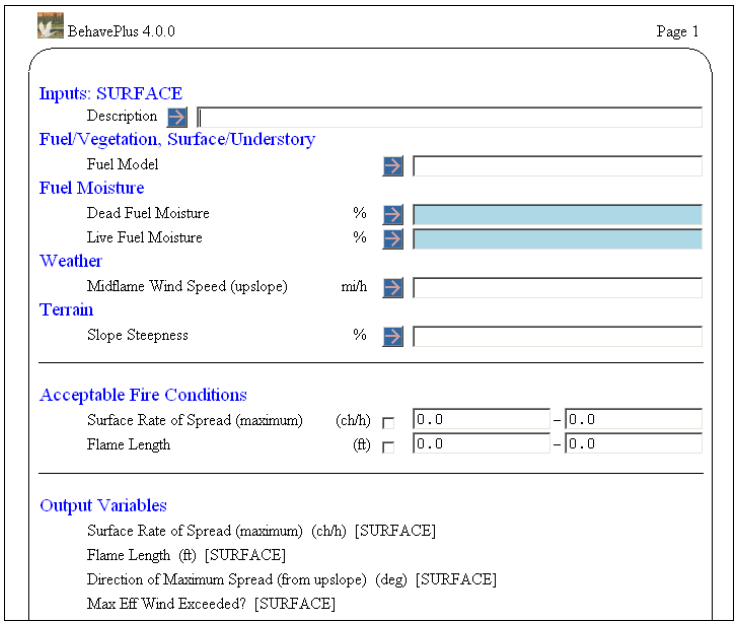
Table shading for acceptable fire conditions is designed to display the conditions that contribute to acceptable fire behavior, such as in developing a prescribed fire prescription. It replaces the RXWINDOW program of the old BEHAVE system (Andrews and Bradshaw 1990). RXWINDOW reversed the calculations to determine conditions that corresponded to specified fire conditions. As additional fire models have become available, this approach is unfeasible. The approach taken in BehavePlus is different from that in RXWINDOW.

7.1. Activating the Table Shading Option

To implement the table shading option select the Table shading for acceptable fire conditions check box in the "Module Selection" dialog box.



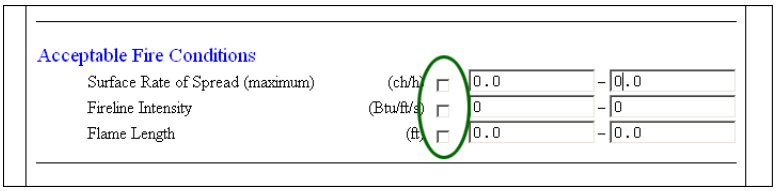
Once the Table shading for acceptable fire conditions check box is selected a new section, Acceptable Fire Conditions, appears on the Worksheet.



Notice that some of the output variables are listed in the Acceptable Fire Conditions section. Not all the output variables are available to be constrained. The output variables that can be used to identify acceptable fire conditions are listed in the Variables paper.

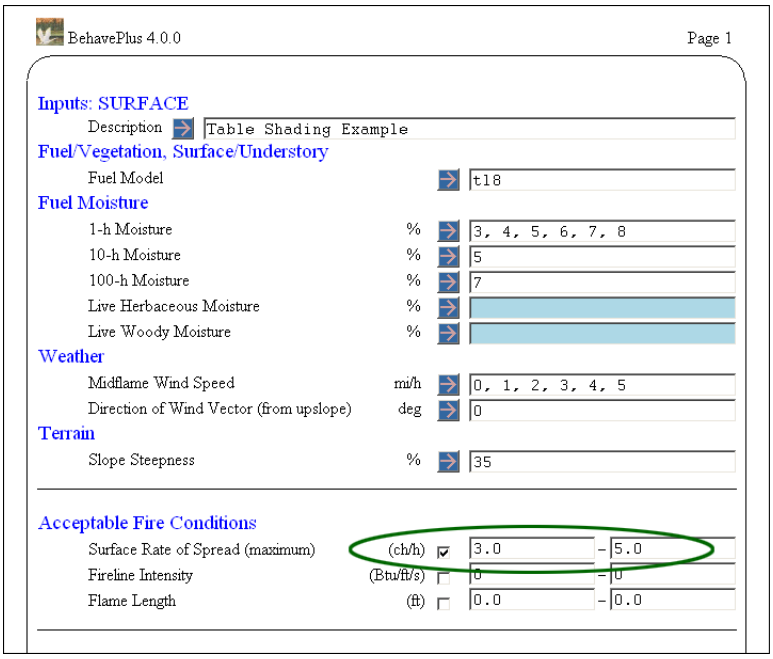
7.2. Entering Acceptable Fire Conditions

In the Acceptable Fire Conditions section each output variable listed has a check box and two text boxes for entering the range of acceptable fire conditions. By default the check boxes are cleared. The ranges specified in the text boxes are only considered if the output variable check box is selected.



This allows you to view all the output variables you want while only using a subset to define your acceptable fire conditions. Of course if an output variable is of no interest then clear it from the Outputs tab for the appropriate module and it appears in neither the Acceptable Fire Conditions or Output Variables section.

After selecting the output variables to define acceptable fire conditions enter the acceptable ranges in the corresponding text boxes.



When you clear a check box in the Acceptable Fire Conditions section there is no need to zero out the range text boxes. Ranges are ignored if the check box is cleared.

7.3. Viewing Results

After calculating the Run the table output will look like this. Rate of Spread values less than 3.0 ch/h or greater than 5.0 ch/h are crossed off.

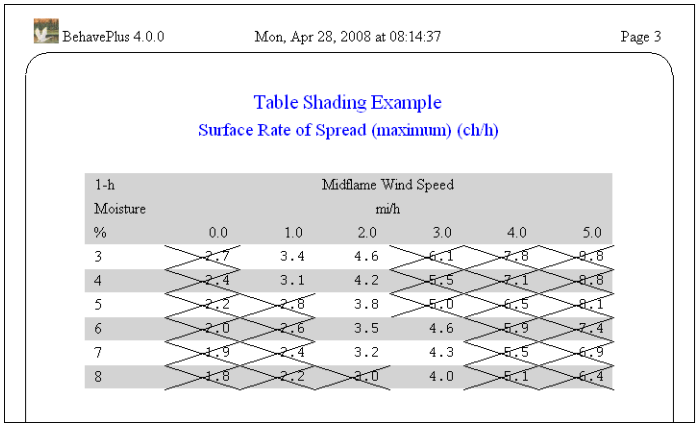


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Table Shading Example

Surface Rate of Spread (maximum) (ch/h)

1-h Moisture %	Midflame Wind Speed mi/h 0.0	1.0	2.0	3.0	4.0	5.0
3	2.7	3.4	4.6	6.1	7.8	8.8
4	2.4	3.1	4.2	5.5	7.1	8.8
5	2.2	2.8	3.8	5.0	6.5	8.1
6	2.0	2.6	3.5	4.6	5.9	7.4
7	1.9	2.4	3.2	4.3	5.5	6.9
8	1.8	2.2	3.0	4.0	5.1	6.4

The corresponding cells are also crossed off on the fireline intensity table,

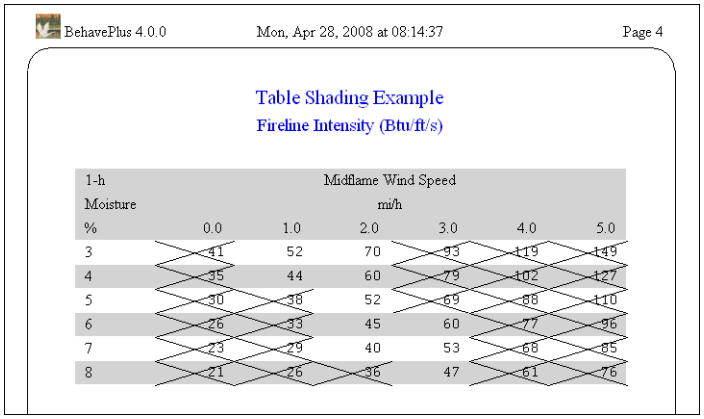

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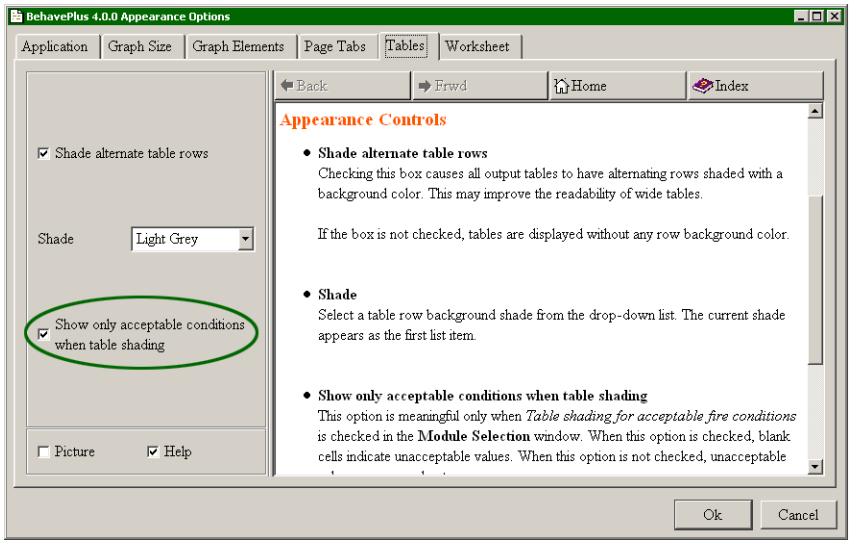
Table Shading Example

Fireline Intensity (Btu/ft/s)

1-h Moisture %	Midflame Wind Speed mi/h 0.0	1.0	2.0	3.0	4.0	5.0
3	41	52	70	93	119	149
4	35	44	60	79	102	127
5	30	38	52	69	88	110
6	26	33	45	60	77	96
7	23	29	40	53	68	85
8	21	26	36	47	61	76

Once you have developed a prescription window that you want, you can produce a table with blanks in place of the crossed-off values. Select the Configure > Appearance preferences > Tables tab and select the Show only acceptable conditions when table shading check box.



The table now looks like this.

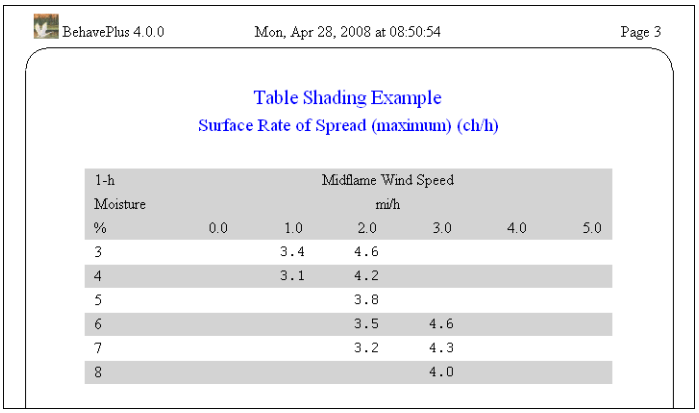


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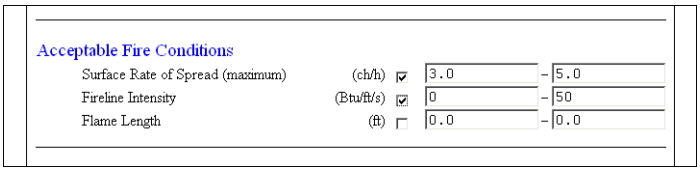
Table Shading Example

Surface Rate of Spread (maximum) (ch/h)

1-h Moisture %	Midflame Wind Speed mi/h 0.0	1.0	2.0	3.0	4.0	5.0
3		3.4	4.6			
4		3.1	4.2			
5			3.8			
6			3.5	4.6		
7			3.2	4.3		
8				4.0		

If Fireline Intensity is also selected to define acceptable fire conditions all output tables will change.



Acceptable Fire Conditions

Surface Rate of Spread (maximum)	(ch/h)	3.0	5.0
Fireline Intensity	(Btu/ft/s)	0	50
Flame Length	(ft)	0.0	0.0

For the above ranges using the same fuel, weather, and topography inputs the table outputs looks like this;

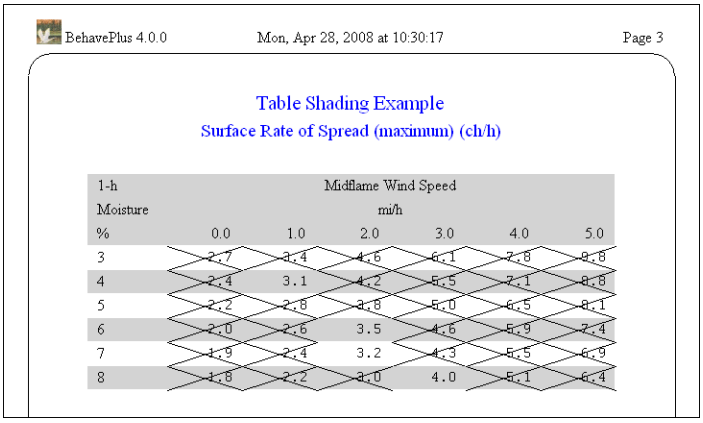


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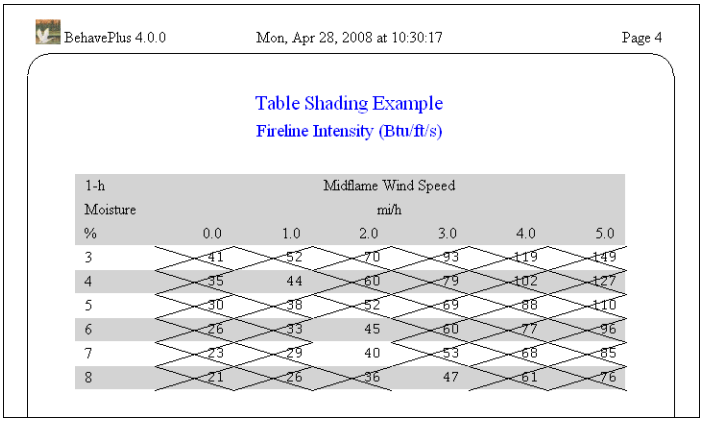
Table Shading Example

Surface Rate of Spread (maximum) (ch/h)

1-h Moisture %	Midflame Wind Speed mi/h 0.0	1.0	2.0	3.0	4.0	5.0
3	2.7	3.4	4.6	6.1	7.8	9.8
4	2.4	3.1	4.2	5.5	7.1	8.8
5	2.2	2.8	3.8	5.0	6.5	8.1
6	2.0	2.6	3.5	4.6	5.9	7.4
7	1.9	2.4	3.2	4.3	5.5	6.9
8	1.8	2.2	3.0	4.0	5.1	6.4



BehavePlus 4.0.0 Mon, Apr 28, 2008 at 10:30:17 Page 4

Table Shading Example

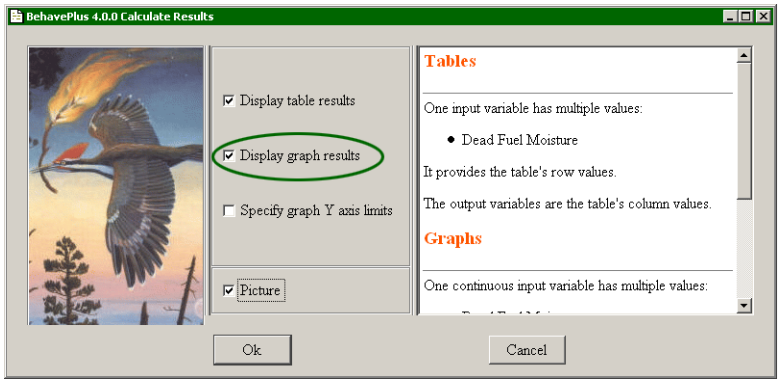
Fireline Intensity (Btu/ft/s)

1-h Moisture %	Midflame Wind Speed mi/h 0.0	1.0	2.0	3.0	4.0	5.0
3	41	52	70	93	119	149
4	35	44	60	79	102	127
5	30	38	52	69	88	110
6	26	33	45	60	77	96
7	23	29	40	53	68	85
8	21	26	36	47	61	76

Now acceptable output must meet both ranges of acceptable conditions which further constrains the fuel moisture and wind conditions that give desired results. Selecting two or more variables in the Acceptable Fire Conditions section give results that should be interpreted carefully.

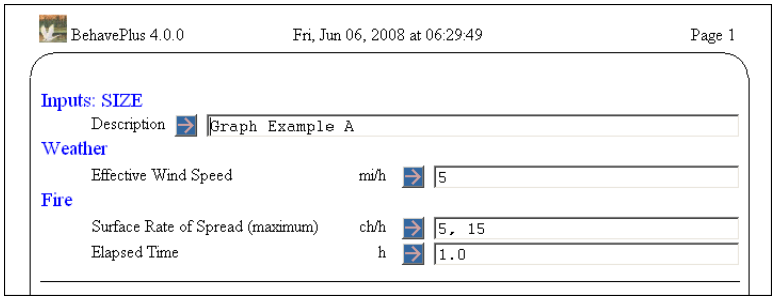
8. Graph output

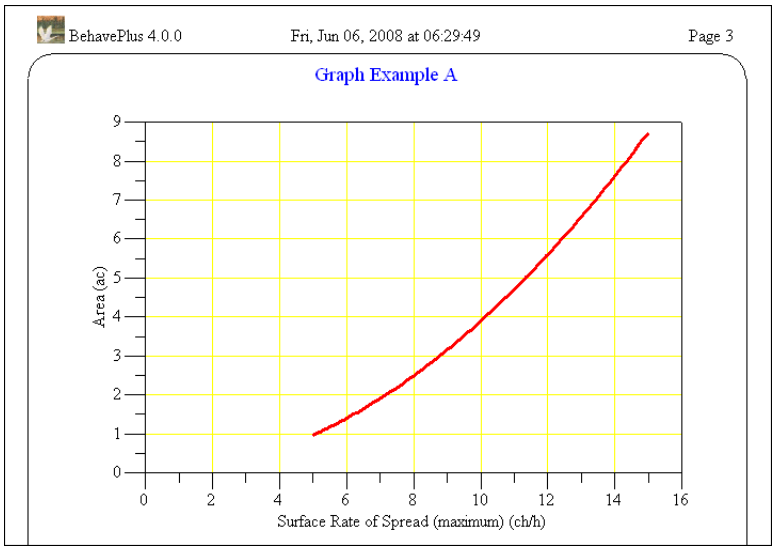
When more than one value is entered for one or two input variables, graphs can be produced. Graphs are viewed by selecting the Display Graph Results check box in the "Calculate Results" dialog box that displays after Calculate is requested. The form of the graph depends on whether the variables are continuous or discrete. The program automatically takes care of the differences for the user.



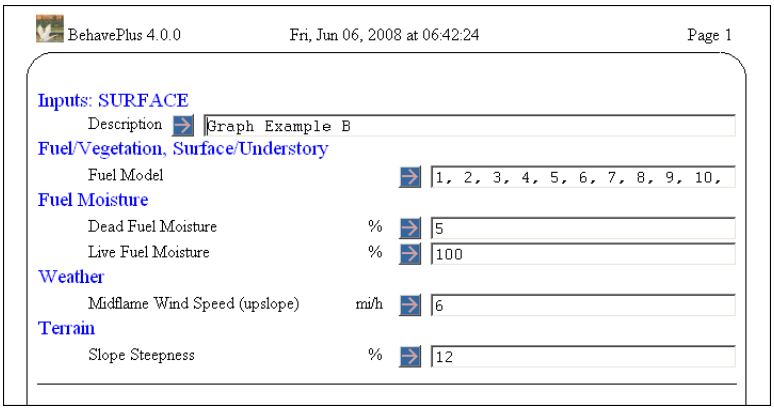
8.1. Single variable graph

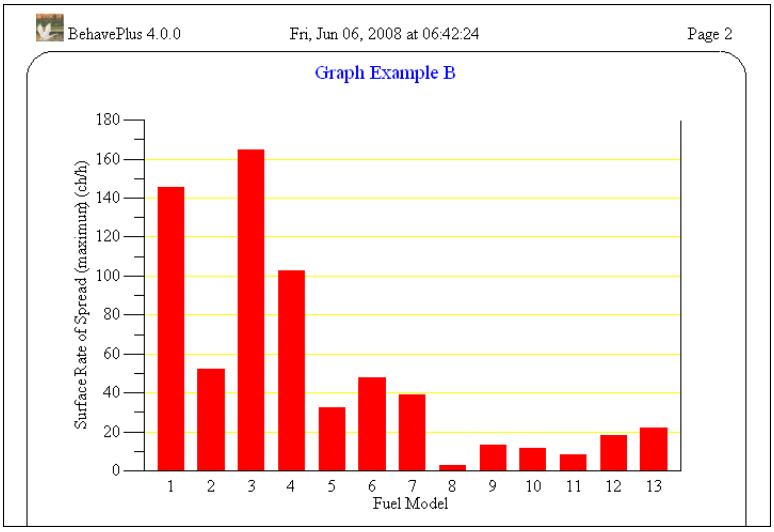
When a range of values is entered for a single continuous variable, a graph is produced by calculating a fixed number of points (which can be changed in the Configure > Appearance > Graph Elements tab) over the entered range. Intermediate values entered on the Worksheet are ignored. For example, rate of spread entry of 5, 7, 9, 11, 13, 15 produces the same graph as rate of spread entry of 5, 15:





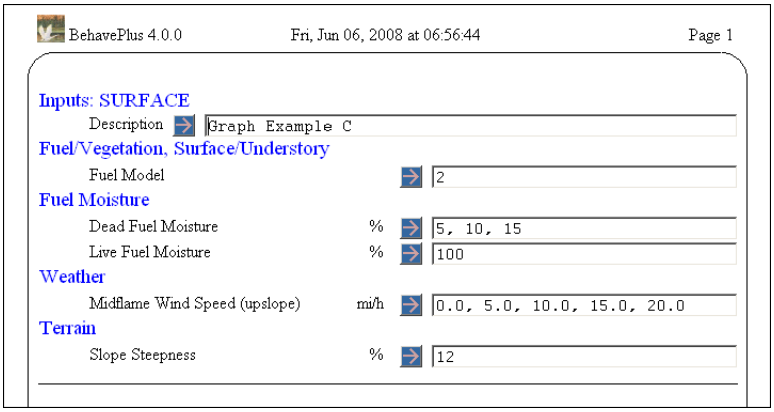
When a range of values is assigned to a discrete variable, a bar graph is produced. For example, the following is a comparison of surface fire spread rates for the standard 13 fire behavior fuel models:



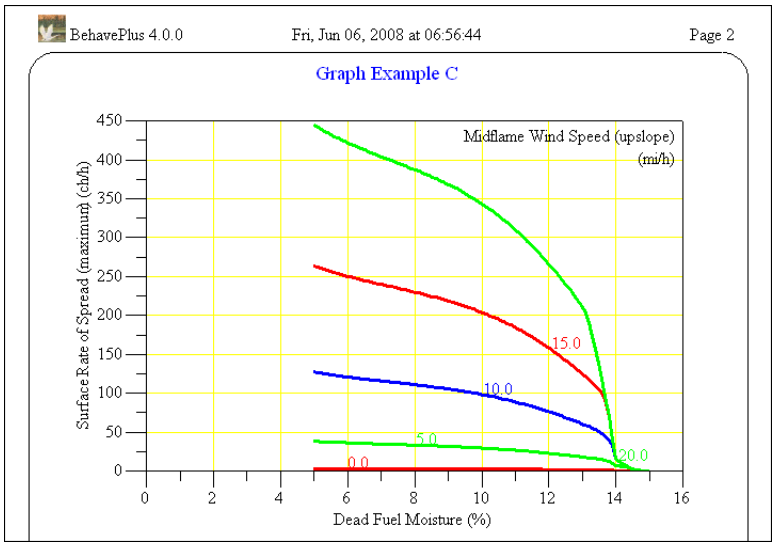


8.2. Two variable graph

When a range of values is assigned to two variables, a graph is produced. If both variables are continuous, the variable used for the X-axis can be selected from the "Calculate Results" dialog box. For example:

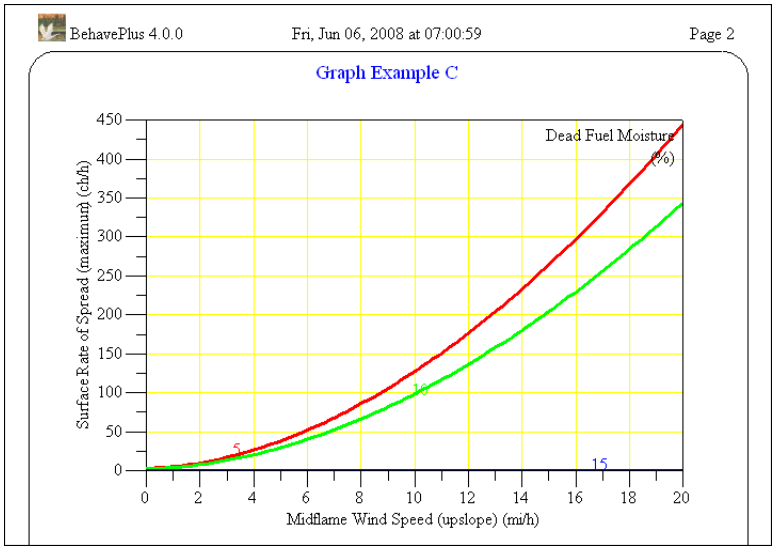


In the "Calculate Results" dialog box clear the Display table results check box and accept the defaults in the Display graph results section:

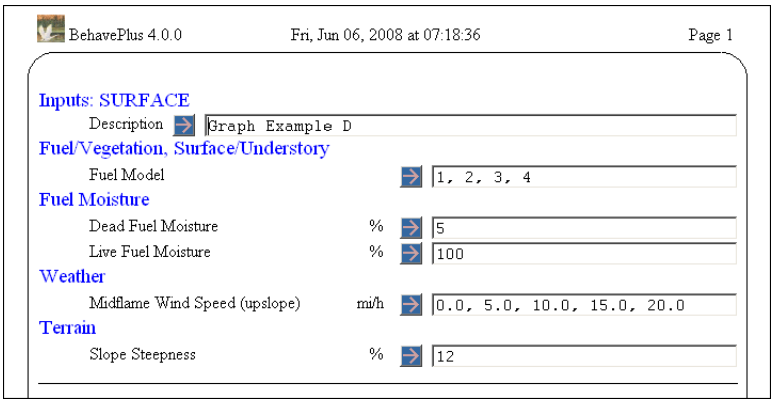


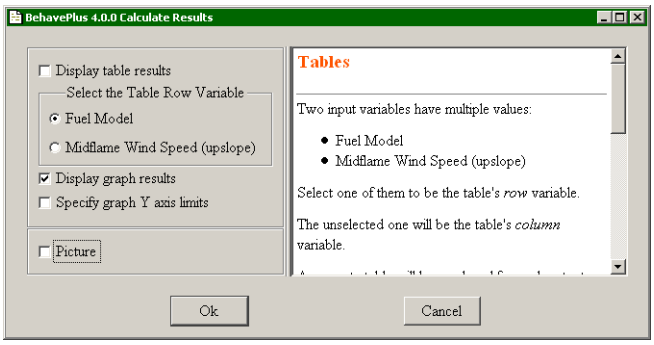
With Dead Fuel Moisture(%) as the X-Axis Variable a seperate line is produced for each of the other multiple input worksheet values (Midflame Wind Speed (upslope) in this example).

Changing the X-Axis Variable to the Midflame Wind Speed (upslope) in the "Calculate Results" dialog box produces a very different graph:

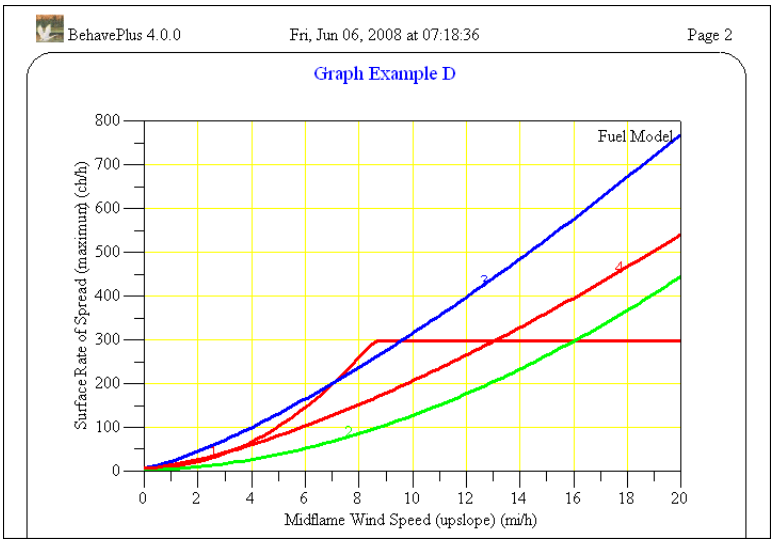


If a range is assigned to two variables, one continuous and one discrete, the continuous variable is always on the X-axis. For example:





With two variables, one continuous and one discrete, you no longer have the option of changing the X-Axis Variable in the "Calculate Results" dialog box.



A graph is not possible when ranges are selected for two discrete variables.

8.3. Axis scales

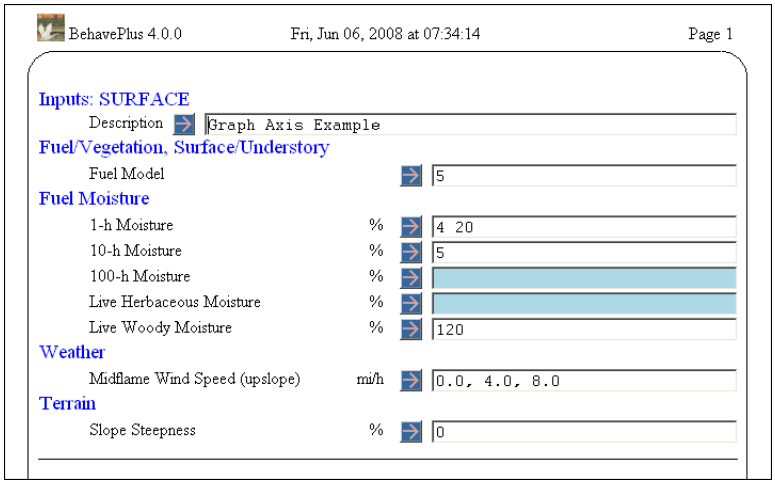
Setting axis scales is important for getting the best information from your Runs, and especially for comparing graph output from different Runs.

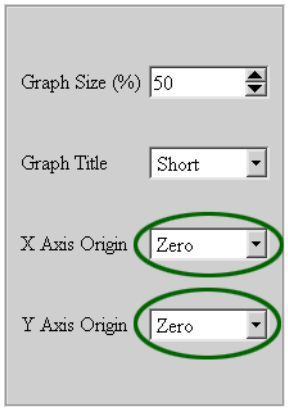
8.3.1. X-axis

The X-axis variable and scale are the same for all graphs produced by a Run. The maximum for the x-axis is set to be the maximum value specified for the variable on the Worksheet.

X Axis Origin and Y Axis Origin (minimum values) can be set for each as either zero or as the variable's minimum value as specified on the input Worksheet. The graph origin is set to (0,0) as the default.

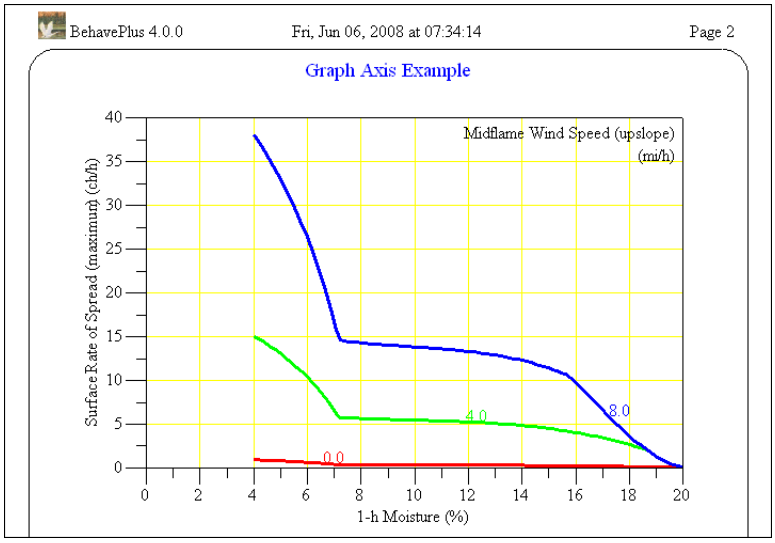
For example, consider the following Run:

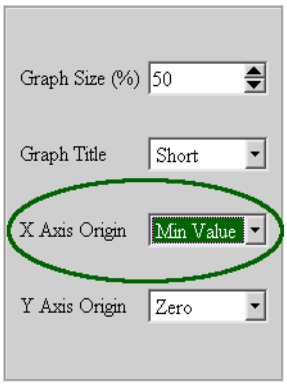




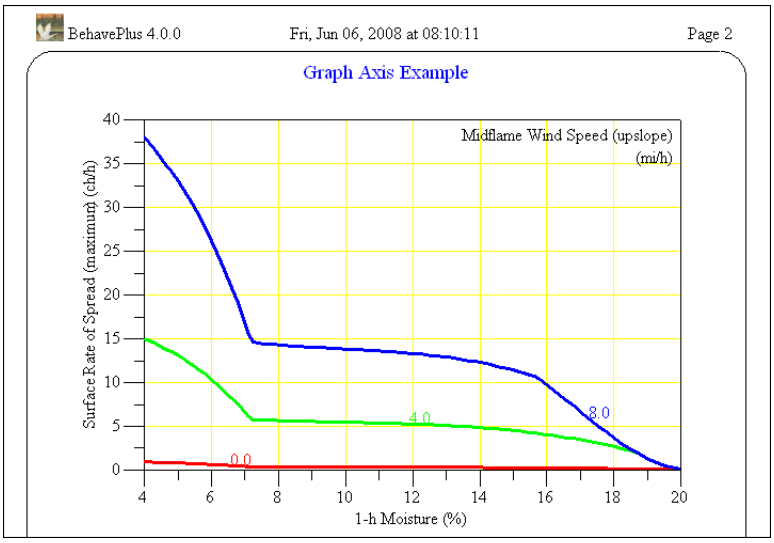
Options to define the origin of the graph are set through the Configure > Appearance > Graph Size tab.

Setting both the X Axis Origin and Y Axis Origin to zero produces the following graph:





In the Configure > Appearance > Graph Size tab select Min Value from the X-Axis Origin drop-down list to alter the graph appearance.

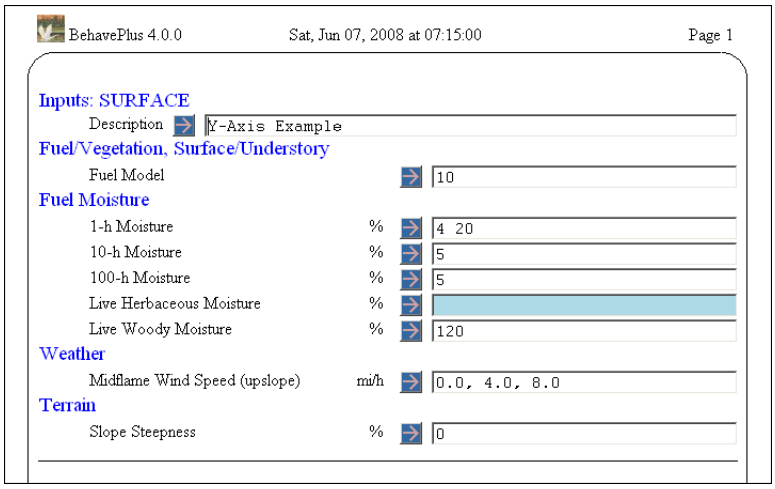


8.3.2. Y-axis

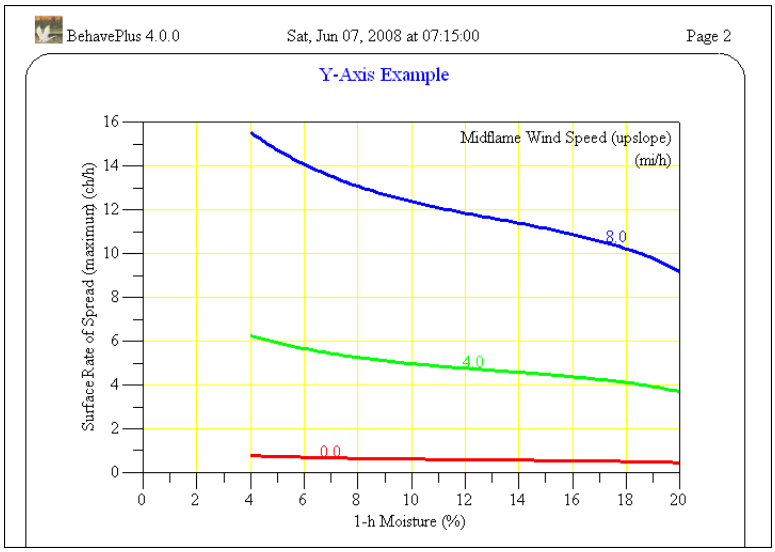
The Y-axis scale normally differs between graphs produced by a Run since each graph is for a different output variable. For example, fireline intensity and flame length have different ranges of output and require a different Y-axis scale. By default the Y-axis is scaled to the maximum calculated output value for the variable to make best use of the graph area.

When you want to compare graphs between Runs, different Y-axis scales can obfuscate the comparison. A rate of spread graph for fuel model 10, for example, usually has a narrower output range than for fuel model 5 under the same conditions. To better compare calculated rate of spread graphs for the two fuel models, you can set both graphs to have the same Y-axis scale.

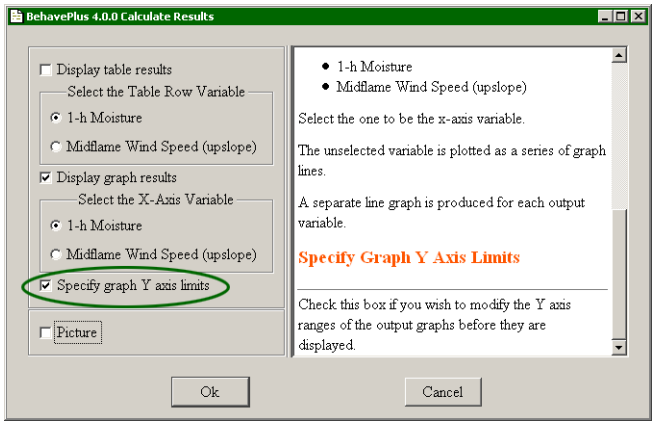
The following Run is for fuel model 10, which has relatively low rates of spread.



With the X Axis Origin and Y Axis Origin set to zero, the rate of spread graph below is produced:

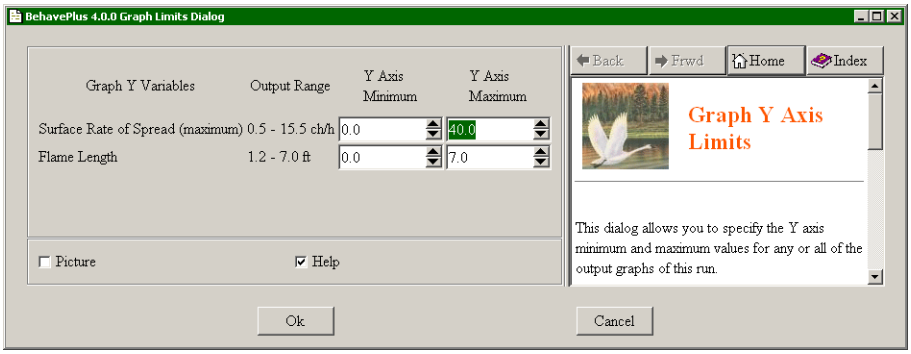


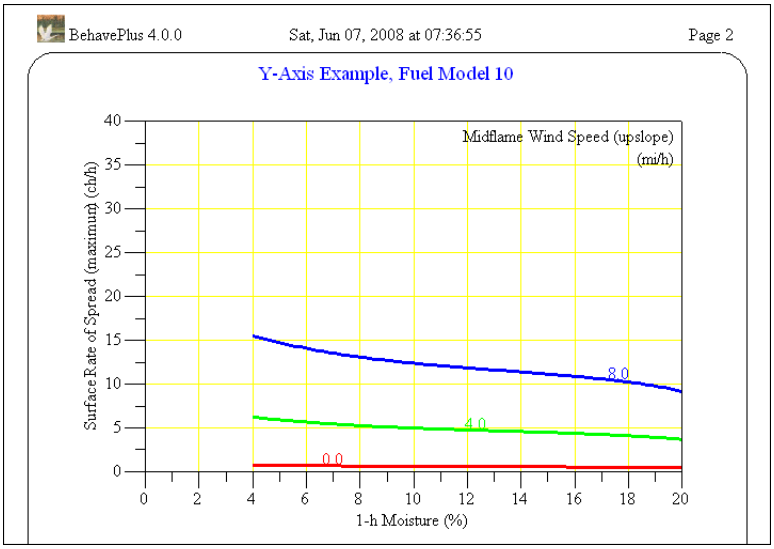
To compare the results for fuel model 10 with the faster spreading fuel model 5, the scale for the fuel model 10 Run is changed to match that produced by model 5. The calculated maximums are given for each of the selected output variables as a reference.



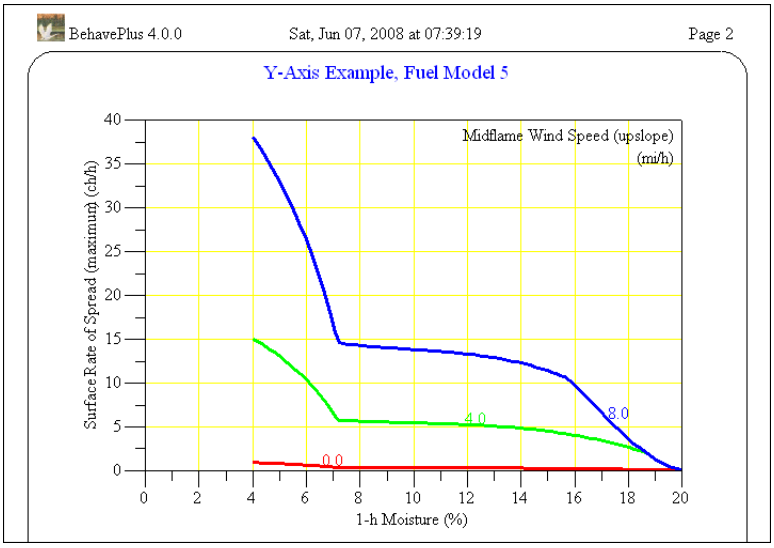
In the "Calculate Results" dialog box select the Specify graph Y axis limits check box if you wish to modify the Y-axis ranges of the output graphs before they are displayed.

This displays the "Graph Limits" dialog box, where you can change the Y-axis maximum for the variable Rate of Spread (maximum) to 40:

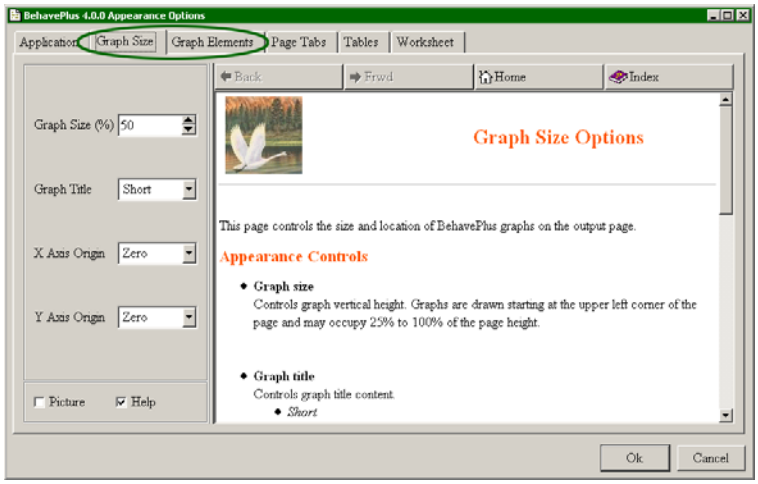




The comparison with the corresponding graph for fuel model 5 is now more straightforward now that the axes are the same.

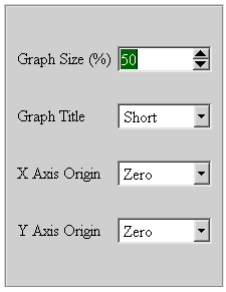


8.4. Graph appearance



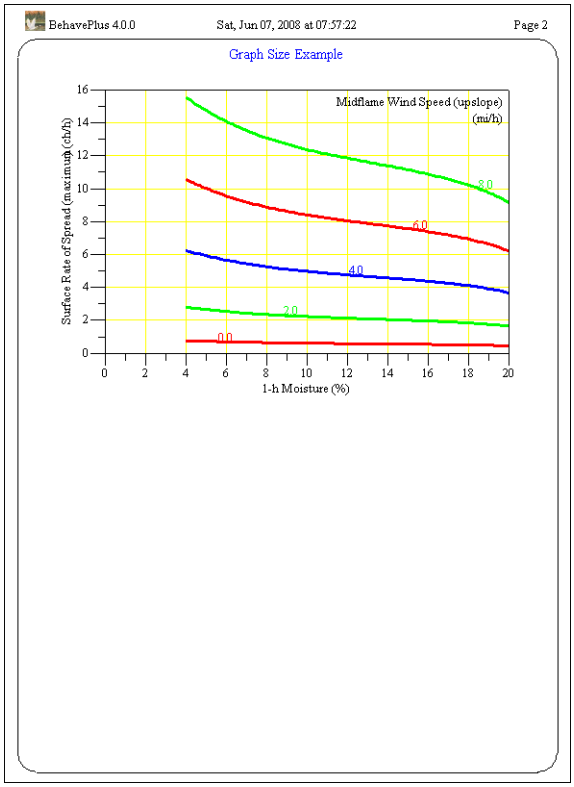
The appearance of the graph can be changed through the Configure > Appearance > Graph Size and Configure > Appearance > Graph Elements tabs.

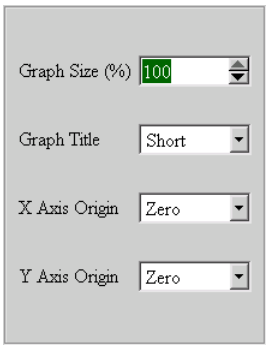
8.4.1. Graph Size



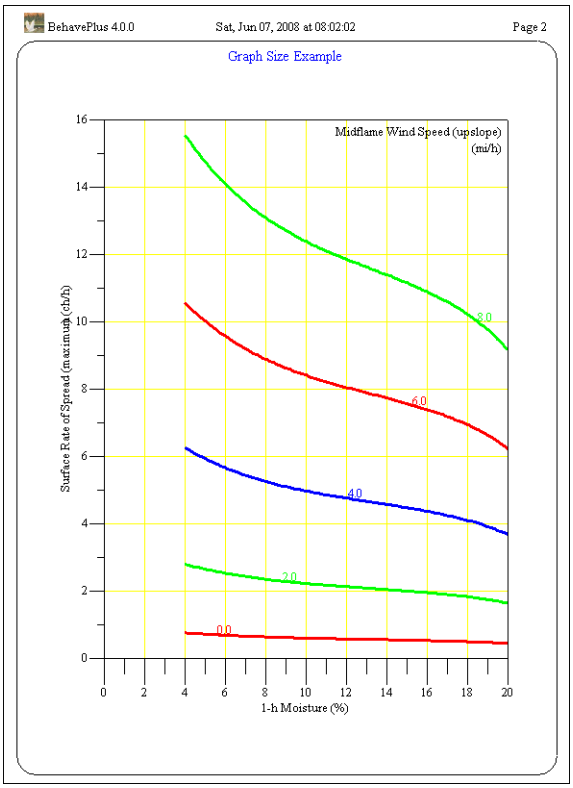
The vertical graph height on the page is set with the Graph Size(%) spin box on the Configure > Appearance > Graph Size tab.

Graphs are drawn starting at the upper left corner of the page and may occupy 25% to 100% of the page height. The default is 50%, as shown in the following graph.

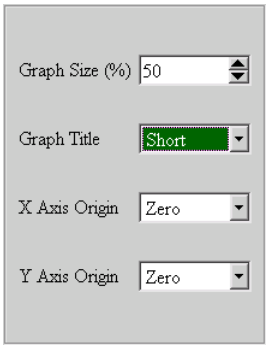




Changing the Graph Size to 100% changes the above to the following graph:

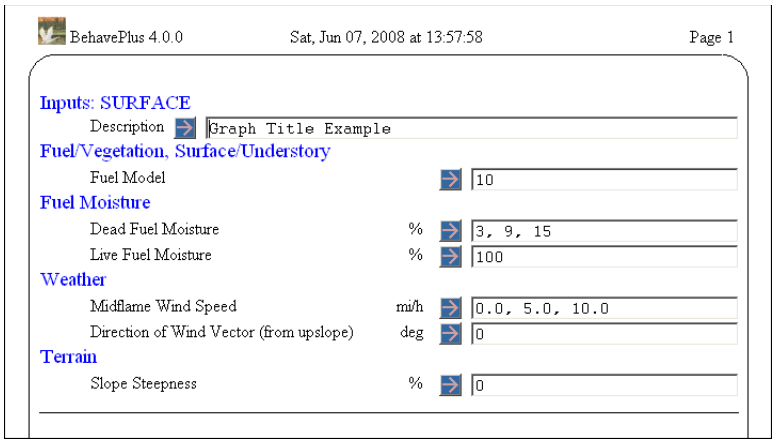


8.4.2. Graph Title

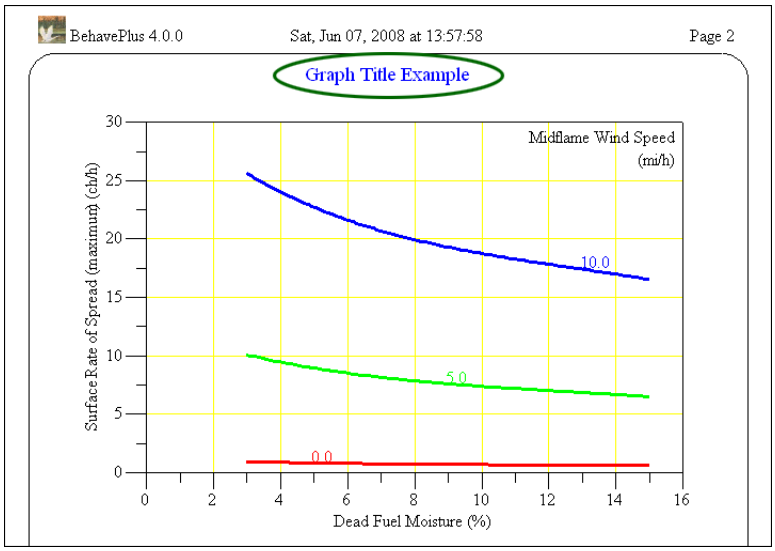


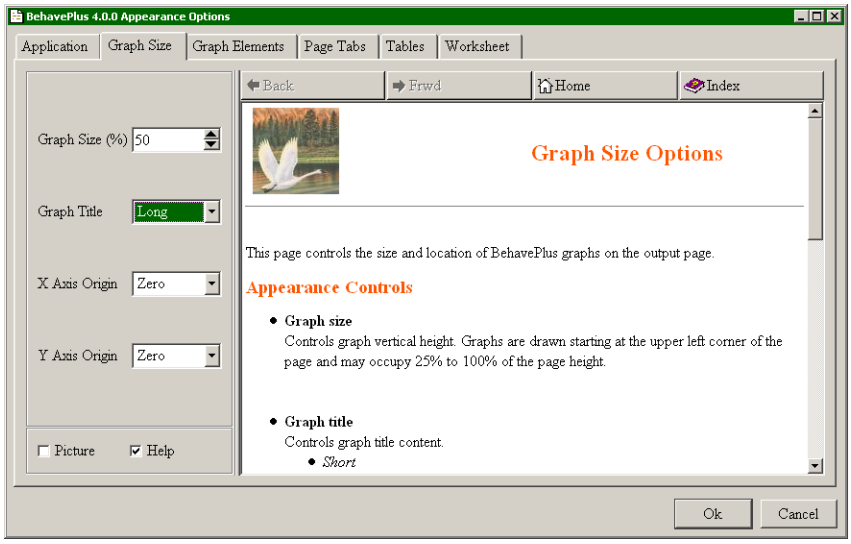
The graph title content is controlled using the Graph Title drop-down list on the Configure > Appearance > Graph Size tab.

Selecting Short from the Graph Title drop-down list displays just the contents of the Worksheet Description text box as the title. Selecting Long displays the Description text box and the graph variables.

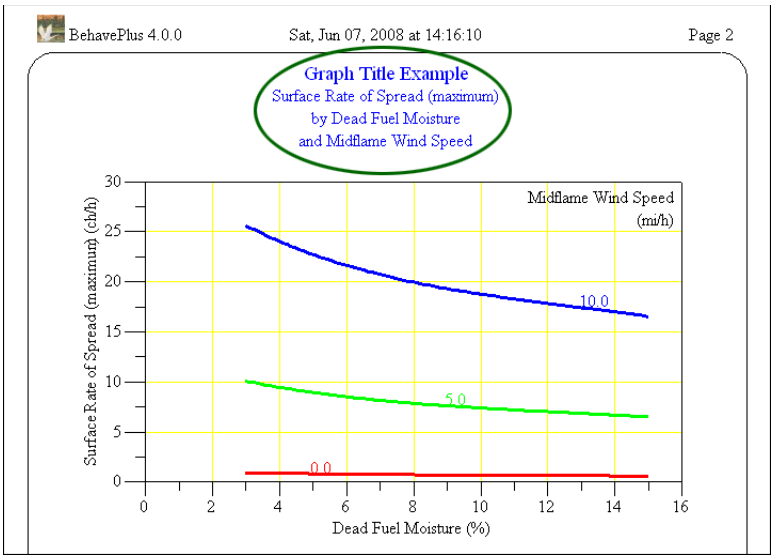


Using the above Run a graph with a short title (the default) looks like the following.



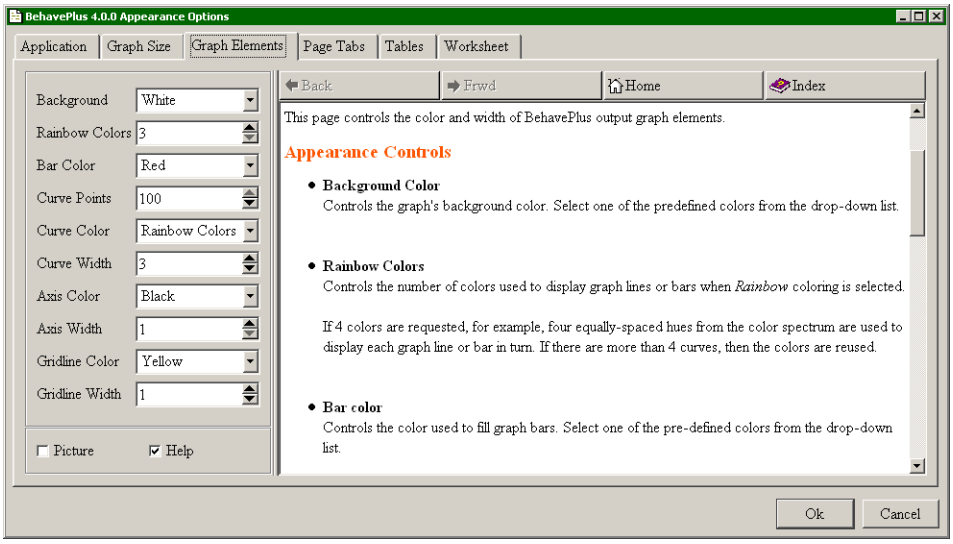


Selecting Long from the Graph Title drop-down list on the Configure > Appearance > Graph Size tab adds more information to the title.



8.4.3. Graph colors

Graph colors can be changed with the Configure > Appearance > Graph Elements tab.



Colors are selected from the predefined drop-down lists.

Background is the background color of the graph.

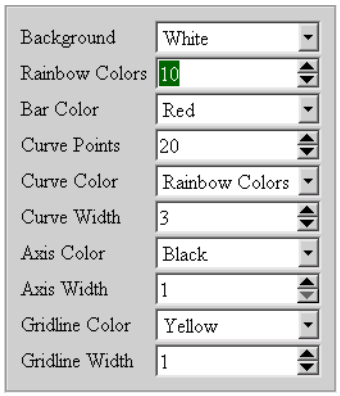
Rainbow Colors sets the number of colors used to display graph lines or bars when Rainbow Colors is selected as the curve color. With three rainbow colors, the colors are red, green, and blue. If 4 colors are requested, four equally spaced hues from the color spectrum are used to display each graph line or bar in turn.

Bar Color is used to fill graph bars. Selecting Rainbow Colors fills each bar with its own color. The number of rainbow colors is set by the Rainbow Colors spin box discussed above.

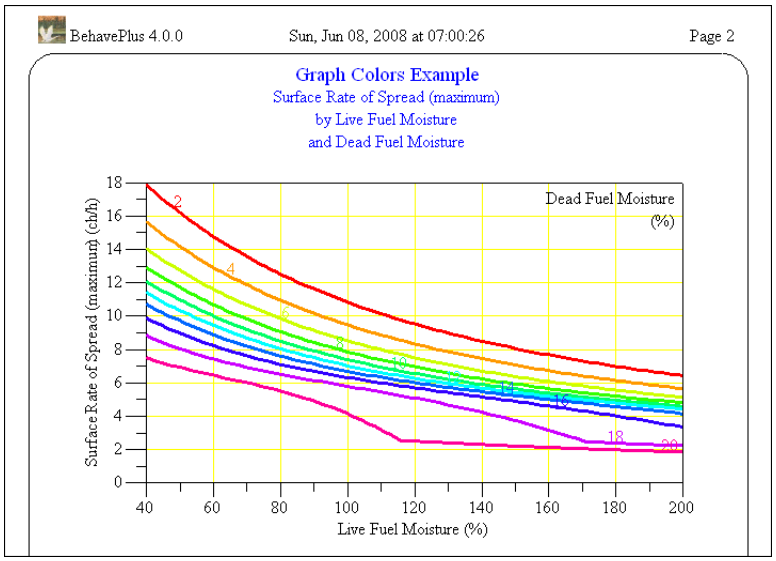
Curve Color is used to draw graph lines. Selecting Rainbow Colors draws each line with its own color. The number of rainbow colors is set by the Rainbow Colors spin box discussed above.

Axis Color is used to draw graph axis lines, tic marks, and axis labels.

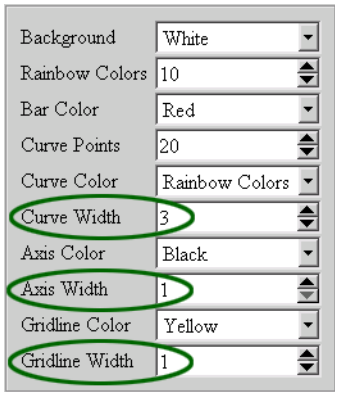
Gridline Color is for the graph grid lines. The default is yellow.



Changing Rainbow Colors to 10 results in the following graph coloring:



8.4.4. Line widths



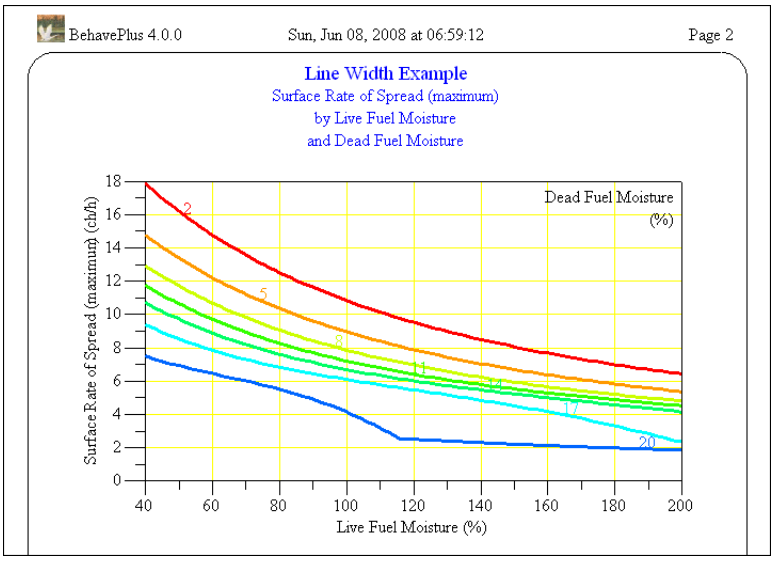
Line widths can be changed using the Curve Width, Axis Width, and Gridline Width spin boxes on the Configure > Appearance > Graph Elements tab.

Curve Width sets the width of graph lines. 0 is the thinnest and 9 thickest.

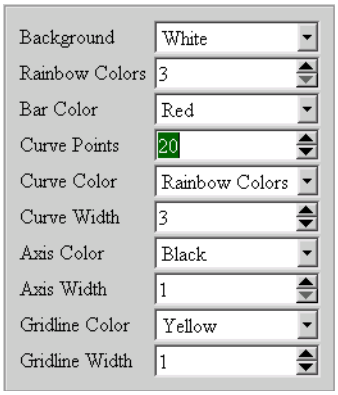
Axis Width sets the width of axis lines drawn on the graph. 1 is thinnest and 9 thickest.

Gridline Width sets the width of grid lines drawn on the graph. 1 is thinnest and 9 thickest. To prevent the display of any grid lines set Gridline Width to 0.

The following graph uses the default line settings.



8.5. Number of curve points



The resolution of the curves can be changed with the Curve Points spin box on the Configure > Appearance > Graph Elements tab.

The Curve Points spin box determines the number of points calculated for each curve in the graph. A straight-line segment is drawn between each pair of points. The default is 100 points. In cases where many curves are plotted and the calculation time is slow, reducing the number of curve points will speed things up.

9. Diagram output

In addition to the usual table and graph output, BehavePlus produces diagrams for the following output variables.

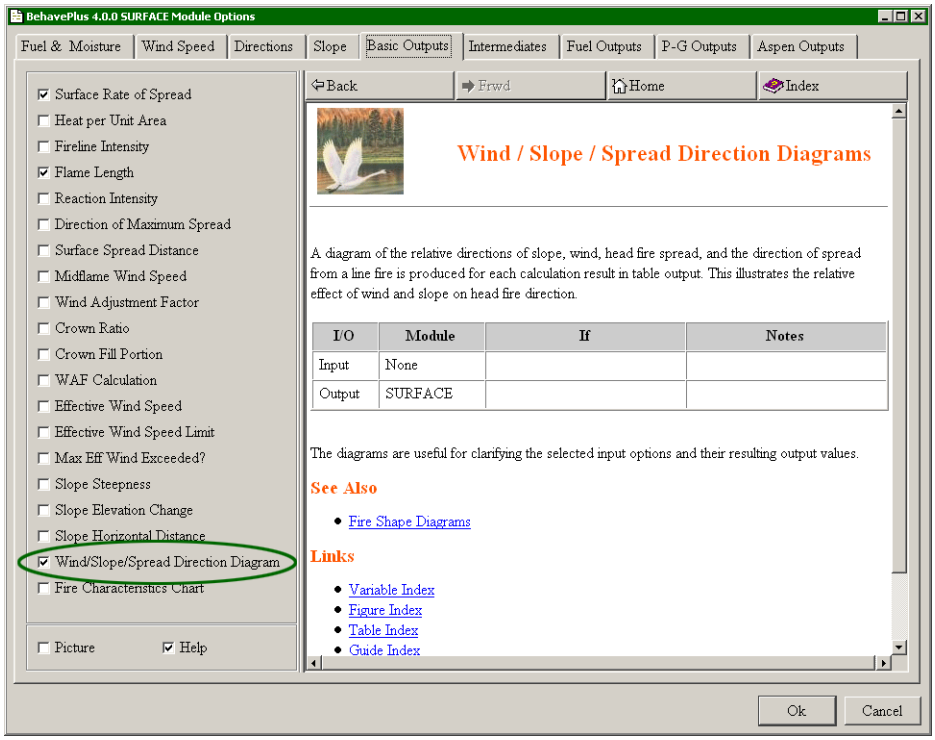
- Wind/slope/fire spread direction diagrams from the SURFACE module
- Fire characteristics chart from the SURFACE module
- Shape of a point source fire from the SIZE module
- Shape of a fire after suppression action from the CONTAIN module

Diagram output is selected from the lists on the Configure > Module selection > (module name) > Options... > Outputs tab for the corresponding module.

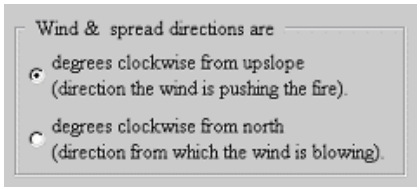
9.1. Wind/slope/spread direction

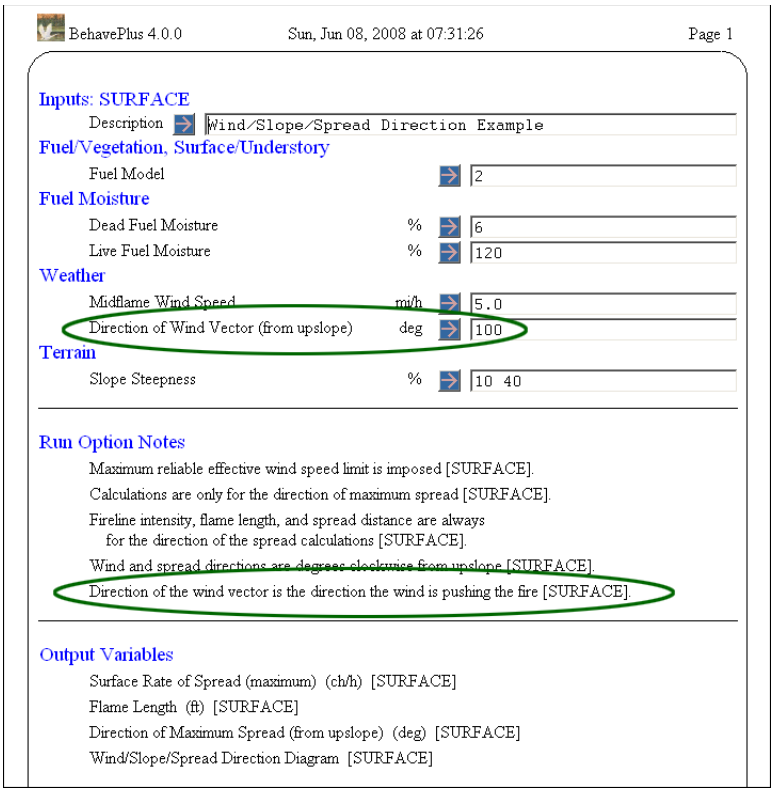
Direction diagrams can help the user avoid confusion on directions for wind, slope, and spread directions. Direction input options are selected on the Configure > Module selection > SURFACE > Options... > Directions tab.

Direction diagrams are produced with the Configure > Module selection > SURFACE > Options... > Basic Outputs tab and selecting the Wind/Slope/Spread Direction Diagram check box.



The diagrams differ according to the direction Input Options selected from the Configure > Module selection > SURFACE > Options... > Directions tab. The following shows the Input Option selection, the resulting Worksheet, the outputs table and diagrams.





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Inputs: SURFACE

Description: Wind/Slope/Spread Direction Example

Fuel/Vegetation, Surface/Understory

Fuel Model: 2

Fuel Moisture

Dead Fuel Moisture: % 6

Live Fuel Moisture: % 120

Weather

Midflame Wind Speed: mi/h 5.0

Direction of Wind Vector (from upslope): deg 100

Terrain

Slope Steepness: % 10 40

Run Option Notes

Maximum reliable effective wind speed limit is imposed [SURFACE].

Calculations are only for the direction of maximum spread [SURFACE].

Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].

Wind and spread directions are degrees clockwise from upslope [SURFACE].

Direction of the wind vector is the direction the wind is pushing the fire [SURFACE].

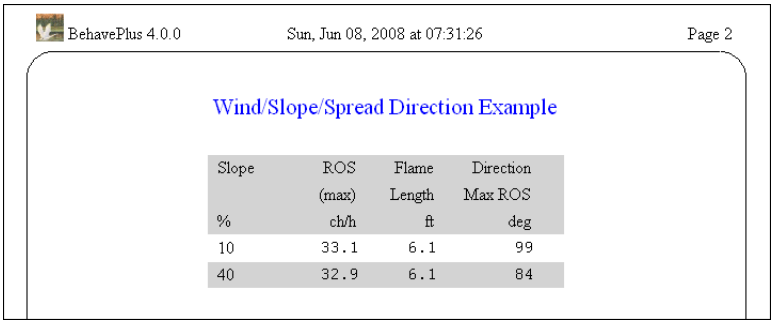
Output Variables

Surface Rate of Spread (maximum) (ch/h) [SURFACE]

Flame Length (ft) [SURFACE]

Direction of Maximum Spread (from upslope) (deg) [SURFACE]

Wind/Slope/Spread Direction Diagram [SURFACE]



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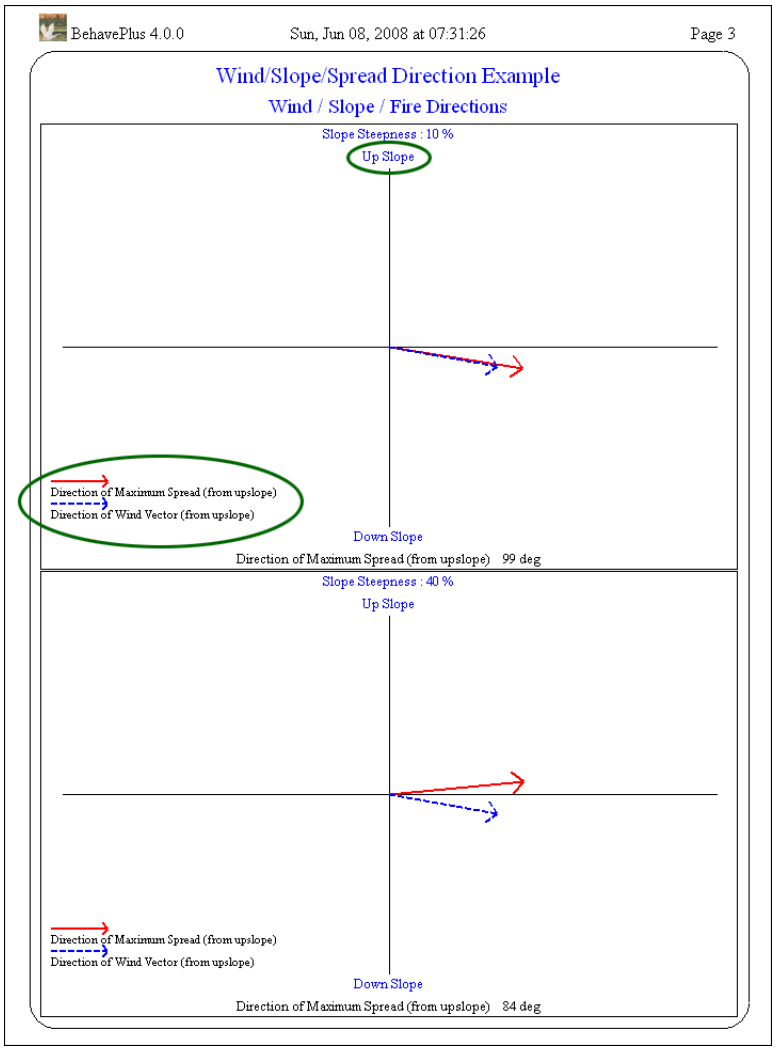
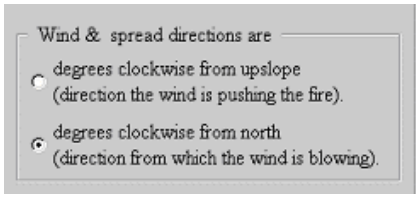
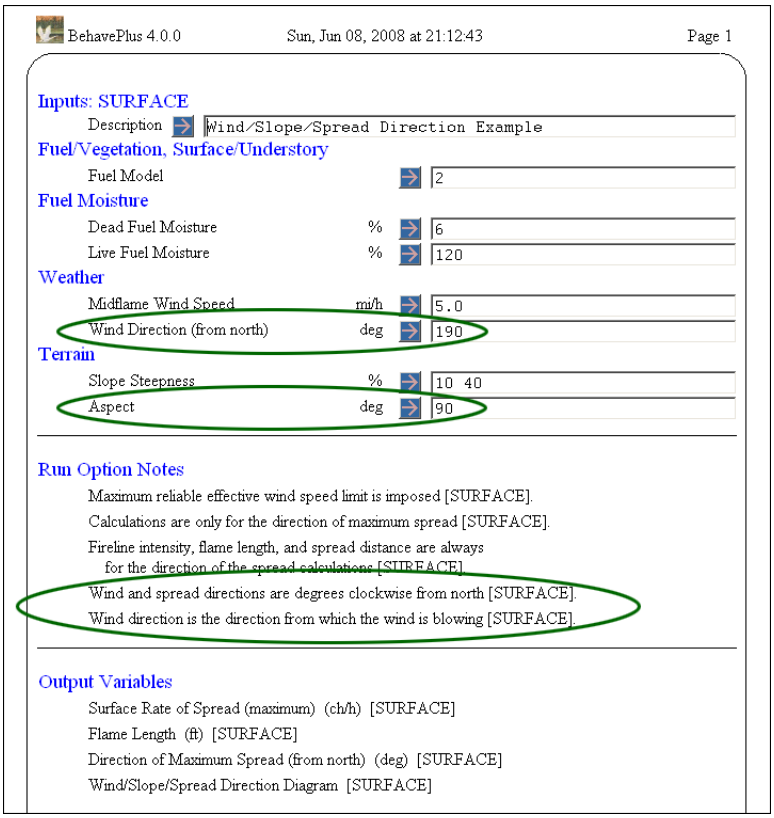
Wind/Slope/Spread Direction Example

Slope	ROS (max)	Flame Length	Direction Max ROS
%	ch/h	ft	deg
10	33.1	6.1	99
40	32.9	6.1	84



The following illustrates the effect of selecting the Wind & spread directions are radio button on the variables that are requested on the Worksheet.





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Inputs: SURFACE

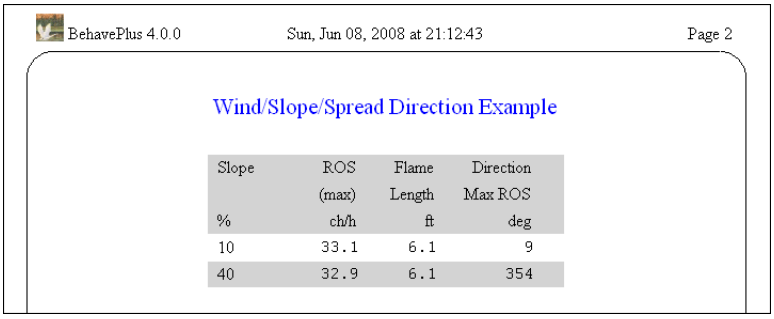
Description		Wind/Slope/Spread Direction Example
Fuel/Vegetation, Surface/Understory		
Fuel Model		2
Fuel Moisture		
Dead Fuel Moisture	%	6
Live Fuel Moisture	%	120
Weather		
Midflame Wind Speed	mi/h	5.0
Wind Direction (from north)	deg	190
Terrain		
Slope Steepness	%	10 40
Aspect	deg	90

Run Option Notes

Maximum reliable effective wind speed limit is imposed [SURFACE].
Calculations are only for the direction of maximum spread [SURFACE].
Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].
Wind and spread directions are degrees clockwise from north [SURFACE].
Wind direction is the direction from which the wind is blowing [SURFACE].

Output Variables

Surface Rate of Spread (maximum) (ch/h) [SURFACE]
Flame Length (ft) [SURFACE]
Direction of Maximum Spread (from north) (deg) [SURFACE]
Wind/Slope/Spread Direction Diagram [SURFACE]



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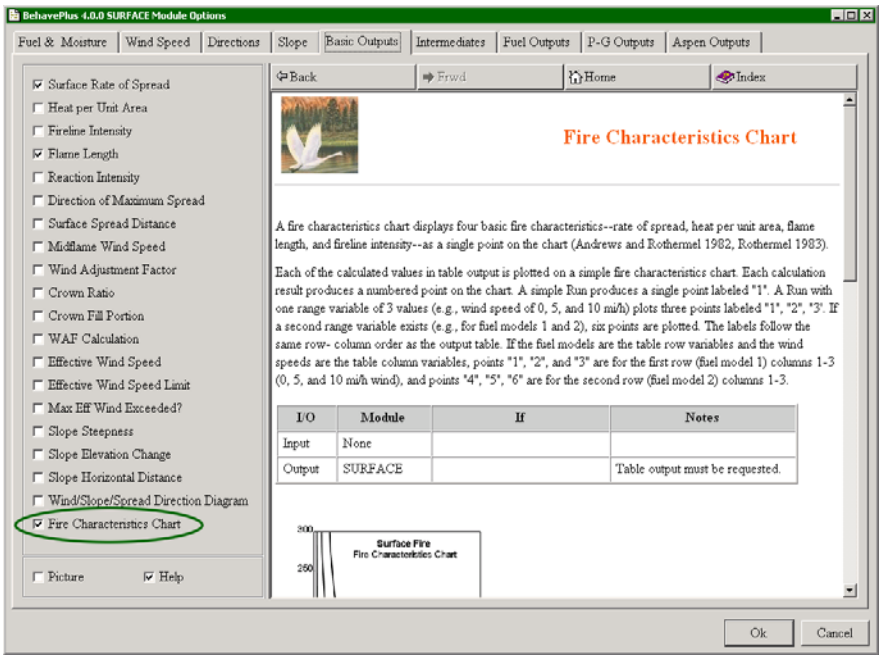
Wind/Slope/Spread Direction Example

Slope	ROS (max)	Flame Length	Direction Max ROS
%	ch/h	ft	deg
10	33.1	6.1	9
40	32.9	6.1	354

9.2. Fire characteristics chart

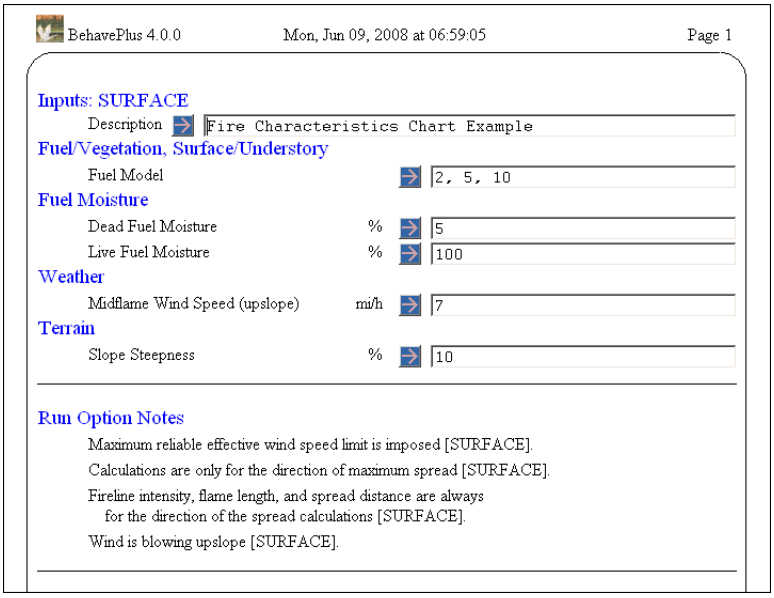
A fire characteristics chart diagram plots the relationship of rate of spread, heat per unit area, flame length, and fireline intensity. This option is a simplified plot and does not offer the user any display options. Axis scales are set automatically and points are labeled with simple numbers. In the future, BehavePlus will provide a Fire Characteristics Tool so that the user can customize it for a specific need.

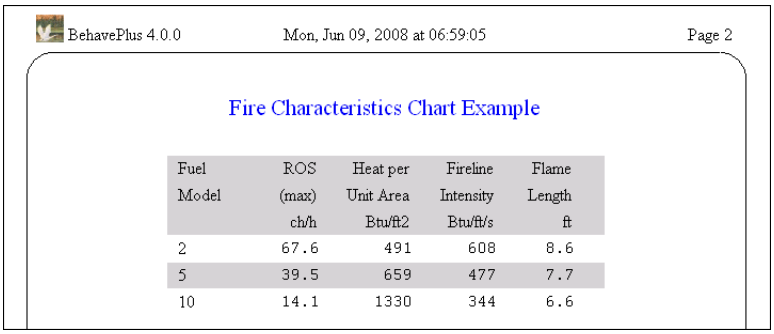
Fire characteristics charts are produced with the Configure > Module selection > SURFACE > Options... > Basic Outputs tab and selecting the Fire Characteristics Chart check box.

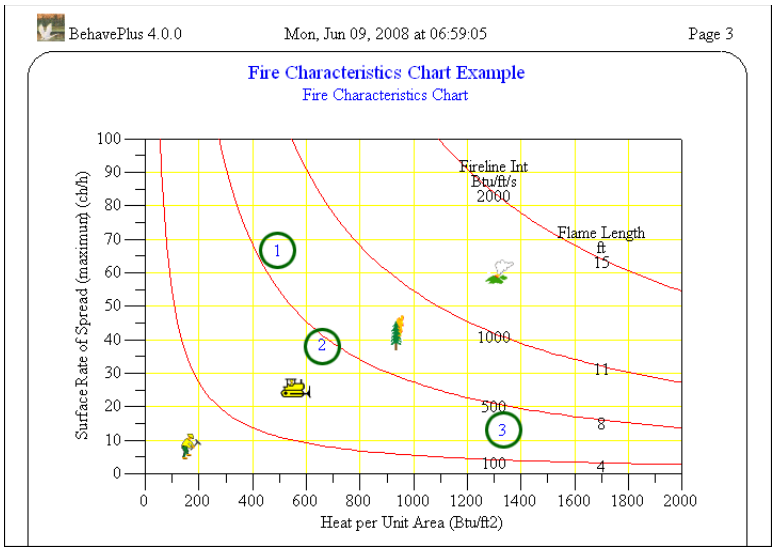


It is not necessary to select the four output variables that are plotted on the chart.

The following shows the Worksheet and resulting output table and Fire Characteristics Chart.

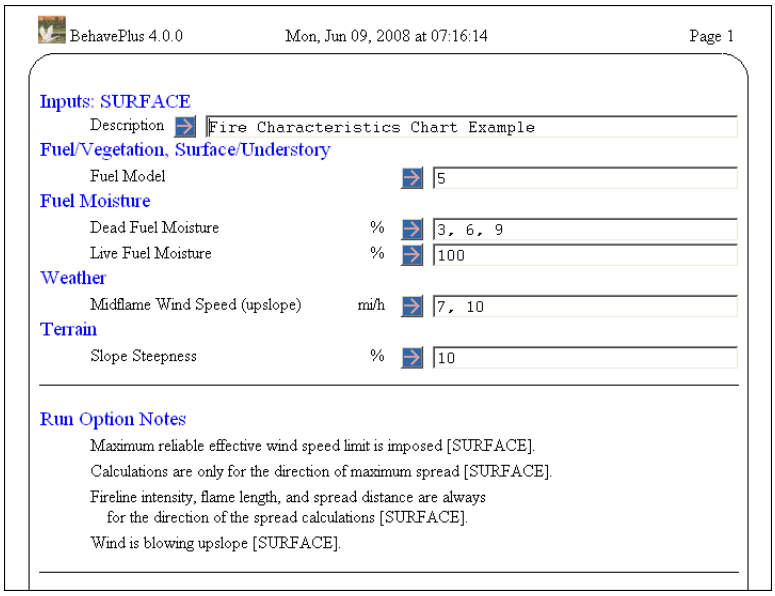


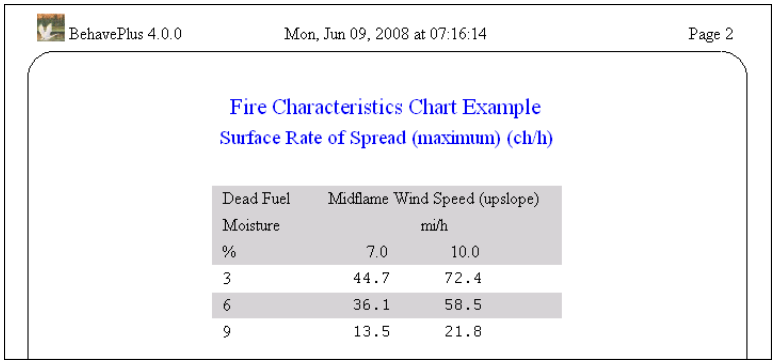




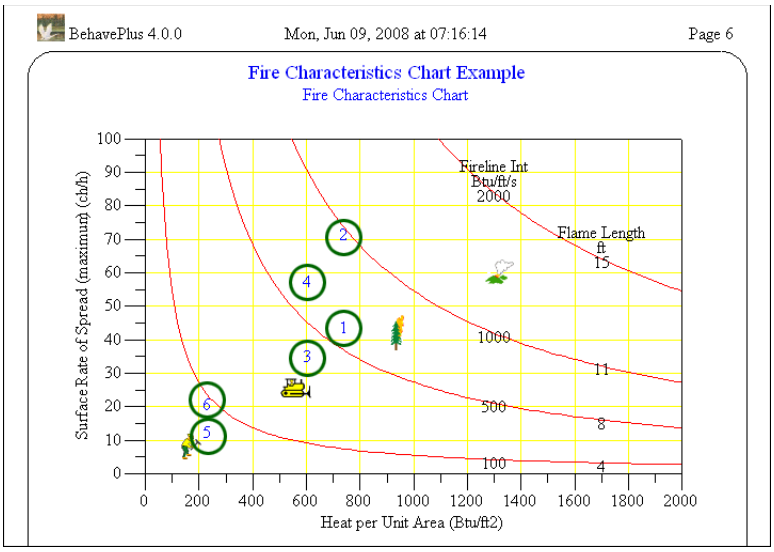
The points labeled 1, 2, and 3 correspond to the three lines of the output table. Point 1 is for fuel model 2, point 2 for fuel model 5, and point 3 for fuel model 10.

In the case of two variables with multiple entry values a two-way table is produced:



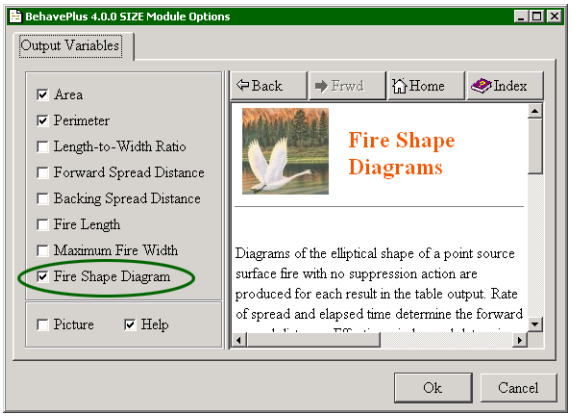


Dead Fuel Moisture	Midflame Wind Speed (upslope) mi/h	
%	7.0	10.0
3	44.7	72.4
6	36.1	58.5
9	13.5	21.8



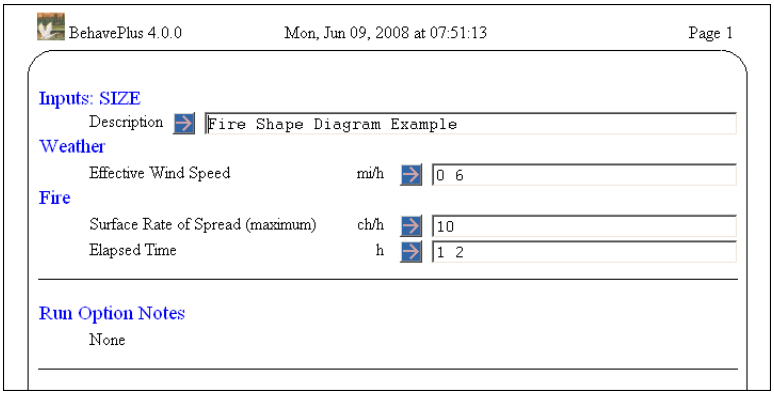
The numbers on the chart correspond to the table cells in left-to-right and top-to-bottom order. In this example, Points 1 and 2 are for the first row of the result table (3% moisture) at the two wind speeds (7 and 10 mi/h). Points 3 and 4 are for the second row of the result table (6% moisture) at the two wind speeds. Points 5 and 6 are for the third row of the result table (9% moisture) at the two wind speeds.

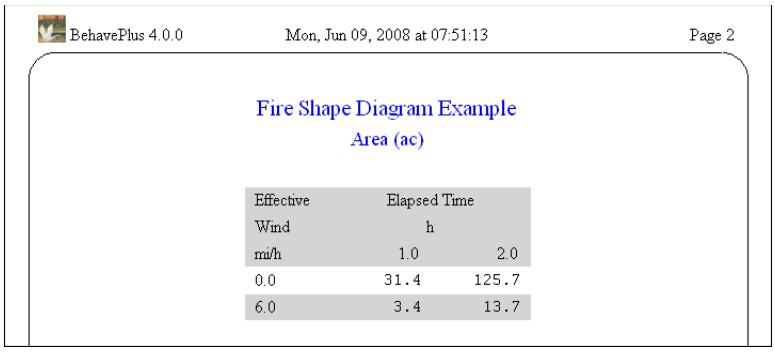
9.3. Shape of a point source fire



The elliptical shape of a point source fire can be plotted on the Configure > Module selection > SIZE > Options ... > Output Variables tab by selecting the Fire Shape Diagram check box.

For example, the following shows the Worksheet, output table, and Fire Shape Diagram.





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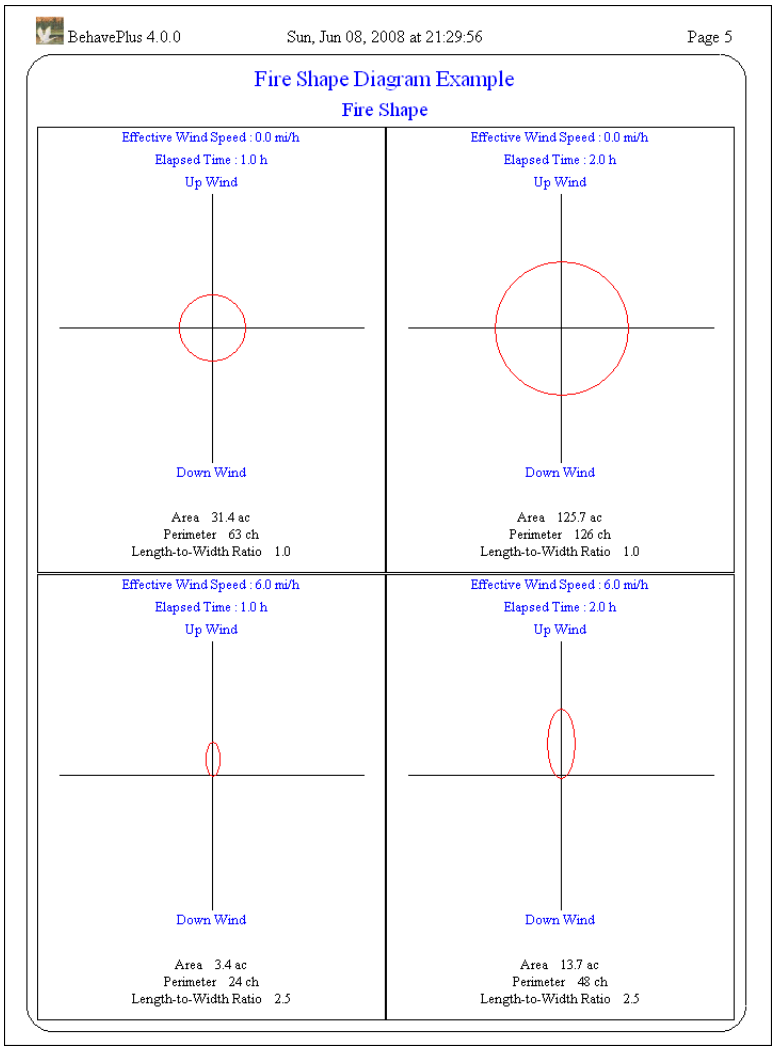
Fire Shape Diagram Example

Area (ac)

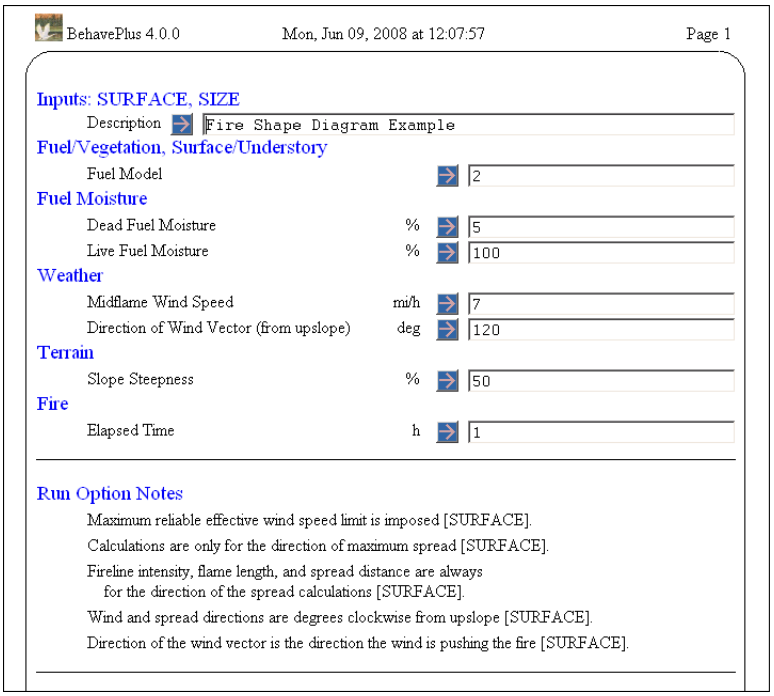
Effective Wind	Elapsed Time h	
mi/h	1.0	2.0
0.0	31.4	125.7
6.0	3.4	13.7



In addition to the shape diagrams, values for all of the selected output variables are given on each diagram.

A word of caution when using the SIZE module by itself as shown by the above example. The above diagram could be wrongly interpreted to show that higher wind speeds result in a smaller fire. But remember the surface rate of spread (10 ch/h) was the same for 0 and 6 m.p.h. winds, which is not realistic if all other fire environment conditions were the same. In this example the wind speed only determines the shape of a fire for a given forward spread distance.

When the SIZE Module is linked to the SURFACE Module, the wind vector is also shown on the diagram.



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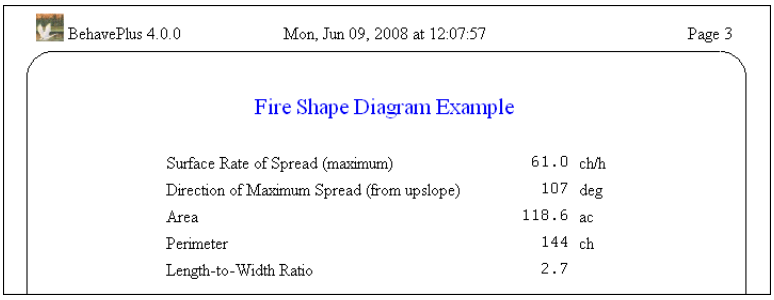
Inputs: SURFACE, SIZE

Description		Fire Shape Diagram Example
Fuel/Vegetation, Surface/Understory		
Fuel Model		2
Fuel Moisture		
Dead Fuel Moisture	%	5
Live Fuel Moisture	%	100
Weather		
Midflame Wind Speed	mi/h	7
Direction of Wind Vector (from upslope)	deg	120
Terrain		
Slope Steepness	%	50
Fire		
Elapsed Time	h	1

Run Option Notes

Maximum reliable effective wind speed limit is imposed [SURFACE].
Calculations are only for the direction of maximum spread [SURFACE].
Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].
Wind and spread directions are degrees clockwise from upslope [SURFACE].
Direction of the wind vector is the direction the wind is pushing the fire [SURFACE].



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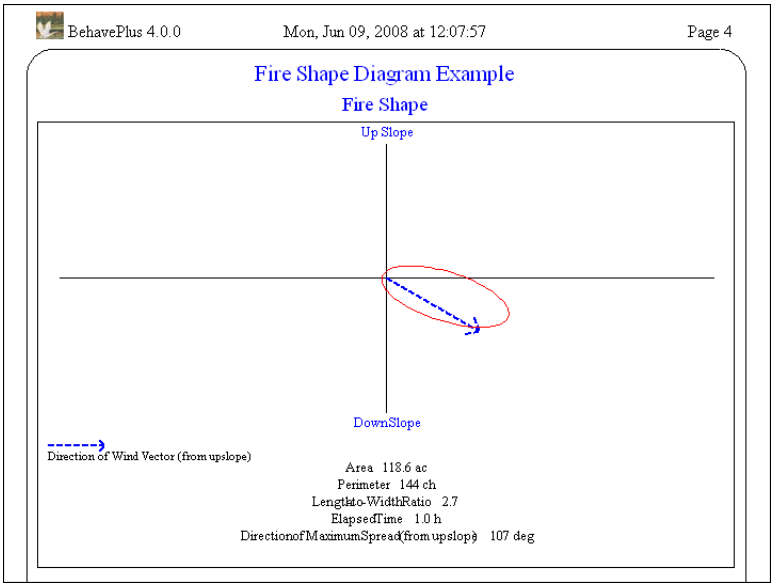
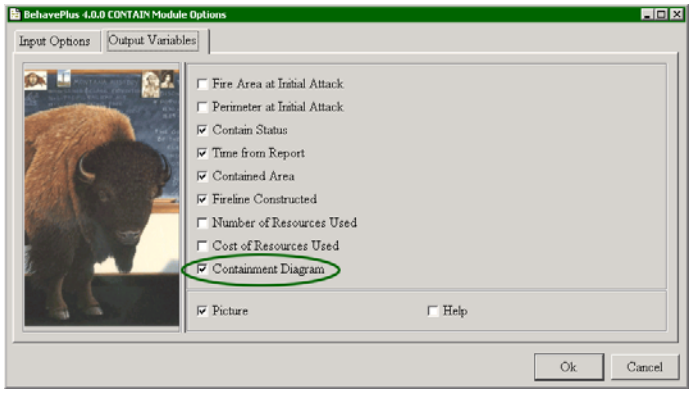
Fire Shape Diagram Example

Surface Rate of Spread (maximum)	61.0	ch/h
Direction of Maximum Spread (from upslope)	107	deg
Area	118.6	ac
Perimeter	144	ch
Length-to-Width Ratio	2.7	

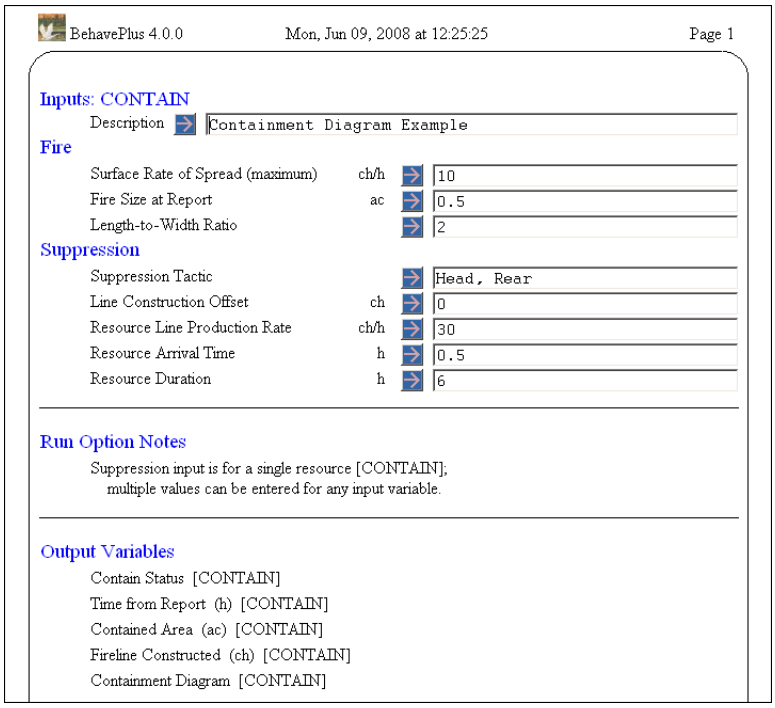


9.4. Containment shape

The Containment Diagram shows fire perimeter at time of report, at initial attack, and constructed fireline at the time the fire was successfully contained or when it escaped initial attack (all resources exhausted before containment).



The Containment Diagram is displayed by selecting the Containment Diagram check box from the Configure > Module selection > CONTAIN > Options ... > Output Variables tab. Also select the Contain Status check box to output whether the fire was Contained or Escaped on the Containment Diagram.



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Inputs: CONTAIN

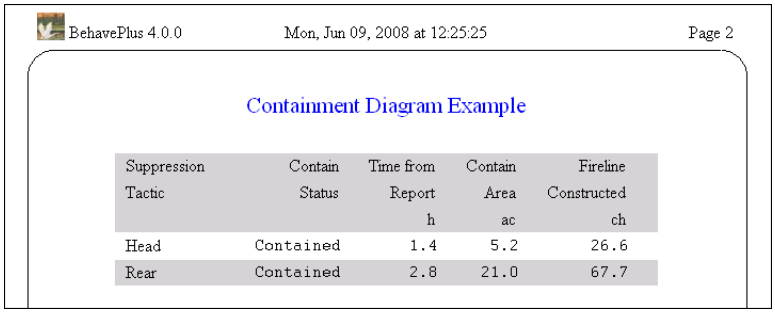
Description		Containment Diagram Example
Fire		
Surface Rate of Spread (maximum)	ch/h	10
Fire Size at Report	ac	0.5
Length-to-Width Ratio		2
Suppression		
Suppression Tactic		Head, Rear
Line Construction Offset	ch	0
Resource Line Production Rate	ch/h	30
Resource Arrival Time	h	0.5
Resource Duration	h	6

Run Option Notes

Suppression input is for a single resource [CONTAIN]; multiple values can be entered for any input variable.

Output Variables

Contain Status [CONTAIN]
Time from Report (h) [CONTAIN]
Contained Area (ac) [CONTAIN]
Fireline Constructed (ch) [CONTAIN]
Containment Diagram [CONTAIN]



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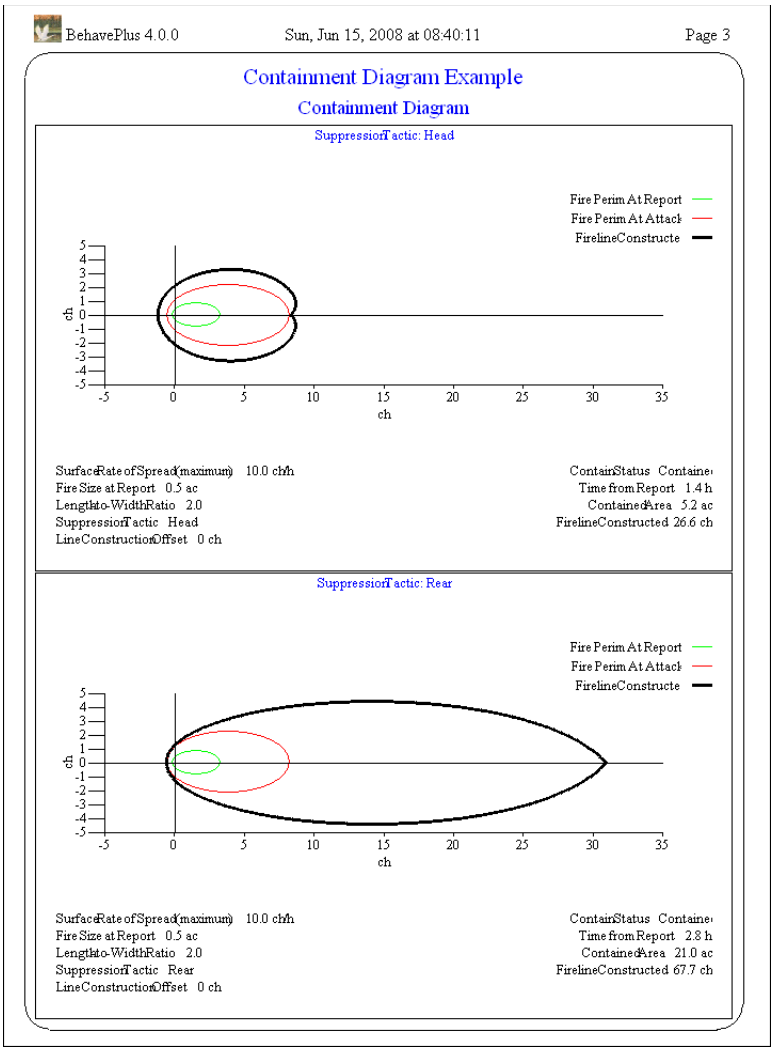
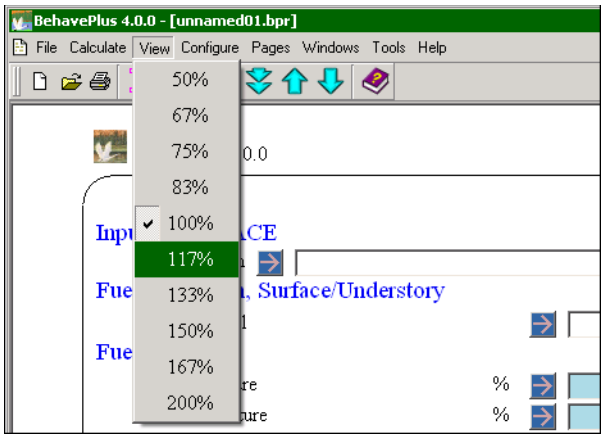
Containment Diagram Example

Suppression Tactic	Contain Status	Time from Report h	Contain Area ac	Fireline Constructed ch
Head	Contained	1.4	5.2	26.6
Rear	Contained	2.8	21.0	67.7


BehavePlus 4.0.0
Sun, Jun 15, 2008 at 08:40:11
Page 3
Containment Diagram Example
Containment Diagram
SuppressionTactic: Head
Fire Perim At Report
Fire Perim At Attack
FirelineConstructe
ch
ch
SurfaceRateofSpread(maximum) 10.0 ch/h
Fire Size at Report 0.5 ac
LengthtoWidthRatio 2.0
SuppressionTactic Head
LineConstructionOffset 0 ch
ContainStatus Containe
Time from Report 1.4 h
ContainedArea 5.2 ac
FirelineConstructed 26.6 ch
SuppressionTactic: Rear
Fire Perim At Report
Fire Perim At Attack
FirelineConstructe
ch
ch
SurfaceRateofSpread(maximum) 10.0 ch/h
Fire Size at Report 0.5 ac
LengthtoWidthRatio 2.0
SuppressionTactic Rear
LineConstructionOffset 0 ch
ContainStatus Containe
Time from Report 2.8 h
ContainedArea 21.0 ac
FirelineConstructed 67.7 ch

10. View, print, & capture results

10.1. View size



The `View > xx%` command changes the size of your Worksheet and Run when viewed on screen. It does not affect the size of printed output.

10.2. Pages

While each Run has its own window, the window has one or more Pages. The first page(s) contain the Worksheet, and subsequent pages contain results tables, graphs, and diagrams.

You can navigate between pages using the following toolbar buttons:

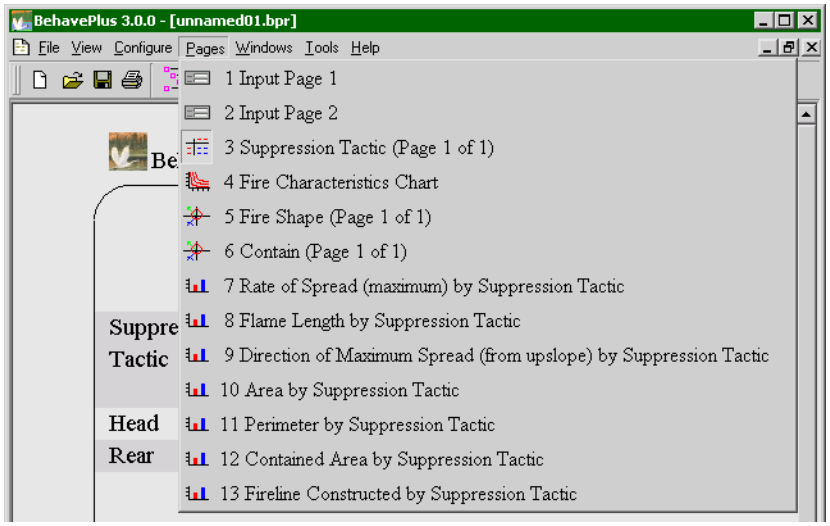
Go to the first page

Go to the last page

Go to the previous page

Go to the next page

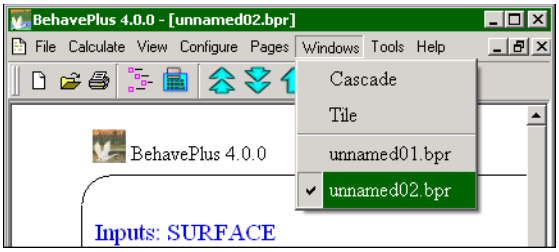
The keyboard navigation arrows will also move you from one page to the next. The `Pages >` command allows you to jump directly to a specific page. Selection can be made from the list of pages with text descriptions and an icon indicating whether it is a table, graph, diagram, etc.



10.3. Windows

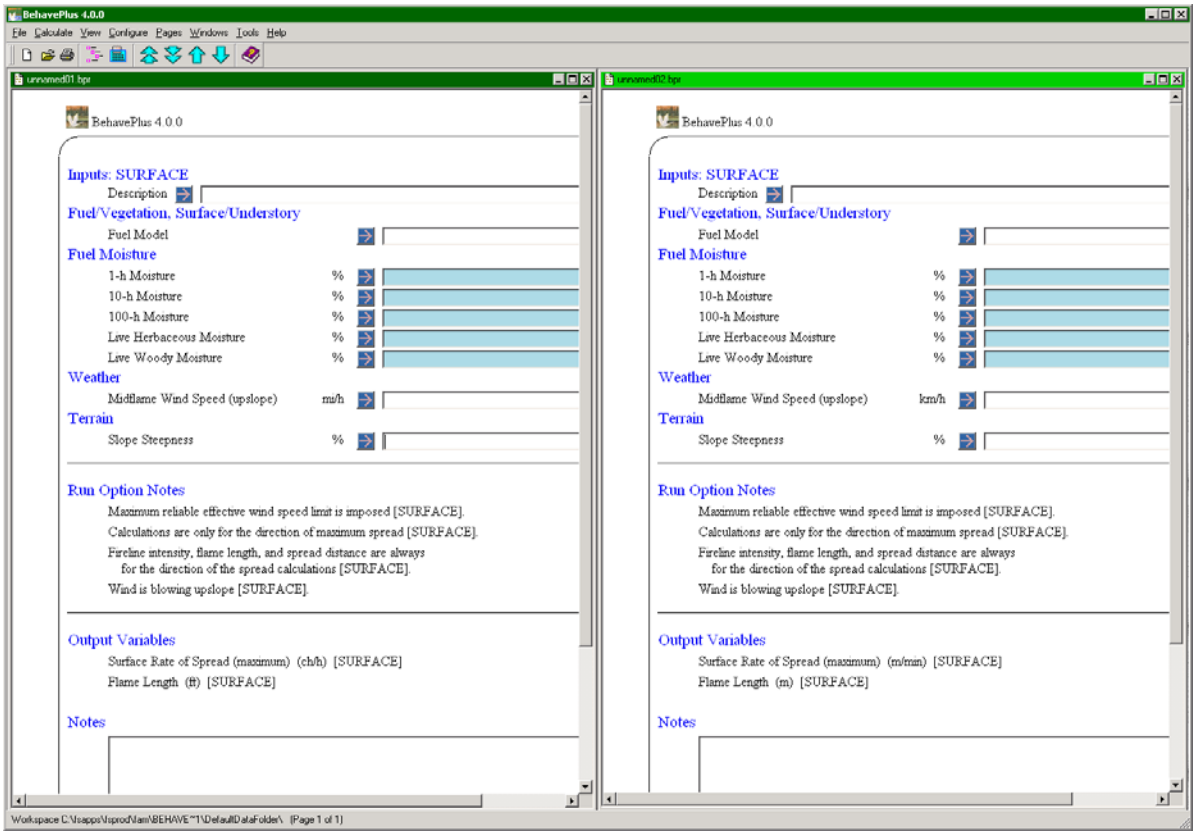
When a Worksheet is first opened, the Run it represents is assigned a default name such as "unnamed01.bpr", "unnamed02.bpr", etc. This name is displayed on the title bar at the top of the BehavePlus application window.

When you save a Run with the File > saveAs > Run command you should rename the Run. The name of the Run is then displayed in the title bar of the BehavePlus window. The complete path name for the Run is shown at the bottom of the BehavePlus application window.



BehavePlus allows you to have any number of Runs open at once. Each Run has its own display window containing a Worksheet and possibly containing calculation results. Only one Run window is active at a time. The Windows menu item allows you to switch between Runs. It also allows you to cascade or tile the Runs within the BehavePlus window area with the Windows > Cascade or Windows > Tile commands. By default the Run windows are stacked on top of each other, so you only see the active Run. If your Run windows are already cascaded or tiled, you can make a Run active by clicking it.

The following is a "tiled" display of the two Runs, one English, one metric. The English Run (unnamed01.bpr) is the active Run.



10.4. Print

You can print all pages or selected pages with the File > Print command. Alternatively, select Print from the shortcut menu when you right click inside a page.

Whenever an output page is printed, it is good practice to print the associated input Worksheet pages to avoid confusion on conditions for the Run. Printed pages are numbered and the date and time of the Run are included on the page header.

10.5. Saving Output

You can save BehavePlus results in several ways. Each page can be saved as an image of the screen display using BehavePlus features. Another way is to use the Alt-Print Screen key stroke combination available on all personal computers. In addition, table output with associated input values can be exported to an HTML file, which can be viewed with a web browser or spreadsheet application.

10.5.1. Saving a screen image

The currently displayed page can be captured and saved as a file in bmp, jpg, or png format with the File > Save as an image command. In the "Save As" dialog box enter a file name in the Capture File text box and select a file type from the Capture Type drop-down list. The file extension will be automatically added to the file name

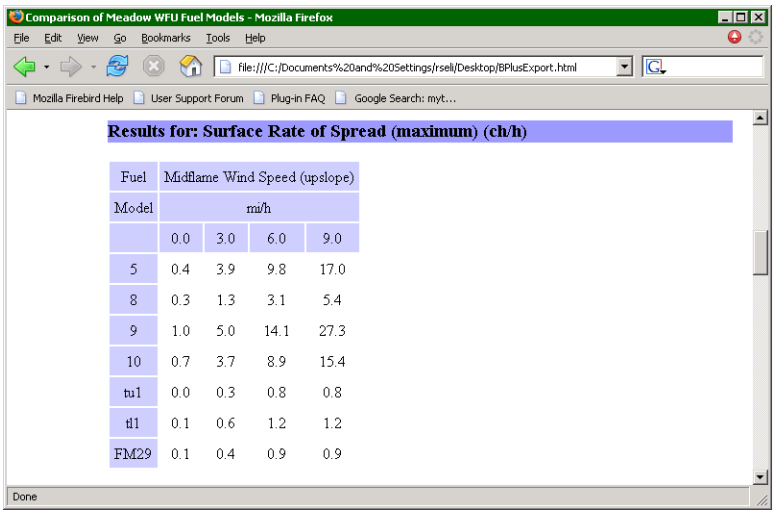
In addition to the File > Save as an image command, you can use the ALT-Print Screen keystroke combination or a screen capture utility (e.g. FullShot) to insert results from BehavePlus into other documents. This is a quick and efficient method. There is no need to save the image in a file of its own. The following steps are an example and do not constitute endorsement of specific software.

- Startup BehavePlus and Microsoft Word software
- Make BehavePlus the active window
- Use the Alt-Print Screen keystroke combination to copy the image of the BehavePlus window
- Make Microsoft Word the active window
- Paste the BehavePlus image into the Word document
- Select the BehavePlus image you just pasted into the WORD document
- Now you can use the Word picture tools to manipulate the BehavePlus image, you may need to display Word's Picture Toolbar by selecting the View > Toolbars > Picture.

10.5.2. Saving an HTML File

Once you have calculated a Run you can save the Run as an HTML file. In addition to the table outputs the HTML file also contains the Input Variables and Run Option Notes sections of the Worksheet. Select the File > Export results command to open a standard Windows "Save As" dialog box. You can save this file anywhere, it does not have to be in a BehavePlus Workspace. The HTML file extension will be automatically added to your file name.

Simply double-clicking your saved file will display your Run in your Web browser.



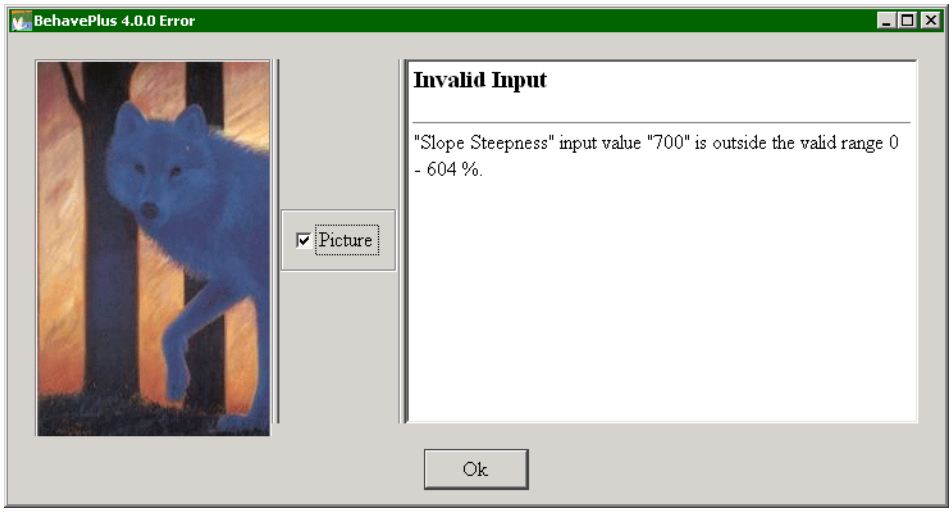
Results for: Surface Rate of Spread (maximum) (ch/h)

Fuel Model	Midflame Wind Speed (upslope) mi/h			
	0.0	3.0	6.0	9.0
5	0.4	3.9	9.8	17.0
8	0.3	1.3	3.1	5.4
9	1.0	5.0	14.1	27.3
10	0.7	3.7	8.9	15.4
tu1	0.0	0.3	0.8	0.8
tl1	0.1	0.6	1.2	1.2
FM29	0.1	0.4	0.9	0.9

You can also open the HTML file with a spreadsheet application. The column widths may need to be changed to make the values readable. A useful technique is to copy the output table to another worksheet so the results can be reformatted or graphed as desired.

11. Error checking

When you do something in error, the program will tell you what the problem is and give you a chance to fix it.



If you do something that causes the program to crash or freeze, it is a program bug. First check the Known Bugs page at www.firemodels.org. If you find the issue has not already been reported, please report it to the Help desk at (800) 253-5559 or (208) 387-5290, fire_help@fs.fed.us.

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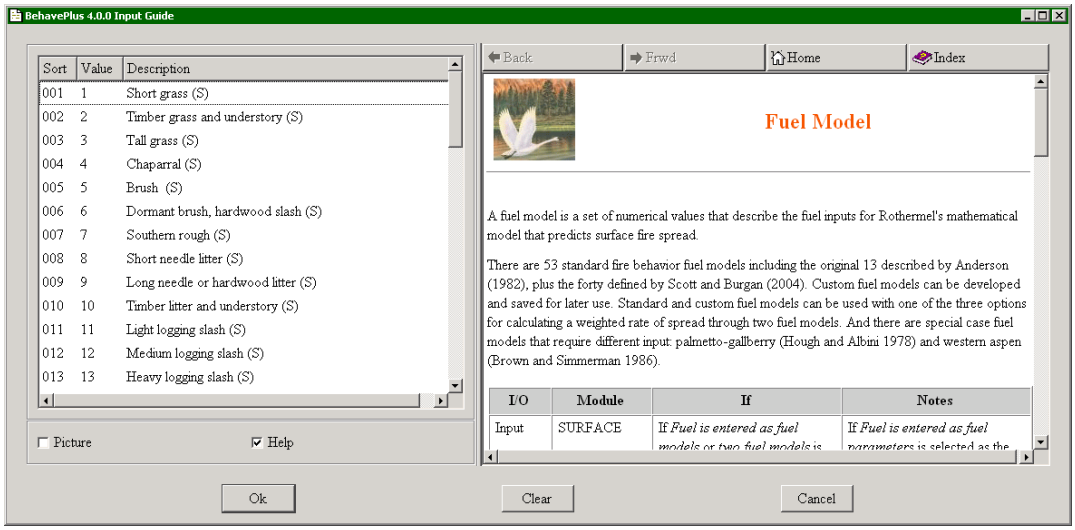
12. Fuel models

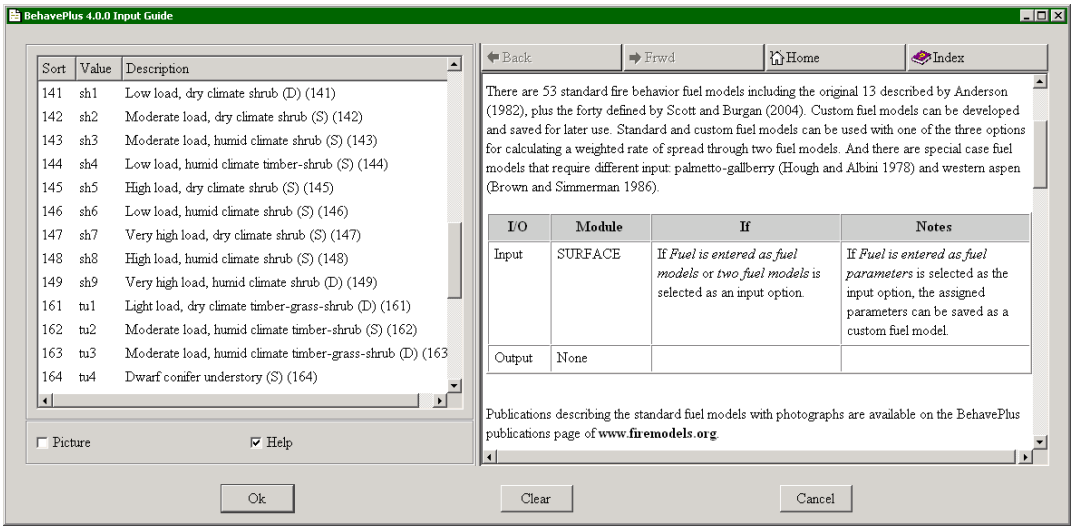
A fuel model is a set of values that describe a fuel type for the surface fire spread model. There are 53 standard fire behavior fuel models. The original standard fuel models are numbered 1 through 13. An expanded set of 40 fuel models is also available. Additionally Custom Fuel Models, can be developed, tested, saved, used in BehavePlus, and exported for use in other applications.

12.1. 53 Standard fire behavior fuel models

The original 13 standard fuel models are always available by using the Fuel Model Input Guide Button or entering the fuel model code directly into the text box from the keyboard. A complete description of the 13 standard fuel models is found in the publication Aids to Determining Fuel Models For Estimating Fire Behavior. Gen. Tech. Rep. INT-122. Anderson, 1982. These fuel models are found at the top of the list in the Fuel Model "Input Guide" dialog box.

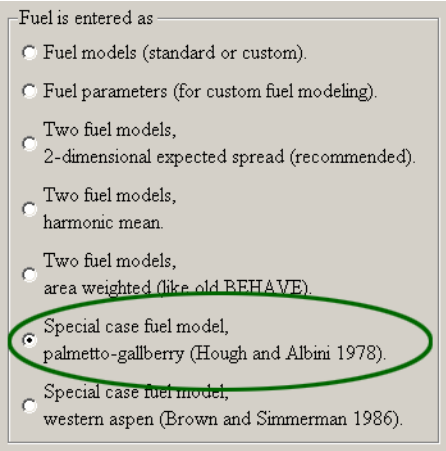


The expanded set of 40 fuel models is also always available in BehavePlus. These fuel models are also selected from the Fuel Model Input Guide or entered directly in the Fuel Model text box on the Worksheet. They are listed after the original 13 in the "Input Guide" dialog box, but they use an alpha-numeric code rather than a number for the value on the Worksheet.



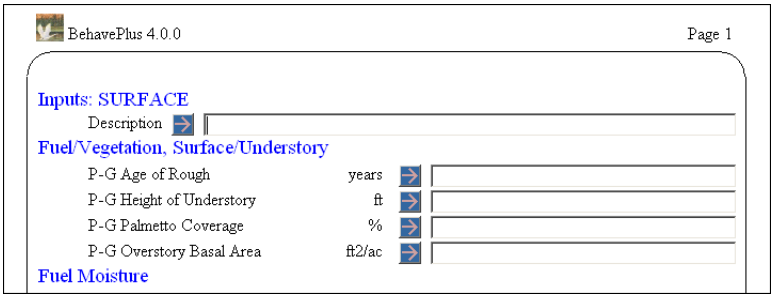
Notice that the expanded models are identified as dynamic or static with a (D) or (S) in the description. See Section 12.4 below for more on dynamic fuel models. Example Runs (e.g. FuelCompare.bpr) can be found in the ExampleRuns folder to explore the expanded fuel model set and see the effect of dynamic fuel models. A full description of the 40 fuel models is found in Scott and Burgan (2005).

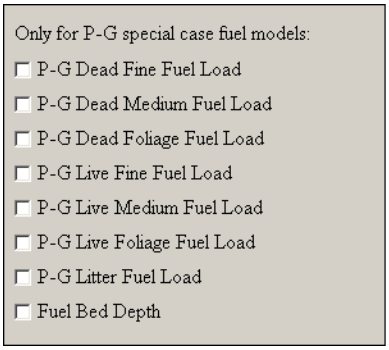
12.2. Palmetto-Gallberry special case fuel model



The Palmetto-Gallberry fuel model is not selected from the "Input Guide" dialog box like the standard fuel models, but is selected with the Special case fuel model, palmetto-gallberry radio button on the Configure > Module selection > SURFACE > Options... > Fuel & Moisture tab.

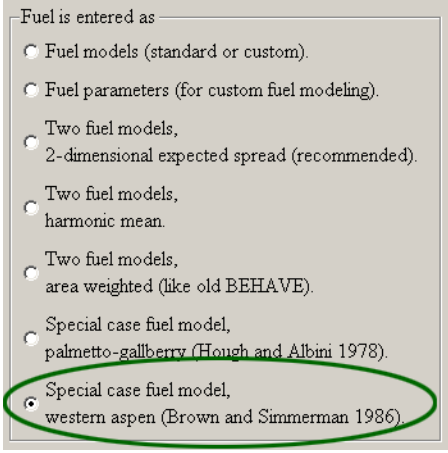
The palmetto-gallberry fuel model estimates fuel parameters from vegetation characteristics (Hough and Albini 1978). Selecting the Special case fuel model, palmetto-gallberry radio button adds different input variables to the "Fuel/Vegetation, Surface/Understory" section of the Worksheet.





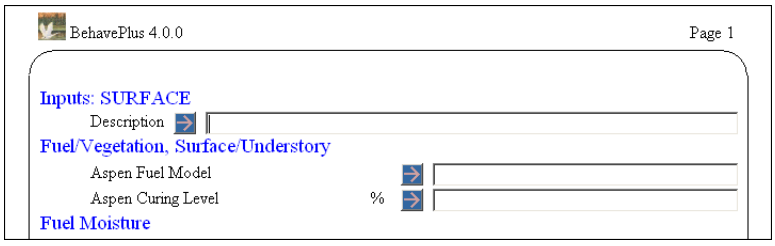
Fuel parameters are calculated and available for display as output variables by selecting them on the Configure > Module selection > SURFACE > Options... > P-G Outputs tab.

12.3. Western Aspen special case fuel model

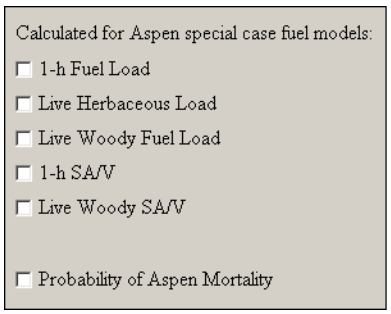


Like the palmetto-gallberry fuel model, the western aspen fuel model is selected with the Special case fuel model, western aspen radio button on the Configure > Module selection > SURFACE > Options... > Fuel & Moisture tab.

Selecting the special case western aspen fuel model adds additional items to the to the "Fuel/Vegetation, Surface/Understory" section of the Worksheet.



The western aspen fuel model estimates fuel parameters from vegetation characteristics (Brown and Simmerman 1986).

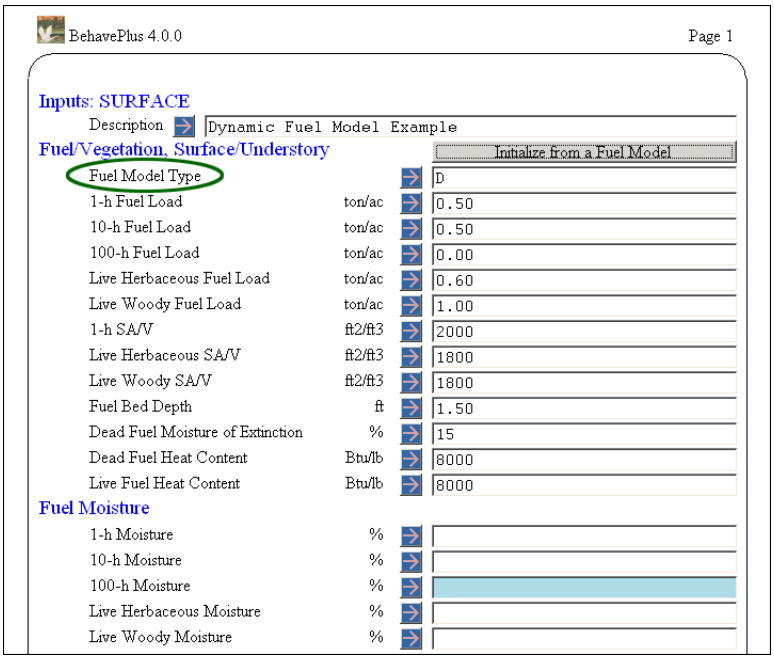


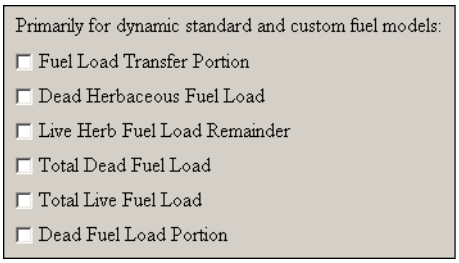
In addition tree morality is calculated in this model. It is not in the MORTALITY module, because a different mathematical model is used for this tree species.

12.4. Dynamic fuel models

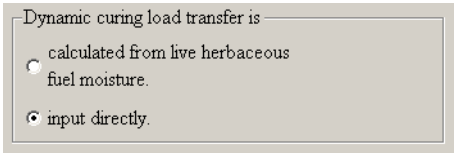
Dynamic load transfer of herbaceous fuel is available in BehavePlus. If the Fuel Model Type is identified as dynamic, then fuel load is transferred from herbaceous live to dead herbaceous fuel as a function of the Live Herbaceous Moisture value entered on the Worksheet. Dynamic fuel models must have a live herbaceous fuel load while static fuel models may or may not have a live herbaceous fuel load.

The original 13 standard fuel models are all static. Seventeen of the expanded 40 standard fuel models are dynamic. The dynamic fuel models are identified by a (D) at the end of their description and a Fuel Model Type parameter of D.



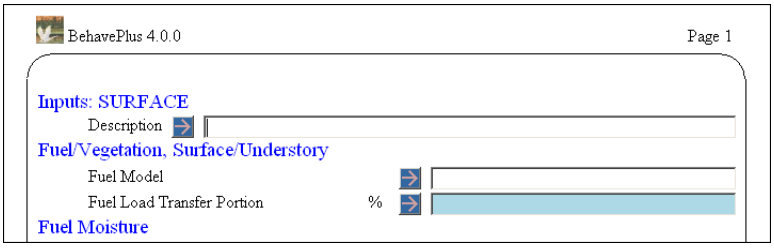


Additional output variables are available to help uses understand dynamic fuel models. The following variables can be selected from the Configure > Module selection > SURFACE > Options... > Fuel Outputs tab. A full explanation of dynamic fuel models is found in Scott and Burgan (2005).



BehavePlus offers the option of user specification of curing level (fuel load transfer portion) rather than using the value calculated from live herbaceous fuel moisture. This output option is selected with the input directly radio button on the Configure > Module selection > SURFACE > Options... > Fuel &Moisture tab.

An additional input field is added to the "Fuel/Vegetation, Surface/Understory" section of the Worksheet.

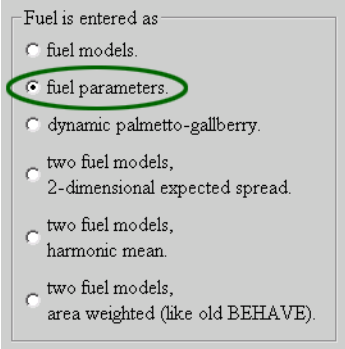


12.5. Custom fuel models

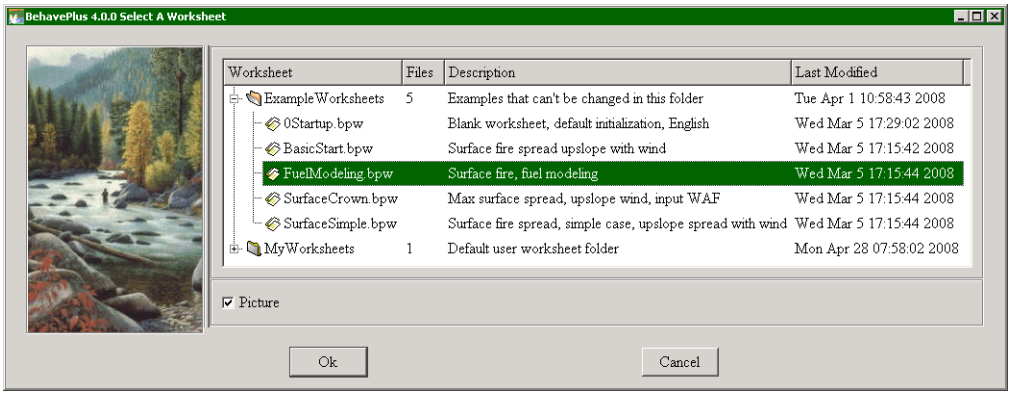
In addition to the standard fuel models you can create, save, and reuse custom fuel models in BehavePlus. These custom fuel models can be exported in a file format used by *FARSITE,* NEXUS, and FlamMap.

12.5.1. Defining and saving custom fuel models

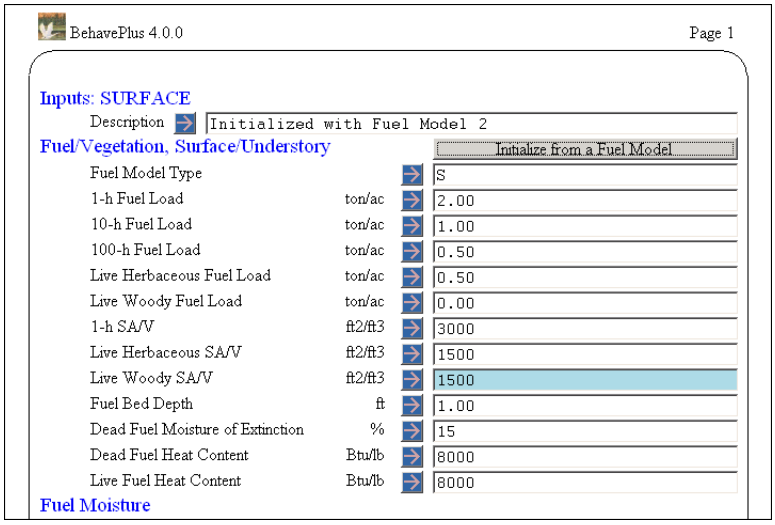
The first step in creating a custom fuel model is to change the Worksheet so that individual fuel parameters are entered in place of the fuel model code. Use the Configure > Module selection > SURFACE > Options... > Fuel and moisture tab and select the fuel parameters. radio button.



Or you can load the Example Worksheet FuelModeling.bpw, which as been set up to use fuel parameters, using the File > Open worksheet command or toolbar button.



Fuel model parameters can be typed directly into the parameter text boxes. Or they can be initiated with an existing fuel model by clicking the Initialize from a Fuel Model button on the Worksheet.



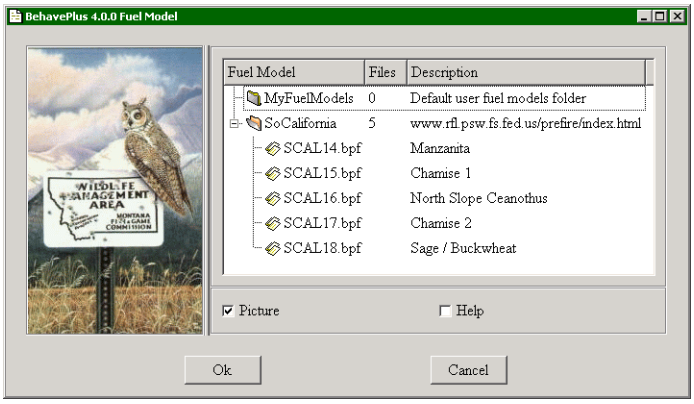
The process of developing a custom fuel model is more complex that just filling in these blanks. It involves a process of evaluation and revision which is not covered in this User's Guide.

Once the fuel model parameters are defined, a custom fuel model can be saved for later use with the File > saveAs > Fuel model > BehavePlus format command. In the "Save As" dialog box enter a file name in the Fuel Model File text box and a short description in the Fuel Model Description text box. If more than one value is assigned to a fuel model parameter for testing purposes, the first value in the list is the one that is saved.

Fuel models should be grouped in folders named by some logical association of meaning to the user. See Section 17.4, Save As…, for more information.

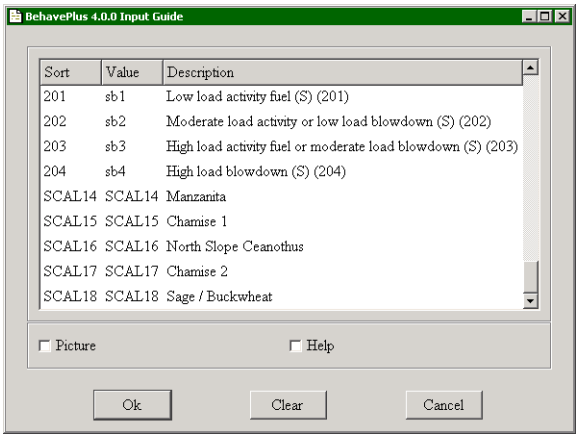
12.5.2. Using previously saved custom fuel models

In order to use previously saved custom fuel models, the folder in which they are stored must be attached using the Configure > Fuel model set selection command.



Click on a folder's button to view its fuel model files. Each fuel model is stored in a separate file.

Fuel model files are available by attaching the folder in which they reside. This makes the fuel models in that folder accessible for use. It is not possible to select and attach individual fuel models; the entire folder must be attached. For example, all the southern California fuel models are attached by selecting the SoCalifornia folder in the "Fuel Model" dialog box and clicking the Ok button. Once a fuel model folder is attached, the fuel models appear in the Fuel Model input guide and may be entered as the Fuel Model input variable.



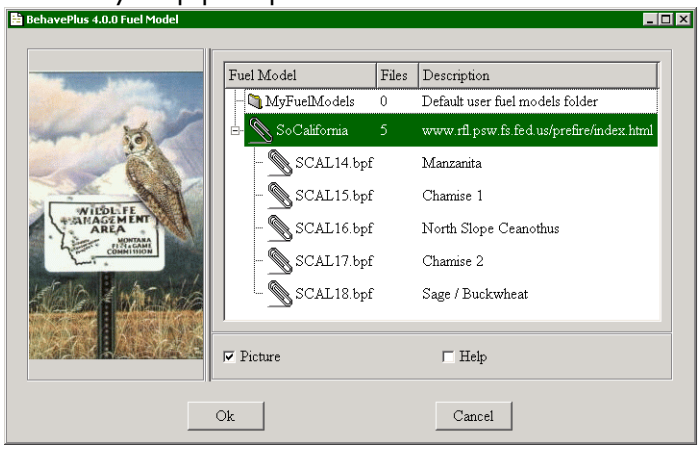
After the SoCalifornia fuel model folder is attached, the Fuel Model input Guide Button gives the following valid selections for the Fuel Model text box.

To view the parameters of a particular fuel model, right-click on its name and select the View parameters command from the shortcut menu.

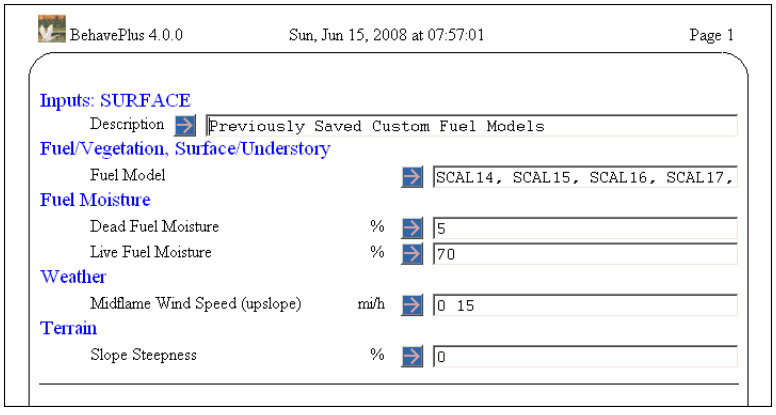
Fuel Model SCAL14

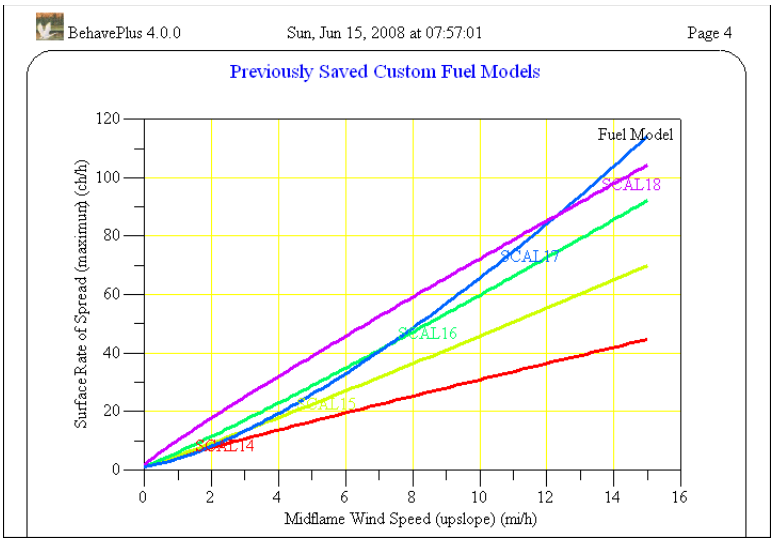
Fuel Model Name	SCAL14
Description	Manzanita
1-h Fuel Load	3 tons/ac
10-h Fuel Load	4.5 tons/ac
100-h Fuel Load	1.05 tons/ac
Live Herbaceous Fuel Load	1.45 tons/ac
Live Woody Fuel Load	5 tons/ac
1-h Surface Area/Vol Ratio	350 ft2/ft3
Live Herbaceous Surface Area/Vol Ratio	1500 ft2/ft3
Live Woody Surface Area/Vol Ratio	250 ft2/ft3
Fuel Bed Depth	3 feet
Dead Fuel Moisture of Extinction	15 percent
Dead Fuel Heat Content	9211 Btu/lb
Live Fuel Heat Content	9211 Btu/lb

When viewed in the "Fuel Model" dialog box (opened with the Configure > Fuel model set selection command), folders and files with a paper clip icon are currently attached to (i.e., accessible for use by) BehavePlus in the current session. Once the Ok button is pressed, only the currently selected folders will have their files attached. Unselected folders will NOT have their files attached, even if they are currently marked as attached by the paper clip icons.



Custom fuel models are selected just like the standard models. They can be selected with the Fuel Model input guide or entering the fuel model code directly into the text box from the keyboard.

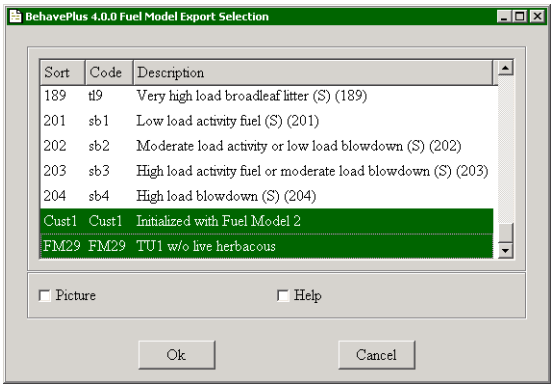




12.5.3. Exporting custom fuel models

Custom fuel models you create and save in BehavePlus can be exported in the Custom Fuel Model (.fmd) file format used by *FARSITE,* NEXUS, and FlamMap. To avoid confusion, remember the distinction between saving and exporting custom fuel models; saving a fuel model lets you reuse it only in another BehavePlus session, while exported fuel models can only be used in an application that uses the Custom Fuel Model (.fmd) file format. Files with a .fmd extension cannot be used in BehavePlus and .bpf files cannot be used in *FARSITE,* NEXUS, or FlamMap.

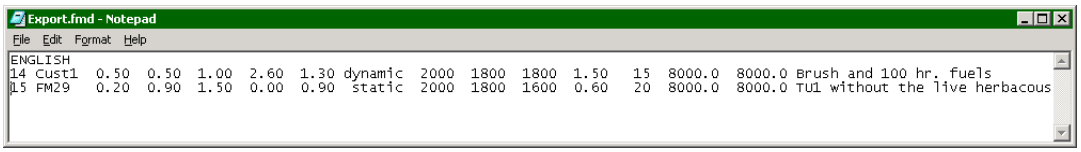
Before you can export a BehavePlus custom fuel model it must be saved and attached. See Sections 12.5.2 and 12.5.1 above for information on saving and attaching custom fuel models.



To export a custom fuel model use the File > saveAs > Fuel model > FARSITE format command. In the "Fuel Model Export Selection" dialog box the attached custom fuel models are found at the end of the standard fuel models list.

For custom fuel models both the Sort and Code columns in the list display the file name truncated to five characters. You select one or more fuel models to export and then click the Ok button. Type the filename in the "Save As" dialog box and BehavePlus will automatically attach a .fmd extension.

The exported .fmd file will look similar to this when viewed in a text editor.



The first field for each fuel model is the fuel model number. Exported fuel models begin with number 14 and continue to 90 if you elect to export that many fuel models. If these fuel model numbers do not match the landscape file in *FARSITE* or FlamMap you should change these to match by editing the exported .fmd file. You may also want to edit the second field, the fuel model code. The default that is exported is the first five characters of the BehavePlus .bpf filename.

13. Moisture scenarios

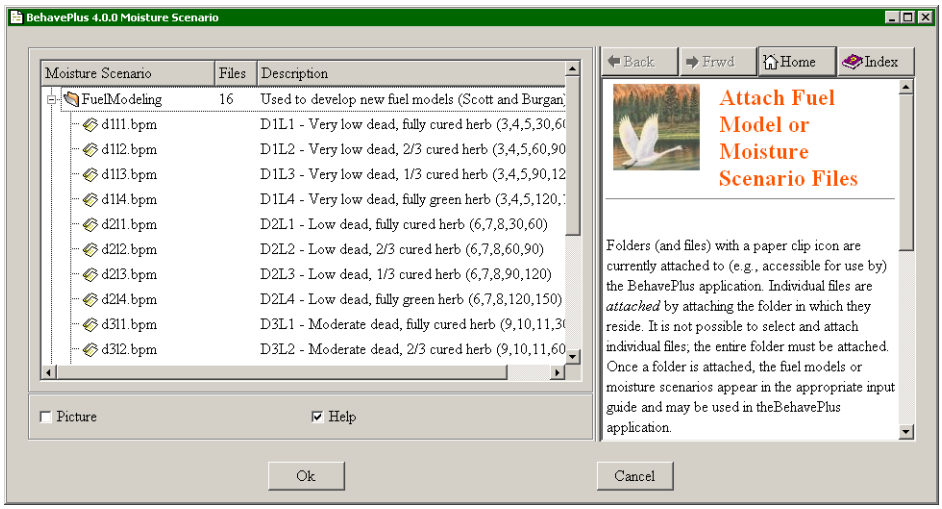
A moisture scenario is a set of fuel moistures for 1-h, 10-h, and 100-h dead fuel and herbaceous and woody live fuel. It is analogous to the fuel model concept in that a single code represents a set of live and dead fuel moisture values. Fuel moisture scenarios may be developed, for example, to represent local 90-, 95-, and 97-percentile weather situations. The set of moisture scenarios used in the old BEHAVE TSTMDL fuel modeling program and the set used to test the 40 standard fuel models are provided with the BehavePlus program.

Fuel model scenarios are for developing and comparing fuel models. They are not designed for fire behavior prediction, in which case actual fuel moisture values should be assigned directly.

13.1. Using previously saved moisture scenarios

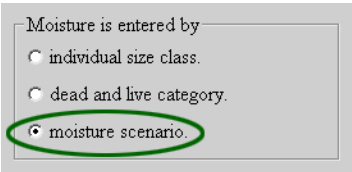
In order to use previously saved moisture scenarios, the folder in which they are stored must be attached. A folder of moisture scenarios is attached using the Configure > moisture scenario set selection command to open the "Moisture Scenarios" dialog box.

Click on a folder's ⊞ to view its moisture scenario files. Each moisture scenario is stored in a separate file. The details of a moisture scenario can be viewed or printed by right-clicking and selecting the appropriate command from the shortcut menu.

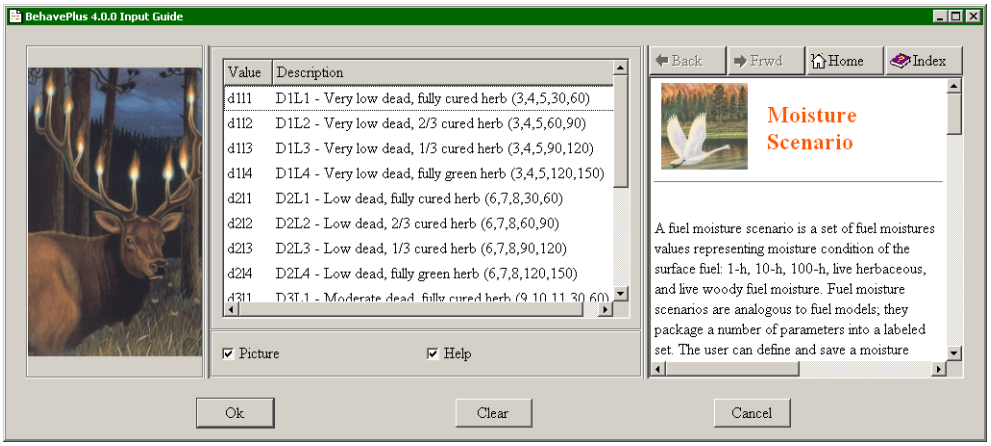


Moisture scenario files are attached by selecting the folder in which they reside and clicking the Ok button in the "Moisture Scenario" dialog box. This makes all the moisture scenarios in that folder accessible for use. It is not possible to select and attach individual moisture scenarios; the entire folder must be attached. For example, one set of the moisture scenarios that come with the BehavePlus program are attached by selecting the FuelModeling folder. Once a moisture scenario folder is attached, its moisture scenarios appear in the Moisture Scenario input guide.

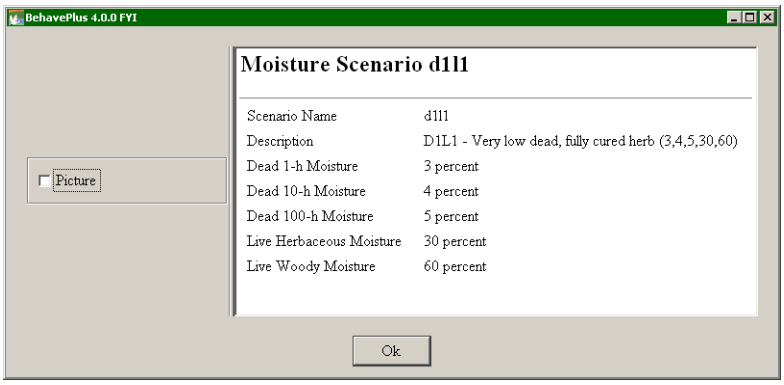
Worksheet options also need to be set to use moisture scenarios. Set up the Worksheet to enter fuel moistures with moisture scenarios using the Configure > Module selection > SURFACE > Options... > Fuel & Moisture tab and select the Moisture is entered by moisture scenario. radio button.



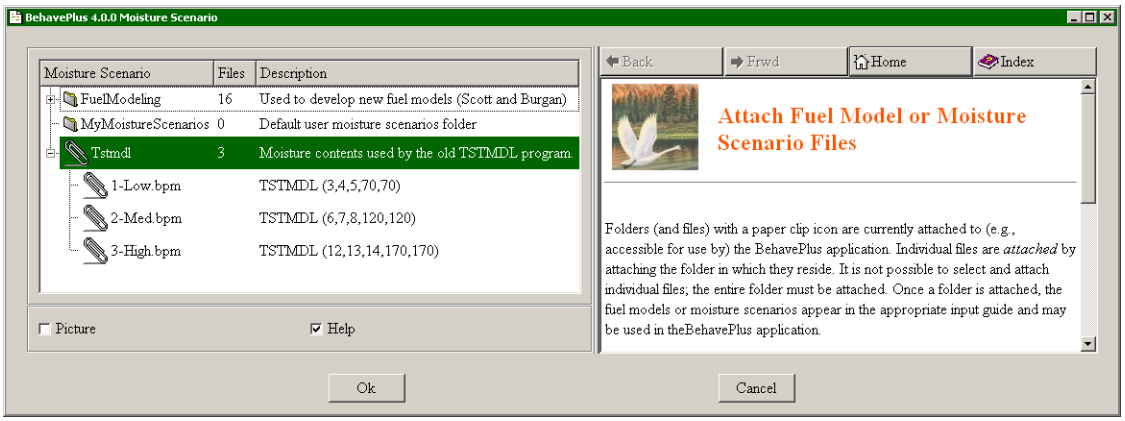
After the FuelModeling moisture scenario folder is attached, the Moisture Scenario Guide button on the Worksheet shows the following valid selections for moisture scenarios in the "Input Guide" dialog box.

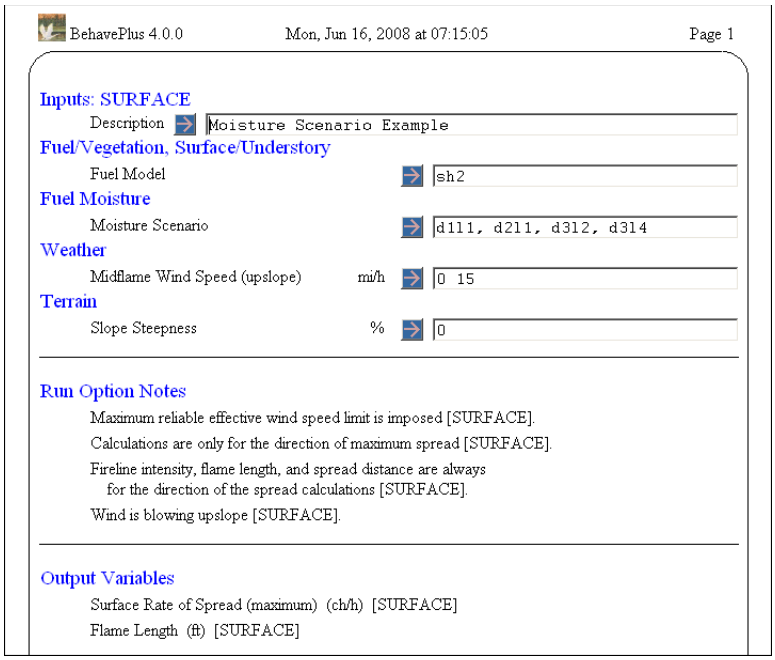


To view the parameters of a particular moisture scenario, right-click on the description and select View parameters from the shortcut men.



When viewing folders (and files) in the "Moisture Scenario" dialog box, those scenarios with a paper clip icon are currently attached to (e.g., accessible for use by) the BehavePlus application. Once the Ok button is pressed, only the selected folders will have their files attached. Currently attached folders will NOT have their files attached if not selected when the Ok button is clicked. Use the Cancel button to maintain the current attached sets.

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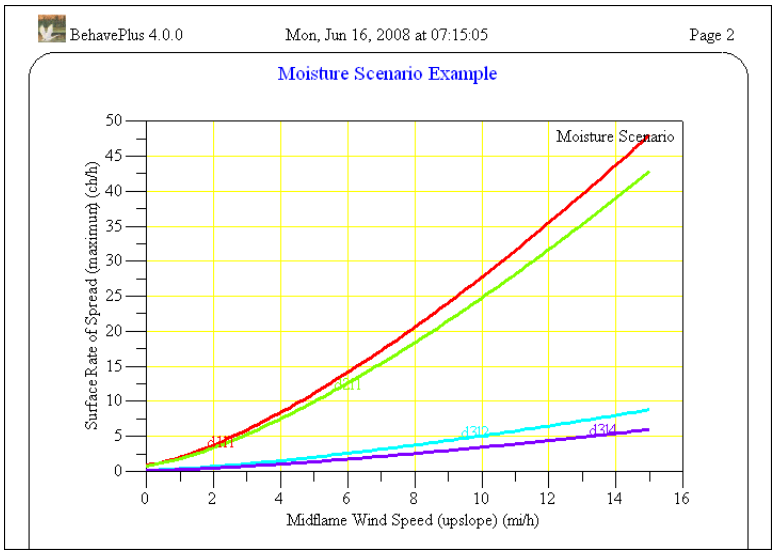
Inputs: SURFACE
Description: Moisture Scenario Example
Fuel/Vegetation, Surface/Understory
Fuel Model: sh2
Fuel Moisture
Moisture Scenario: d111, d211, d312, d314
Weather
Midflame Wind Speed (upslope) mi/h: 0 15
Terrain
Slope Steepness %: 0

Run Option Notes
Maximum reliable effective wind speed limit is imposed [SURFACE].
Calculations are only for the direction of maximum spread [SURFACE].
Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].
Wind is blowing upslope [SURFACE].

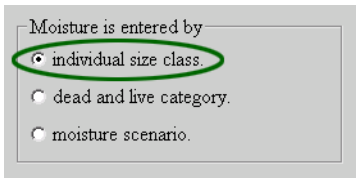
Output Variables
Surface Rate of Spread (maximum) (ch/h) [SURFACE]
Flame Length (ft) [SURFACE]

This Worksheet creates the following graph. The fuel model used is a dynamic type, and the output graph indicates the dramatic effect the live fuel moisture can have when using a dynamic fuel model.

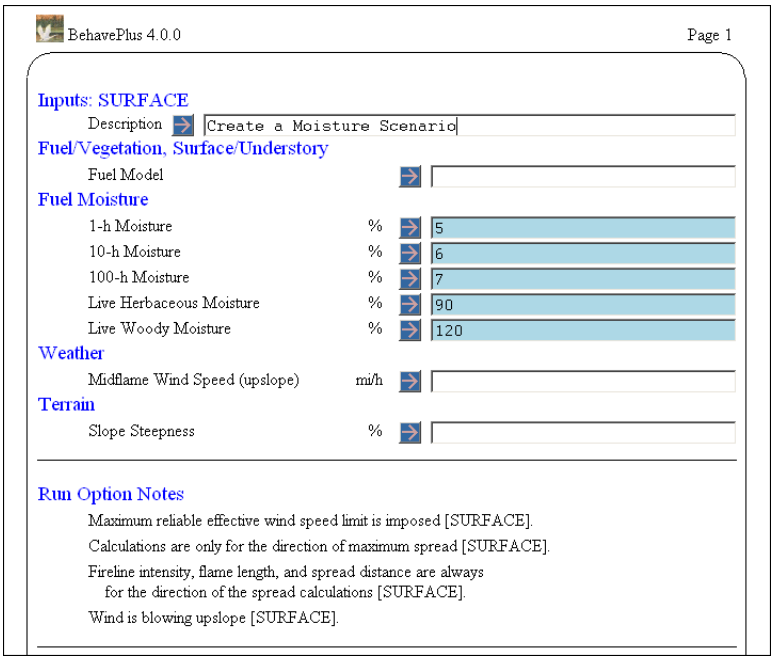


13.2. Defining and saving moisture scenarios

To define a Moisture Scenario first set the Worksheet to require individual fuel moisture values by selecting individual size class in the Configure > Module selection > SURFACE > Options... > Fuel & Moisture tab.



Enter values for each size class on the Worksheet, even if that item is shaded. Other input text boxes don't matter.



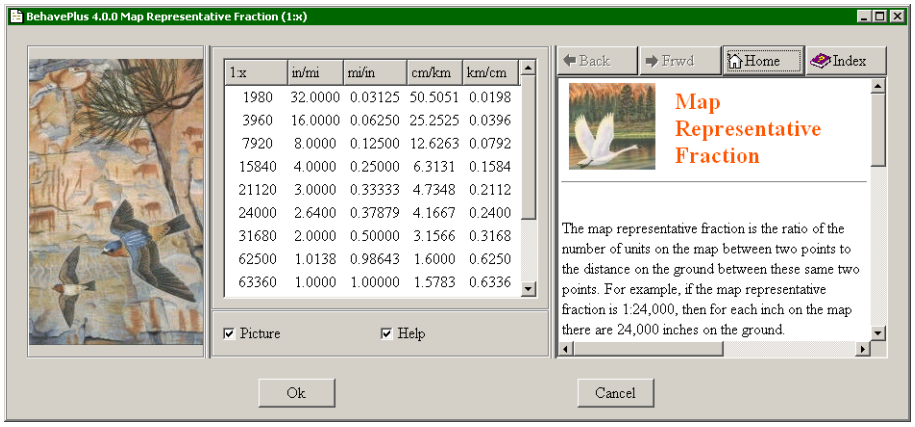
Save the moisture scenario with the File > saveAs > Moisture scenario command. In the "Save As" dialog box enter a file name in the Moisture Scenario File text box and a short description in the Moisture Scenario Description text box. See Section 18.4, Save As…, for more information on saving moisture scenarios.

14. Map applications

BehavePlus allows the calculation of slope steepness from map measurements and conversion of distances to map measurements.

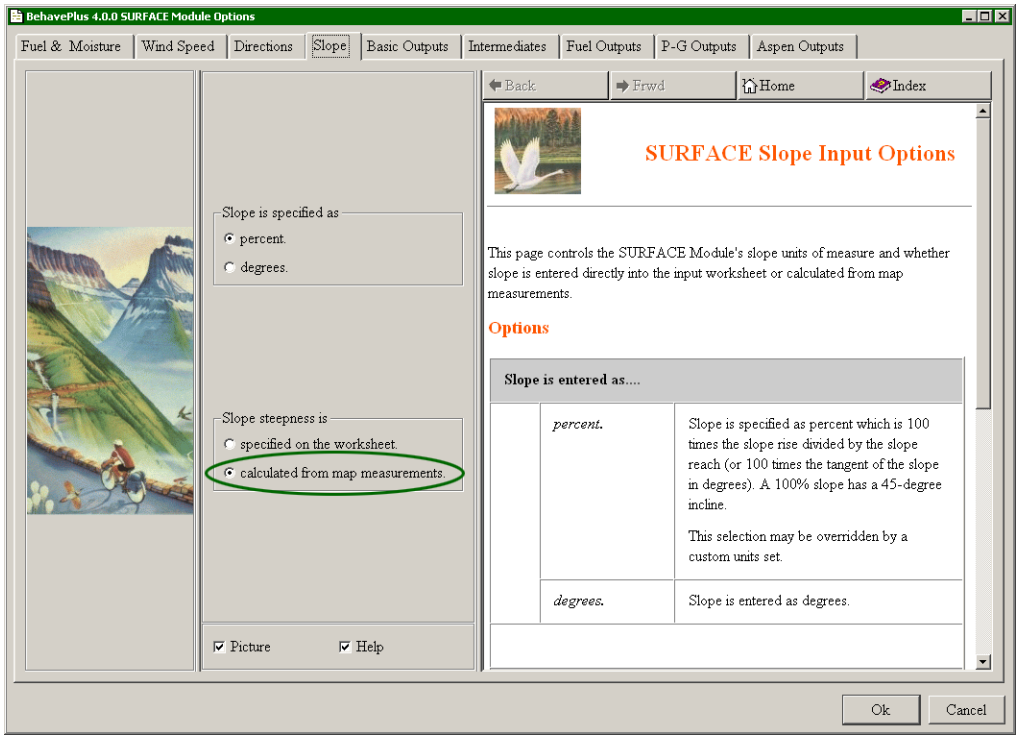
Map scale is given as map representative fraction, which is the ratio of the number of units on the map between two points to the distance on the ground between the same two points. For example, if the map representative fraction is 1:24,000, then for each inch on the map there are 24,000 inches on the ground.

Although any value can be entered, the "Input Guide" dialog box provides common map scales, available by clicking the Choices button.

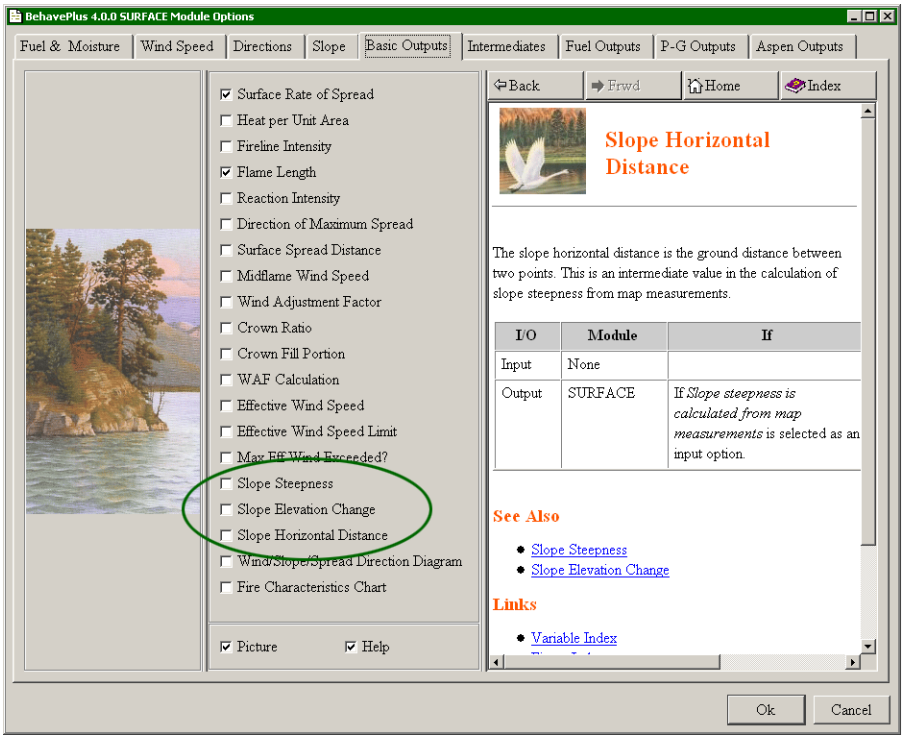


14.1. Slope from map measurements

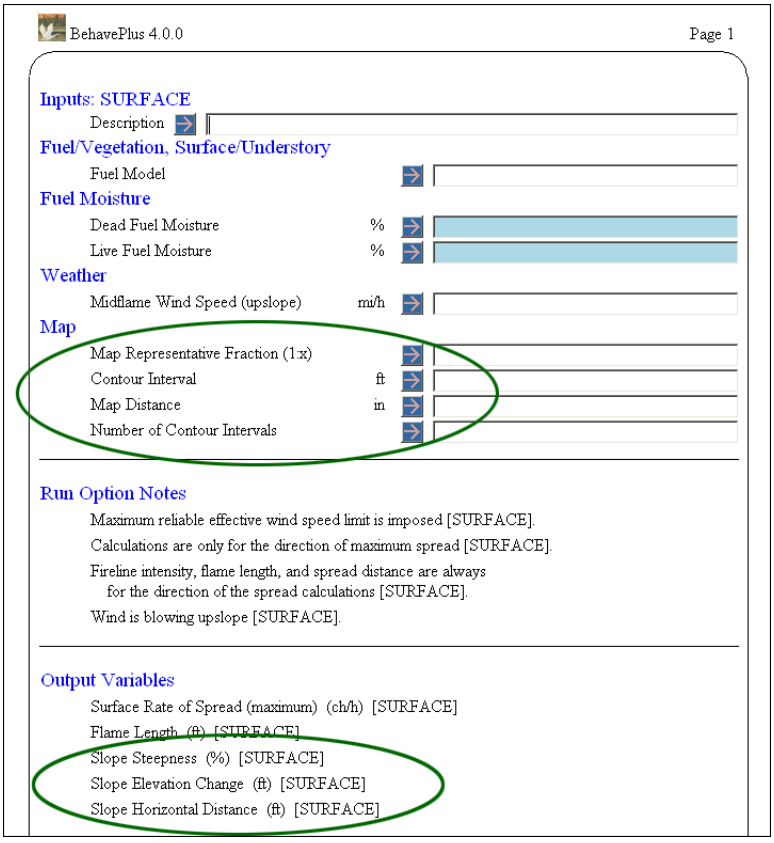
To set up a Worksheet to calculate slope steepness from measurements on a topographic map use the Configure > Module selection > SURFACE > Options... > Slope tab and select the Slope steepness is calculated from map measurements radio button.



You can add the calculated slope steepness and intermediate values to the output list with the Configure > Module selection > SURFACE > Options... > Outputs tab. Select any or all of the Slope Steepness, Slope Elevation Change, or Slope Horizontal Distance check boxes.



The Worksheet then includes a Map section with text boxes for data.

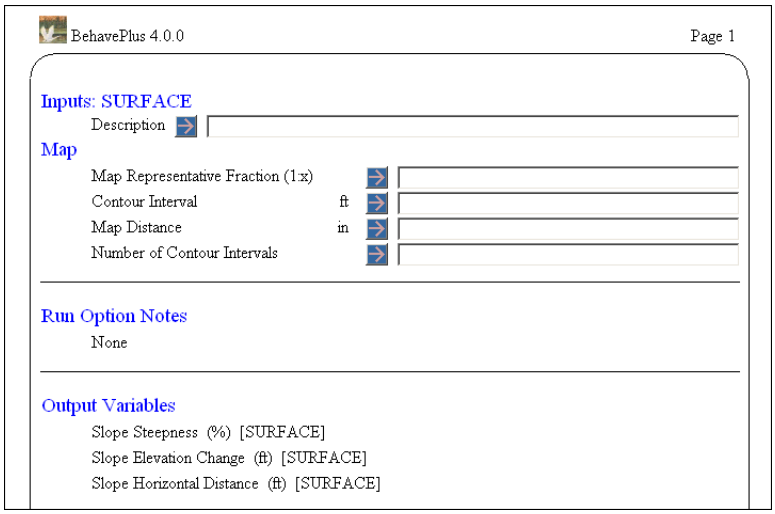


The contour interval is the difference in elevation between adjacent topographic contours on a topographic map.

The map distance is the distance between two points on a map generally expressed in inches or centimeters.

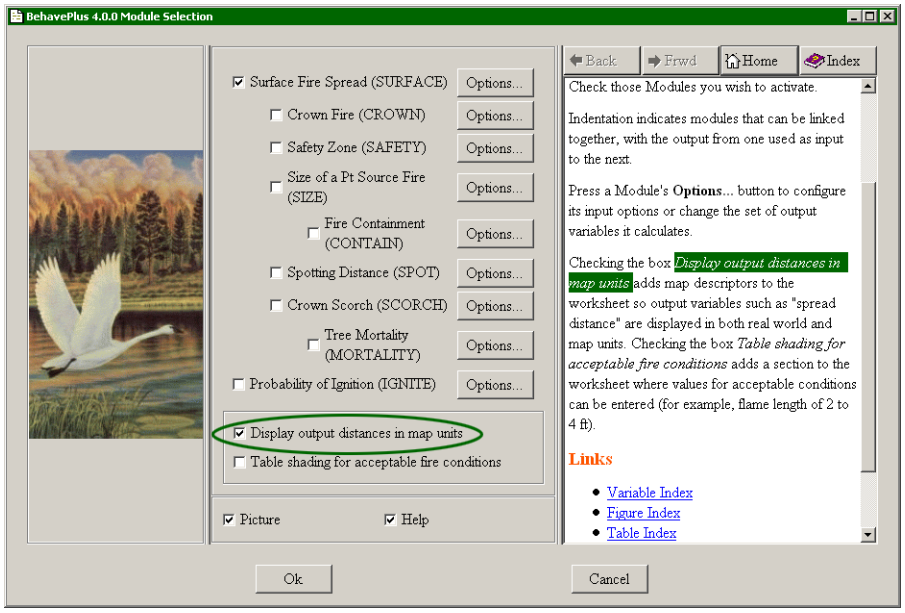
Number of contour intervals is a count between two points on a map.

If only slope values are requested as output, then only Map input variables are requested.



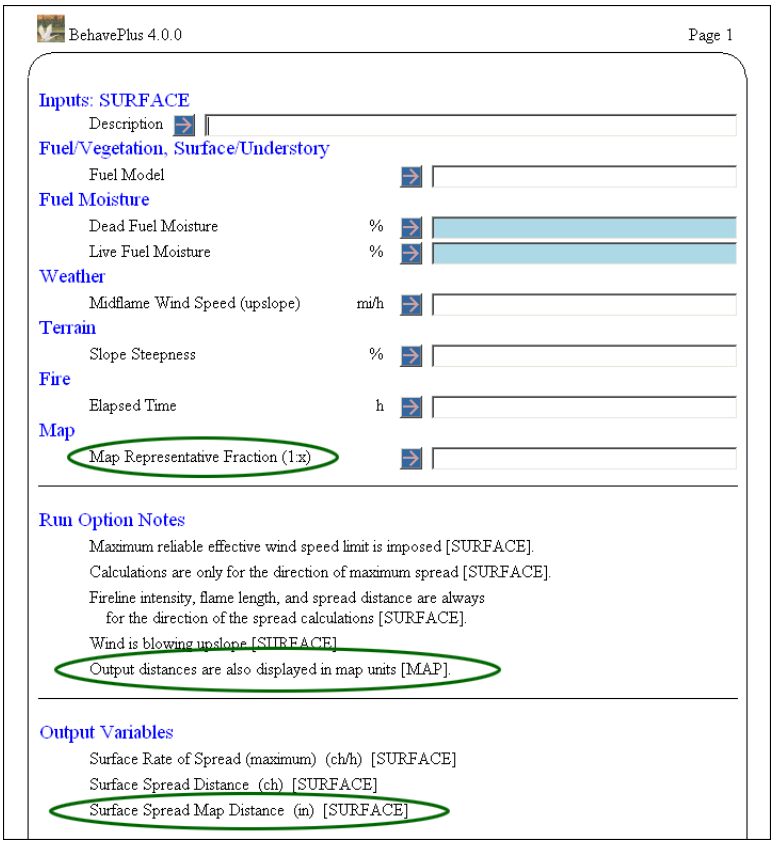
14.2. Map distances

To specify that output calculated distances should also be given in map units use the Configure > Module selection command and select the Display output distances in map units check box below the list of modules.



When a distance is calculated in SURFACE, SIZE, or SPOT and the Display output distances in map units check box is selected, a Map Representative Fraction (1:x) text box is added to the Worksheet and map distances are added to the list of output variables.

For example, when the Spread Distance check box is selected in the Configure > Module selection > SURFACE > Options... > Outputs tab the following Worksheet results: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Inputs: SURFACE
Description
Fuel/Vegetation, Surface/Understory
Fuel Model
Fuel Moisture
Dead Fuel Moisture %
Live Fuel Moisture %
Weather
Midflame Wind Speed (upslope) mi/h
Terrain
Slope Steepness %
Fire
Elapsed Time h
Map
Map Representative Fraction (1:x)

Run Option Notes
Maximum reliable effective wind speed limit is imposed [SURFACE].
Calculations are only for the direction of maximum spread [SURFACE].
Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].
Wind is blowing upslope [SURFACE].
Output distances are also displayed in map units [MAP].

Output Variables
Surface Rate of Spread (maximum) (ch/h) [SURFACE]
Surface Spread Distance (ch) [SURFACE]
Surface Spread Map Distance (in) [SURFACE]

15. Units and Decimals

Default units for BehavePlus are English for use in the United States. It is easy to change all units to metric using the Configure > Units set selection > Metric command.

If a user wishes to use something other than the units we have selected for English or metric, a custom set of units can be defined and saved for later use.

The Units set also defines the number of decimal places displayed for each variable.

Note that whenever a Worksheet or Run is saved, its current units of measure and display decimals are saved with it. The next time you open the Worksheet or Run, the units and decimal settings are restored.

BehavePlus also provides a quick units conversion tool accessed with the Tools > Units converter command.

15.1. English or metric

The units set can be changed using the Configure > Units set selection > English or Metric or Custom commands.

Immediately upon change, the units on the active Worksheet and all values that have been entered are changed.

Because units are stored with a Worksheet or Run, if units are changed to metric and then another Worksheet is loaded from the ExamplesWorksheets folder, with the File > Open worksheet command, the new Worksheet will use English units.

15.2. Custom units set

Develop and save a custom units set using the "Units Editor" dialog box opened with the Configure > Custom units preferences command.

The "Units Editor" dialog box controls the selection of units of measure and decimal places for the input, display, and output of variables. The selected units are then applied to the current Worksheet and can be saved as a custom units set.

The units of measure initially displayed by the dialog are those in use for the current Worksheet.

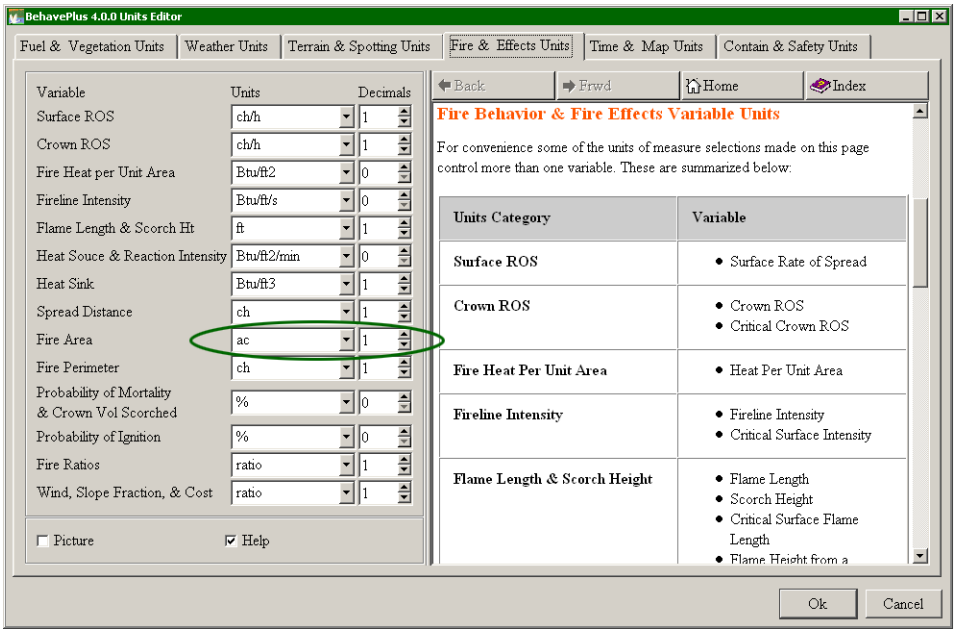
Select the desired units for each variable set. Rather than repetitiously having to enter units for every variable, they are grouped by type of unit of measure. The help window lists the groupings.

Once you have defined and saved a custom units set, you can apply it to a Worksheet or Run with the Configure > Units set selection > Custom command that opens the "Select A Units Set" dialog box.

15.3. Number of decimal places

In addition to setting units of measure, the "Units Editor" dialog box also allows you to change the number of digits displayed after the decimal place of all input and output variables.

For example, the variable Fire Area has 1 decimal place as the default. You may want to round area to the nearest acre by changing the number of decimals to 0.



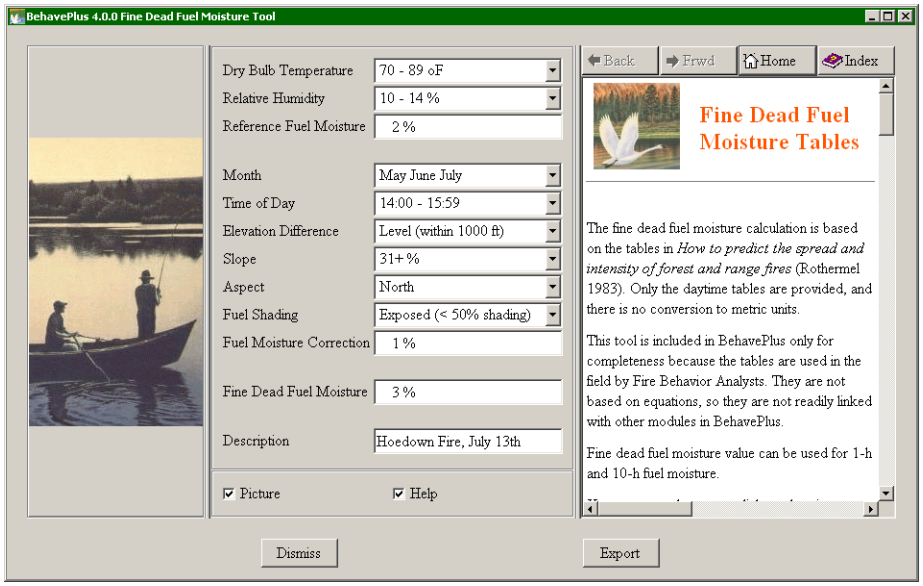
16. Tools

BehavePlus tools are stand-alone utilities. They are not linked with any other modules or calculations.

16.1. Fine Dead Fuel Moisture

This tool is an automation of only the *daytime* tables from Rothermel (1983). Since these tables are not based on equations, they can't effectively be linked to any other tools or modules in BehavePlus.

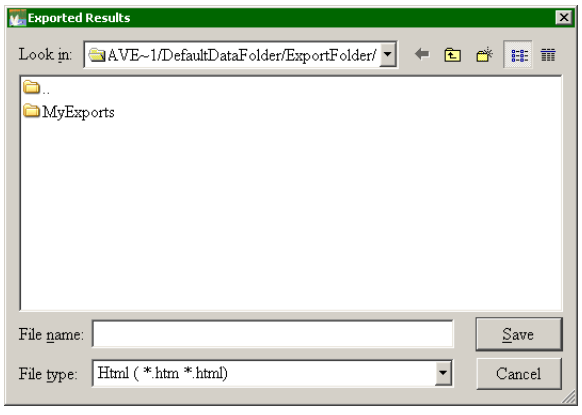
The "Fine Dead Fuel Moisture Tool" dialog box can be accessed with the Tools > Fine dead fuel moisture command.



Inputs are made through the drop down lists. As soon as a change is made, the results are displayed.

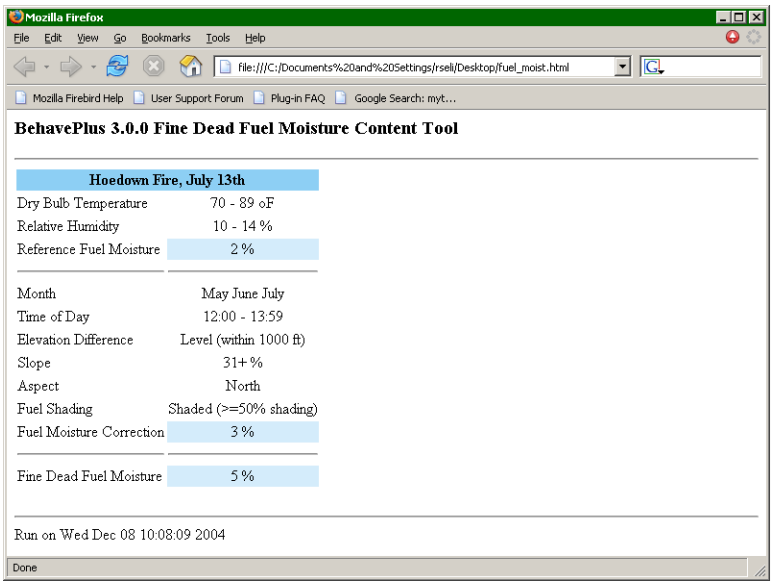
You can save fine dead fuel moisture inputs and results as a HTML file by clicking the Export button. The Description text box at the bottom of the input section allows you to describe a header for the saved results.

When the Export button is clicked, a "Exported Results" dialog box appears.



You may navigate to any drive or directory and select an existing file or specify a new file name. The default location for exporting is the ExportFolder. If you haven't already done so, you should think about your file management and design a structure for you project. (see Chapter 17: File Management)

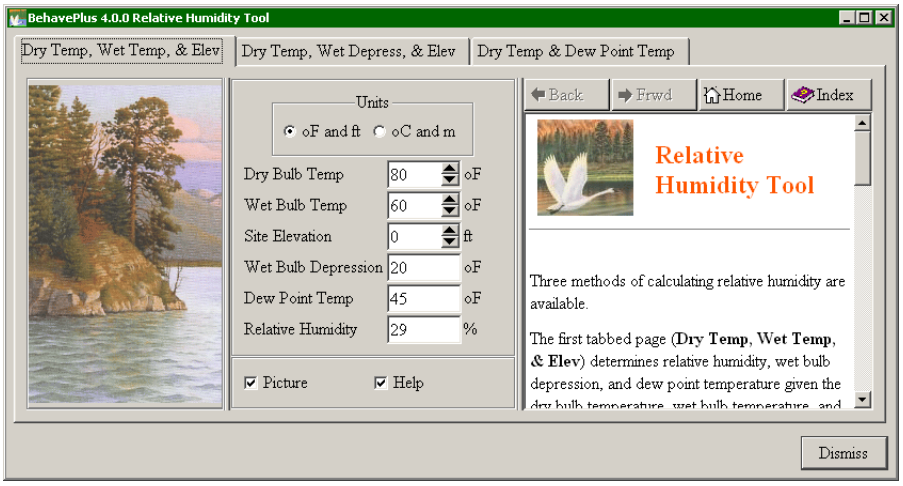
If you select an existing file, a popup will ask you to confirm overwriting the existing file. If you specify a new file without a ".html" or ".htm" extension, a ".html" extension is automatically added. The contents of the "Fine Dead Fuel Moisture Tool" dialog box are then written to the file in HTML format.



You may view the results using any web browser such as FireFox, Mozilla, or Internet Explorer. You may also attach the file to E-mail, or post it to a web site. You can open the exported HTML file with a spreadsheet application.

16.2. Relative Humidity

The "Relative Humidity" dialog box is opened with the Tools > Relative Humidity command.



The "Relative Humidity" dialog box provides three ways to calculate relative humidity depending on available inputs, a tab for each method.

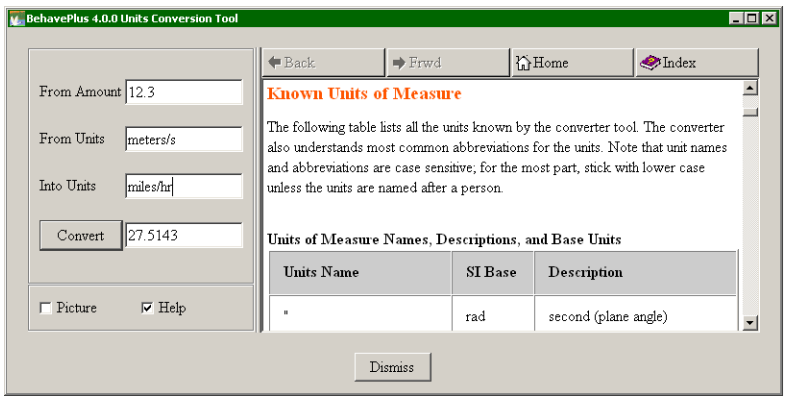
- All three methods require Dry Bulb Temperature as an input.
- The first tab utilizes a Wet Bulb Temperature input, the Dry Temp, Wet Depress, & Elev tab uses the Wet Bulb Depression (the difference between Wet and Dry Bulb Temperatures), and the third tab uses the Dew Point Temperature.
- The first and second tabs also require the Elevation of the temperature observations.

On all three tabs the spin boxes are used to enter the required inputs. The plain text boxes display the outputs and immediately change with input changes.

Remember the RH Tool is a stand alone utility, it does not link to any other tools or modules.

16.3. Units Converter Tool

For all those times when somebody gives you an observed spread rate in furlongs/fortnight or you just need to know what the temperature is at that Canadian RAWS station just across the border, BehavePlus has a utility you can reach with the Tools > Units converter command.



In the "Units Conversion Tool" dialog box enter your known observation into the From Amount and From Units text boxes (12.3 meters per second in the above example). Then enter the desired units in the Into Units text box and click the Convert button to get your results (27.5143 miles per hour in the above example).

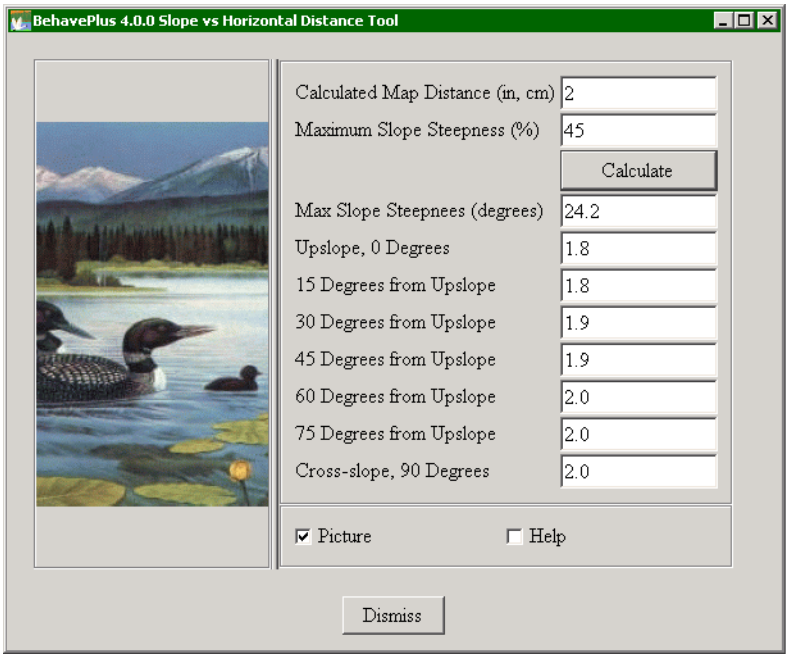
In the "Help" pane of the "Units Conversion Tool" dialog box there is a list of all the available units.

16.4. Slope vs horizontal map distance

The "Slope vs Horizontal Distance Tool" dialog box is opened by selecting the Tools > Slope vs horizontal map distance command.

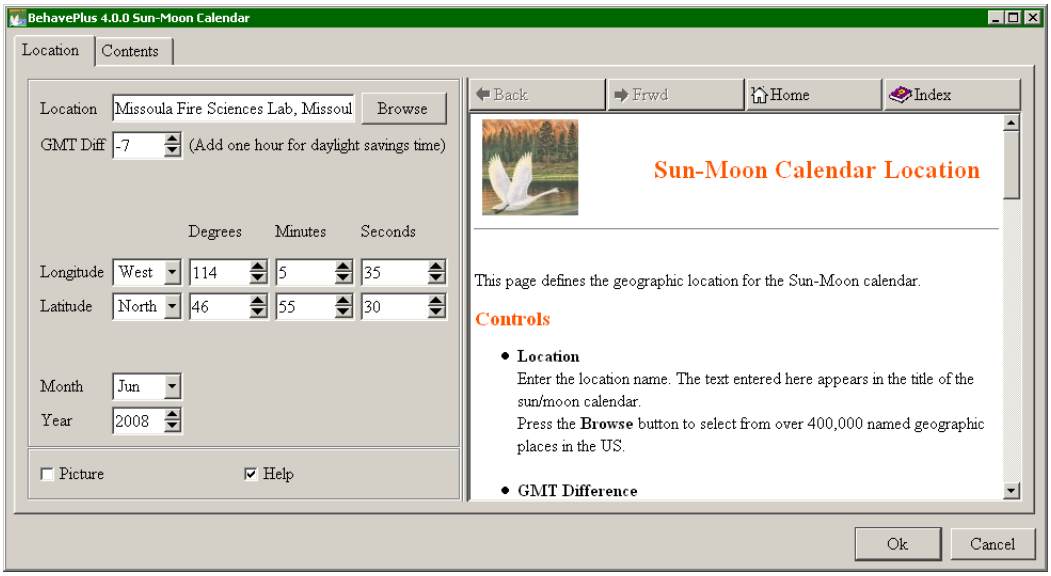
When you select the Display output distances in map units check box from the "Module Selection" dialog box, map distance is found by multiplying slope distance by map scale. This is not technically correct. But because of the many variables that exist in the real world, the difference between slope distance and horizontal distance is not critical. This tool allows you to do the conversion in case you want to make the correction

before you plot the distance on a map. Rather than ask the user to input the direction with respect to the direction of steepest slope, several common options are calculated.



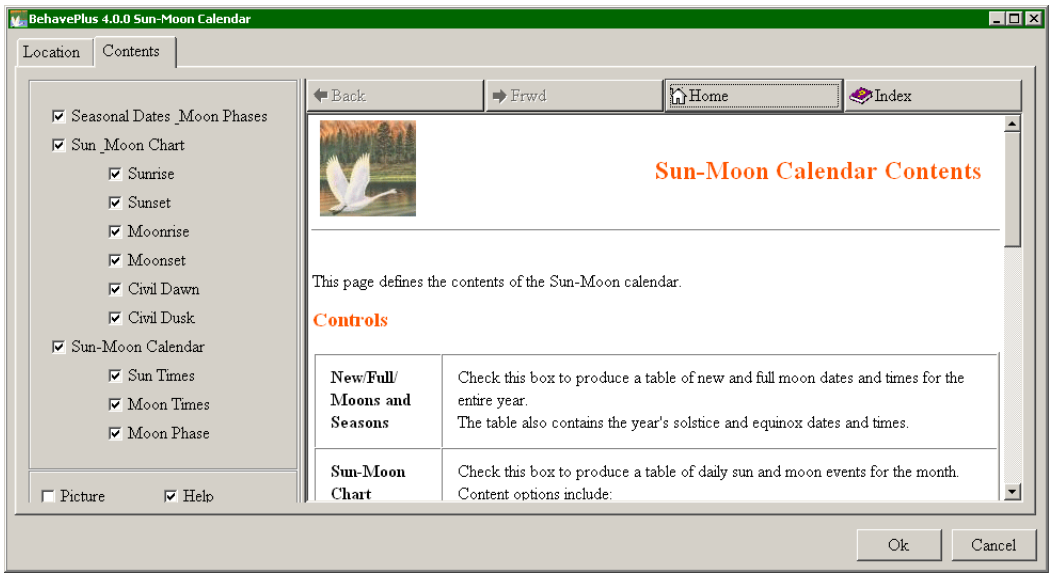
16.5. Sun-Moon Calendar

The "Sun-Moon Calendar" dialog box is opened with the Tools > Sun-moon calendar command.



The Location tab allows you to specify any month of any year at a location on the globe. The tool also includes a large database of named places within the United States so you can select a location by name rather than by coordinates.

The Contents tab lets you select the outputs you need.



You can generate sun-rise, sun-set, civil dawn, civil dusk, moon-rise, and moon-set times in table or calendar format. It can also display a table of equinox, solstice, and moon phases for the year.

Example table of sun-rise, sun-set, civil dawn, civil dusk, moon-rise, and moon-set times.

Page 2

Sun & Moon Chart
Missoula Fire Sciences Lab, Missoula, Montana
June 2008
(Lon 114.093, Lat 46.925, GMT -7.0)

Day	Sunrise	Sunset	Moonrise	Moonset	Civil Dawn	Civil Dusk
Sun 1	04:45	20:23	02:44	18:23	04:06	21:02
Mon 2	04:44	20:24	03:17	19:50	04:05	21:03
Tue 3	04:43	20:25	04:02	21:09	04:05	21:04
Wed 4	04:43	20:26	05:02	22:13	04:04	21:05
Thu 5	04:42	20:27	06:16	23:01	04:04	21:06
Fri 6	04:42	20:27	07:38	23:36	04:03	21:07
Sat 7	04:42	20:28	09:01	-----	04:03	21:08
Sun 8	04:41	20:29	10:20	00:01	04:02	21:08
Mon 9	04:41	20:29	11:35	00:22	04:02	21:09
Tue 10	04:41	20:30	12:45	00:39	04:02	21:10
Wed 11	04:41	20:30	13:53	00:55	04:01	21:10
Thu 12	04:41	20:31	15:01	01:12	04:01	21:11
Fri 13	04:40	20:32	16:08	01:29	04:01	21:12
Sat 14	04:40	20:32	17:16	01:49	04:01	21:12
Sun 15	04:40	20:32	18:22	02:12	04:01	21:13
Mon 16	04:40	20:33	19:27	02:42	04:01	21:13
Tue 17	04:40	20:33	20:24	03:20	04:01	21:13
Wed 18	04:40	20:34	21:13	04:07	04:01	21:14
Thu 19	04:41	20:34	21:53	05:04	04:01	21:14
Fri 20	04:41	20:34	22:24	06:08	04:01	21:14
Sat 21	04:41	20:34	22:49	07:17	04:01	21:14
Sun 22	04:41	20:34	23:10	08:27	04:02	21:15
Mon 23	04:42	20:34	23:29	09:39	04:02	21:15
Tue 24	04:42	20:35	23:46	10:49	04:02	21:15
Wed 25	04:42	20:35	-----	12:02	04:03	21:15
Thu 26	04:43	20:35	00:03	13:16	04:03	21:15
Fri 27	04:43	20:34	00:21	14:34	04:04	21:14
Sat 28	04:44	20:34	00:44	15:57	04:04	21:14
Sun 29	04:44	20:34	01:12	17:22	04:05	21:14
Mon 30	04:45	20:34	01:50	18:43	04:05	21:14

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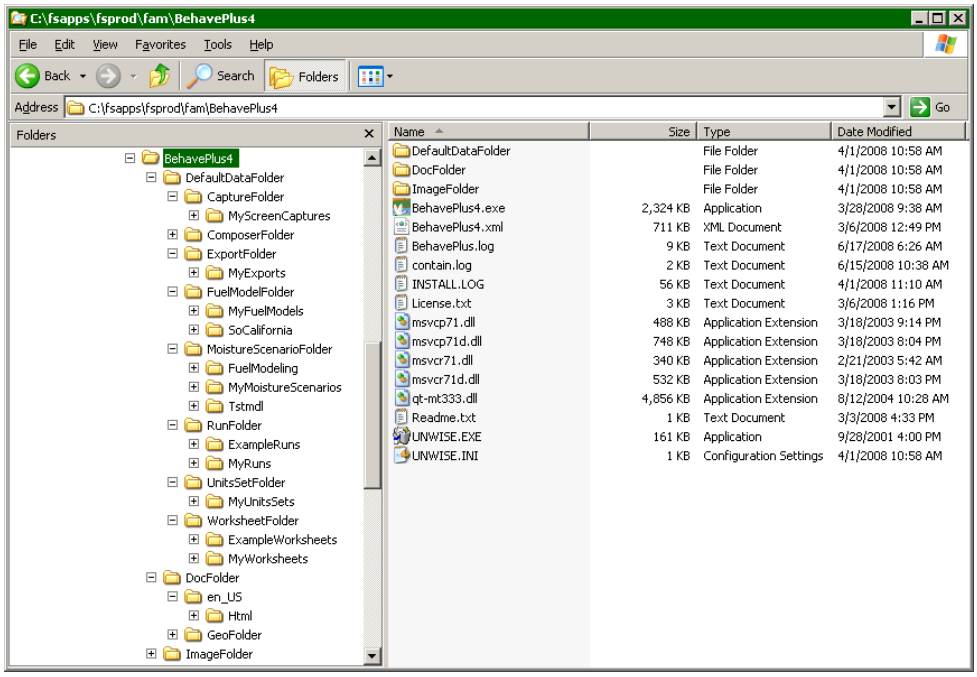
17. File management

17.1. Workspaces

BehavePlus has a proscribed file system structure; all files must be located in specific subdirectories. The parent directory of this file structure and all its subdirectories and files are collectively known as a Workspace.

A Workspace is a complete subdirectory tree containing all required BehavePlus files plus any additional Worksheet, Run, Fuel Model, Moisture Scenario, Units Set, or screen capture files saved by the user. A Workspace can correspond to a single BehavePlus project. Workspaces are created with either the File > Workspaces > New workspace or Clone current workspace commands.

When BehavePlus is first installed it has a single Workspace called "DefaultDataFolder". This is the default current Workspace every time BehavePlus is started.



We recommend you create a new Workspace using the File > Workspaces > New Workspace command for every BehavePlus project you're working on. A project can be a collection of fire behavior projections for a wildfire or a fuels analysis for an environmental impact statement. The new, "pristine" Workspace is automatically populated with all example Worksheets, example Runs, and standard and predefined custom fuel models just like the DefaultDataFolder Workspace.

Alternatively, you may clone an existing Workspace with the File > Workspaces > Clone current workspace command to copy all of the current Workspace into a new Workspace, including all Run, Units Sets, custom Fuel Models, and custom Moisture Scenarios.

The Workspace concept provides the following benefits:

- All files pertaining to a specific training class, fire situation, or other project are segregated into their own file structure.
- Workspaces are easily backed up or copied onto removable media using either the File > Workspaces > Clone current workspace command or Windows Explorer.
- BehavePlus has self-validation tests and informs you whenever it is missing required files.
- BehavePlus knows where to find all custom Fuel Models and Moisture Scenarios and include them in Guide Button dialog boxes.

We recommend using a compression utility such as WinZip, PKZip, or gzip when E-mailing or moving a Workspace over the Internet as compression significantly reduces BehavePlus file sizes.

A list of three letter file extensions used by BehavePlus is shown in the following table. These extensions are automatically attached to the files you create in BehavePlus.

File extension	File type	Folder
.bpf	Custom fuel models	FuelModelFolder
.bpm	Moisture scenarios	MoistureScenarioFolder
.bpw	Worksheets	WorksheetFolder
.bpr	Runs	RunFolder
.bpu	Custom Units Sets	UnitsSetFolder
.exe	Executable program file	BehavePlus
.png	Portable network graphic image format	MyScreenCaptures
.bmp	Bitmap graphic image format	MyScreenCaptures
.jpg	JPEG graphic image format	MyScreenCaptures
.xml	Extensible Markup Language	Various places

17.2. Load a Worksheet

A previously saved Worksheet is loaded with the File > Open worksheet command, which opens the "Select a Worksheet" dialog box.

The Worksheet is 'blank' in that none of the input variables have been assigned values. But all of the associated options are still part of the Worksheet (e.g., graph appearance).

17.3. Load a Run

A previously saved Run is loaded through File > Open Run command, which opens the "Select a Run" dialog box.

A Run is a Worksheet with valid values assigned to all input variables. Calculated values, tables, graphs, and diagrams are not saved. These are generated with the File > Calculate command.

17.4. Save as...

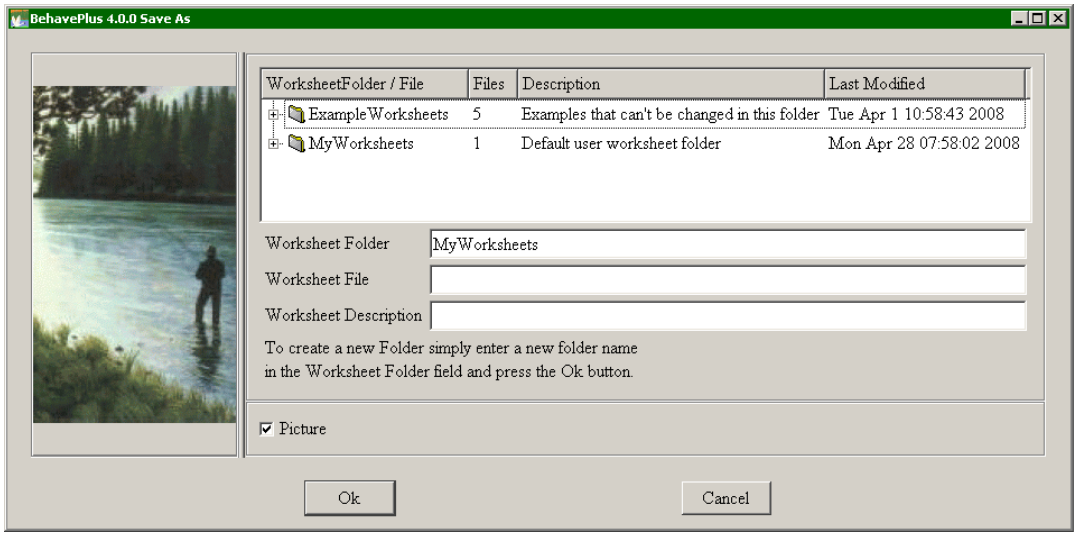
There are five File > saveAs... commands offering several choices of what to save from the active Worksheet or Run:

- File > Save as a worksheet - When a Worksheet is saved, it is saved without any values assigned to input variables. The Worksheet can be opened at a later time using the File > Open worksheet command or the toolbar button.
- File > Save as a run - A Run can be saved only if all valid values have been assigned to all variables on the Worksheet. The Run can be opened at a later time using the File > Open run command or the toolbar button.
- File > Save as a fuel model - Fuel models can be saved in either BehavePlus or the *FARSITE* Custom Fuel Model (.fmd) format. Before saving a fuel model make sure the SURFACE module check box is selected and the fuel parameters check box is selected in the Fuel is entered as section of the

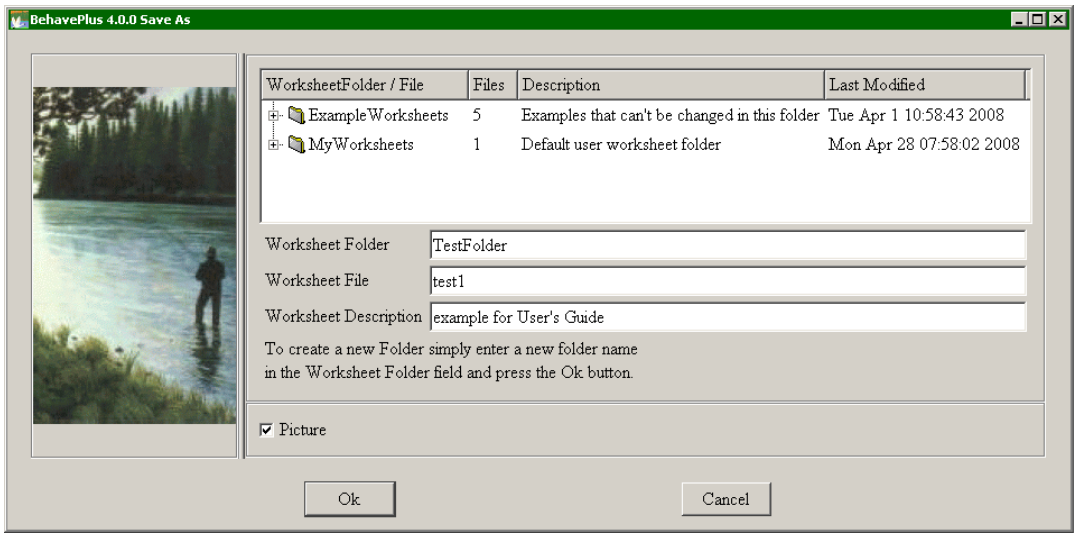
SURFACE > Options... > Fuel & Moisture tab. Valid values must be assigned to each fuel model parameter. Also make sure the Fuel Model Type parameter is correct, dynamic (D) fuel models must have a live herbaceous fuel load. (see Section 12.4) To use custom fuel models at a later time they must be attached with the Configure > Fuel model set selection command. (see Section 12.5.2)

- File > Save as a moisture scenario - Before saving a moisture scenario make sure the SURFACE module is selected and the individual size class check box is selected in the Moisture is entered by section of the SURFACE > Options... > Fuel & Moisture tab. Valid values must be assigned to each size class, even those that are shaded. To make a moisture scenario available use the Configure > moisture scenario set selection command. (See Section 13.2)
- File > Save as an image - Images of table, graph, and diagram screens can all be saved as an image file. The image file can then be edited with an image processor or inserted into word processor or layout documents. (See Section 10.5.1)

The following example saves a Worksheet. The process is similar for other file types. The File > Save as a worksheet command requests input of folder name, file name, file description, or file type in the "Save As" dialog box.



In this case, the Worksheet Folder text box is initially set to MyWorksheets. To create a new folder, simply type a new name into the Worksheet Folder text box: TestFolder in the example below.



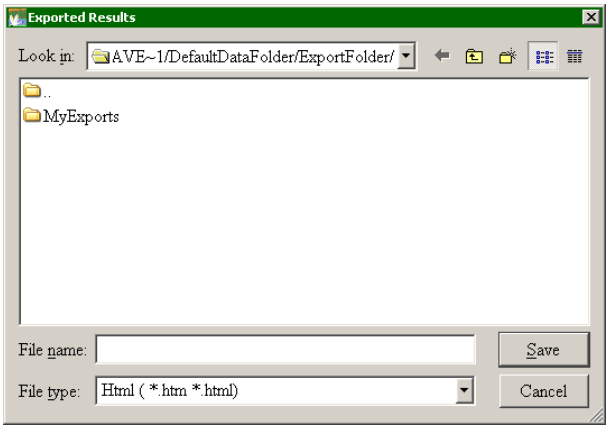
You are asked to enter a Worksheet folder description. The folder description subsequently appears in the file selection dialog box as a reminder of its contents. The Worksheet description is initially set to whatever is in the Description text box on the Worksheet. When saving a Worksheet, you should assure that it describes the blank Worksheet, not the specific Run.

17.5. Deleting Files & Folders

Files and folders in a BehavePlus Workspace are deleted using Windows Explorer. However you should only delete files and folders you create, not any of the files and folders BehavePlus automatically creates for the Workspace.

17.6. Export Results

Table output can be saved as an HTML file using the File > Export Results command. The default location is the ExportFolder, but you can save results to any location.



The HTML file can be viewed with a web browser or used in a web page. It is a compact format to email BehavePlus outputs.

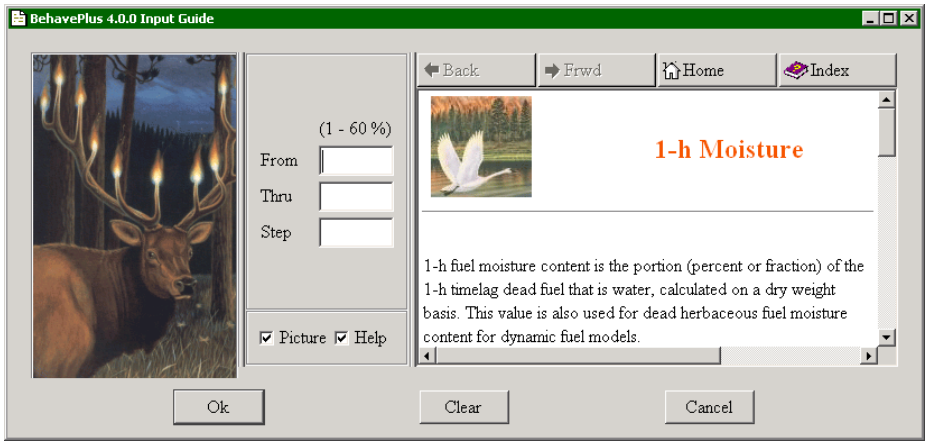
HTML files can be opened with a spreadsheet application such as Microsoft Excel. If tables are reformatted, plotted, or if additional analysis is done, save the your work in the spreadsheet file format.

18. Help

The Help system is a primary feature of BehavePlus. The Users Guide and Variables paper are available from the menu bar, and all dialogs and wizards include a help browser pane. Input fields include a Guide button for help in entering range inputs or selecting one or more discrete choices.

18.1. Browser pane help

The right-hand pane of many BehavePlus dialog boxes is a help browser. These can be printed by right-clicking in the help window to display a shortcut menu and selecting the appropriate command.

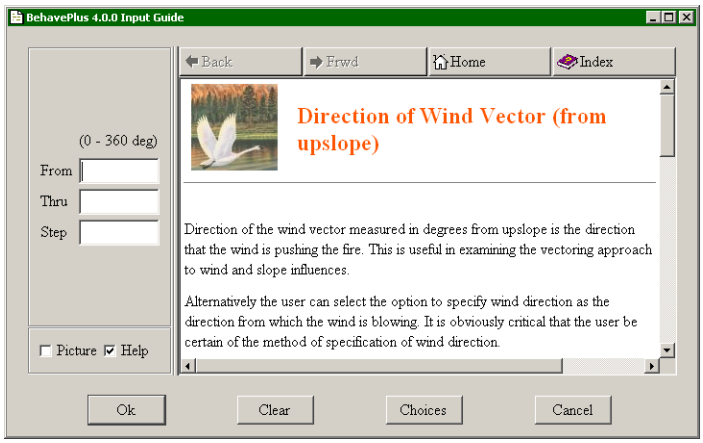


It includes a description of input variables when the guide button associated with the variable on the Worksheet is clicked. It includes a description of output variables when the cursor is held over a variable name on the list of possible output variables for a MODULE, reached through Configure > Module selection > MODULE > Options... > Outputs tab.

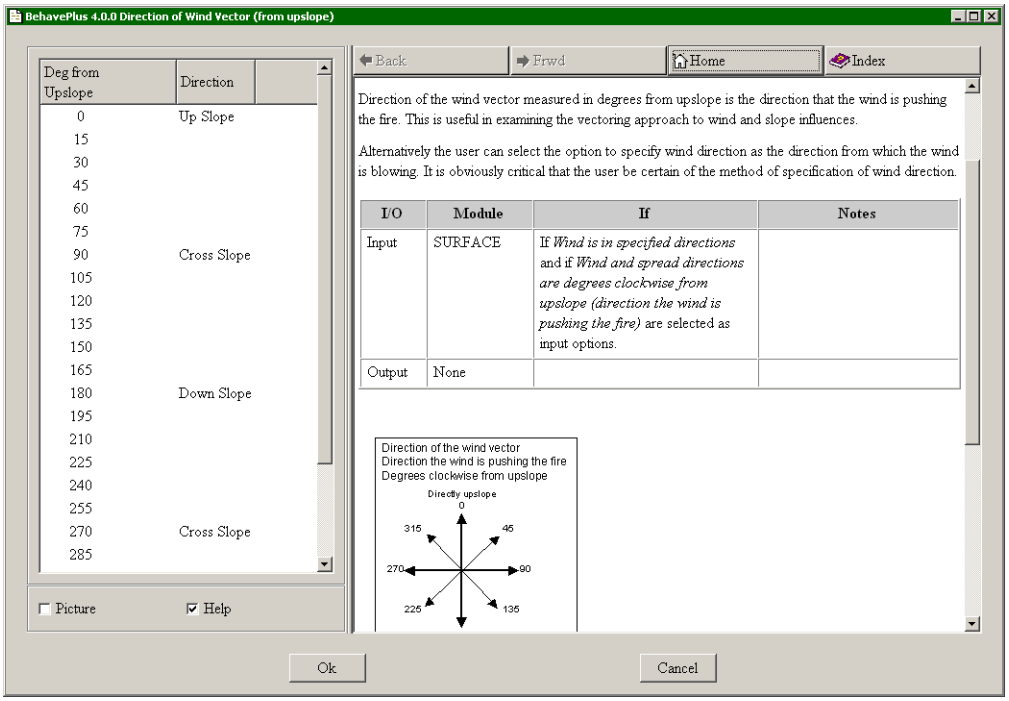
For each variable, information includes a description of the variable and a table showing the modules that use it. Some variables have additional descriptions, diagrams, and tables.

18.2. Guide button

Help on entering a specific Worksheet variable is available by pressing the Guide button next to each Worksheet entry field to activate an "Input Guide" dialog box containing a help browser pane and input assistance. For continuous variables, the dialog facilitates entry of a large number of inputs by specifying the minimum input value, maximum input value, and increment value.



Additional values are sometimes displayed by clicking the Choices button where available in the "Input Guide" dialog box.



For discrete variables the dialog contains a list of all valid inputs from which the user may select values.

18.3. User's Guide

This User's Guide can either be printed or accessed interactively using a PDF viewer such as Adobe Acrobat Reader. It serves as the online help for operation of the BehavePlus application. It can be opened with the Help > User's Guide command. When viewed with the Adobe Acrobat Reader, the contents at the left provide access to the section in question.

18.4. Variables paper

The Variables paper (Andrews 2008) can be either printed or accessed interactively using a PDF viewer such as Adobe Acrobat Reader. It includes descriptions of the many input and output variables in BehavePlus. It can be opened by selecting the Help > Variables command. When viewed on the computer screen, the contents at the left provide access to the section in question. There is also an alphabetical list of variables, a table of input variables, with the modules that use them, and a table of output variables available from each module. There are many hyperlinks in the document, which make it most valuable when viewed using a PDF viewer.

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Rothermel, Richard C. 1991. Predicting behavior and size of crown fires in the northern Rocky Mountains. Res. Pap. INT-438. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

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Appendix: Version Comparison

Summary of changes from the old BEHAVE through each version of BehavePlus

The BEHAVE fire behavior prediction and fuel modeling system was first available to the field in 1984. JFSP funded a much-needed redesign and update to the BehavePlus fire modeling system version 1.0, which was released in 2002. Version 2.0 was released in 2003, Version 3.0 in 2005, and Version 4.0 in 2008. Each version update has offered additional features and fire modeling capabilities. The most significant changes are given here.

BehavePlus version 1 compared to the old BEHAVE

The old BEHAVE fire behavior prediction and fuel modeling system is a set of five DOS programs, three of which were first available in 1984. The whole look and feel of the BehavePlus fire modeling system is different, using updated user interface technology. Following are some specific differences that will be of interest to users of the old BEHAVE system:

- BehavePlus is one program. The old BEHAVE was 5 programs (FIRE1, FIRE2, RXWINDOW, NEWMDL, TSTMDL). The separation was due to computer limitations at the time and an extended development period.
- BehavePlus gives the user control of input options that were fixed on the old BEHAVE. For example, the BehavePlus SURFACE module allows users to specify the method of entry for fuel moisture, wind speed, and directions. In the old BEHAVE:
  - The DIRECT module required direct input of fuel moisture by size class, midflame wind speed, and direction of wind and spread with respect to upslope.
  - The SITE module calculated fine fuel moisture and requested input of 20-ft wind speed, exposure to the wind, and direction of wind and spread.
  - The DISPATCH module requested dead and live fuel moisture, 20-ft wind speed and wind adjustment factor. Calculations were for upslope spread with the wind.
  - In the TSTMDL program, fuel moisture was specified by category.
- In BEHAVE only continuous variables could be assigned more than one value for a maximum of 7 values. For example, wind speed could be assigned a range of values, but fuel model could not. BehavePlus allows multiple input values for every variable and there is essentially no limit to the number of values. Table output is carried over to multiple pages if necessary.
- BehavePlus produces graphs and diagrams as well as tables. The primary output of the old BEHAVE was tables. Crude graphs were produced using characters.
- The fuel modeling portion of the old BEHAVE consisted of the NEWMDL and TSTMDL programs. The features in NEWMDL are not in BehavePlus. The TSTMDL fuel model testing methods are in BehavePlus.
- BehavePlus does not include the fine dead fuel moisture model in MOISTURE and SITE modules in the FIRE2 program of BEHAVE. A better moisture model based on hourly weather data has been developed and is used in FARSITE and is being incorporated into the National Fire Danger Rating System (NFDRS) and the FireFamily Plus program. Eventually it will be available for fire behavior calculations in BehavePlus. BehavePlus offers the fuel moisture tables as a tool.
- The CONTAIN module of BehavePlus is different from that used in BEHAVE. The old model had a mathematical problem that occasionally surfaced. BehavePlus uses a model by Fried and Fried (1996) that offers the application of multiple resources with various productivity rates and arrival times, and direct or parallel attack at either the fire head or rear. BehavePlus does not offer the option of reverse calculation that was in the old BEHAVE (i.e. given a final fire size, what is the required line production rate).
- The RxWindow program is not and will not be part of BehavePlus. Reverse calculation becomes more difficult (essentially impossible) as models are added. The plan is to provide a new method of table shading to aid in prescribed fire planning.

- The equations in the MORTALITY module in BehavePlus have been updated to match those of FOFEM. Many new tree species have been added.
- BehavePlus lists input values by category (Fuel/Vegetation, Weather, …) rather than by module (DIRECT, SIZE, …) as was done in the old BEHAVE.
- In BehavePlus users select the output variables to be displayed. In BEHAVE the output list was fixed.
- Map distance calculation was a stand-alone feature in BEHAVE. It is integrated into BehavePlus.
- BEHAVE asked users whether they were using a computer with a screen. The program could be run in either WORDY or TERSE mode. BehavePlus assumes that it is being run on a 21st century personal computer.

BehavePlus version 2 compared to version 1

- Safety zone size model is added as a new SAFETY module.
- Containment model is added as a new CONTAIN module. This is a new model that allows multiple resources to make direct or parallel attack.
- Probability of ignition by lightning model is added to the IGNITE module.
- Three methods of weighting two fuel models for rate of spread calculations is added to the SURFACE module.
- Dynamic palmetto-gallberry fuel model (Hough and Albini 1978) is added to the SURFACE module.
- Size diagram output is added to SIZE.
- Contain diagram output is in CONTAIN.
- Direction diagram is added to SURFACE.
- Fire characteristics chart diagram output is added to SURFACE.
- Fine dead fuel moisture is added as a new tool.
- A Run Option section is added to the worksheets for clarification.
- The contents of the Notes section on example worksheets is blank. The description of the worksheet that was there for version 1 is not necessary, especially with the addition of the Run Options section.
- The 'Standard' worksheet folder that was supplied with version 1 of the program is called the ExampleWorksheets folder in version 2 to better reflect what it is. The worksheets in that folder are just some that the developers put together. The term 'standard' gave them significance that they didn't deserve.
- The Blank.bpw Worksheet that was in version 1 is called the 0Startup.bpw Worksheet in version 2 to better reflect what it is, the worksheet to use as a startup in selecting calculation modules. (The '0' as a first character of the file name puts it as the first item on the list for easy selection.)
- The program now automatically loads the 0Startup.bpw worksheet upon initiation. This saves some steps if the worksheet is set up by module selection. If a previously saved worksheet is desired, it is selected and loaded as before with File > New.
- The Fuel model guide button gives you access to the photographs and descriptions in Anderson (1982) "Aids to selecting fuel models" and to the selection key in Rothermel (1983) "How to predict the spread and intensity of forest and range fires".
- The Program Help and the Users Guide for version 1 have been replaced by a single, new document-a users guide in PDF format that can be both printed and accessed online for specific help.
- A Language option has been added. Portuguese is provided as an example.
- Additional Workspace options aid in file management.
- Graph y-axes are now user-scalable.

BehavePlus version 3 compared to version 2

- A new CROWN module to calculate transition to crown fire and crown fire spread rate is added.
- Calculation of wind adjustment factor (WAF) for fuel sheltered by overstory trees is added to SURFACE.

- Table shading according to user-specified ranges of acceptable conditions for prescribed fire planning is available.
- A CONTAIN option is added for single resource dispatch so tables and graphs can be produced for ranges of line construction rate, etc.
- The ability to export table output to a spreadsheet for further analysis or custom display is available.
- RH module is replaced by an RH tool.
- The step function from the calculation of probability of ignition by a firebrand is resolved and removed.
- Forty new surface fuel models, some with dynamic herbaceous live-to-dead fuel load transfer as a function of live fuel moisture are available in SURFACE.
- A new moisture scenario set (named "FuelModeling") that was used to develop the new fuel models is added.
- Custom fuel models can be exported in the file format required by FARSITE, FlamMap, and NEXUS.
- When the program starts up, a new BasicStart.bpw example worksheet is automatically loaded.
- Module names are included on the Output Variables and Run Options lists for added clarity.
- The Fuel/Vegetation worksheet section has been split into Surface/Understory and Overstory sections.
- The Worksheet tab on the "Appearance Options" dialog box has a new option Show descriptions only for entered variable codes as well as the Show descriptions for all discrete variable codes. The new option is the default for example worksheets.
- A SurfaceCrown.bpw worksheet has been added to the set of example worksheets.
- An updated User's Guide reflects operational changes. An index has been added.
- In-program help screens are updated with variable definitions and explanations.
- Tutorials 1- 4 are updated and reorganized.
- New tutorials focus on new modeling capabilities.

BehavePlus version 4 compared to version 3

- The User's Guide is updated to reflect operational changes.
- A new Variables paper includes variable descriptions from the help windows and input/output tables (Andrews 2008). The PDF document is available through the help system and includes many internal linkages to make it a useful reference guide.
- As part of a JFSP funded project, the tutorials were updated, new lessons are available, and a plan for future training material development was prepared.
- The BehavePlus program and supporting material has been moved to a new web site: www.firemodels.org, for fire behavior and fire danger software.
- Photographs and values for canopy cover, stand height, canopy bulk density, and canopy base height are available in help windows. The information is taken from Scott and Reinhardt (2005) "Stereo photo guide for estimating fuel characteristics in conifer stands."
- The user has the option of identifying a worksheet to open at startup, rather than the BasicStart.bpw worksheet.
- A tool was added to calculate horizontal map distance from ground map distance and direction with respect to upslope.
- The option was added to not impose the maximum reliable wind speed limit for the Rothermel surface fire spread model. Spread rate increases with increasing wind speed rather than being constant for high wind speeds.
- The option was added to input curing level (fuel load transfer portion) for dynamic fuel models rather than calculating curing from live herbaceous fuel moisture.
- A special case fuel model was added for western aspen (Brown and Simmerman 1986).

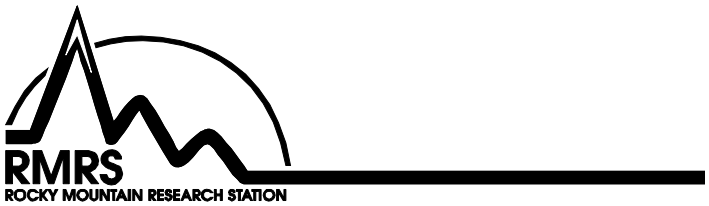
- If bark thickness is a user input for the MORTALITY module, Mortality Equation (spruce or not-spruce) is an input variable on the Worksheet. This clarifies that the 206 species available for mortality species is used only to calculate bark thickness.
- Additional output variables are available for SURFACE. Intermediate output values will aid understanding of the Rothermel surface fire spread model.
- Fuel model names were changed to specifically mention short and long needle litter and to clarify that the fuel models are for surface fuel, not for the overstory.
  - 8 "Closed timber litter" to "Short needle litter"
  - 9 "Hardwood litter" to "Long needle or hardwood litter"
  - 10 "Timber with litter & understory" to "Timber litter & understory"
  - TU4 "Dwarf conifer with understory" to "Dwarf conifer understory"
- Output variables were added to help understanding of calculated Wind Adjustment Factor: Crown fill portion and WAF calculation (sheltered or unsheltered).
- Crown fire area and perimeter output variables were added, using the equations in Rothermel (1991).
- "Conditional crown fire" was added as a "fire type". In version 3 if Transition to crown fire? was "no", then the fire type was "surface", whether Active crown fire? was "yes" or "no".
- Changes to the main menu are more logical. For example, File > New is now File > Open worksheet.
- File > saveAs > Results > Spreadsheet or Html is now File > Export Results. In version 3, save as spreadsheet saved the output table without input values as a .txt file. In version 4, only html files are exported. These files can be viewed in a web browser, or they can be opened with spreadsheet software and then saved in spreadsheet format.
- An ExportFolder has been added as the default location for Export Results.
- For the option Table shading for acceptable fire conditions, the option is added to produce tables with blank cells rather than crossed out values. The option is available in Configure > Appearance preferences > Tables tab.
- Values entered in the "Fine dead fuel moisture" tool are remembered the next time the tool is used for the current session.
- Another option has been added for worksheet header lines, for prescribed fire planning.
- The Language option was eliminated. Portuguese was available in version 3, as an example of how a translated version of BehavePlus could be developed. Due to lack of interest, the option has been disabled for now.
- In version 3.0.2, the program sometimes ran slowly or not at all, particularly when installed in the default directory of C:/SEM. This has been fixed in version 4.0.

Index

W

X

Y



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