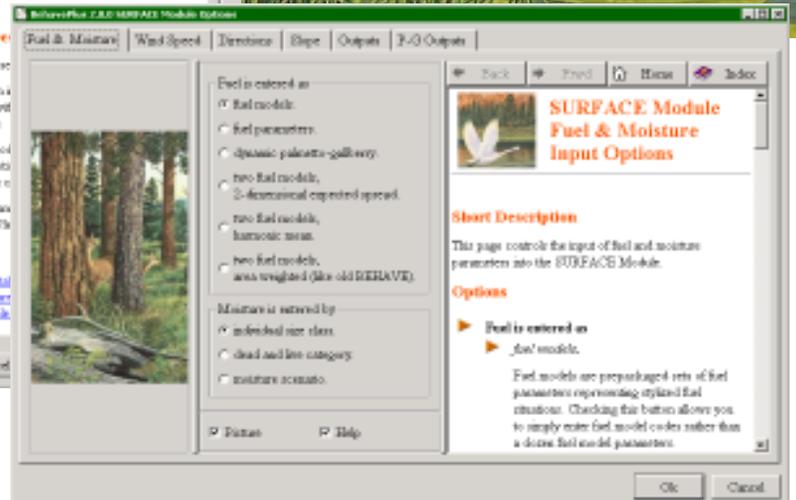
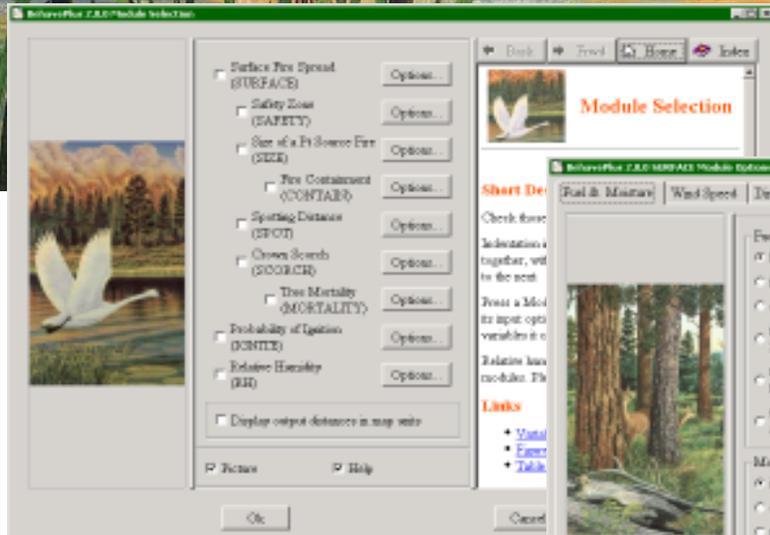




# BehavePlus fire modeling system Version 2.0 User's Guide

Patricia L. Andrews  
Collin D. Bevins  
Robert C. Seli



## Abstract

Andrews, Patricia L.; Bevins, Collin D.; Seli, Robert C. 2003. BehavePlus fire modeling system, version 2.0: User's Guide. Gen. Tech. Rep. RMRS-GTR-106WWW. Ogden, UT: Department of Agriculture, Forest Service, Rocky Mountain Research Station. 132p.

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, safety zone size, size of point source fire, fire containment, spotting distance, crown scorch height, tree mortality, 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, version 2 User's Guide), Don Carlton (version 1 User's Guide and online help system), Deb Tirmenstein (program testing, document review and editing), Joe Scott (online help and supporting material for the fire models added in version 2), and Miguel Cruz (Portuguese translation for the 'language' option).

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

Software technical support is provided by USDA 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 and provide comments through the BehavePlus web site, <http://fire.org>

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

This publication will be updated as features and modeling capabilities are added to the program.

The BehavePlus system is supported by

USDA Forest Service  
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(800) 253-5559

[fire\\_help@dms.nwcg.gov](mailto:fire_help@dms.nwcg.gov)

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# 1. Introduction



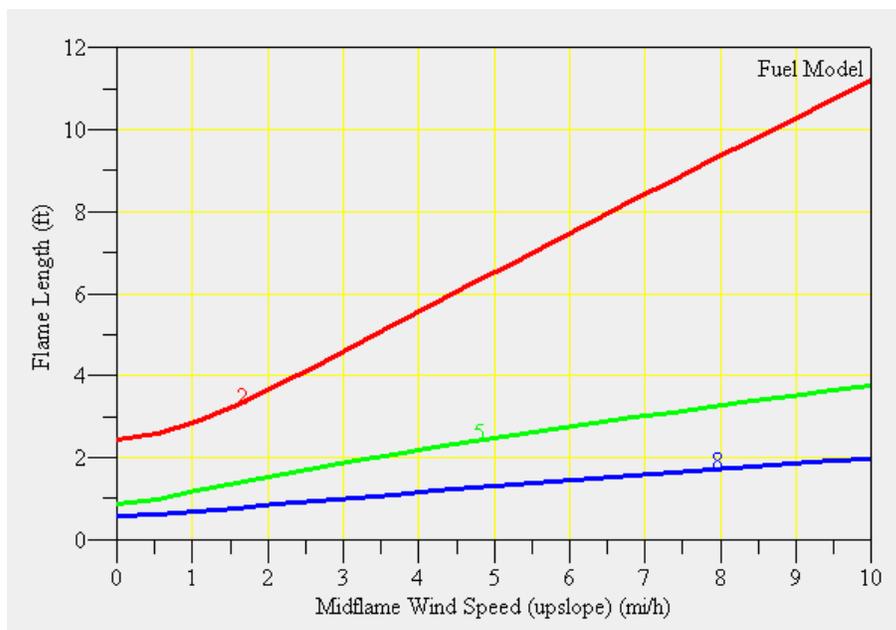
The BehavePlus fire modeling system is a PC-based program that is a collection of models that describe fire and the fire environment. It is a flexible system that produces tables and graphs and can be used for a multitude of fire management applications. BehavePlus is the successor to the BEHAVE fire 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 and Bevins 1999).

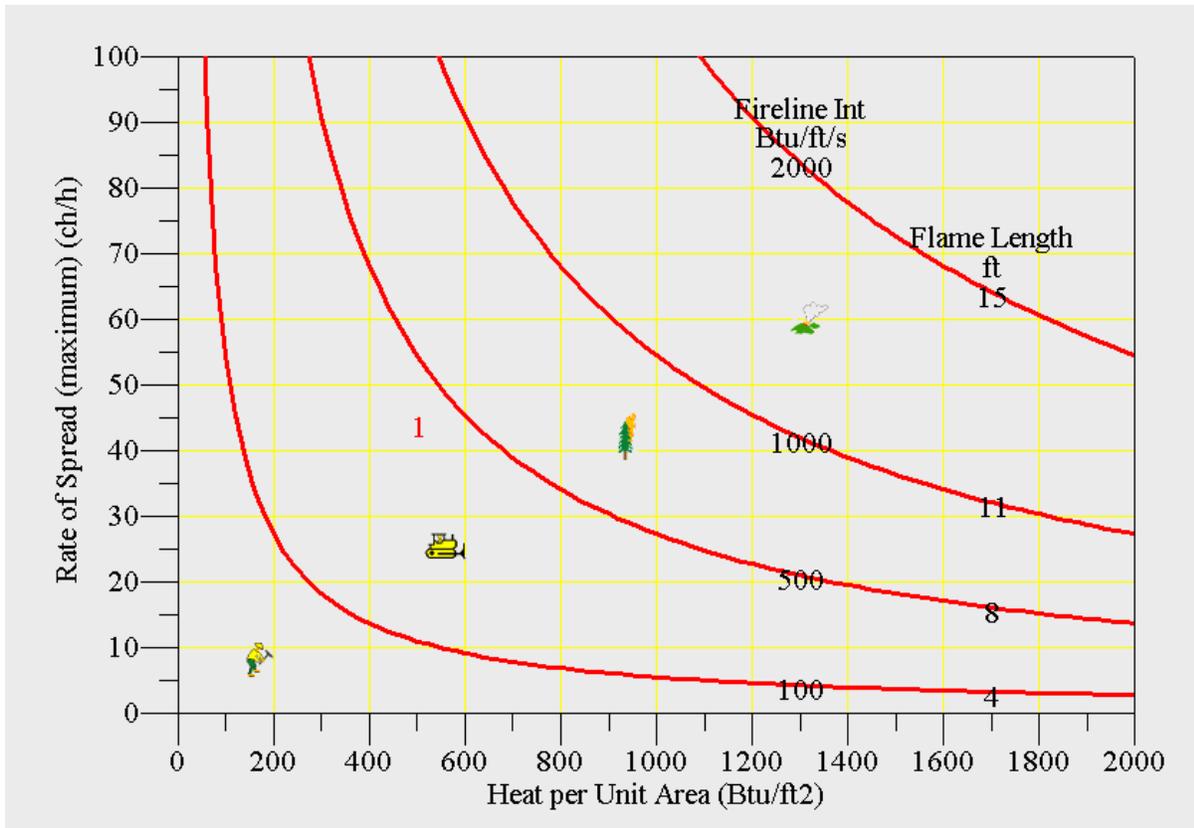
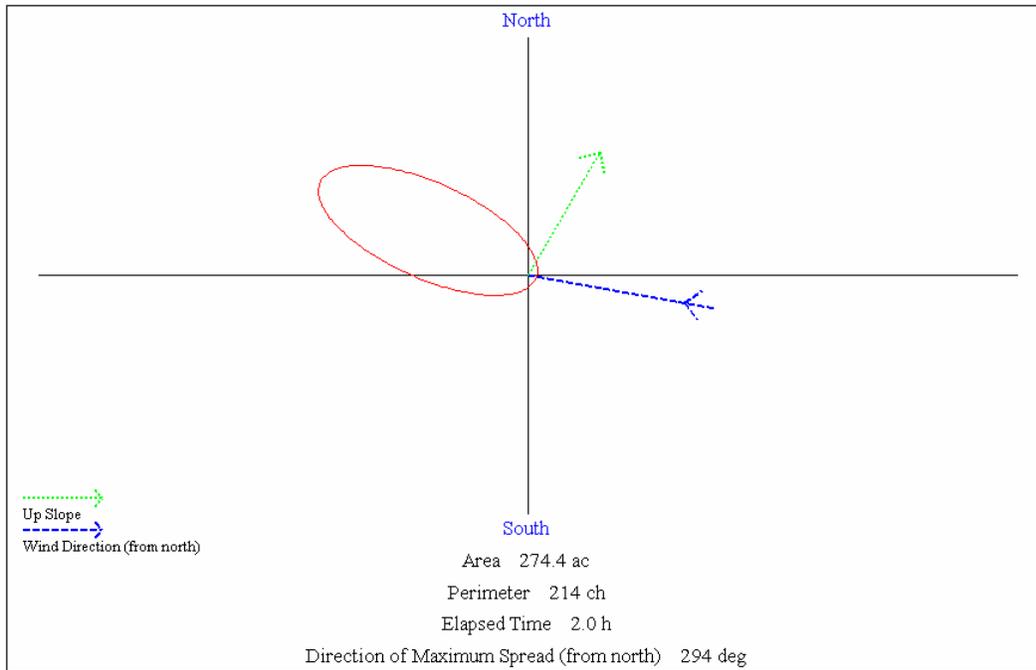
This document describes operation of the BehavePlus program. The fire models and their application are described elsewhere.

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. Each system meets a different need. The same surface fire spread model (Rothermel 1972) was used in each case. These three programs and supporting documentation are available through [www.fire.org](http://www.fire.org). Shown below are example outputs from each system.

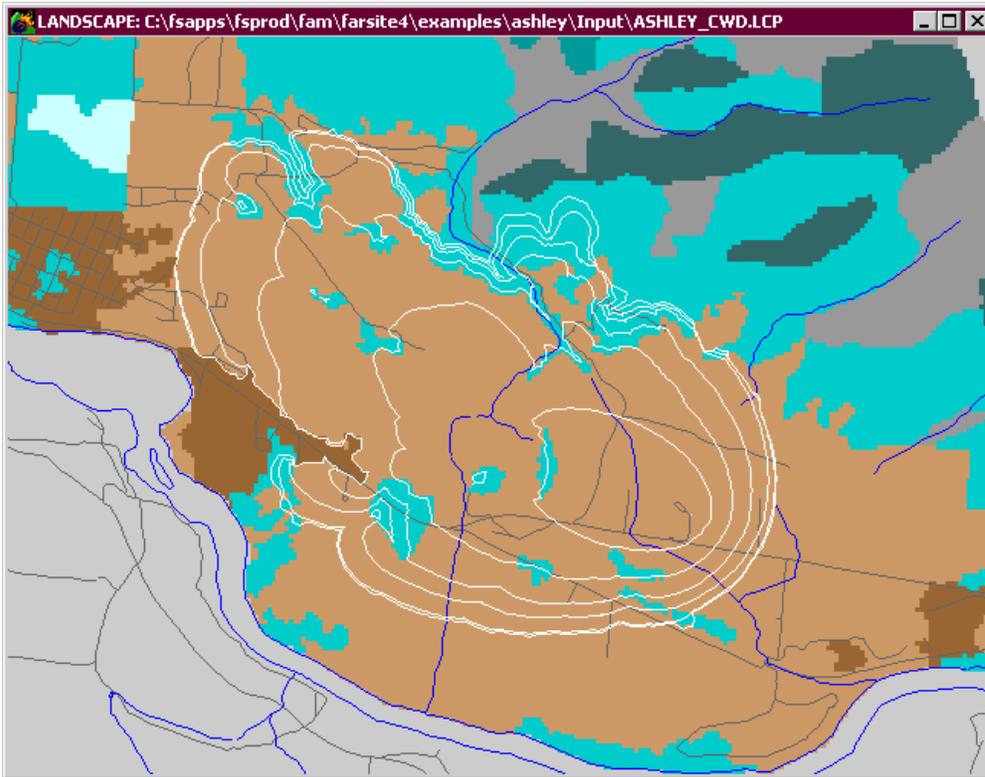
Sample table, graph, and diagram output from BehavePlus:

Fuel Model	Midflame Wind Speed (upslope) mi/h		
	0.0	5.0	10.0
2	2.5	6.5	11.2
5	0.9	2.5	3.8
8	0.6	1.3	2.0

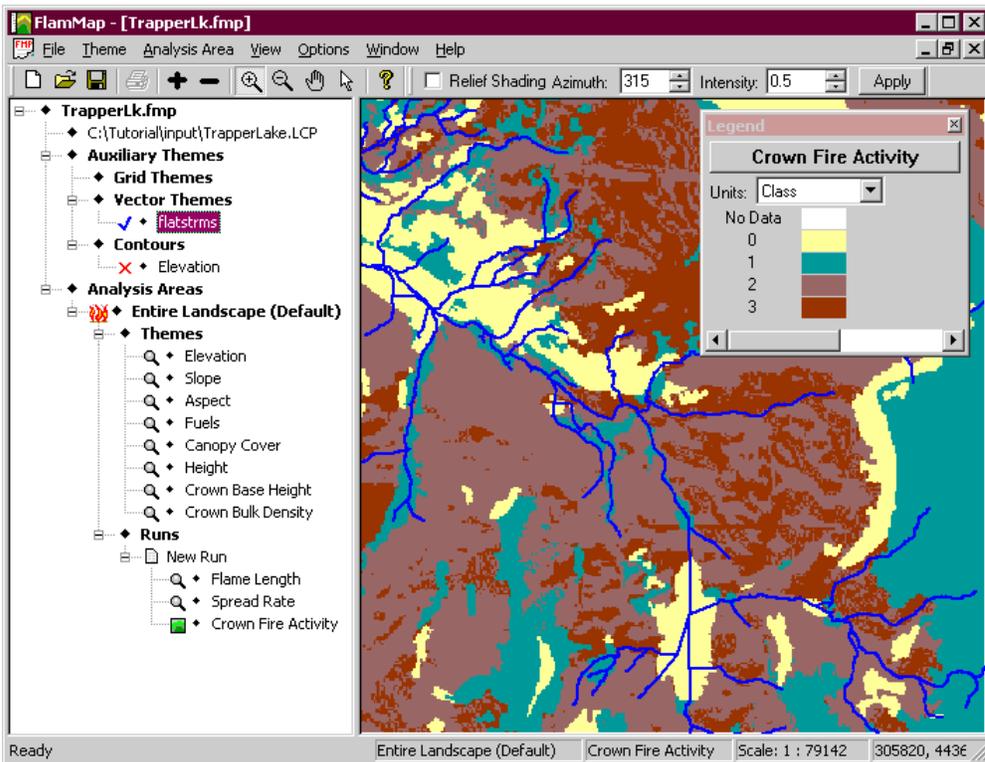




Sample fire perimeter output from FARSITE:



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 2.0, which provides additional models and features. A summary of changes from version 1.0 to version 2.0 is given in Appendix A.

The primary modeling capabilities of BehavePlus, version 2.0, 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

Other modeling capabilities include

- Tables for fine dead fuel moisture
- Tables for relative humidity or dew point
- Standard and custom fuel models
- Dynamic palmetto-gallberry fuel
- Three methods for weighting two fuel models: two-dimensional expected spread, harmonic mean, area weighted
- Sunrise, sunset, dawn, and dusk at any location or date

Key features include

- Diagrams for point source fire shape, shape of a contained fire, fire characteristics chart, wind / slope / fire directions
- Photographs and a key for the standard 13 fuel models
- 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
- User interface language can be changed (currently English and Portuguese)

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.

← Back
→ Frwd
🏠 Home
📖 Index

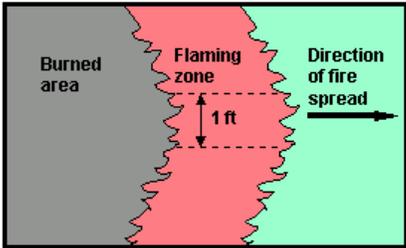


## Fireline Intensity

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### Short Description

The heat energy release per unit time from a one-foot (one-meter) wide section of the fuel bed extending from the front to the rear of the flaming front.



### Input to Modules

- ◆ SCORCH, if SURFACE is not also selected and if *Fire intensity* is entered as *fireline intensity* is selected as an input option.

### Output from Modules

- ◆ SURFACE

This page is blank on purpose.

## 2. Operation



### 2.1. Overview

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

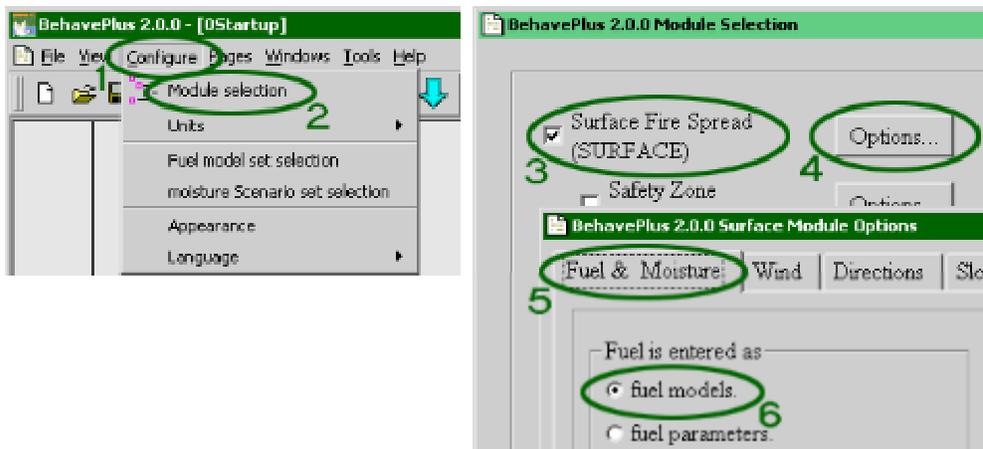
Organization of material on Operation of the BehavePlus program is different from the organization of the program itself. It is designed to help you find the answer to a question. Most users are comfortable with looking at menus and dialog boxes and associated information in the program without use of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

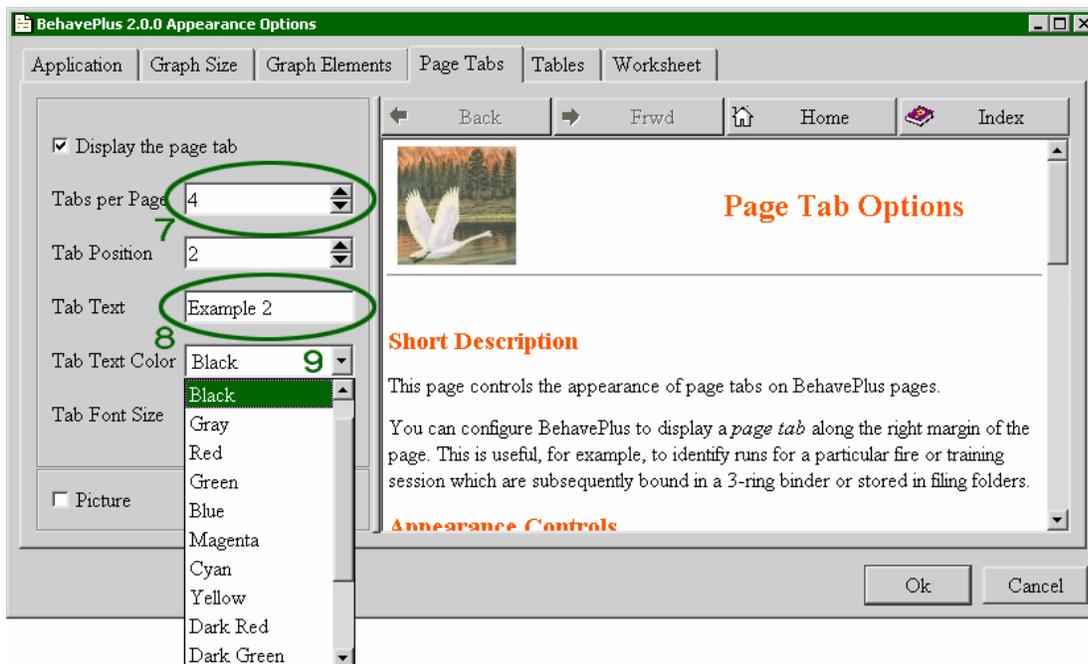
Configure > Module selection > SURFACE > Options... > Fuel & Moisture > fuel models option button.

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 option 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. The Tutorials include more complete screen captures.

## 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. BehavePlus is meant to be run over and over for multiple purposes, so it is meant to be self-documenting.

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, they all fit on a standard printer page; merely press the Print button and file the copy. 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 designed 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 lets you print selected pages.

### 2.2.2. Highly Configurable

BehavePlus is meant to be the repository of many current and future 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. The language displayed on Worksheets and output pages may be changed.

BehavePlus may be used for fire behavior training, for fire planning, or for real-time fire behavior assessment. It may be used to assess just fire behavior, or just fire effects, or the link between them. It may be used to build custom fuel models, to determine astronomical events, or as a units conversion utility.

### 2.2.3. Self Documenting

The brooding step-brother of configurability is complexity. Because BehavePlus is so highly configurable and may be used by people in various roles for various purposes, it strives to be self-documenting in an attempt to thwart entropy. 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 contains a notes field for free-field entry of expository text.

### 2.2.4. User Manual and Help

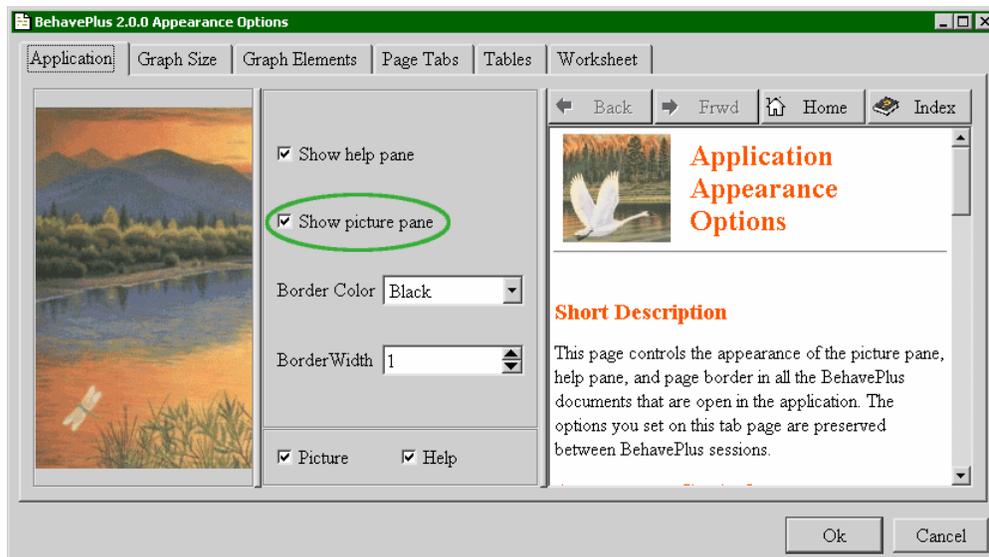
BehavePlus tries to provide pertinent information to you when you need it the most. The Guide Button  next to each entry field opens a dialog containing a help browser pane with suggested or valid inputs. The help browser pane describes input and output variables and program operation. The browser provides tables, photographs, and figures to help you select inputs.

In addition, this manual is available as part of BehavePlus through Help > Program help.

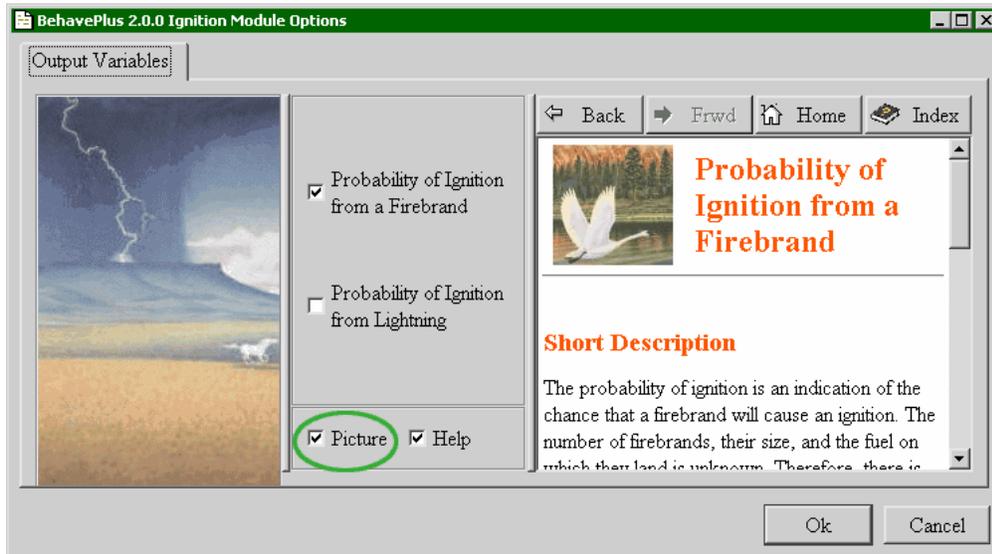
### 2.2.5. Not Boring

Finally, every attempt has been made to keep BehavePlus from becoming yet another boring program with a gray personality. Just in case all the complexity, configurability, widgets, dialogs, models, diagrams, tables, graphs, browsers, and quirky behavior aren't enough to hold your attention, here and there we've inserted some paintings we rather enjoy to ease our weary eyes.

If you, however, prefer the gray approach, you can eliminate the pictures for the entire session by clearing the Show picture pane check box on the Configure > Appearance > Application tab



You can also choose to show the picture or not in individual windows by selecting or clearing the Picture check box



## 2.3. Features

### 2.3.1. Fire Models

BehavePlus contains models to estimate

- surface fire spread, intensity, flame length, scorch height, and direction of maximum spread
- surface fire spread rate, intensity, flame length, and scorch height in any compass direction
- fire shape, area, and perimeter
- spotting distance from a burning pile, from torching trees, or from a wind-driven surface fire
- success or failure of suppression resources to build line around a fire
- recommended fire safety zone radius, separation distance, and zone size
- fire-induced tree mortality
- probability of fire ignition from firebrands
- probability of fire ignition from lightning strikes
- relative humidity or dew point temperature
- midflame wind speed
- fine dead fuel moisture content
- sun-rise, sun-set, dawn, and dusk at any location or date
- palmetto-gallberry dynamic fuels
- custom fuel models
- custom moisture scenarios
- weighted fire behavior within a two fuel model complex

## 2.3.2. Operation

BehavePlus has the following operational features:

- BehavePlus is cross-platform and works identically on all versions of Windows and Linux.
- 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 > Options > Input Options dialog box.
- Module output variables can be toggled on/off via the Configure > Modules > Options > Output Variables dialog box.
- Modules may be linked so the outputs from one module are automatically input into another module.
- All distance outputs may be scaled to map units.
- All 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 multipage 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 > Program Help makes this manual and all associated documentation available in PDF format for reading, web browsing, and printing.
- The user interface language may be dynamically changed via Configure > Language. Currently English (U.S.) and Portuguese (Portugal) are supported. (Contact [cbevins@montana.com](mailto:cbevins@montana.com) if you'd like to volunteer to add support for another language).
- Completed Runs may be saved and re-used.

## 2.4. Installation

### 2.4.1. Download

BehavePlus is available for download from [www.fire.org](http://www.fire.org). Simply follow the BehavePlus links to the download page and select either the Windows or Linux installation package.

You should check the downloaded file size against the original to ensure you received the entire package. To be absolutely certain the package arrived intact, use the **md5sum** program from a command line prompt:

```
➤ md5sum bp_2_0_0.exe
```

If the resulting 32-digit hexadecimal number is not identical to the one published on the BehavePlus download page, your download copy is corrupt.

## 2.4.2. System Requirements

BehavePlus has modest system requirements met by the most inexpensive computers available on the market:

- Linux or Windows 95, 98, ME, NT, 2000, or XP
- 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\_2\_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. Linux Installation

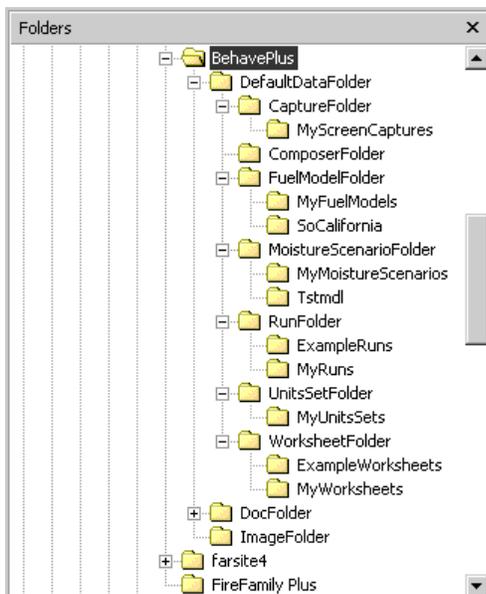
BehavePlus for Linux is packaged as a tarball using **tar** and **gzip**. Move the downloaded file (bp-2.0.0.tar.gz) into the parent directory where you wish it to be installed, and enter

➤ **tar xvzf bp-2.0.0.tar.gz**

This creates the bp-2.0.0 subdirectory and unpacks the BehavePlus binary executable, supporting library files, and data subdirectory structure within it.

## 2.4.5. 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.

We recommend that you use Workspaces to aid file management as you apply BehavePlus to several projects. See the section 18.1 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 Units 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, units of measure, and diagram/table/graph options. Thus there are a large number of possible Worksheets. Some Example Worksheets are supplied with the BehavePlus distribution and are included in every Workspace. You may reconfigure BehavePlus as needed for any purpose, then save its Worksheet for later reuse. Functionally, a Worksheet is a BehavePlus configuration that does not have any input values associated with it.

A Run is a Worksheet that has a complete set of valid inputs, but no outputs are saved in a Run. You must calculate a saved Run to obtain outputs. Any given Worksheet may have an infinite number of Runs, each determined by its input values. Runs may be saved for later use and review. 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. While BehavePlus contains many models, you will more commonly see references to Modules, which are collections of models.

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 Models that can be activated/deactivated by the user during Worksheet configuration. Selecting 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 values. Continuous variables have a minimum and maximum valid value. Examples include fuel moisture content, and wind speed.

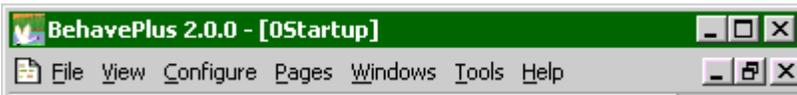
A Discrete Variable has a finite set of valid values. Examples include Fuel Model, Spotting Source Location, and Tree Species.

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 a large number of inputs by specifying the minimum input value, maximum input value, and increment value. For discrete variables the dialog contains a list of all valid inputs from which the user may select zero or more 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 corresponds to a single BehavePlus project, and each BehavePlus project should have its own Workspace. Workspaces are created by the File > Workspaces > New workspace and the Files > Workspaces > Clone current workspace commands.

## 2.6. Menus and Toolbar

All 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	Definition	Equivalent menu operation
	Open a new Worksheet	File > New
	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	Page > then select page #
	Display last page	Page > then select page #
	Display previous page	Page > then select page #
	Display next page	Page > then select page #
	Access User's Guide	Help > Program help

### 3. Worksheets

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A Worksheet is a form on which you enter input. Worksheets vary in appearance and content in response to the current module configuration: a SURFACE module configuration requires different inputs than a SPOT module configuration.

Module selection, input options, and output variable selections determine BehavePlus configuration, which in turn defines the Worksheet appearance and content.

A number of predefined example Worksheets are included in the BehavePlus installation. You may use these Worksheets as provided, or use them as starting points for your own configuration. Simply open an example Worksheet and proceed to change your Module selection, input options, and/or output variables. Once BehavePlus 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 and BehavePlus is configured as expected.

#### 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 sections:

**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 > 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 > 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 for training applications or for fire projection applications are optionally activated through Configure > Appearance > 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”, “Fuel Moisture”, “Weather”, and “Terrain”.

**Run Options** – This section documents some of the 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 > 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 > Worksheet tab.

Following is an example Worksheet:

BehavePlus 2.0.0 Mon, Feb 24, 2003 at 15:32:05 Page 1

**Modules:** SURFACE, SPOT

Description

**Fuel/Vegetation**

Fuel Model

Mean Cover Height ft

**Fuel Moisture**

Dead Fuel Moisture %

Live Fuel Moisture %

**Weather**

20-ft Wind Speed (upslope) mi/h

Wind Adjustment Factor

**Terrain**

Slope Steepness %

Ridge-to-Valley Elevation Difference ft

Ridge-to-Valley Horizontal Distance mi

Spotting Source Location

---

**Run Options**

Wind direction is upslope.  
 Calculations are only for the direction of maximum spread.  
 Wind and spread directions are degrees clockwise from upslope.  
 Wind direction is the direction the wind is pushing the fire.

---

**Output Variables**

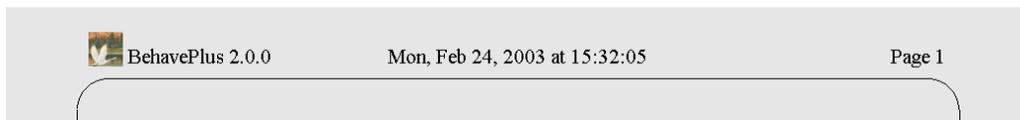
Rate of Spread (maximum) (ch/h)  
 Flame Length (ft)  
 Midflame Wind Speed (upslope) (mi/h)  
 Spotting Distance from a Wind Driven Surface Fire (mi)

**Notes**

### 3.1.1. Page Header

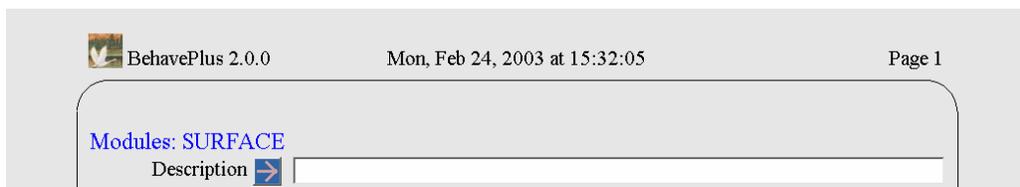
The header of each page includes the version number of the BehavePlus program, the date and time of the calculation, and the page number.

The date and time and page number can be used to correctly collate printed documents.



### 3.1.2. Documentation

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



Fire projection documentation

Training documentation

Additional documentation lines can be added by selecting the Fire projection documentation and/or Training documentation check boxes from the Configure > Appearance > Worksheet tab.

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

BehavePlus 2.0.0 Mon, Feb 24, 2003 at 15:32:05 Page 1

Modules: SURFACE

Description [Guide] [Text Box]

Fire Name [Guide] [Text Box]

Fire Date & Projection Period [Guide] [Text Box]

Fire Analyst [Guide] [Text Box]

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

BehavePlus 2.0.0 Mon, Feb 24, 2003 at 15:32:05 Page 1

Modules: SURFACE

Description [Guide] [Text Box]

Training Course [Guide] [Text Box]

Training Exercise [Guide] [Text Box]

Trainee Name and Date [Guide] [Text Box]

Both options can be checked.

### 3.1.3. Input section

The required input variables and their units are displayed next to their entry fields. 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 the fuel model.

The Guide [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 Appendix B.

BehavePlus 2.0.0 Page 1

Modules: SURFACE

Description [Guide] [Text Box]

**Fuel/Vegetation**

Fuel Model [Guide] [Text Box] 1

**Fuel Moisture**

1-h Moisture % [Guide] [Text Box]

10-h Moisture % [Guide] [Shaded Text Box]

100-h Moisture % [Guide] [Shaded Text Box]

Live Herbaceous Moisture % [Guide] [Shaded Text Box]

Live Woody Moisture % [Guide] [Shaded Text Box]

**Weather**

Midflame Wind Speed mi/h [Guide] [Text Box]

Direction of Wind Vector (from upslope) deg [Guide] [Text Box]

**Terrain**

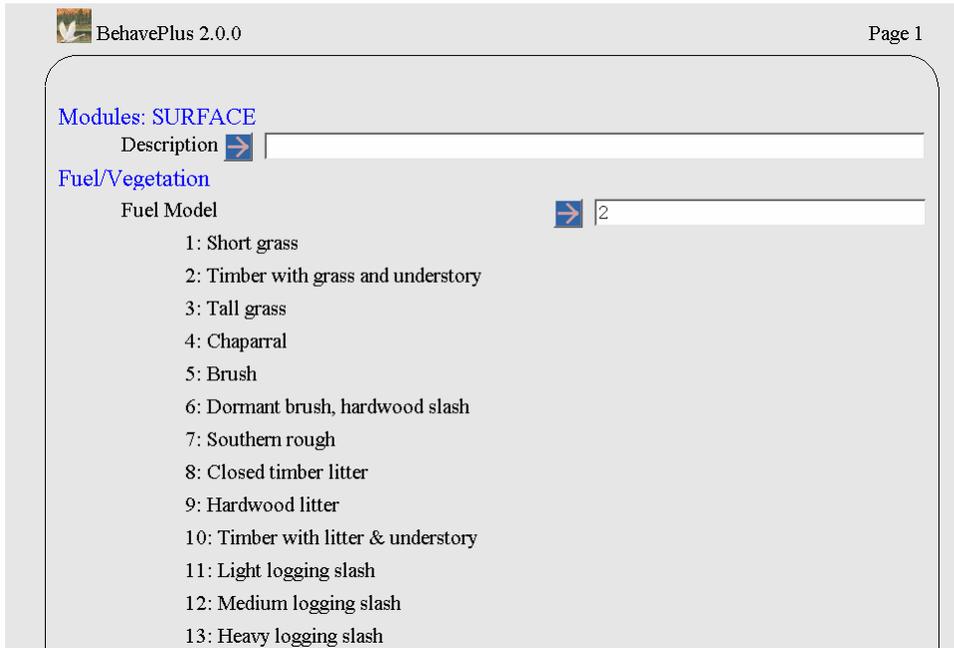
Slope Steepness % [Guide] [Text Box]

### 3.1.4. Input codes

**Show input codes  
for all discrete variables**

The definition of valid input codes can be displayed on the Worksheet by selecting the Show input codes for all discrete variables check box on the Configure > Appearance > Worksheet tab.

For example, with this option selected, fuel models names are given.



### 3.1.5. Run options

For clarification, Run options are given after the input variables. The user does not have the option of suppressing this information.

#### Run Options

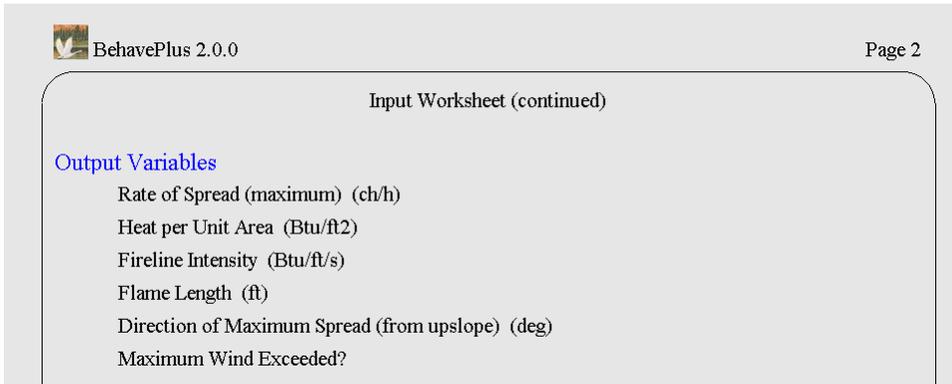
Calculations are only for the direction of maximum spread.  
Wind and spread directions are degrees clockwise from upslope.  
Wind direction is the direction the wind is pushing the fire.

### 3.1.6. Output variables

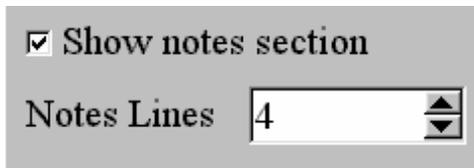
**Show output variables  
to be calculated**

Selected output variables and their units can be displayed at the end of the input Worksheet using the Configure > Appearance > Worksheet tab.

For example:

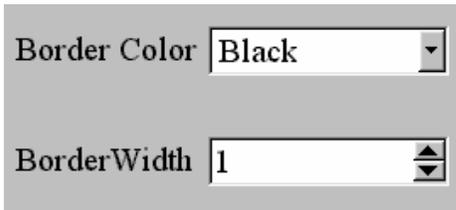


### 3.1.7. Notes



The Notes section of the Worksheet allows the user to enter a large amount of text associated with 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 > Worksheet tab with the Show notes section check box and the Notes Lines spin box.

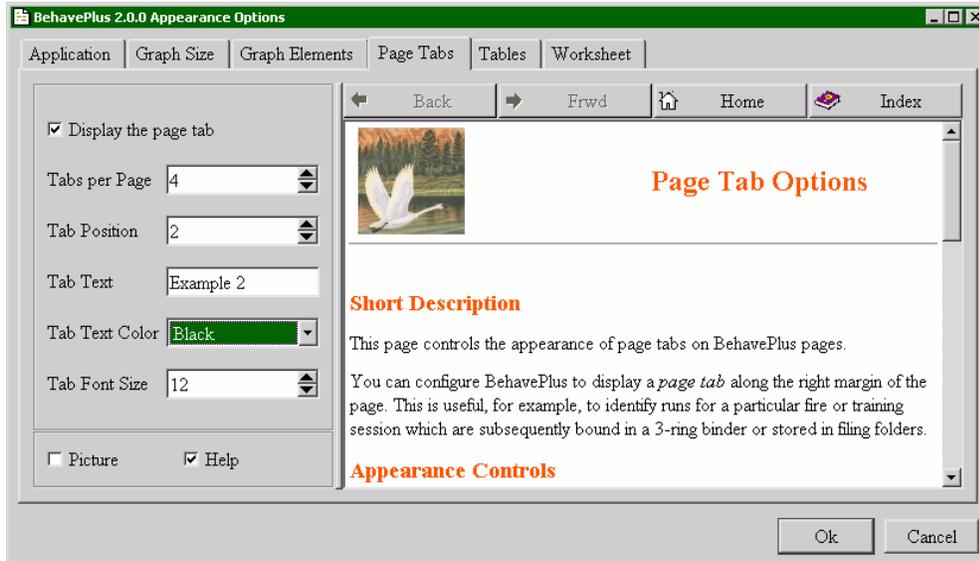
### 3.1.8. Borders



The border color and thickness on the Worksheet and output pages can be changed on the Configure > Appearance > 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.

### 3.1.9. 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 > Page Tabs tab.



**Tab 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.

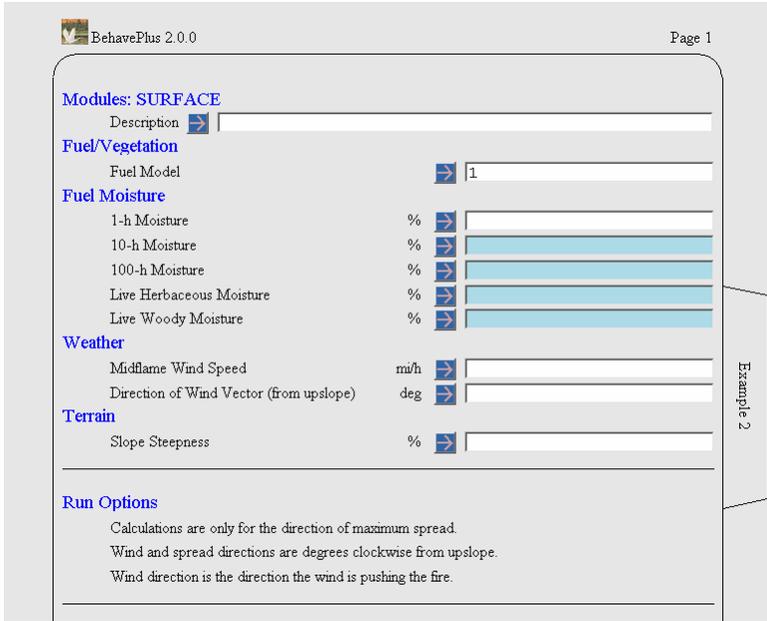
**Tab position** -- Determines the position of the displayed tab. Tab position 1 is always at the upper edge of the right margin.

**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:



### 3.2. Loading a previously saved Worksheet

A previously saved Worksheet can be loaded using

- the File > New 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. A short description is given for each. See Appendix E for further description of the "ExampleWorksheets".

Worksheet	Files	Description
Example	9	Standard BehavePlus worksheets
0Startup.bpw		Blank worksheet, default initialization, English
FuelModeling.bpw		Surface fire, fuel modeling
SlopeMap.bpw		Slope calc from map measurements
SurfaceBasic.bpw		Surface fire in the dir of max spread (DIRECTION)
SurfaceBasicFrom.bpw		Wind direction "from"
SurfaceMap.bpw		Surface spread map application
SurfaceScorchMortality.bpw		Linked models, spread direction input
SurfaceSimple.bpw		Surface fire spread, simple case, upslope spread
SurfaceSpotIgnite.bpw		Spotting from a wind-driven surface fire
MyWorksheets	0	Default user worksheet folder

### 3.3. The startup Worksheet

The 0Startup.bpw Worksheet automatically loads whenever you start Behave Plus v2.0. This Worksheet is a special case. It is used as the starting place for selecting calculation modules. It shows no input or output variables, but it sets defaults for all Run settings as described in Appendix D. 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 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.

### 3.4. 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.

### 3.5. Saving a Worksheet or a Run

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

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

See the Section 18.4, Save As, for more specific information.

## 4. Modules



Modules define a set of fire models for a Worksheet. Selection can be made with the Configure > Module command.

The output variables that can be calculated by each module are given in the output variable table in Appendix B.

Surface Fire Spread (SURFACE) Options...

Safety Zone (SAFETY) Options...

Size of a Pt Source Fire (SIZE) Options...

Fire Containment (CONTAIN) Options...

Spotting Distance (SPOT) Options...

Crown Scorch (SCORCH) Options...

Tree Mortality (MORTALITY) Options...

Probability of Ignition (IGNITE) Options...

Relative Humidity (RH) Options...

Display output distances in map units

Indentation indicates that the modules 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, all required input is entered by the user. A table of input variables and associated modules is given in Appendix B.

Selection of modules, options, and output variables determines the required input variables.

The Options... button is used to configure a modules input options or change the output variables it calculates.

### 4.1. Input options

Some modules offer options on alternate ways of specifying input. Others do not. For example, clicking the MORTALITY Options... button displays the “Mortality Module Options” dialog box with the Bark thickness is input option:

Bark thickness is

specified on the worksheet.

estimated from species and d.b.h.

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

BehavePlus 2.0.0 Page 1

Modules: MORTALITY

Description

Fuel/Vegetation

Tree Height ft

Crown Ratio

Mortality Tree Species

Bark Thickness in

Fire

Scorch Height ft

---

Run Options

No run options selected.

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

BehavePlus 2.0.0 Page 1

Modules: MORTALITY

Description

Fuel/Vegetation

Tree Height ft

Crown Ratio

Mortality Tree Species

D.B.H. in

Fire

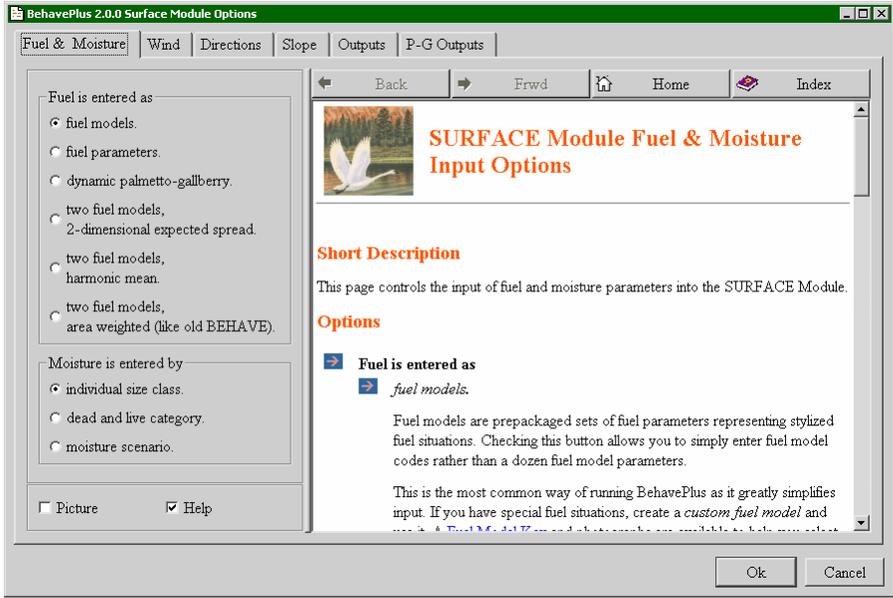
Scorch Height ft

---

Run Options

No run options selected.

The SURFACE module has many input options. For readability, they are available on several tabs:



## 4.2. Output options

The desired output variables are selected through the Options... button associated with each module. The selected output determines the input requirements. For example, input variables for the SPOT Module are different for each spotting source.



Pause the mouse over the name of an output variable to see its description in the browser pane. For example, a pause over Spotting Distance from a Wind Driven Surface Fire in the SPOT Output Variables tab results in this browser pane.

This page is blank on purpose.

## 5. Entering input



There are several ways to supply input to the BehavePlus program. Values can be typed directly into the input field, a choice 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 entry fields. Using the 'Enter' or 'Tab' keys move the cursor to the next field. The cursor can be moved to any field by a mouse click.

Valid input values can be viewed by using the guide  button.

### 5.3. Range of values

More than one value can be entered for an input variable. Multiple values are separated by space or comma delimiters.

(0.0 - 60.0 mi/h)	
From	0
Thru	20
Step	5

For continuous variables the Guide button 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 below.

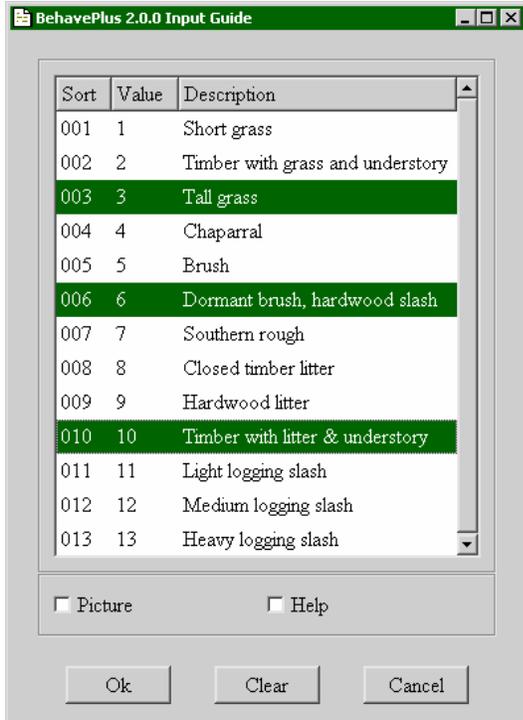
Weather	Midflame Wind Speed (upslope) mi/h 	0.0, 5.0, 10.0, 15.0, 20.0
---------	--	----------------------------

You do not need to always specify equal steps. You can enter several independent values separated by commas directly in the text box.

### 5.4. Discrete variables

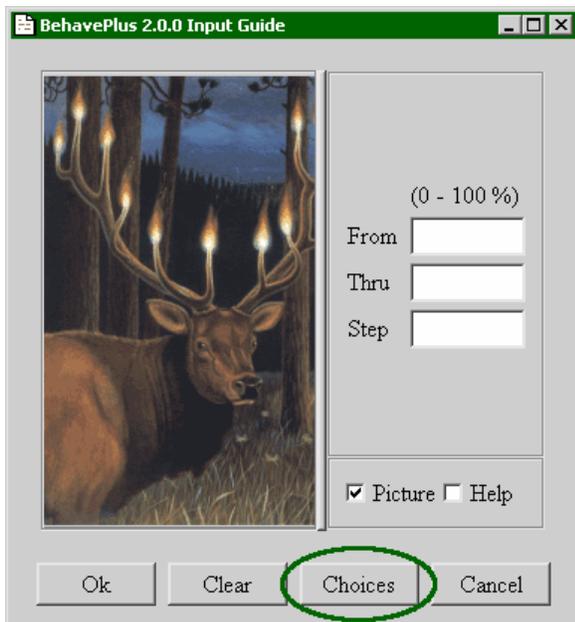
When the Guide button is clicked for a discrete variable, the allowed selections are given in the center pane.

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

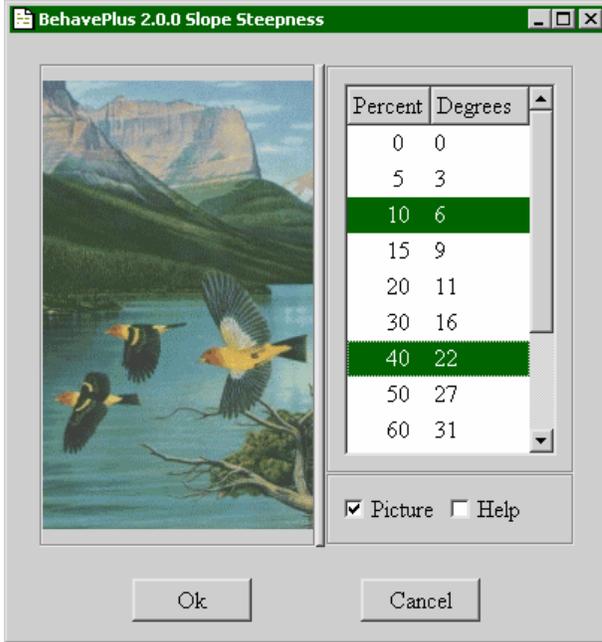


### 5.5. Choices

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.



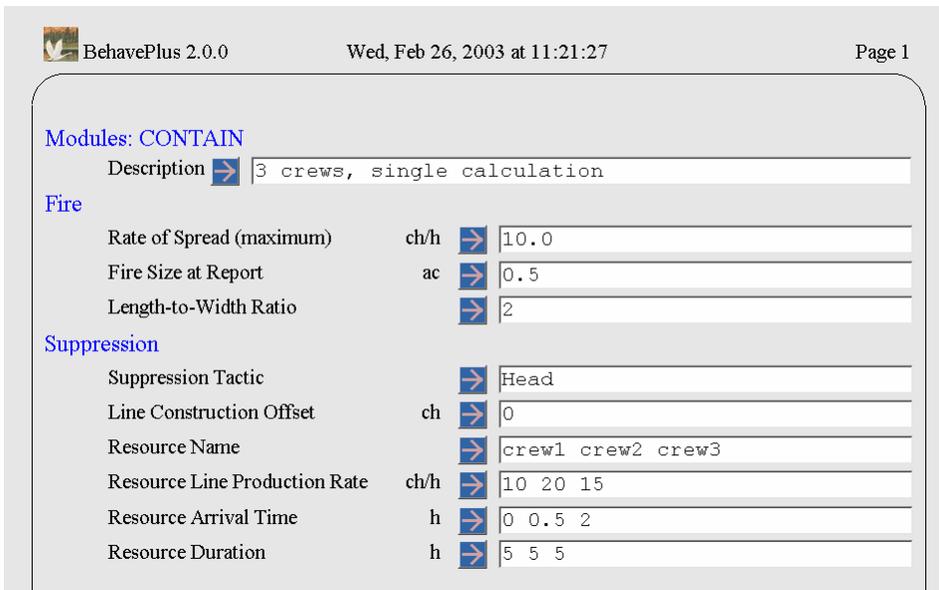
Clicking the Choices button displays commonly used values.



Selected values in the Slope Steepness choices. Clicking the Ok button enters them on the Worksheet.

### 5.6. Linked input variables

In some cases input variables are directly associated with each other (an exception to the general rule). For example, in CONTAIN a line production rate, arrival time, and duration are assigned to each resource. 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.



BehavePlus 2.0.0      Wed, Feb 26, 2003 at 11:21:27      Page 2

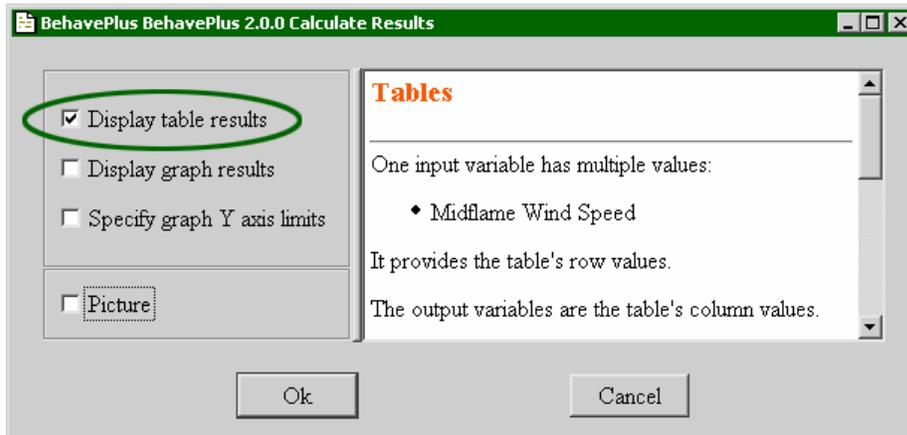
**3 crews, single calculation**

Time from Report	1.4 h
Contain Status	Contained
Contained Area	5.2 ac
Fireline Constructed	26.6 ch
Number of Resources Used	2

## 6. Table output

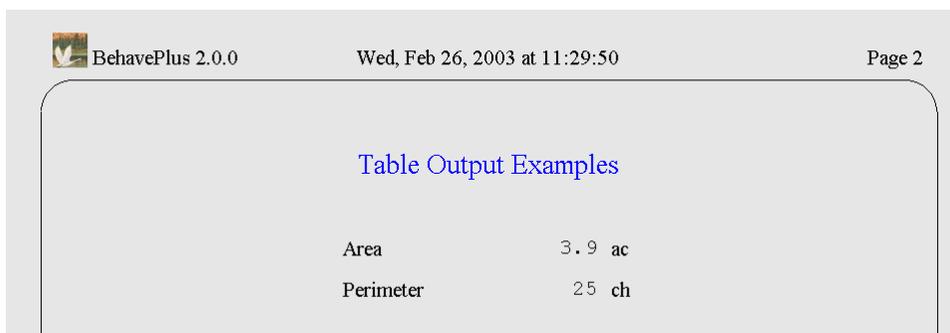
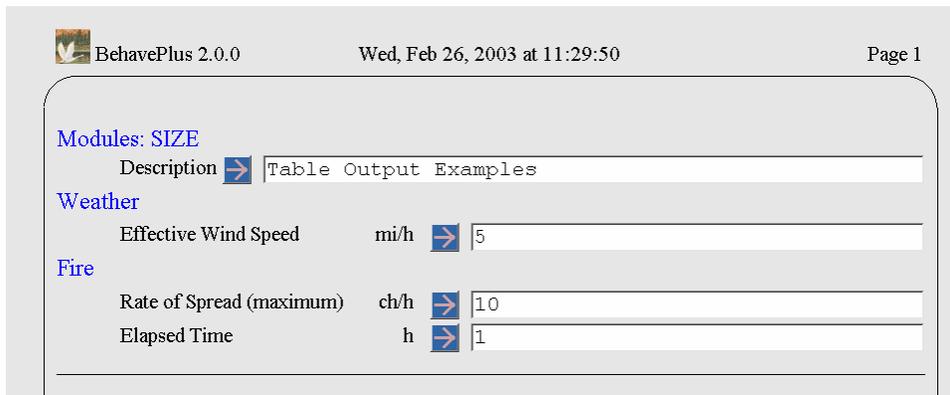


When more than one value is assigned to one or two input variables, table output is produced. Tables are produced by selecting the Display table results checkbox in the “Calculate Results” dialog box that displays after selecting a File > Calculate command.



### 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 Rate of Spread inputs produce the page 2 table below:

BehavePlus 2.0.0 Wed, Feb 26, 2003 at 11:40:25 Page 1

Modules: SIZE  
Description [Table Output Examples]

Weather  
Effective Wind Speed mi/h [5]

Fire  
Rate of Spread (maximum) ch/h [5, 10, 15]  
Elapsed Time h [1]

BehavePlus 2.0.0 Mon, Apr 14, 2003 at 15:08:26 Page 2

Table Output Examples

ROS (max) ch/h	Fire Area ac	Fire Perimeter ch
5.0	1.0	12
10.0	3.9	25
15.0	8.7	37

## 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.

BehavePlus 2.0.0 Wed, Feb 26, 2003 at 12:03:19 Page 1

Modules: SIZE  
Description [Table Output Examples]

Weather  
Effective Wind Speed mi/h [5]

Fire  
Rate of Spread (maximum) ch/h [5, 10, 15]  
Elapsed Time h [0.5, 1.0, 1.5, 2.0]

Run Options  
No run options selected.

Output Variables  
Area (ac)  
Perimeter (ch)

Display table results

Select the Table Row Variable

Rate of Spread (maximum)

Elapsed Time

Display graph results

Select the X-Axis Variable

Rate of Spread (maximum)

Elapsed Time

Specify graph Y axis limits

Picture

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:

BehavePlus 2.0.0 Wed, Feb 26, 2003 at 12:03:19 Page 2

Table Output Examples  
Area (ac)

ROS (max) ch/h	Elapsed Time 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

BehavePlus 2.0.0 Mon, Apr 28, 2003 at 06:57:56 Page 3

Table Output Examples  
Perimeter (ch)

ROS (max) ch/h	Elapsed Time 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

Display table results

Select the Table Row Variable

Rate of Spread (maximum)

Elapsed Time

Display graph results

Select the X-Axis Variable

Rate of Spread (maximum)

Elapsed Time

Specify graph Y axis limits

Picture

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

BehavePlus 2.0.0 Mon, May 05, 2003 at 10:36:47 Page 2

**Table Output Examples**  
Area (ac)

Elapsed Time	Rate of Spread (maximum)		
	ch/h		
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

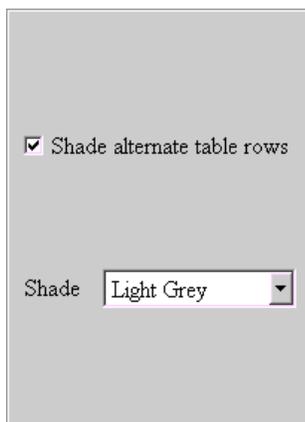
BehavePlus 2.0.0 Mon, May 05, 2003 at 10:36:47 Page 3

**Table Output Examples**  
Perimeter (ch)

Elapsed Time	Rate of Spread (maximum)		
	ch/h		
h	5.0	10.0	15.0
0.5	6	12	19
1.0	12	25	37
1.5	19	37	56
2.0	25	50	74

### 6.4. Table appearance

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

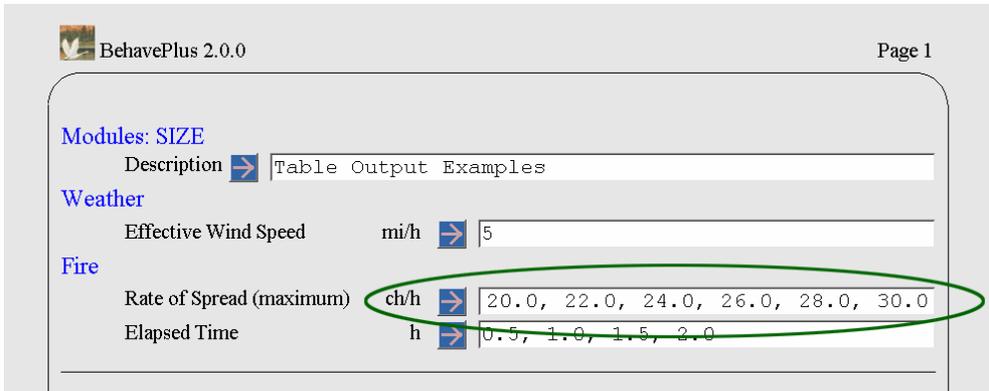


Selecting the Shade alternate table rows check box causes all output tables to have alternating rows shaded with a background color. This may improve the readability of wide tables. If the check box is cleared, tables are displayed without any row background color.

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

### 6.5. Multiple pages

There is essentially no limit on the number of values that can be assigned to a 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.

BehavePlus 2.0.0 Mon, May 05, 2003 at 10:45:44 Page 2

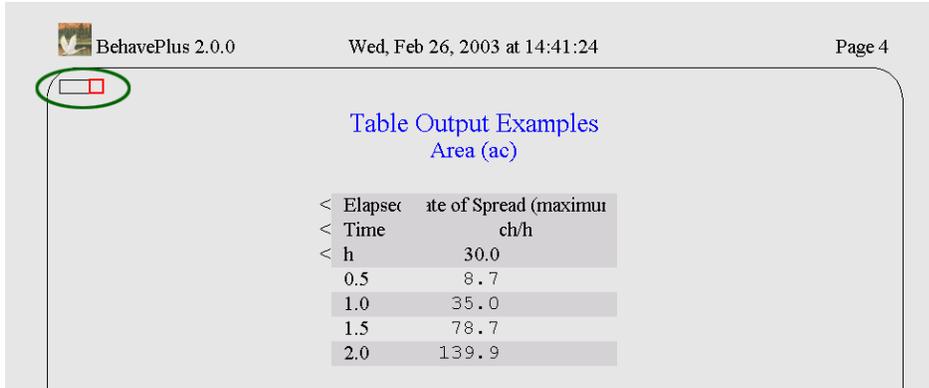
Table Output Examples  
Area (ac)

Elapsed Time h	Rate of Spread (maximum) ch/h						
	2.0	4.0	6.0	8.0	10.0	12.0	14.0
0.5	0.0	0.2	0.3	0.6	1.0	1.4	1.9
1.0	0.2	0.6	1.4	2.5	3.9	5.6	7.6
1.5	0.3	1.4	3.1	5.6	8.7	12.6	17.1
2.0	0.6	2.5	5.6	9.9	15.5	22.4	30.5

BehavePlus 2.0.0 Mon, May 05, 2003 at 10:45:44 Page 3

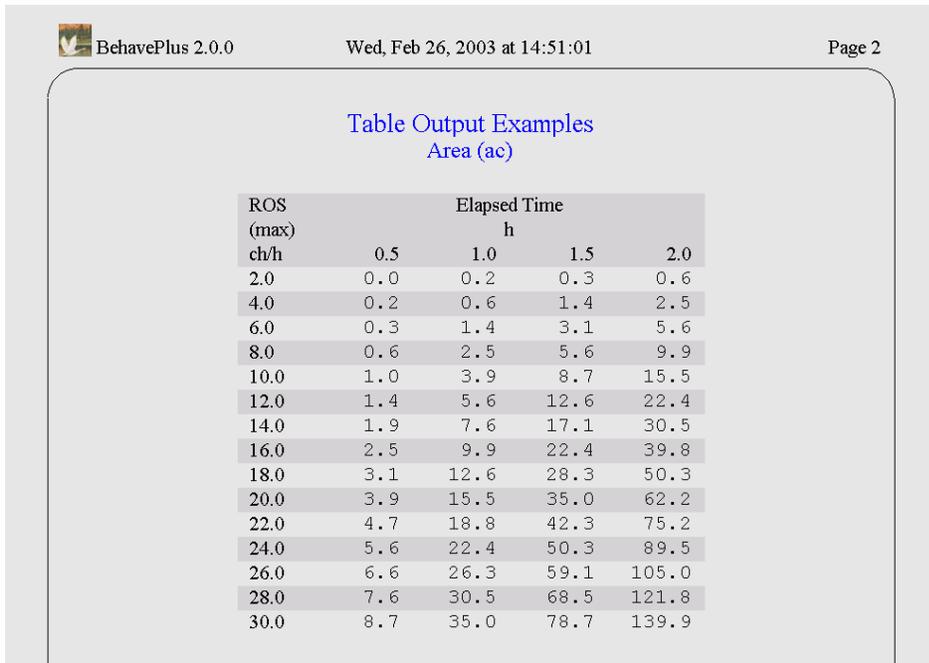
Table Output Examples  
Area (ac)

Elapsed Time h	Rate of Spread (maximum) ch/h						
	16.0	18.0	20.0	22.0	24.0	26.0	28.0
0.5	2.5	3.1	3.9	4.7	5.6	6.6	7.6
1.0	9.9	12.6	15.5	18.8	22.4	26.3	30.5
1.5	22.4	28.3	35.0	42.3	50.3	59.1	68.5
2.0	39.8	50.3	62.2	75.2	89.5	105.0	121.8



The box diagram at the upper left of the pages shows the relative position of the currently viewed page in the multipage 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:



## 7. 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.

Display table results

Display graph results

Specify graph Y axis limits

### 7.1. Single variable graph

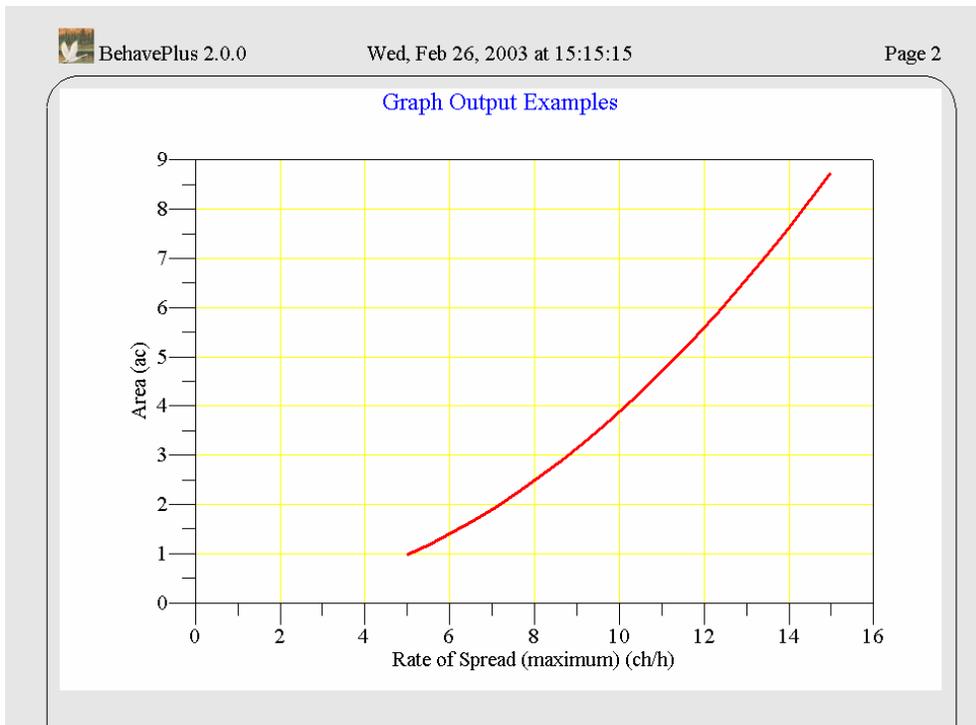
When a range of values is entered for a single continuous variable, a graph is produced by calculating a fixed number of points (which can be changed in the Configure > Appearance > Graph Elements tab) over the entered range. Intermediate values entered on the Worksheet are ignored. For example, rate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

BehavePlus 2.0.0 Wed, Feb 26, 2003 at 14:51:01 Page 1

Modules: SIZE  
Description → Graph Output Examples

Weather  
Effective Wind Speed mi/h → 5

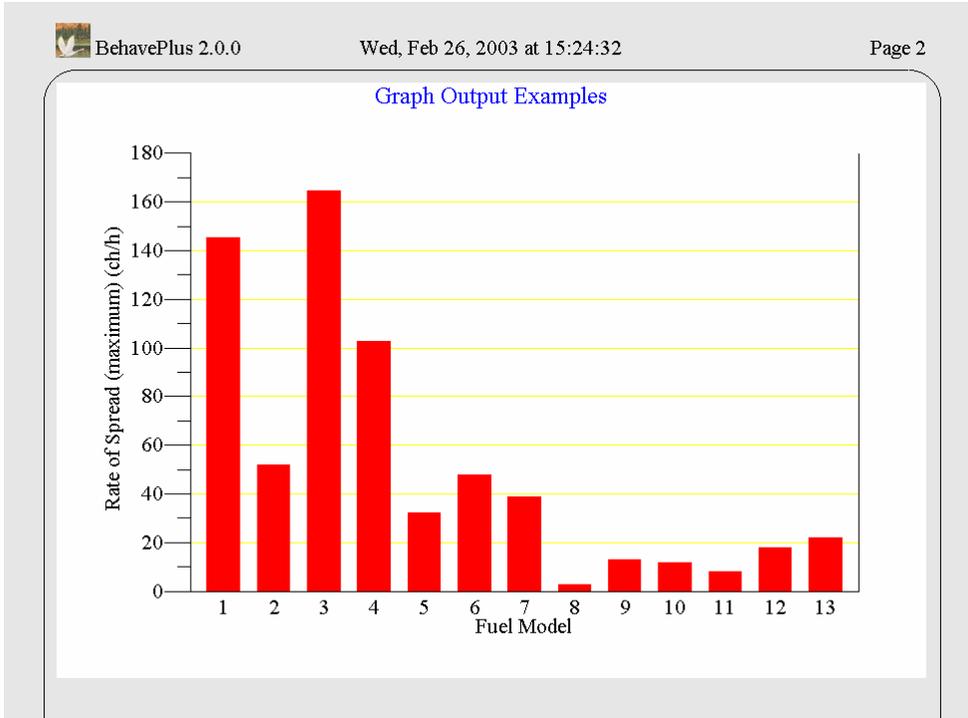
Fire  
Rate of Spread (maximum) ch/h → 5, 15  
Elapsed Time h → 1.0



When a range of values is assigned to a discrete variable, a single calculation is performed for each value and 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:

The figure shows a screenshot of the BehavePlus 2.0.0 software interface. At the top, it displays 'BehavePlus 2.0.0', the date and time 'Wed, Feb 26, 2003 at 15:15:15', and 'Page 1'. The main content area is titled 'Modules: SURFACE' and contains several input fields with dropdown arrows:

- Description**: Graph Output Examples
- Fuel/Vegetation**: Fuel Model (5, 6, 7, 8, 9, 10, 11, 12, 13)
- Fuel Moisture**:
  - Dead Fuel Moisture: 5%
  - Live Fuel Moisture: 100%
- Weather**: Midflame Wind Speed (upslope): 6 mi/h
- Terrain**: Slope Steepness: 12%



### 7.2. 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:

Modules: SURFACE

Description: Graph Output Examples

**Fuel/Vegetation**

Fuel Model: 2

**Fuel Moisture**

Dead Fuel Moisture: 5, 10, 15

Live Fuel Moisture: 100

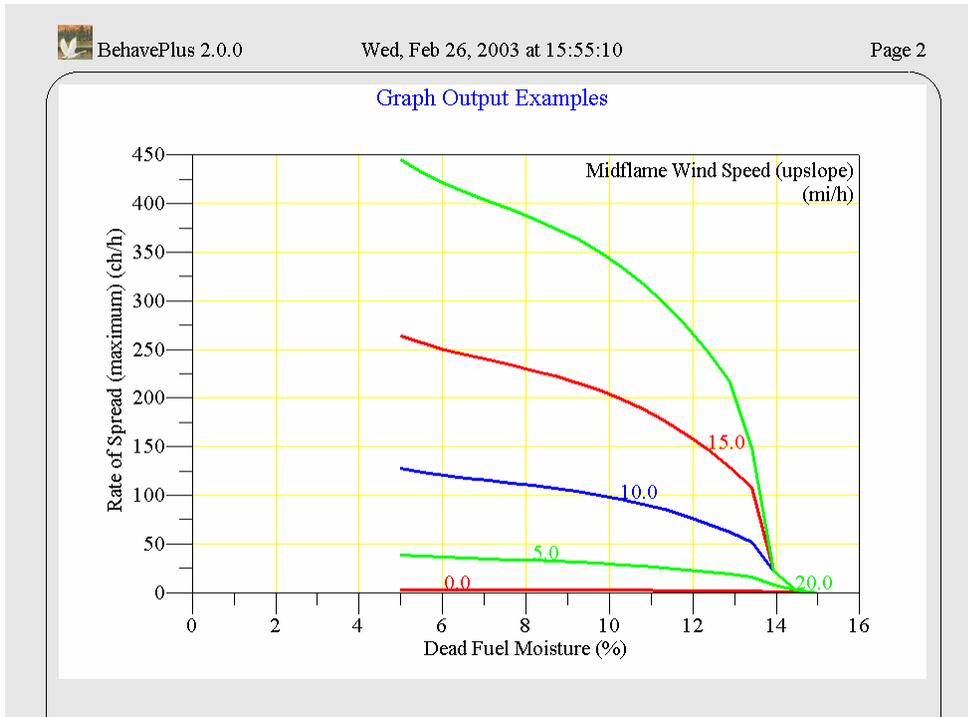
**Weather**

Midflame Wind Speed (upslope): 0.0, 5.0, 10.0, 15.0, 20.0

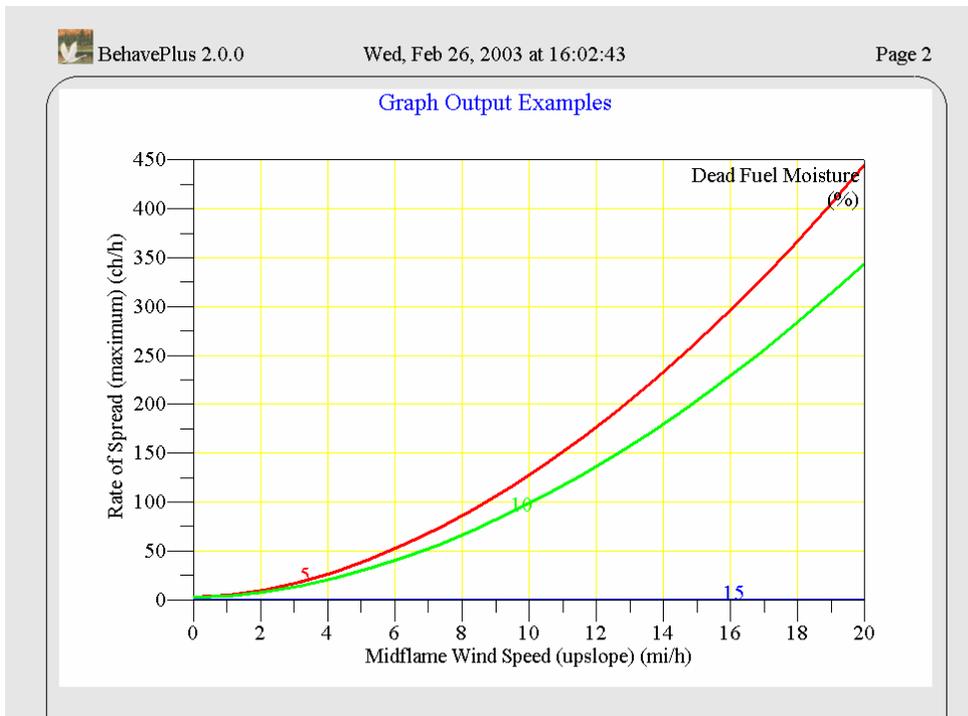
**Terrain**

Slope Steepness: 12

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



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 of which is continuous and one discrete, the continuous variable is always on the X-axis. For example:

BehavePlus 2.0.0 Wed, Feb 26, 2003 at 16:02:43 Page 1

Modules: SURFACE  
Description > Graph Output Examples

Fuel/Vegetation  
Fuel Model > 1, 2, 3, 4

Fuel Moisture  
Dead Fuel Moisture % > 5  
Live Fuel Moisture % > 100

Weather  
Midflame Wind Speed (upslope) mi/h > 0.0, 5.0, 10.0, 15.0, 20.0

Terrain  
Slope Steepness % > 12

Display table results

Select the Table Row Variable

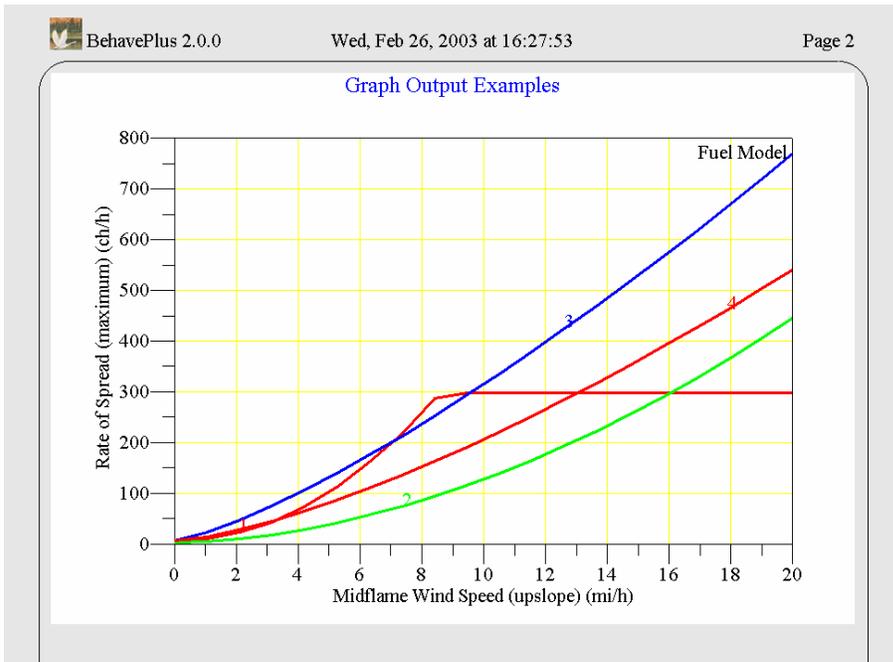
Fuel Model

Midflame Wind Speed (upslope)

Display graph results

Specify graph Y axis limits

Now 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.

## 7.3. Axis scales

### 7.3.1. X-axis

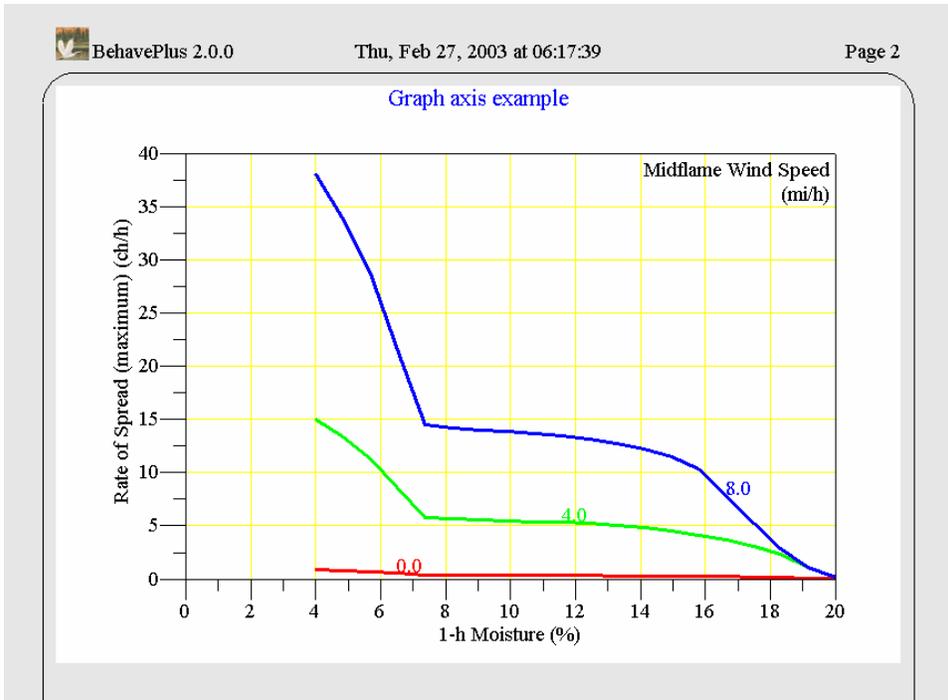
The X-axis variable and scale are the same for all graphs produced by a Run. The maximum for the x-axis is set to be the maximum value specified for the variable on the Worksheet.

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.

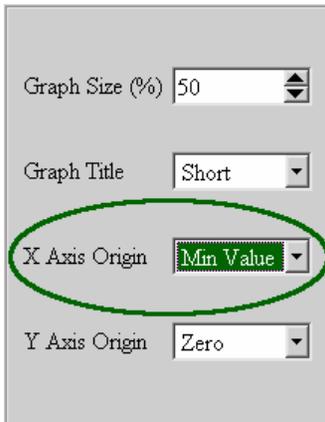
For example, consider the following Run:

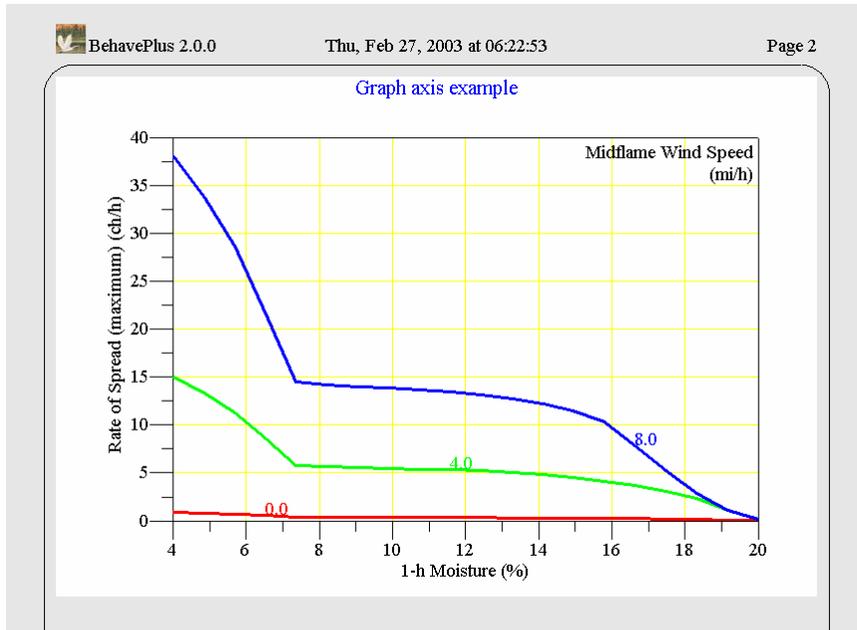
Options to define the origin of the graph are set through the Configure > Appearance > Graph Size tab.

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.





### 7.3.2. 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.

BehavePlus 2.0.0 Thu, Feb 27, 2003 at 06:30:08 Page 1

Modules: SURFACE  
 Description: Graph axis example

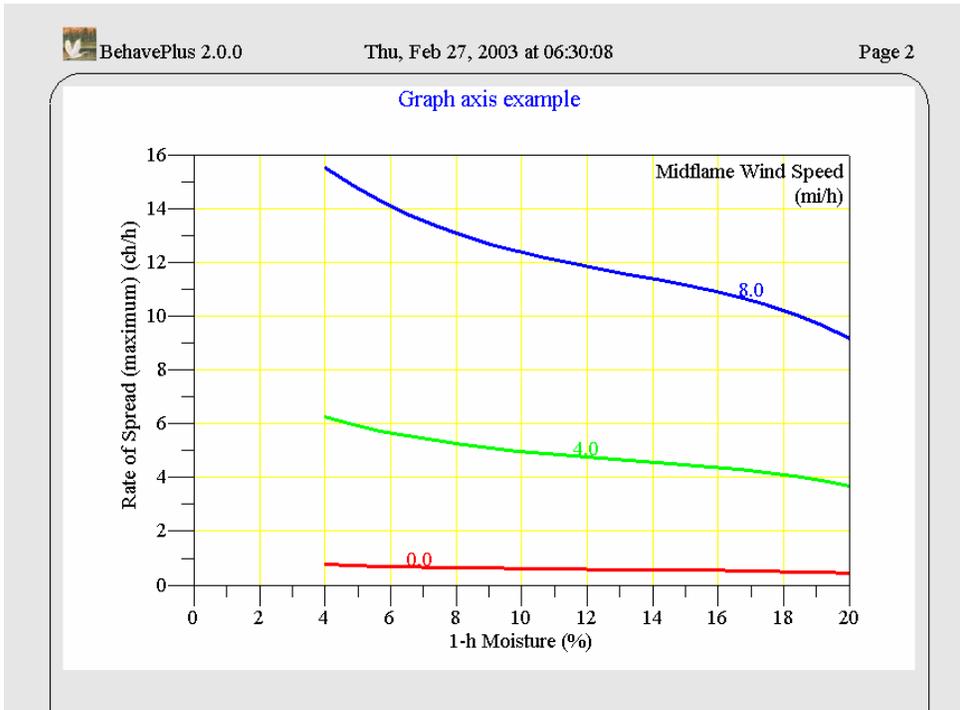
Fuel/Vegetation  
 Fuel Model: 10

Fuel Moisture  
 1-h Moisture: % 4 20  
 10-h Moisture: % 5  
 100-h Moisture: % 5  
 Live Herbaceous Moisture: %  
 Live Woody Moisture: % 120

Weather  
 Midflame Wind Speed: mi/h 0 4 8  
 Direction of Wind Vector (from upslope): deg 0

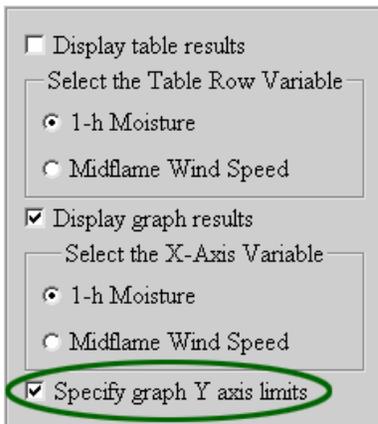
Terrain  
 Slope Steepness: % 0

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

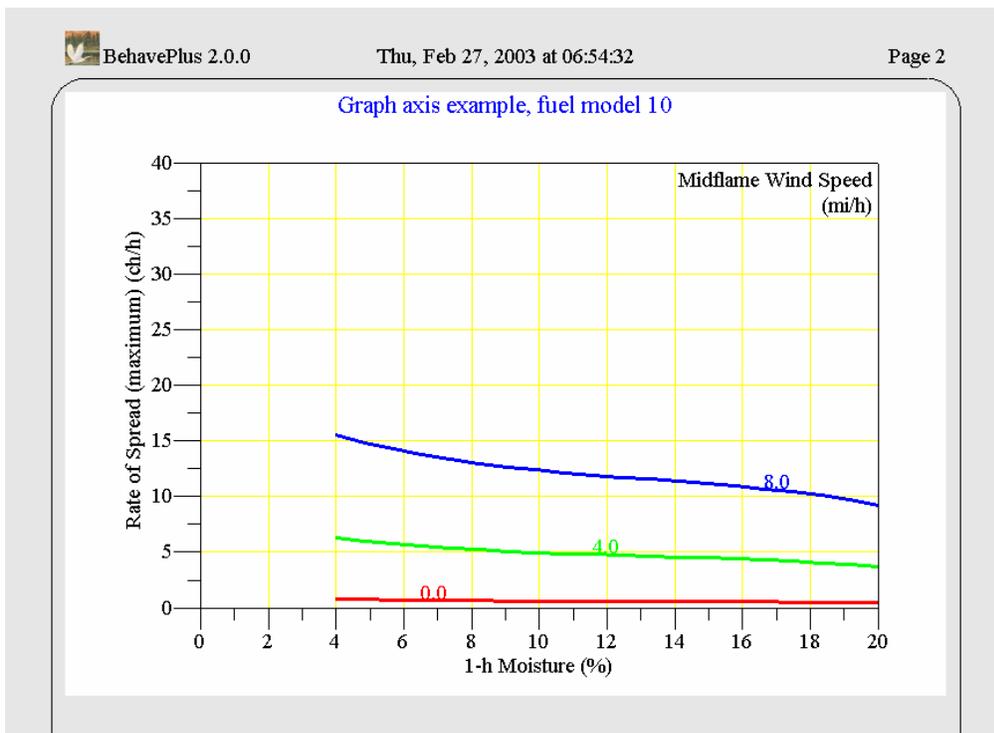
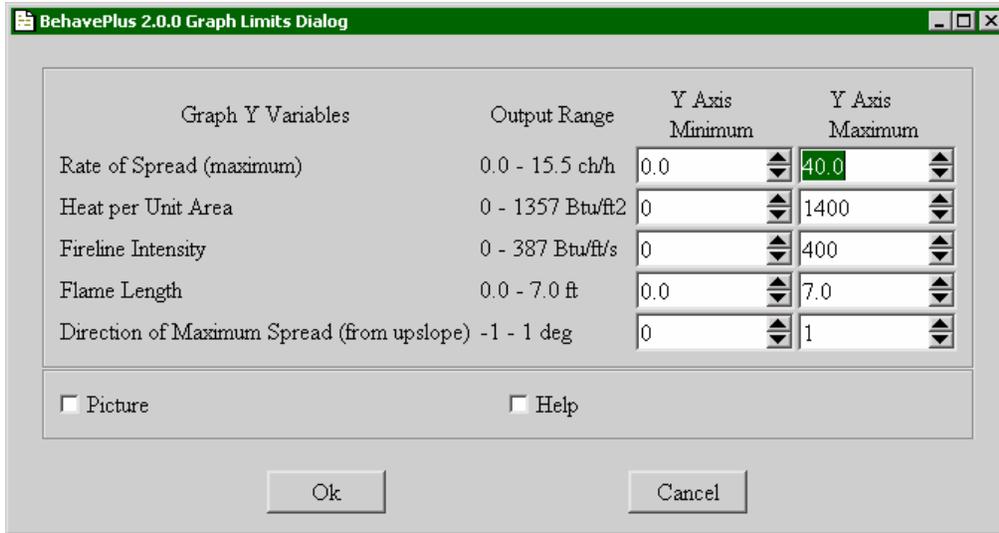


To compare the results for fuel model 10 with the faster spreading fuel model 5, the scale for the fuel model 10 Run is changed to match that produced by model 5. The calculated maximums are given for each of the selected output variables as a reference.

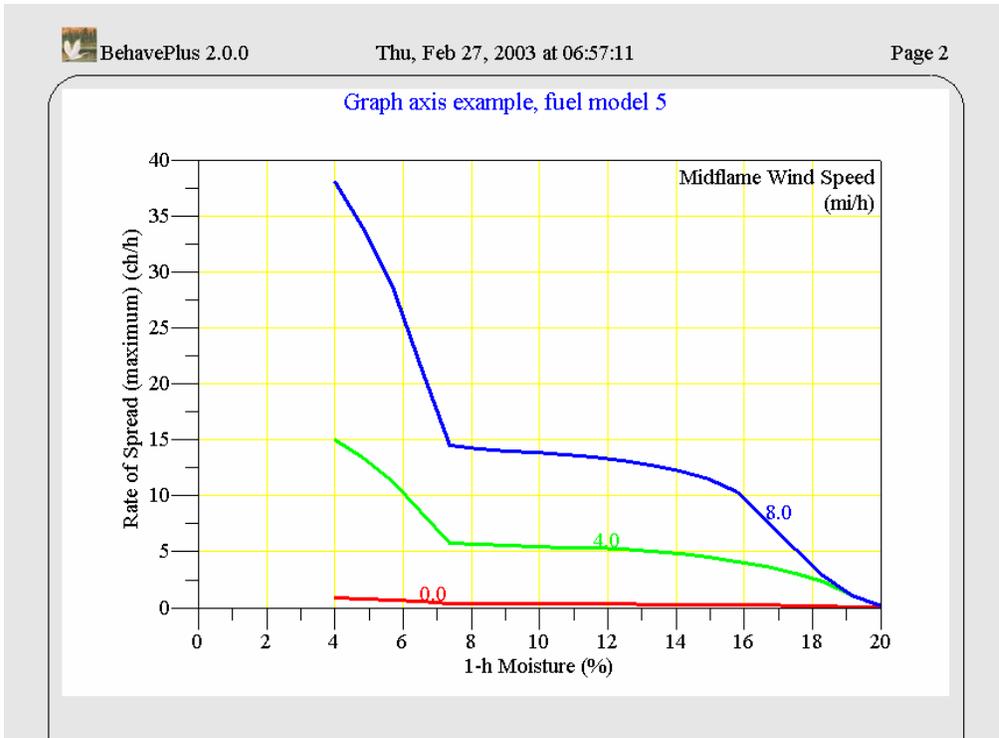
In the “Calculate Results” dialog box select the Specify graph Y axis limits check box if you wish to modify the Y-axis ranges of the output graphs before they are displayed.



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

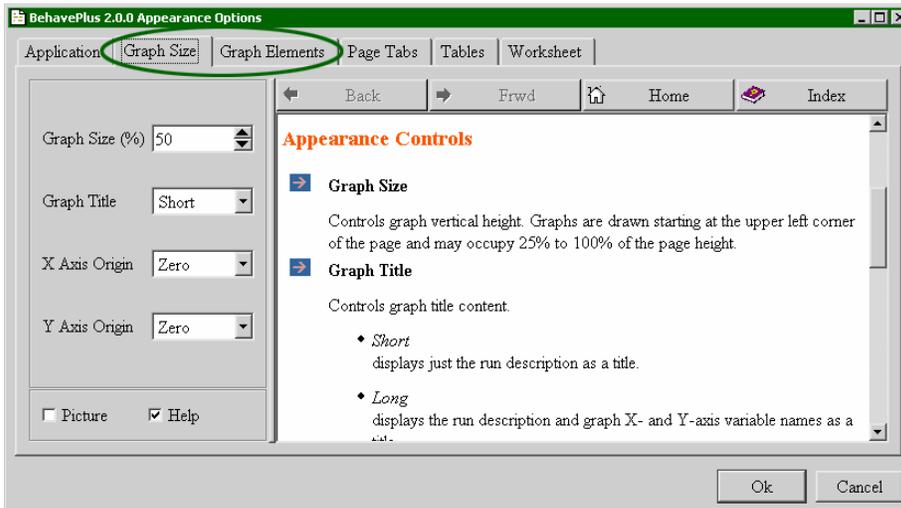


The comparison with the corresponding graph for fuel model 5 is now more straightforward.



### 7.4. Graph appearance

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



### 7.4.1. Graph Size

Graph Size (%)

Graph Title

X Axis Origin

Y Axis Origin

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.

BehavePlus 2.0.0 Thu, Feb 27, 2003 at 06:57:11 Page 1

Modules: SURFACE, SAFETY

Description

**Fuel/Vegetation**

Fuel Model

**Fuel Moisture**

Dead Fuel Moisture %

Live Fuel Moisture %

**Weather**

Midflame Wind Speed mi/h

Direction of Wind Vector (from upslope) deg

**Terrain**

Slope Steepness %

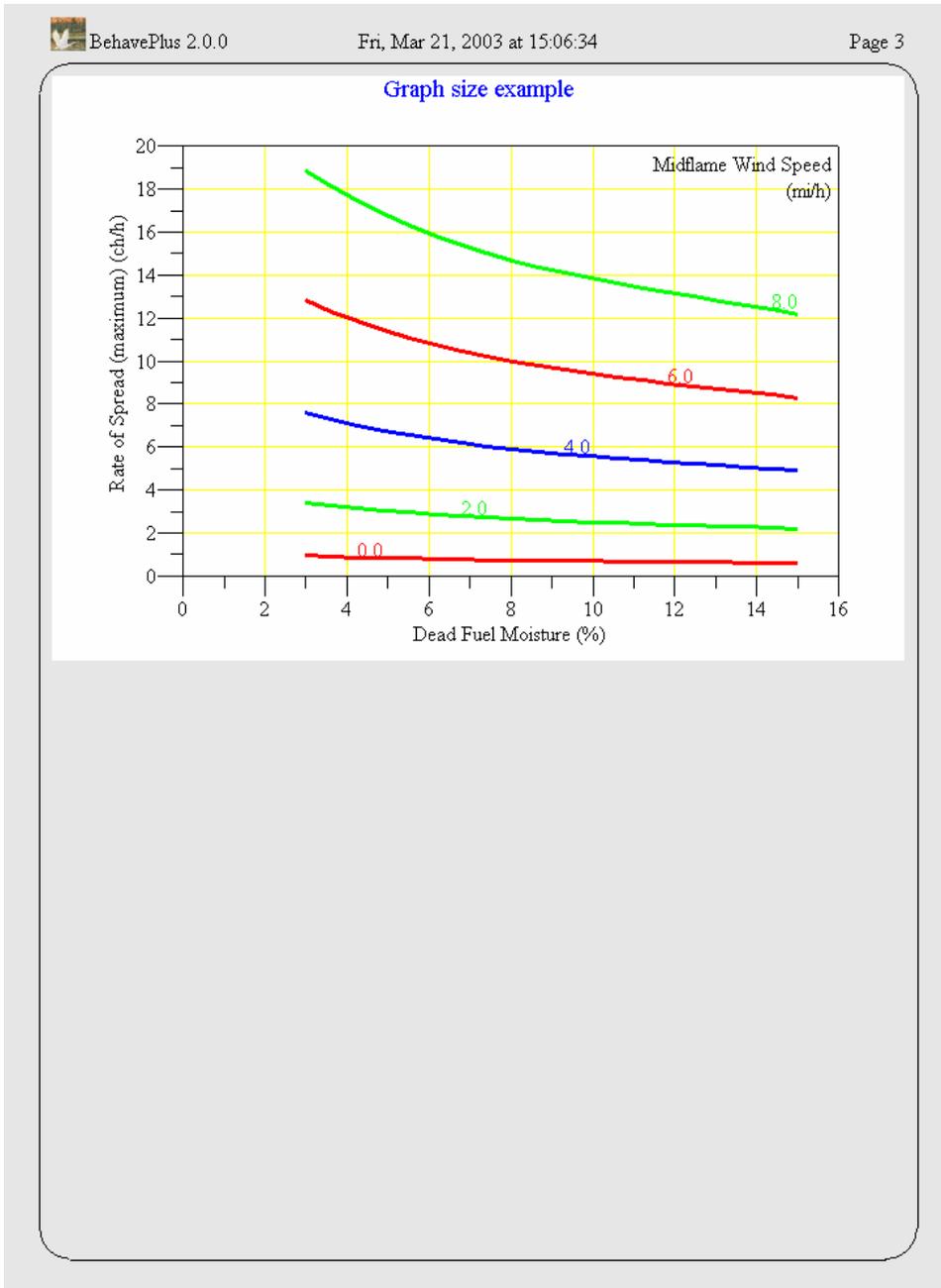
**Suppression**

Number of Personnel

Area per Person ft2

Number of Heavy Equipment

Area per Heavy Equipment ft2



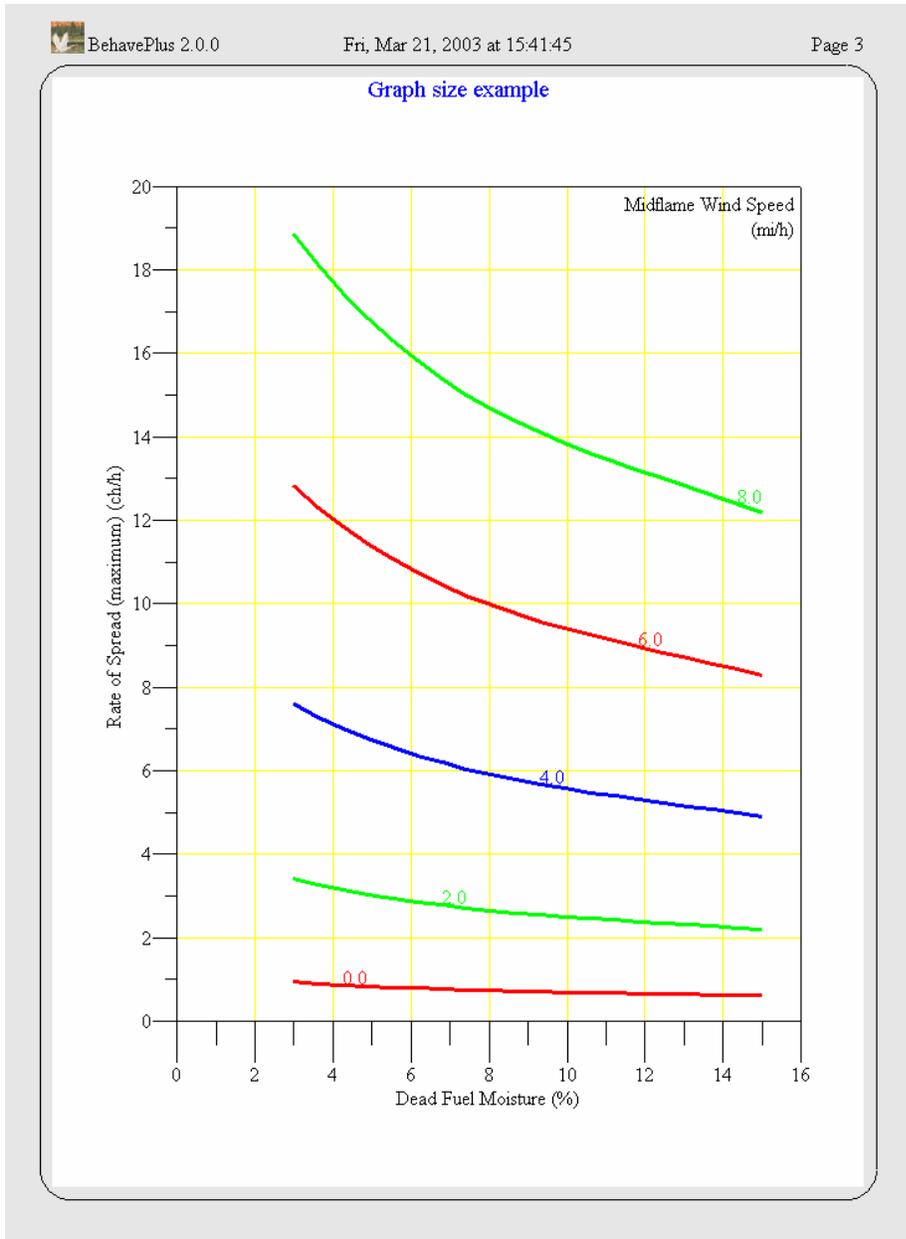
Graph Size (%)

Graph Title

X Axis Origin

Y Axis Origin

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



### 7.4.2. Graph Title

Graph Size (%)

Graph Title

X Axis Origin

Y Axis Origin

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.

BehavePlus 2.0.0 Sat, Mar 01, 2003 at 12:20:36 Page 1

Modules: SURFACE, SCORCH

Description

Fuel/Vegetation

Fuel Model

Fuel Moisture

Dead Fuel Moisture %

Live Fuel Moisture %

Weather

Midflame Wind Speed mi/h

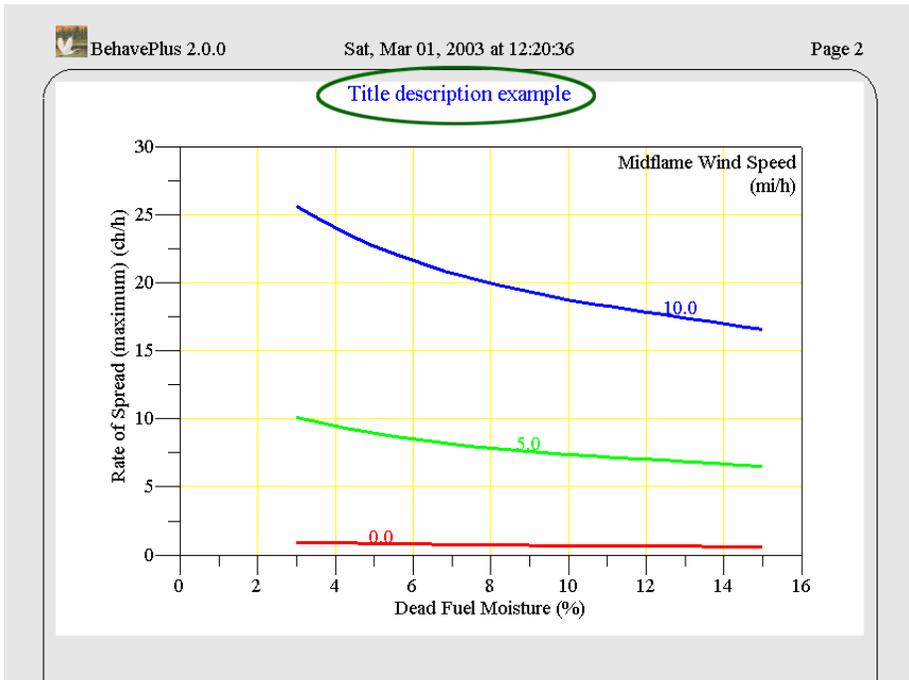
Direction of Wind Vector (from upslope) deg

Air Temperature oF

Terrain

Slope Steepness %

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



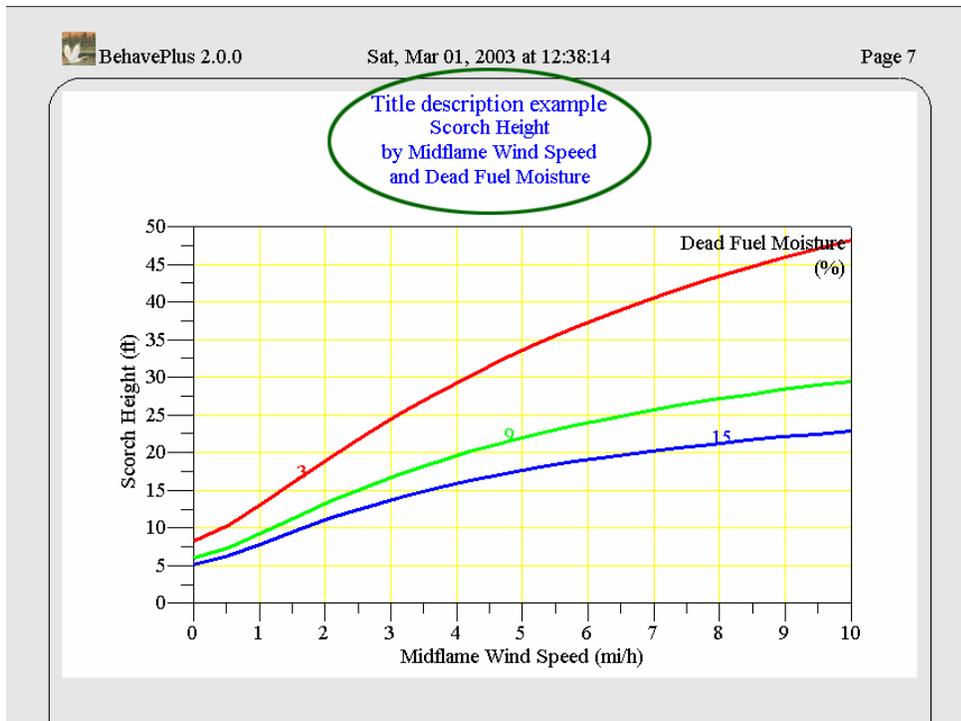
Graph Size (%)

Graph Title

X Axis Origin

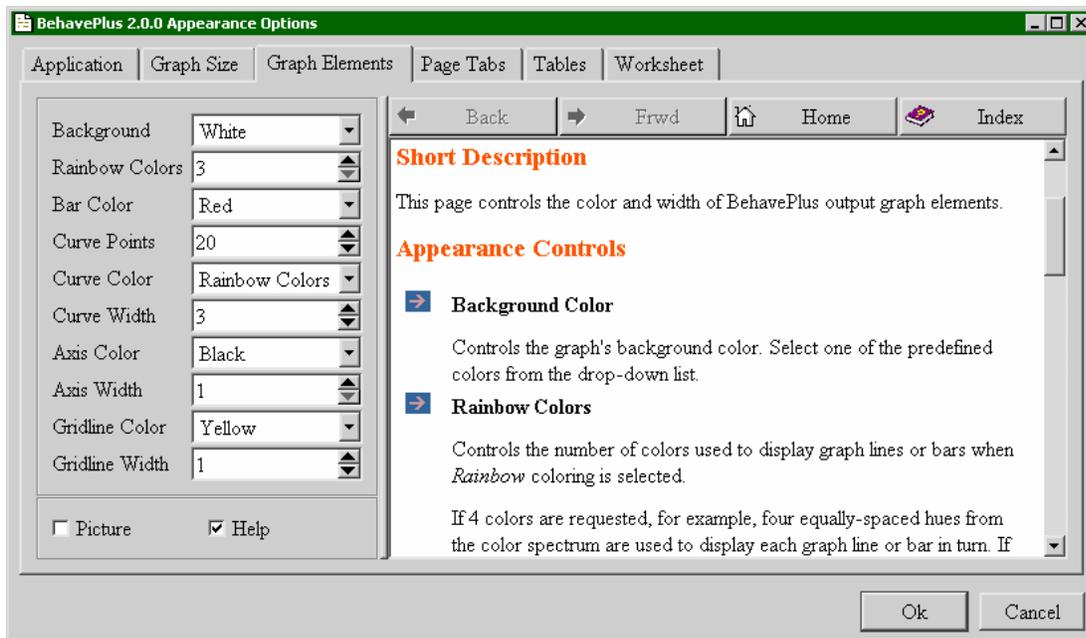
Y Axis Origin

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



### 7.4.3. 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.

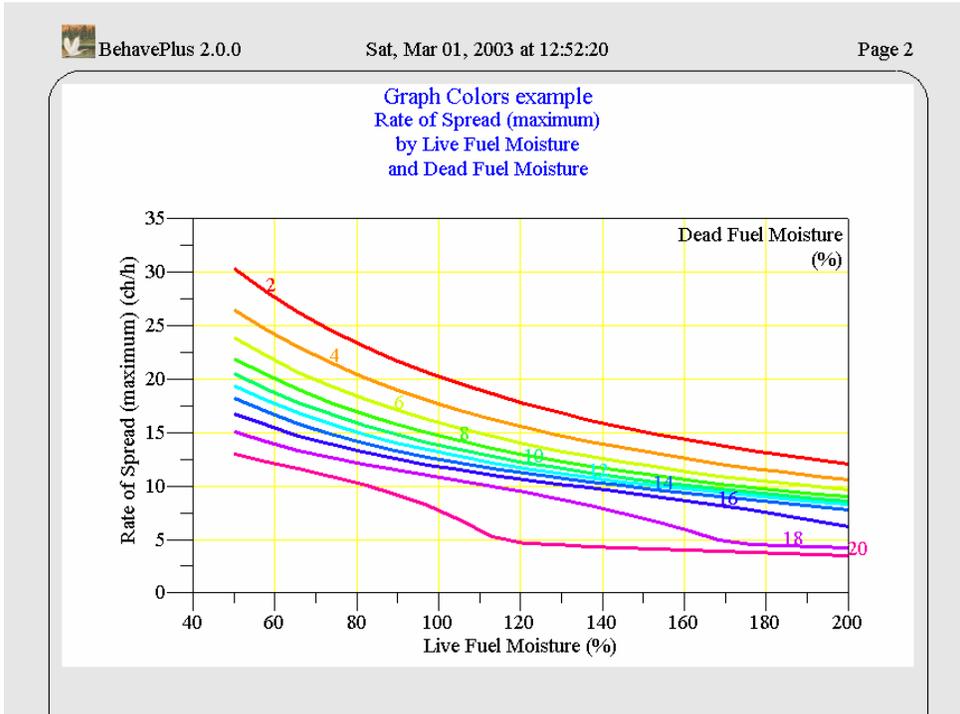
**Curve Color** is used to draw graph lines. Selecting Rainbow Colors draws each line with its own color. The number of rainbow colors is set by the Rainbow Colors spin box discussed above.

**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.

Background	White
Rainbow Colors	10
Bar Color	Red
Curve Points	20
Curve Color	Rainbow Colors
Curve Width	3
Axis Color	Black
Axis Width	1
Gridline Color	Yellow
Gridline Width	1

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



### 7.4.4. 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

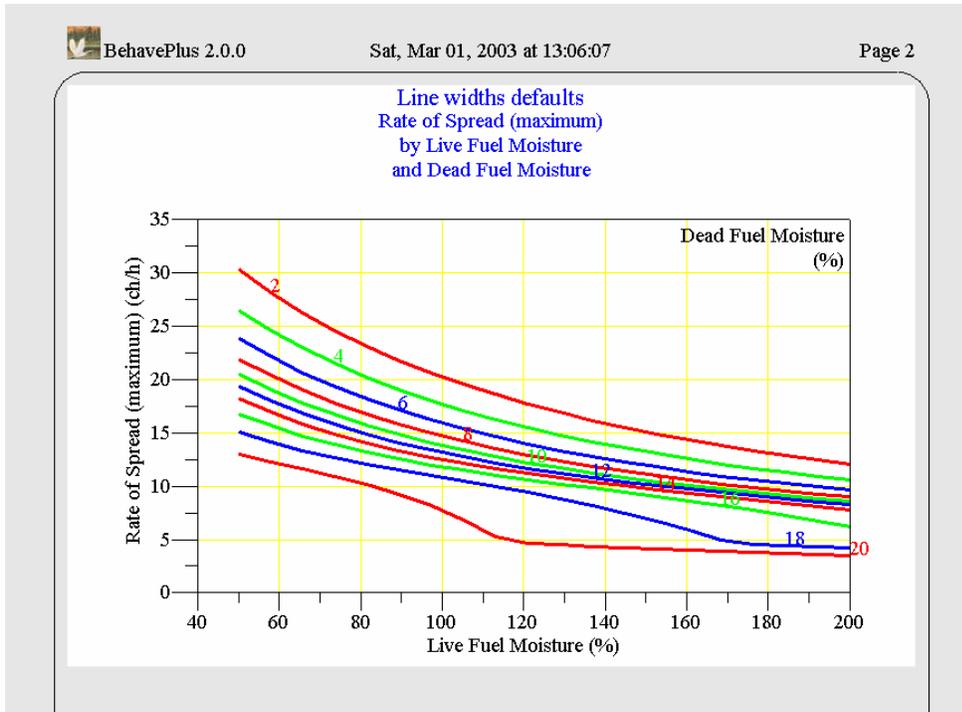


**Curve Width** sets the width of graph lines. 0 is the thinnest and 9 thickest.

**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 and color settings.



### 7.5. Number of curve points

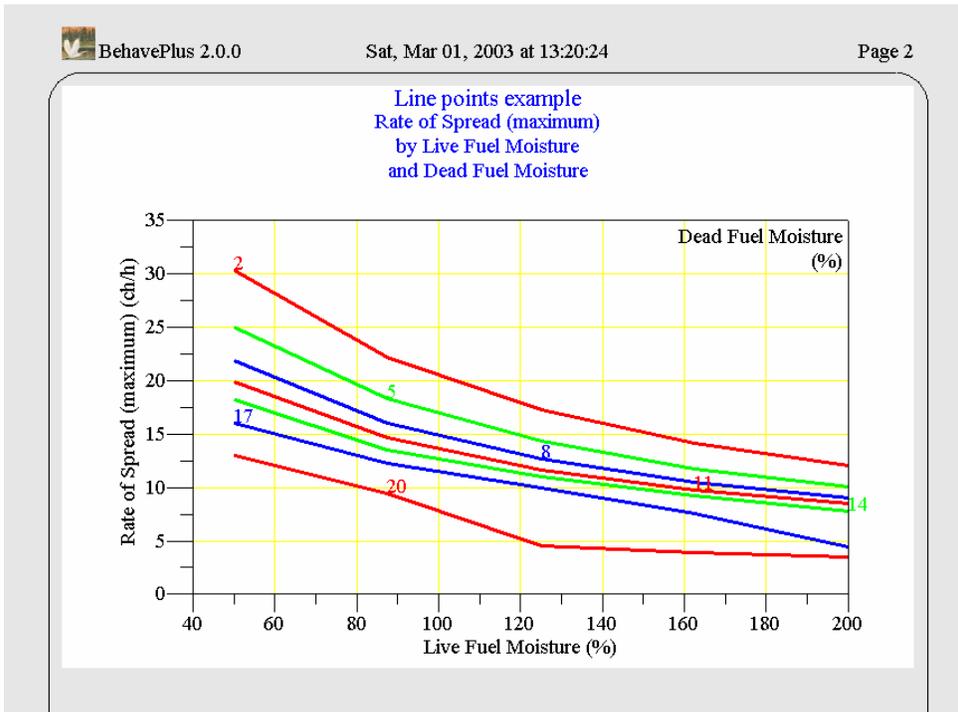
Background	White
Rainbow Colors	3
Bar Color	Red
Curve Points	20
Curve Color	Rainbow Colors
Curve Width	3
Axis Color	Black
Axis Width	1
Gridline Color	Yellow
Gridline Width	1

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 of 20 is visually adequate for most graphs. Requesting more points usually results in a marginal improvement in the visual appearance and requires more computation time. In cases where many curves are plotted and the calculation time is slow, reducing the number of curve points will speed things up.

Background	White
Rainbow Colors	3
Bar Color	Red
Curve Points	5
Curve Color	Rainbow Colors
Curve Width	3
Axis Color	Black
Axis Width	1
Gridline Color	Yellow
Gridline Width	1

Changing Curve Points from the default of 20 to 5 results in the following graph:



This page is blank on purpose.

## 8. 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

The option of diagram output is given in the lists of output variables.

### 8.1. 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... > Outputs tab and selecting the Wind/Slope/Spread Direction Diagram check box.

Rate of Spread  
 Heat per Unit Area  
 Fireline Intensity  
 Flame Length  
 Reaction Intensity  
 Direction of Maximum Spread (from upslope)  
 Spread Distance  
 Midflame Wind Speed  
 Effective Wind Speed  
 Maximum Reliable Wind Speed  
 Maximum Wind Exceeded?  
 Slope Steepness  
 Slope Elevation Change  
 Slope Horizontal Distance  
 Wind/Slope/Spread Direction Diagram  
 Fire Characteristics Chart

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.

Wind & spread directions are

degrees clockwise from upslope  
(direction the wind is pushing the fire).

degrees clockwise from north  
(direction from which the wind is blowing).

BehavePlus 2.0.0 Tue, Mar 18, 2003 at 12:53:05 Page 1

**Modules: SURFACE**

Description → wind/Slope/Spread direction example

**Fuel/Vegetation**

Fuel Model → 2

**Fuel Moisture**

Dead Fuel Moisture % → 6

Live Fuel Moisture % → 120

**Weather**

Midflame Wind Speed mph → 5

Direction of Wind Vector (from upslope) deg → 100

**Terrain**

Slope Steepness % → 10 40

---

**Run Options**

Calculations are only for the direction of maximum spread.

Wind and spread directions are degree clockwise from upslope.

Wind direction is the direction the wind is pushing the fire.

---

**Output Variables**

Rate of Spread (maximum) (ch/h)

Flame Length (ft)

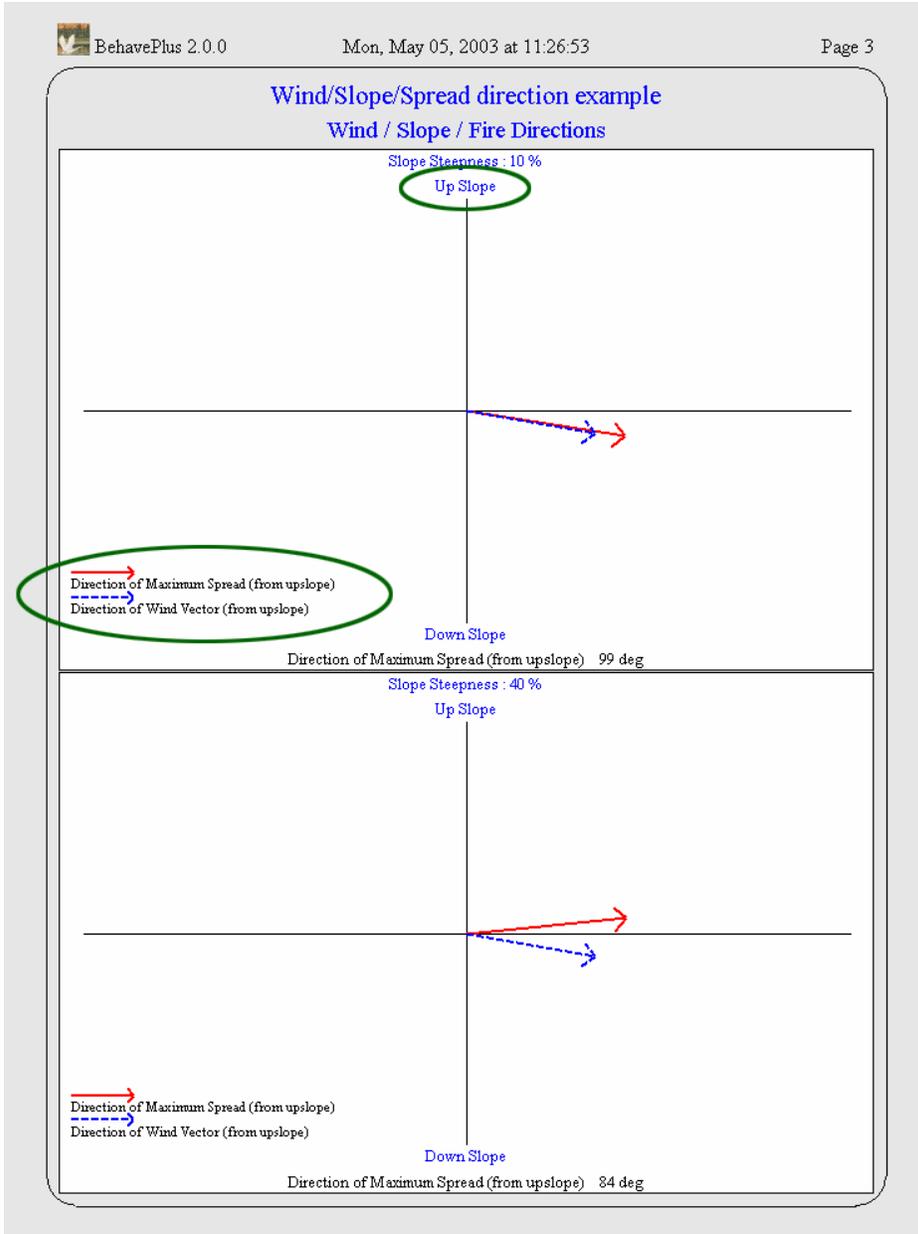
Direction of Maximum Spread (from upslope) (deg)

Wind/Slope/Spread Direction Diagram

BehavePlus 2.0.0 Tue, Mar 18, 2003 at 13:28:42 Page 2

**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 option button on the variables that are requested on the Worksheet.

Wind & spread directions are

- degrees clockwise from upslope  
(direction the wind is pushing the fire).
- degrees clockwise from north  
(direction from which the wind is blowing).

BehavePlus 2.0.0 Mon, May 05, 2003 at 11:26:53 Page 1

**Modules: SURFACE**  
 Description ➤ Wind/Slope/Spread direction example

**Fuel/Vegetation**  
 Fuel Model ➤ 2

**Fuel Moisture**  
 Dead Fuel Moisture % ➤ 6  
 Live Fuel Moisture % ➤ 120

**Weather**  
 Midflame Wind Speed mi/h ➤ 5  
 Wind Direction (from north) deg ➤ 190

**Terrain**  
 Slope Steepness % ➤ 10 40  
 Aspect (from north) deg ➤ 90

---

**Run Options**  
 Calculations are only for the direction of maximum spread.  
 Fireline intensity, flame length, and spread distance are always  
 for the direction of the spread calculations.  
 Wind and spread directions are degrees clockwise from north.  
 Wind direction is the direction from which the wind is blowing.

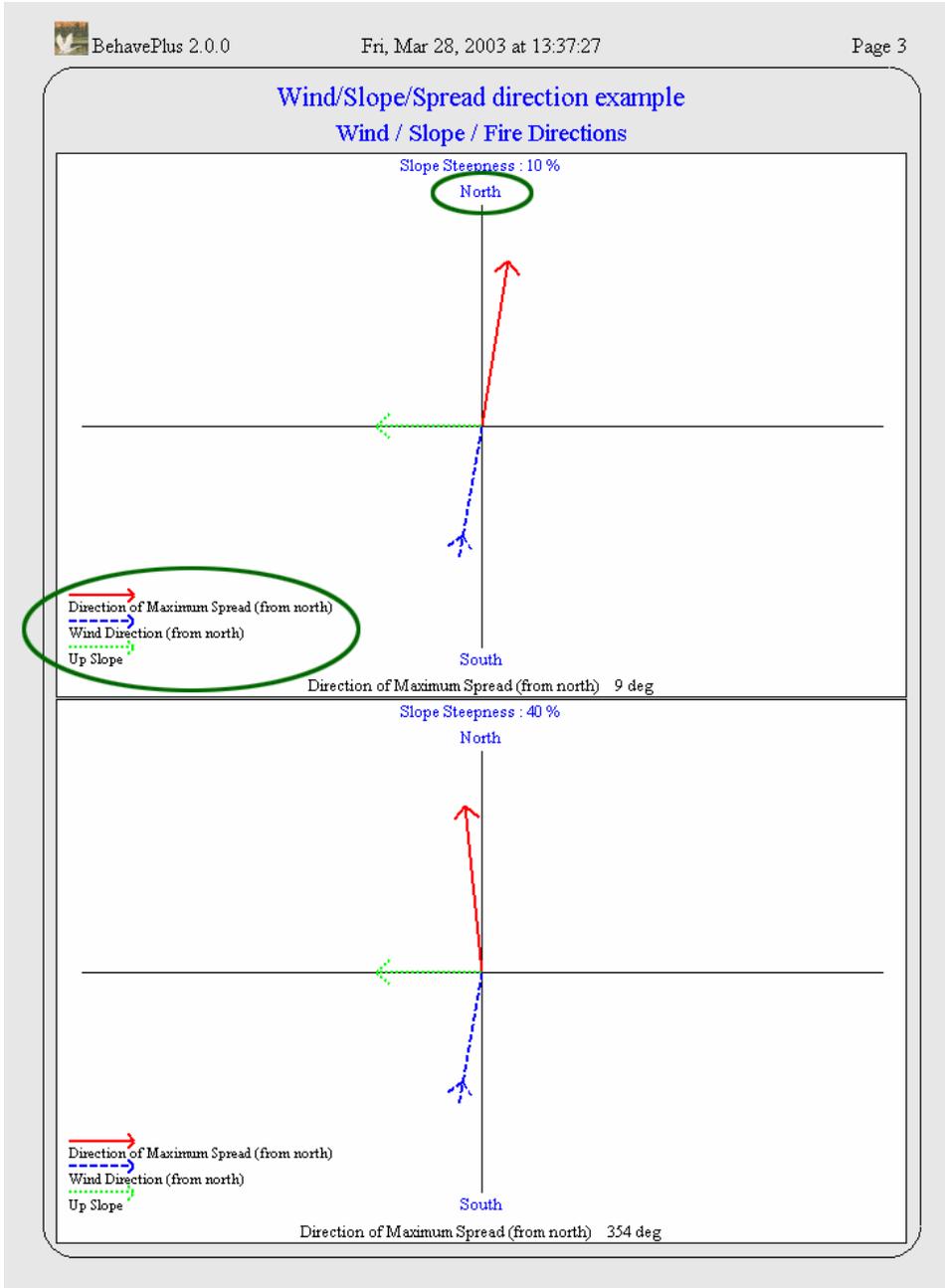
---

**Output Variables**  
 Rate of Spread (maximum) (ch/h)  
 Flame Length (ft)  
 Direction of Maximum Spread (from north) (deg)  
 Wind/Slope/Spread Direction Diagram

BehavePlus BehavePlus 2.0.0 Fri, Mar 28, 2003 at 13:37:27 Page 2

**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



## 8.2. 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 that the user can customize it for a specific need.

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

- Rate of Spread
- Heat per Unit Area
- Fireline Intensity
- Flame Length
- Reaction Intensity
- Direction of Maximum Spread (from upslope)
- Spread Distance
- Midflame Wind Speed
- Effective Wind Speed
- Maximum Reliable Wind Speed
- Maximum Wind Exceeded?
- Slope Steepness
- Slope Elevation Change
- Slope Horizontal Distance
- Wind/Slope/Spread Direction Diagram
- Fire Characteristics Chart

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.

BehavePlus 2.0.0      Fri, Mar 28, 2003 at 13:37:27      Page 1

---

**Modules: SURFACE**

Description → Fire Characteristics Chart example

**Fuel/Vegetation**

Fuel Model → 2 5 10

**Fuel Moisture**

Dead Fuel Moisture % → 5

Live Fuel Moisture % → 100

**Weather**

Midflame Wind Speed (upslope) mi/h → 7

**Terrain**

Slope Steepness % → 10

---

**Run Options**

Wind direction is upslope.  
 Calculations are only for the direction of maximum spread.  
 Wind and spread directions are degrees clockwise from upslope.  
 Wind direction is the direction the wind is pushing the fire.

---

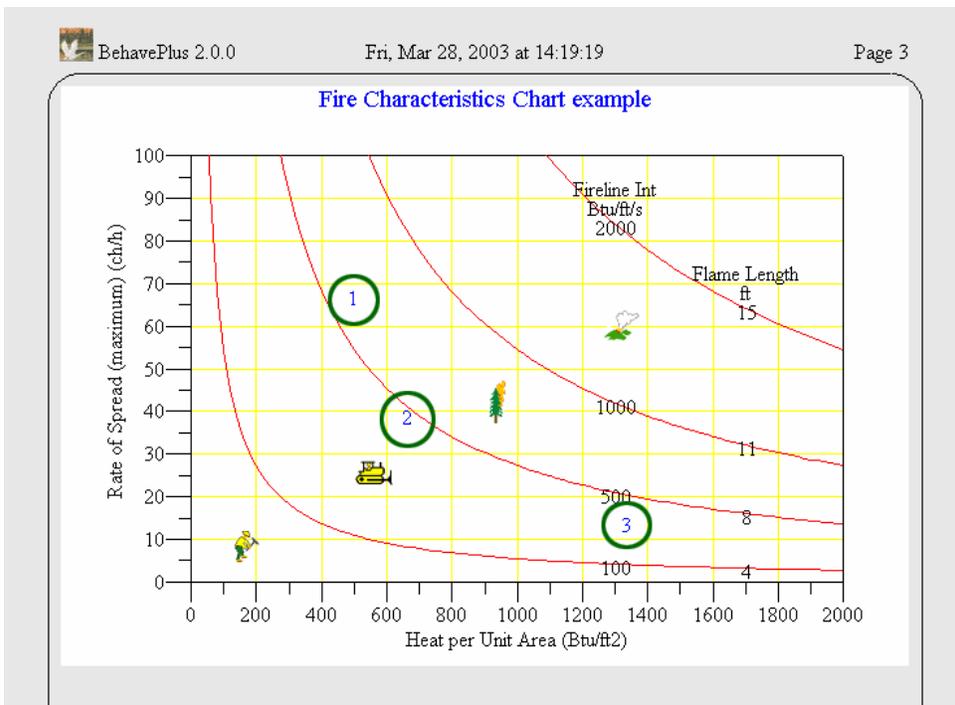
**Output Variables**

Rate of Spread (maximum) (ch/h)  
 Heat per Unit Area (Btu/ft<sup>2</sup>)  
 Fireline Intensity (Btu/ft/s)  
 Flame Length (ft)  
 Fire Characteristics Chart

BehavePlus 2.0.0      Fri, Mar 28, 2003 at 14:19:19      Page 2

### Fire Characteristics Chart example

Fuel Model	ROS (max) ch/h	Heat per Unit Area Btu/ft <sup>2</sup>	Fireline Intensity Btu/ft/s	Flame Length ft
2	67.6	491	608	8.6
5	39.5	659	477	7.7
10	14.1	1330	344	6.6



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:

BehavePlus 2.0.0      Fri, Mar 28, 2003 at 14:19:19      Page 1

**Modules: SURFACE**  
 Description → Fire Characteristics Chart example

**Fuel/Vegetation**  
 Fuel Model → 5

**Fuel Moisture**  
 Dead Fuel Moisture % → 3 6 9  
 Live Fuel Moisture % → 100

**Weather**  
 Midflame Wind Speed (upslope) mi/h → 7 10

**Terrain**  
 Slope Steepness % → 10

---

**Run Options**  
 Wind direction is upslope.  
 Calculations are only for the direction of maximum spread.  
 Wind and spread directions are degrees clockwise from upslope.  
 Wind direction is the direction the wind is pushing the fire.

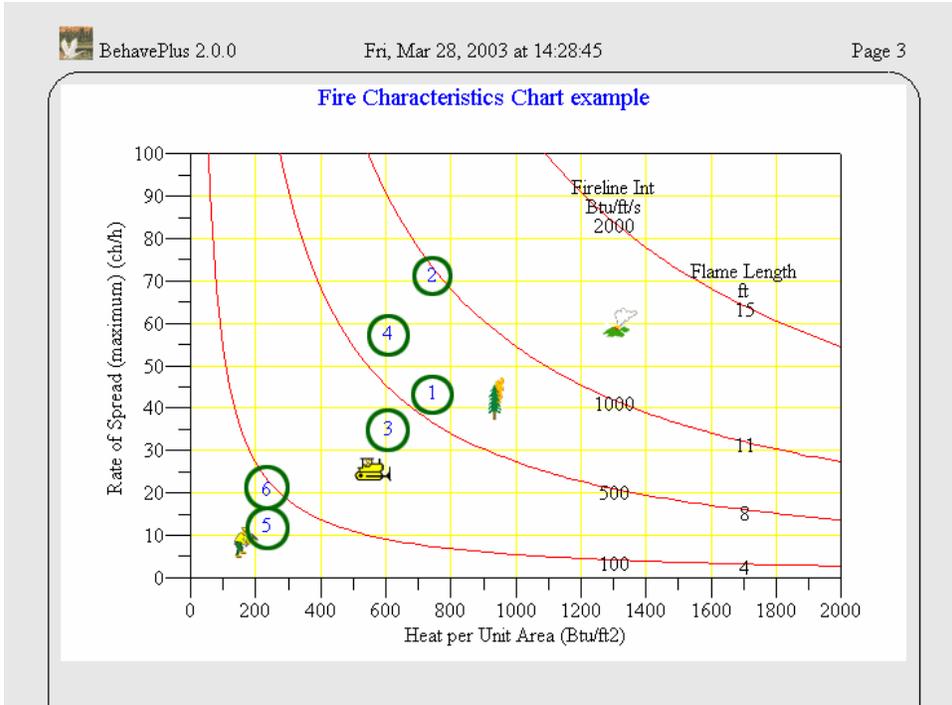
---

**Output Variables**  
 Rate of Spread (maximum) (ch/h)  
 Fire Characteristics Chart

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**Fire Characteristics Chart example**  
**Rate of Spread (maximum) (ch/h)**

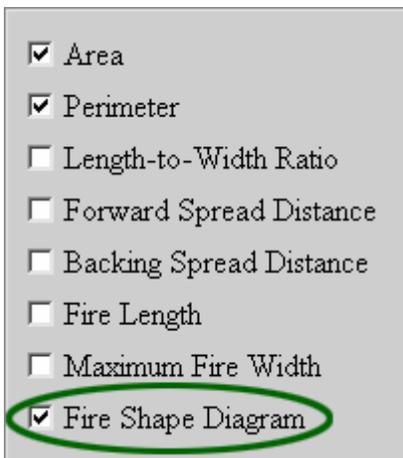
Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h	
	7.0	10.0
3	44.7	72.4
6	36.1	58.5
9	13.5	21.8



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.

### 8.3. Shape of a point source fire

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



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

BehavePlus 2.0.0 Mon, May 05, 2003 at 11:26:53 Page 1

**Modules:** SIZE  
 Description → Fire Shape Diagram example

**Weather**  
 Effective Wind Speed mi/h → 0 6

**Fire**  
 Rate of Spread (maximum) ch/h → 10  
 Elapsed Time h → 1 2

---

**Run Options**  
 No run options selected.

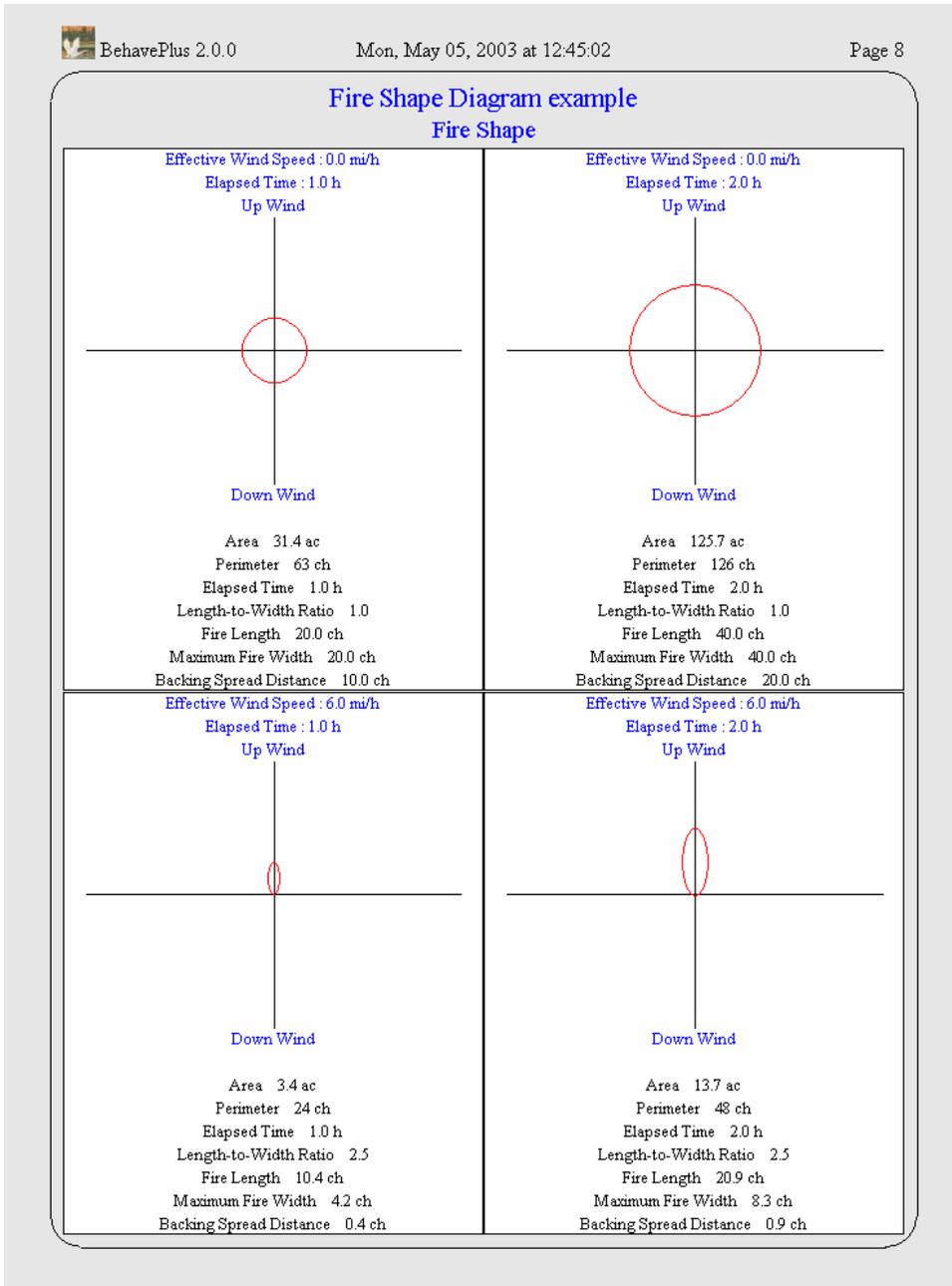
---

**Output Variables**  
 Area (ac)  
 Perimeter (ch)  
 Length-to-Width Ratio  
 Backing Spread Distance (ch)  
 Fire Length (ch)  
 Maximum Fire Width (ch)  
 Fire Shape Diagram

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**Fire Shape Diagram example**  
 Area (ac)

Effective Wind mi/h	Elapsed Time 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.

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

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Modules: SURFACE, SIZE

Description  Fire Shape Diagram example

**Fuel/Vegetation**

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 Options**

Calculations are only for the direction of maximum spread.  
 Fireline intensity, flame length, and spread distance are always  
 for the direction of the spread calculations.  
 Wind and spread directions are degrees clockwise from upslope.  
 Wind direction is the direction the wind is pushing the fire.

---

**Output Variables**

Rate of Spread (maximum) (ch/h)

Flame Length (ft)

Direction of Maximum Spread (from upslope) (deg)

Area (ac)

Perimeter (ch)

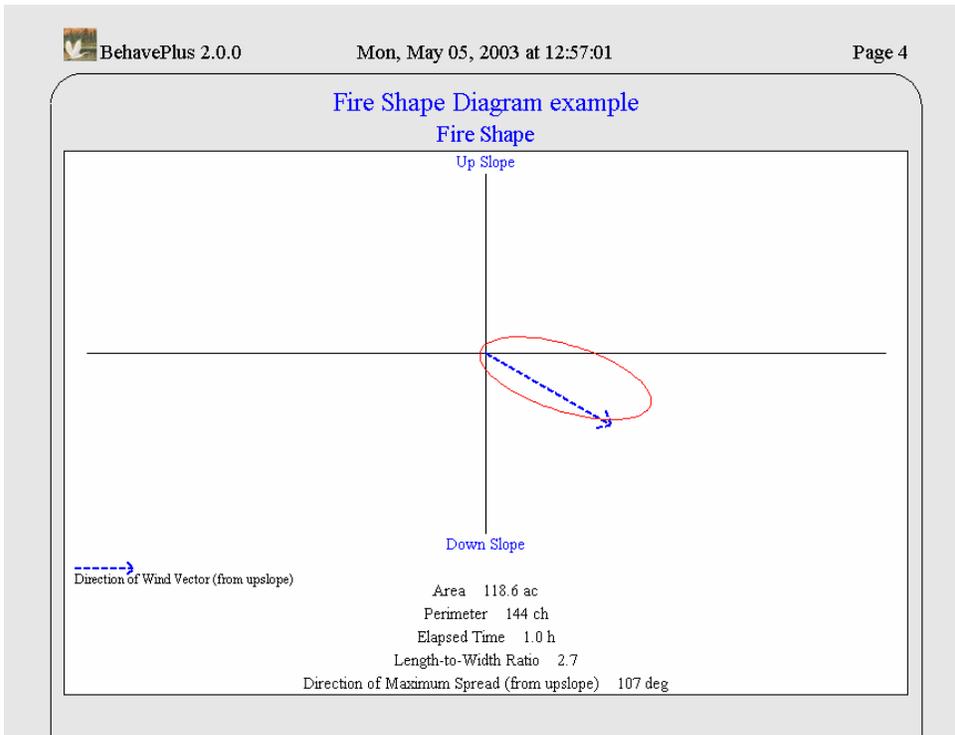
Length-to-Width Ratio

Fire Shape Diagram

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**Fire Shape Diagram example**

Rate of Spread (maximum)	61.0 ch/h
Flame Length	8.2 ft
Direction of Maximum Spread (from upslope)	107 deg
Area	118.6 ac
Perimeter	144 ch
Length-to-Width Ratio	2.7



### 8.4. 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 checkbox from the Configure > Module selection > Containment > Options ... > Output Variables tab.

Select the Contain Status checkbox to output whether the fire was Contained or Escaped on the Containment Diagram.

- Time from Report
- Contain Status
- Contained Area
- Fireline Constructed
- Number of Resources Used
- Cost of Resources Used
- Containment Diagram

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**Modules: CONTAIN**

Description ➤ Containment Diagram example

**Fire**

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 Name ➤ crew1

Resource Line Production Rate ch/h ➤ 30

Resource Arrival Time h ➤ 0.5

Resource Duration h ➤ 6

---

**Run Options**

No run options selected.

---

**Output Variables**

Time from Report (h)

Contain Status

Contained Area (ac)

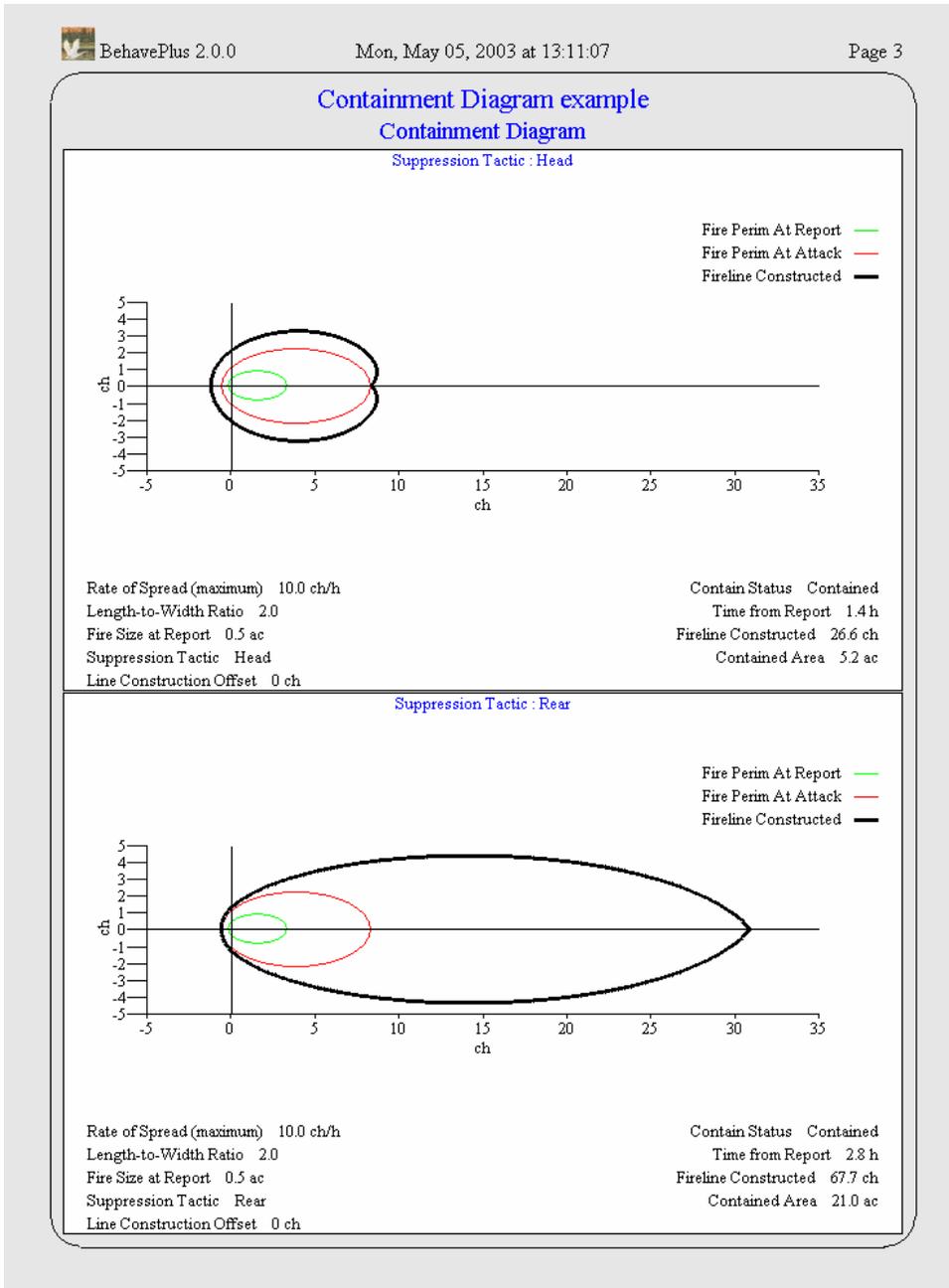
Fireline Constructed (ch)

Containment Diagram

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**Containment Diagram example**

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



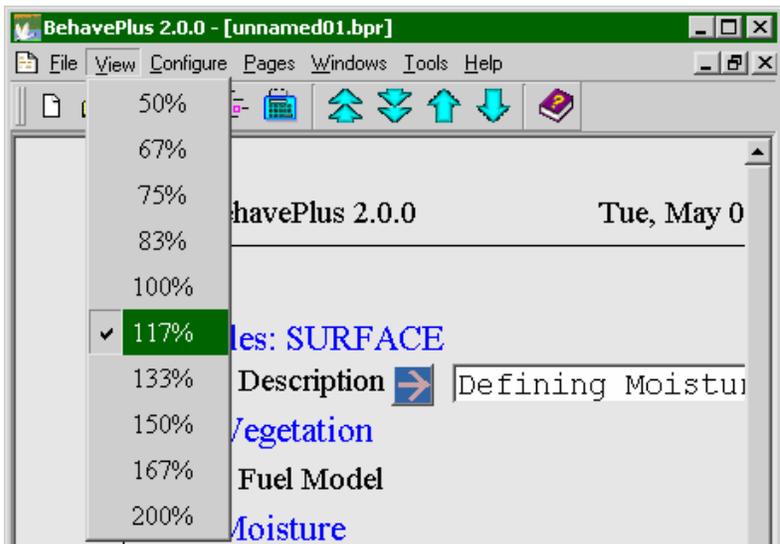
This page is blank on purpose.

## 9. View, print, & capture results



### 9.1. 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.



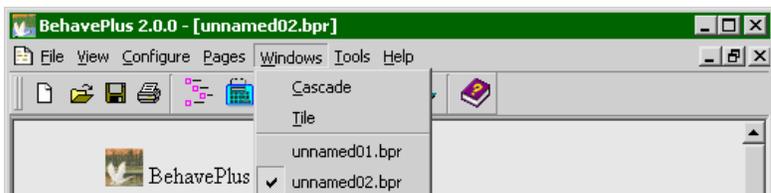
### 9.2. Windows

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.

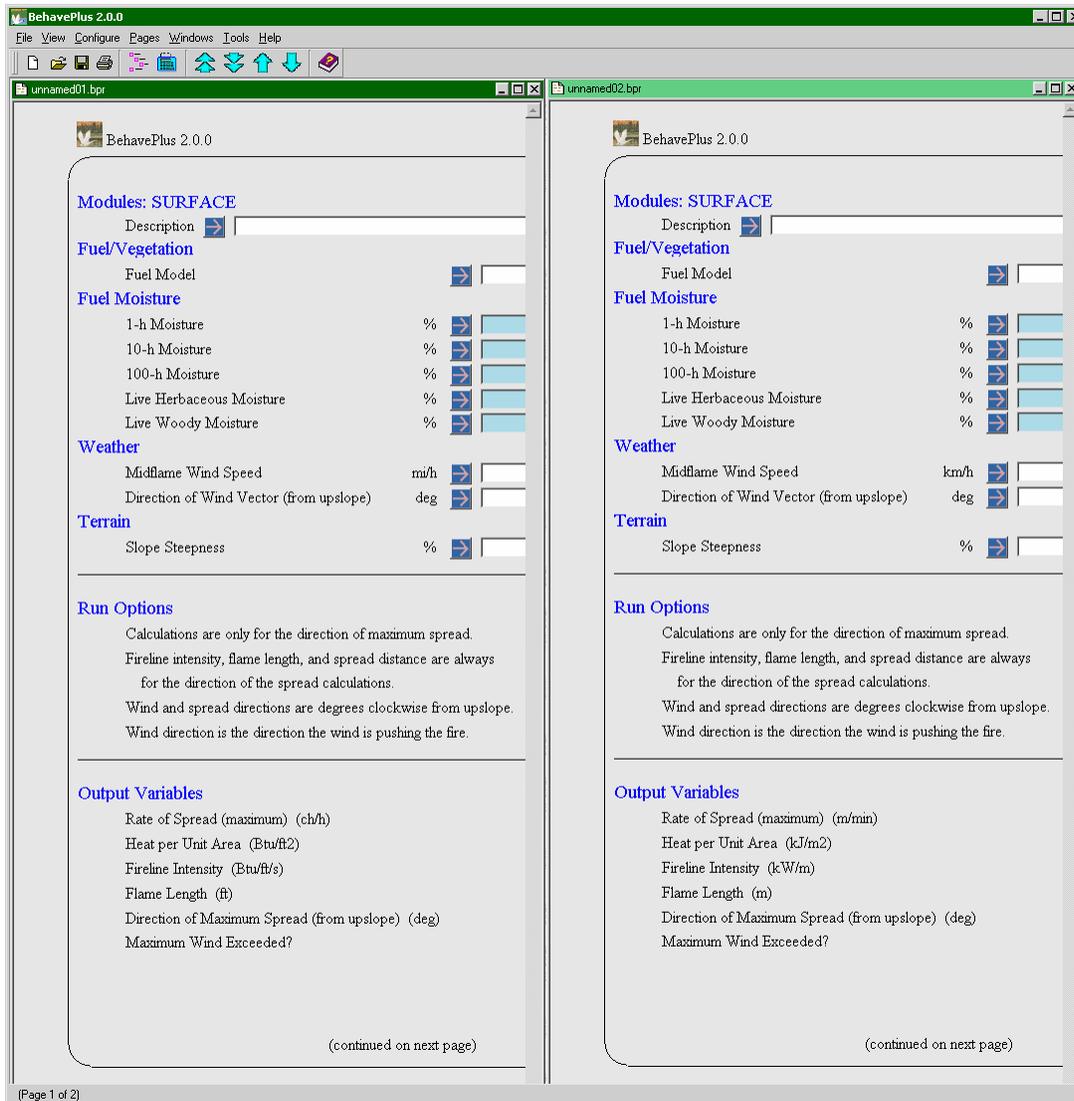


When you save a Run with the File > saveAs > Run command you should rename the Run. The name of the Run is then displayed in the title bar of the BehavePlus window. The complete path name for the Run is shown at the bottom of the BehavePlus application window.

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. 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.



### 9.3. 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

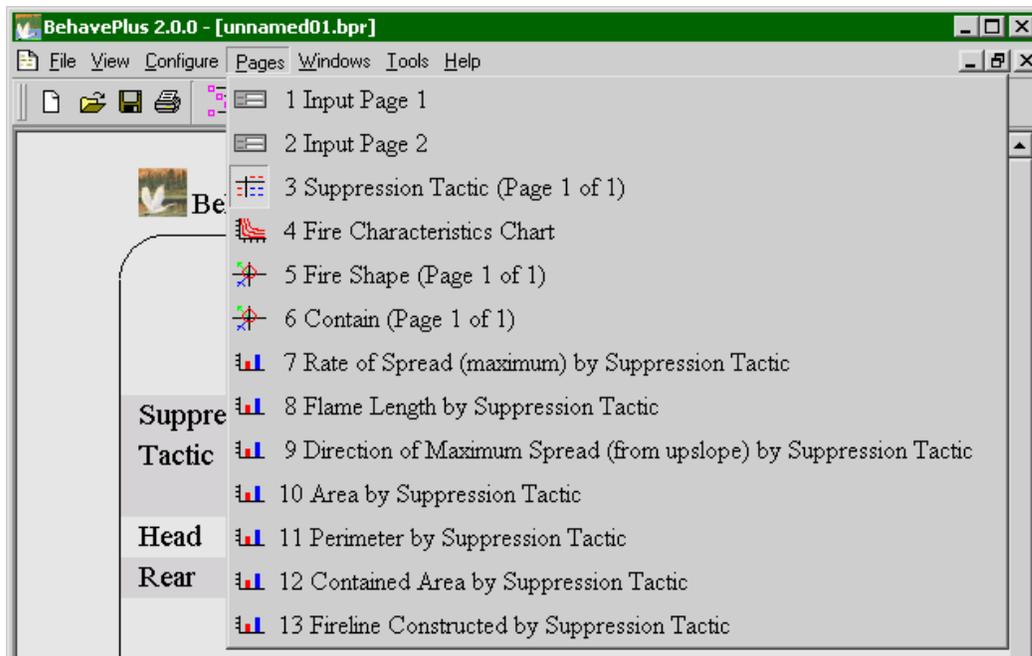


Go to the previous page



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.

## 9.4. 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 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.

## 9.5. Capture

The currently displayed page can be captured and saved as a file in bmp, jpg, or png format with the File > Capture 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 Description drop-down list.

The saved file can then be edited with an image processor or inserted into other documents.

In addition to the File > Capture command, you can use the ALT-Print Screen key or a screen capture utility (e.g. FullShot) to insert results from BehavePlus in other documents. The following steps are an example and do not constitute endorsement of specific software.

- Startup BehavePlus, WORD word processor, and FullShot software.
- On BehavePlus display, select the 'R' (for Region) in upper right hand of the window (put there by FullShot).
- Use the cursor to select the desired area
- Upon release of the mouse, FullShot opens with the selected image
- CTRL-C to save it in a clip board
- Go to the WORD document
- CTRL-V to insert the image

This is a quick and efficient method. There is no need to save the image in a file of its own. The image can be resized, cropped, or moved within WORD if desired.

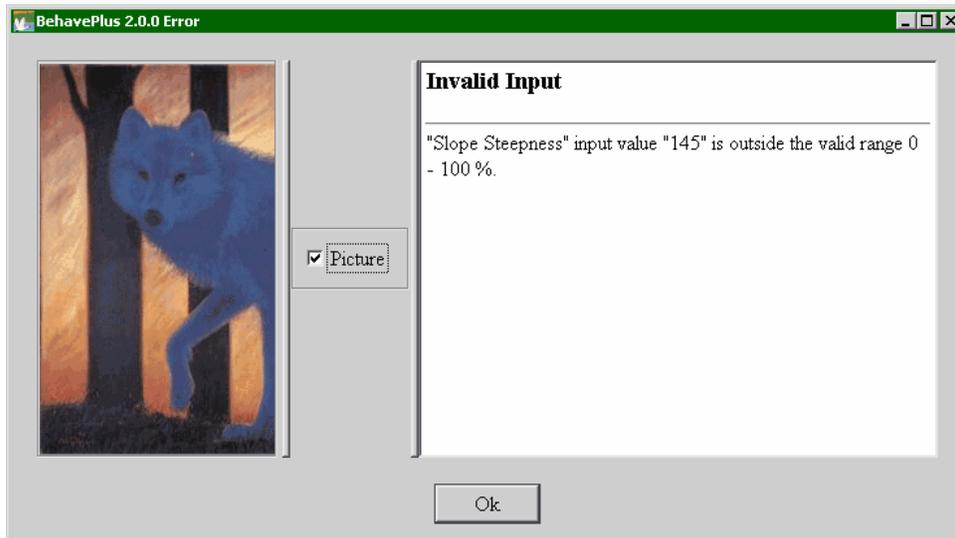
This page is blank on purpose.

## 10. Error checking



If you do something that causes the program to crash, it is a program bug. Please report it through [www.fire.org](http://www.fire.org).

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



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## 11. Custom fuel models



A fuel model is a set of values that describe a fuel type for the surface fire spread model. The standard fuel models are numbered 1 through 13. Additional fuel models, called Custom Fuel Models, can be developed, tested, saved, and used in BehavePlus.

### 11.1. Using previously saved fuel models

The 13 standard fuel models are always available. 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	Description
 MyFuelModels	2	Default user fuel models folder
 SoCalifornia	5	<a href="http://www.rfl.psw.fs.fed.us/prefire/index.html">www.rfl.psw.fs.fed.us/prefire/index.html</a>
 SCAL14.bpf		Manzanita
 SCAL15.bpf		Chamise 1
 SCAL16.bpf		North Slope Ceanothus
 SCAL17.bpf		Chamise 2
 SCAL18.bpf		Sage / Buckwheat

Fuel model files are attached 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. Once a fuel model folder is attached, the fuel models appear in the Fuel Model input guide and may be entered as fuel model input.

Sort	Value	Description
001	1	Short grass
002	2	Timber with grass and understory
003	3	Tall grass
004	4	Chaparral
005	5	Brush
006	6	Dormant brush, hardwood slash
007	7	Southern rough
008	8	Closed timber litter
009	9	Hardwood litter
010	10	Timber with litter & understory
011	11	Light logging slash
012	12	Medium logging slash
013	13	Heavy logging slash
SCAL14	SCAL14	Manzanita
SCAL15	SCAL15	Chamise 1
SCAL16	SCAL16	North Slope Ceanothus
SCAL17	SCAL17	Chamise 2
SCAL18	SCAL18	Sage / Buckwheat

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 View parameters 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 ft <sup>2</sup> /ft <sup>3</sup>
Live Herbaceous Surface Area/Vol Ratio	1500 ft <sup>2</sup> /ft <sup>3</sup>
Live Woody Surface Area/Vol Ratio	250 ft <sup>2</sup> /ft <sup>3</sup>
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

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 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.

Fuel Model	Files	Description
MyFuelModels	0	Default user fuel models folder
SoCalifornia	5	www.rfl.psw.fs.fed.us/prefire/index.ht
SCAL14.bpf		Manzanita
SCAL15.bpf		Charnise 1
SCAL16.bpf		North Slope Ceanothus
SCAL17.bpf		Charnise 2
SCAL18.bpf		Sage / Buckwheat

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**Modules: SURFACE**

Description

**Fuel/Vegetation**

Fuel Model

**Fuel Moisture**

Dead Fuel Moisture      %

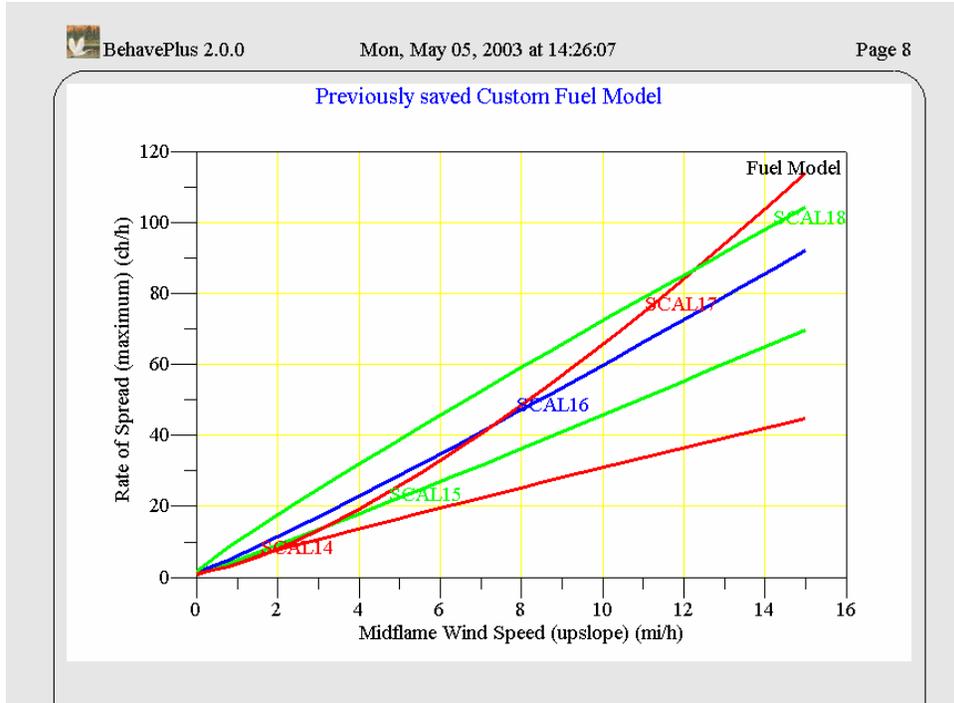
Live Fuel Moisture      %

**Weather**

Midflame Wind Speed (upslope)      mi/h

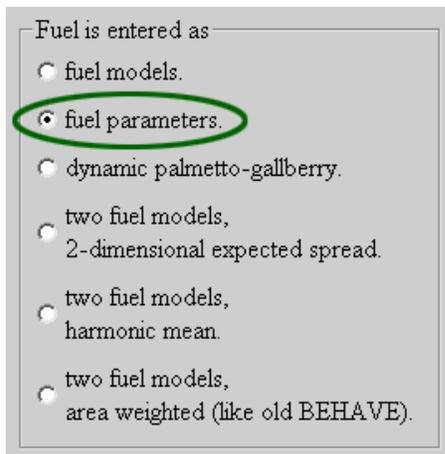
**Terrain**

Slope Steepness      %

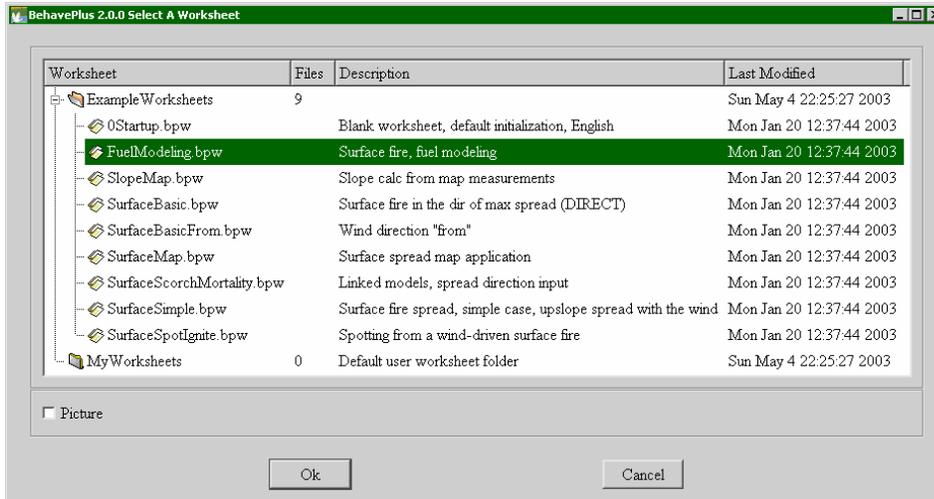


## 11.2. Defining and saving custom fuel models

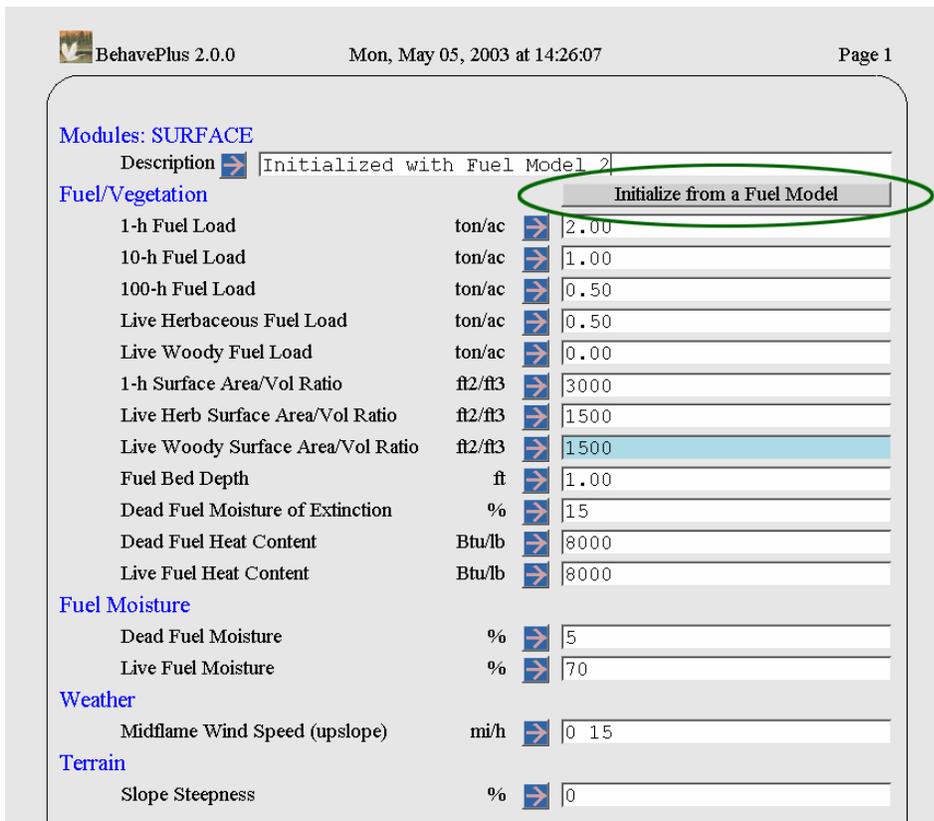
To change the Worksheet so that individual fuel parameters are entered in place of the fuel model code use the Configure > Module selection > SURFACE > Options... > Fuel and moisture tab and select the fuel parameters. option button.



Or you can load the Example Worksheet FuelModeling.bpw, which as been set up this way, using the File > New 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 than just filling in these blanks. It involves a process of evaluation and revision.

Once the fuel model parameters are defined, a custom fuel model can be saved for later use with the File > Save as > Fuel model 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 18.4, Save As, for more information.

## 12. Moisture scenarios



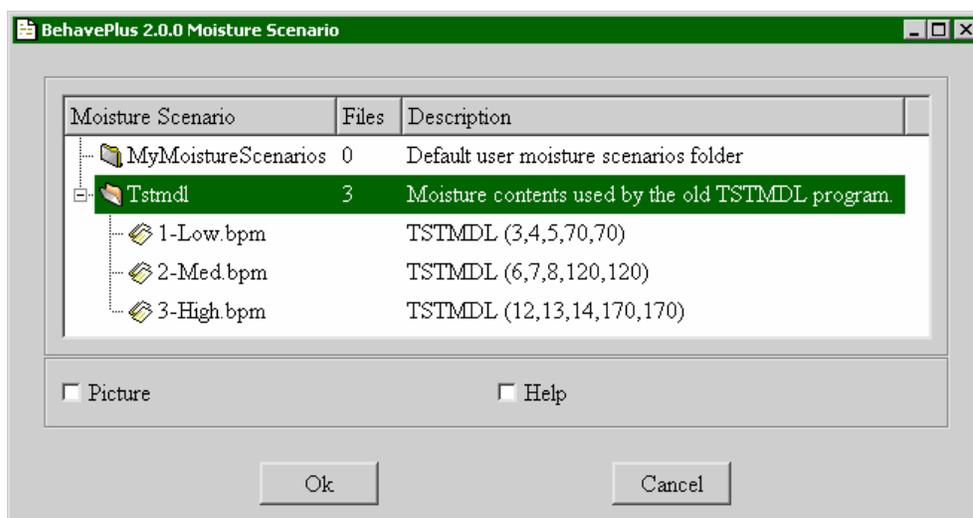
A moisture scenario is a set of fuel moistures for 1-h, 10-h, and 100-h dead fuel and herbaceous and woody live fuel. It is analogous to the fuel model concept in that a single code represents a set of moisture values. Fuel moisture scenarios may be developed, for example, to represent local 90-, 95-,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

### 12.1. Using previously saved moisture scenarios

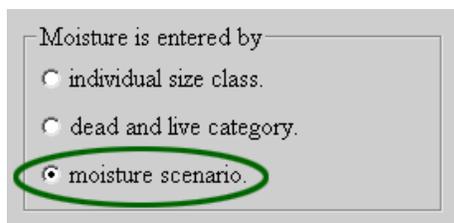
A folder of moisture scenarios is attached using the Configure > moisture Scenario set selection command to open the “Moisture Scenarios” dialog box.

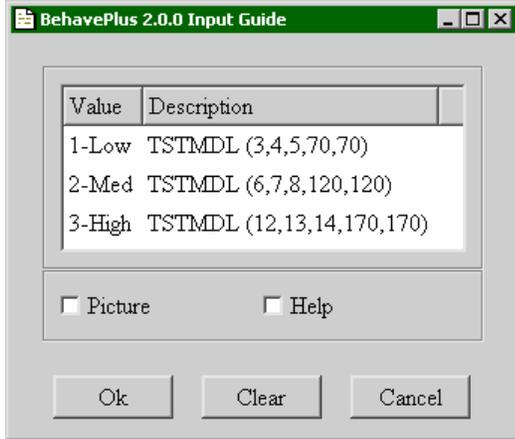
Click on a folder's  to view its moisture scenario files. Each moisture scenario is stored in a separate file.



Moisture scenario files are made available by attaching the folder in which they reside. This makes 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, the moisture scenarios that come with the BehavePlus program are attached by selecting the Tstmdl folder. Once a moisture scenario folder is attached, its moisture scenarios appear in the Moisture Scenario input guide.

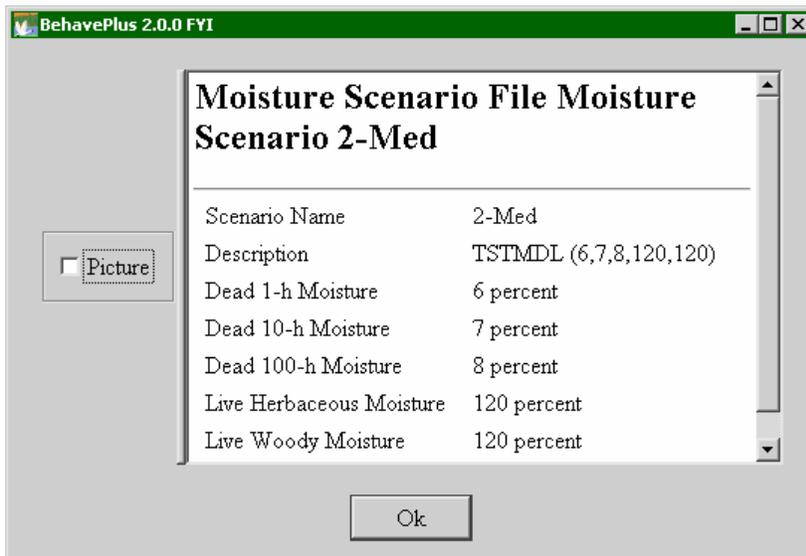
Set up the Worksheet to enter fuel moistures with moisture scenarios using the Configure > Module selection > SURFACE > Options... > Fuel & Moisture tab and select the Moisture is entered by moisture scenario. option button.



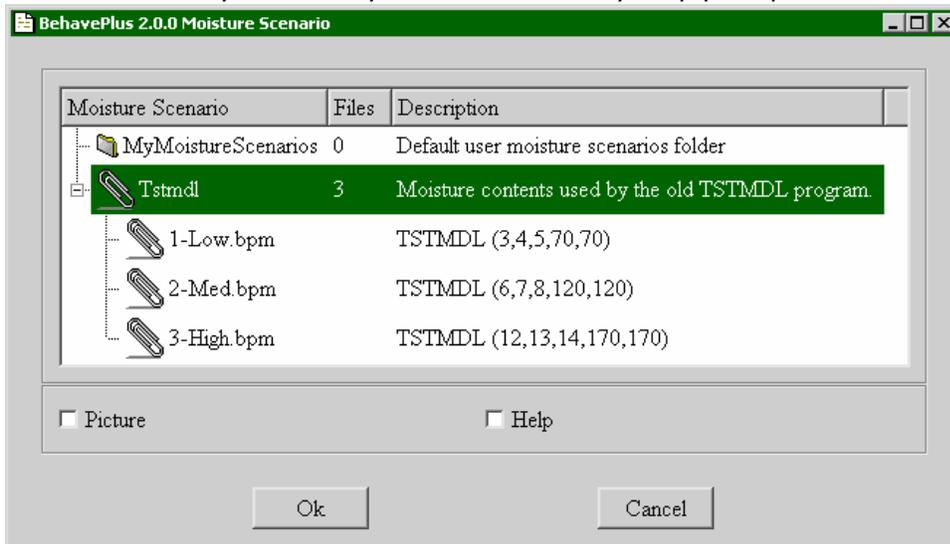


After the Tstmdl moisture scenario folder is attached, the Moisture Scenario Guide button on the Worksheet gives the following valid selections for moisture scenarios.

To view the parameters of a particular moisture scenario, right-click on its name and select View parameters from the context menu.



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 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.



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Modules: SURFACE

Description

Fuel/Vegetation

Fuel Model

Fuel Moisture

Moisture Scenario

Weather

Midflame Wind Speed (upslope) mi/h

Terrain

Slope Steepness %

## 12.2. 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.

Moisture is entered by

individual size class.

dead and live category.

moisture scenario.

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

BehavePlus 2.0.0 Tue, May 06, 2003 at 07:29:18 Page 1

Modules: SURFACE

Description

Fuel/Vegetation

Fuel Model

Fuel Moisture

1-h Moisture %

10-h Moisture %

100-h Moisture %

Live Herbaceous Moisture %

Live Woody Moisture %

Weather

Midflame Wind Speed (upslope) mi/h

Terrain

Slope Steepness %

Save the moisture scenario with the File > Save as > 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.

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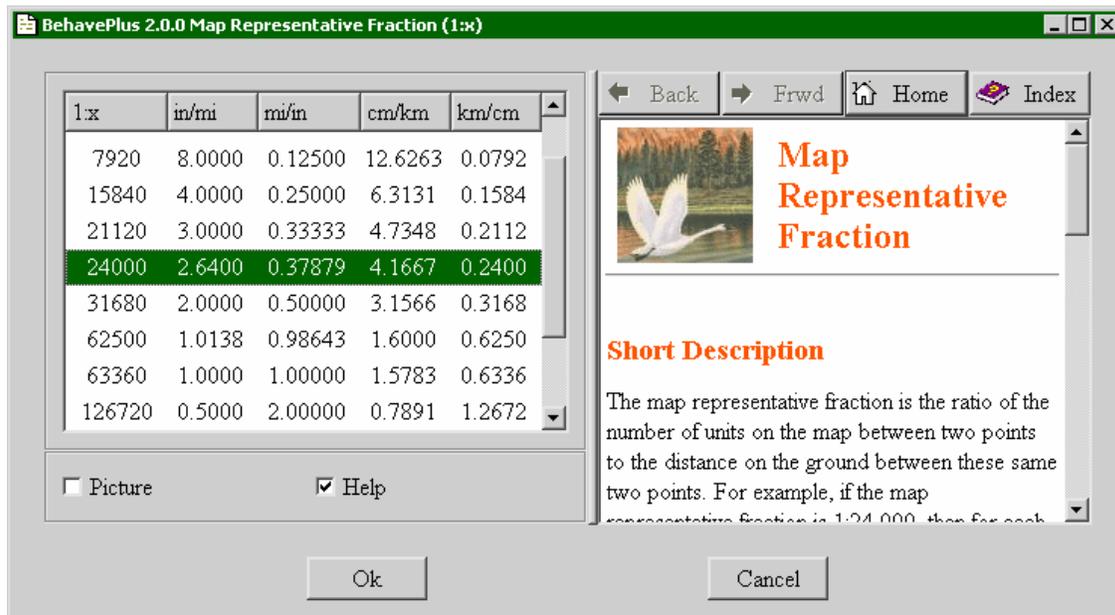
## 13. Map applications



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

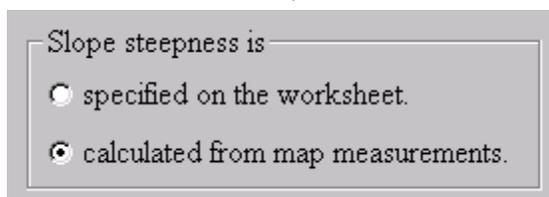
Map scale is given as map representative fraction, which is the ratio of the number of units on the map between two points to the distance on the ground between the same two points. For example, if the map representative fraction is 1:24,000, then for each inch on the map there are 24,000 inches on the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

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

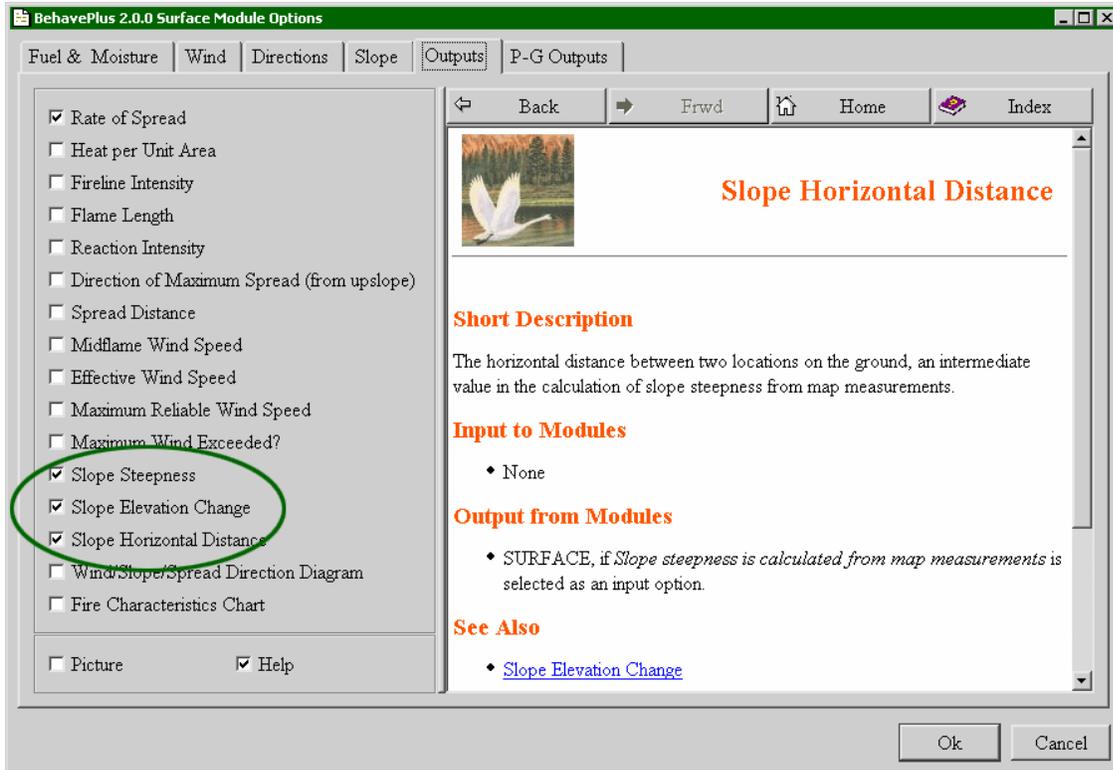


### 13.1. Slope from map measurements

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 Slope steepness is calculated from map measurements.



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.

BehavePlus 2.0.0 Page 1

**Modules: SURFACE**  
 Description

**Fuel/Vegetation**  
 Fuel Model

**Fuel Moisture**  
 Dead Fuel Moisture %   
 Live Fuel Moisture %

**Weather**  
 Midflame Wind Speed (upslope) mi/h

**Map**  
 Map Representative Fraction (1:x)   
 Contour Interval ft   
 Map Distance in   
 Number of Contour Intervals

---

**Run Options**  
 Wind direction is upslope.  
 Calculations are only for the direction of maximum spread.  
 Wind and spread directions are degrees clockwise from upslope.  
 Wind direction is the direction the wind is pushing the fire.

---

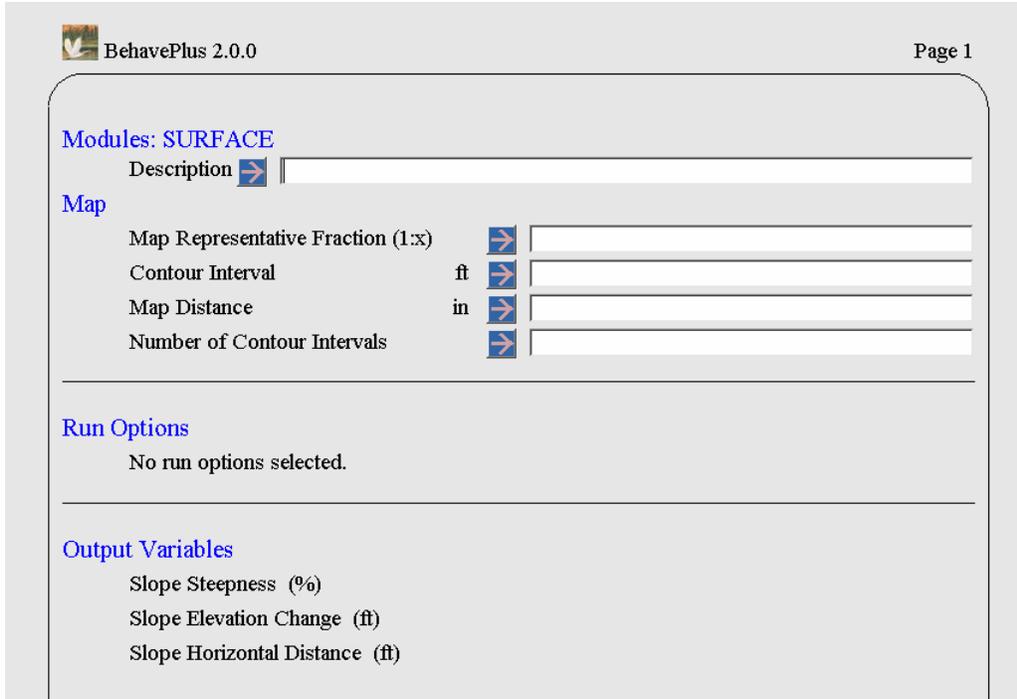
**Output Variables**  
 Rate of Spread (maximum) (ch/h)  
 Slope Steepness (%)  
 Slope Elevation Change (ft)  
 Slope Horizontal Distance (ft)

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.

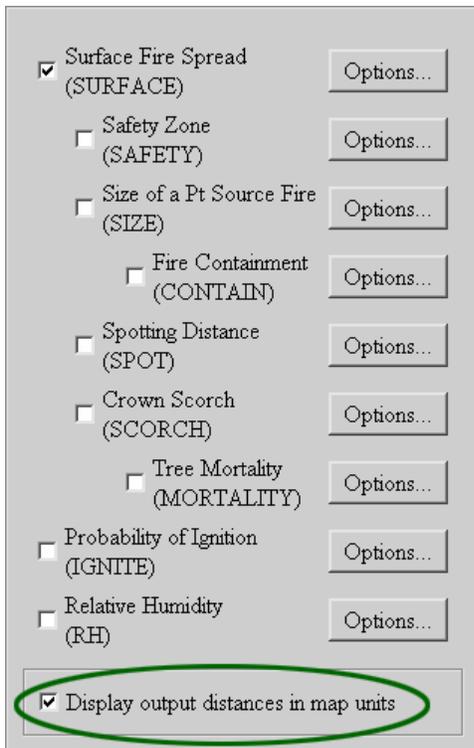
Number of contour intervals is a count between two points on a map.

If only slope values are requested as output, then only Map input variables are requested. An existing Worksheet, SlopeMap.bpw, showing this configuration is found in the ExampleWorksheets folder.



### 13.2. 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.



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 (1x) 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:

BehavePlus 2.0.0 Page 1

**Modules: SURFACE**  
Description

**Fuel/Vegetation**  
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 (1x)

---

**Run Options**  
Output distances are displayed in map units.  
Wind direction is upslope.  
Calculations are only for the direction of maximum spread.  
Wind and spread directions are degrees clockwise from upslope.  
Wind direction is the direction the wind is pushing the fire.

---

**Output Variables**  
Rate of Spread (maximum) (ch/h)  
Spread Distance (ch)  
Spread Map Distance (in)

This page is blank on purpose.

## 14. Units



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 > 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.

### 14.1. English or metric

The units set can be changed using the `Configure > Units > 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 > New` command, the new Worksheet will be English units.

### 14.2. Custom units set

Develop and save a custom units set using the “Units Editor” dialog box opened with the `Tools > units Editor` command.

The Units editor 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 saved as a custom units set.

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

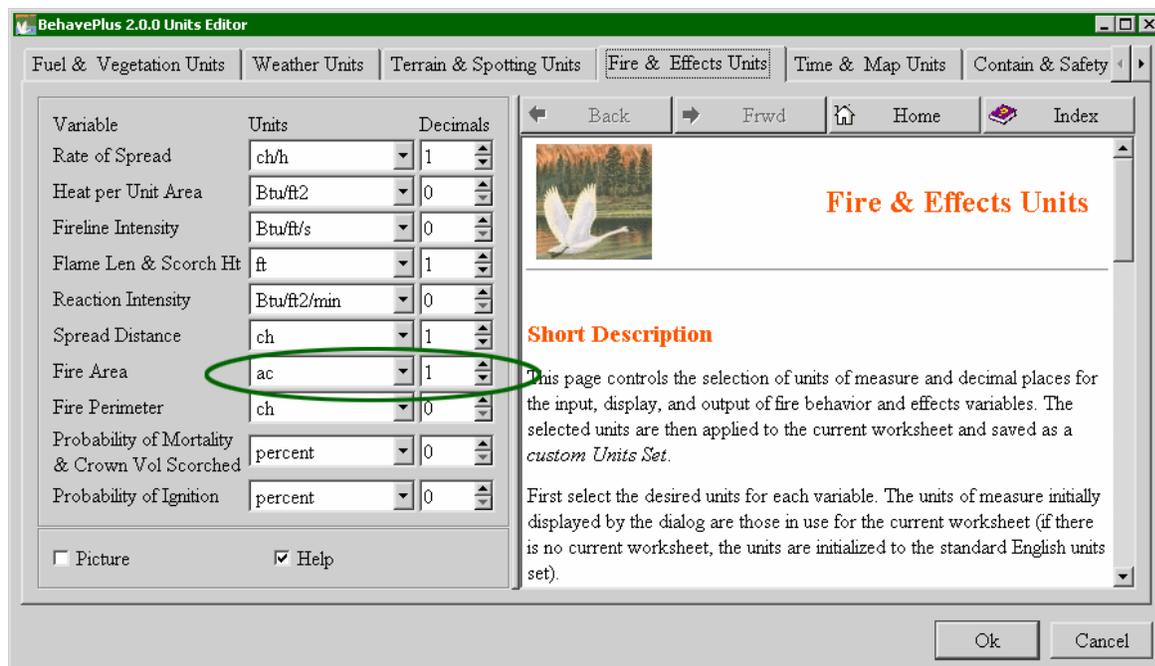
Select the desired units for each variable set. Rather than repetitiously having to enter units for every variable, they are grouped by type of unit of measure. Appendix C gives these groupings and their default English and metric units.

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

### 14.3. Number of decimal places

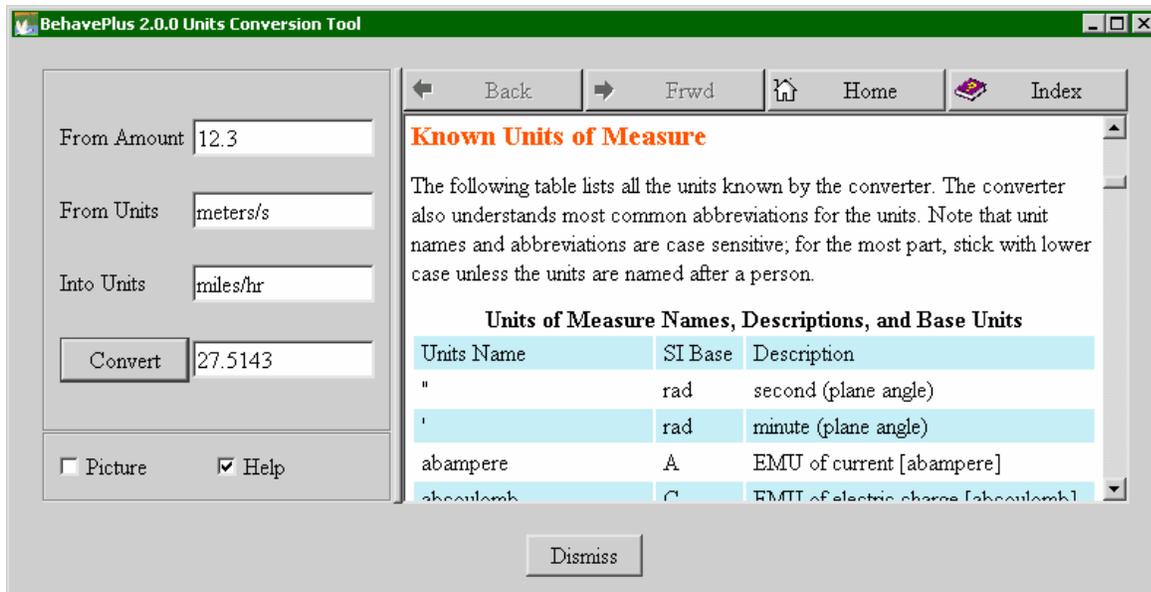
In addition to setting units of measure, the “Units Editor” dialog box also allows you to change the number of digits displayed after the decimal place of all input and output variables.

For example, 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.



### 14.4. Units conversion 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 conversion tool 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 window of the “Units Conversion Tool” dialog box there is a list of all the available units.

## 15. Language



The FIRE1 program of the old BEHAVE system was translated into several languages including Spanish and Chinese. We have designed BehavePlus to make the translation process easier. A Portuguese translation is included as an example. Instructions are available for translation to other languages. This translation process applies to the program interface itself, not to the help files.

### 15.1. English or Portuguese

To change the language from the default English to Portuguese use the Configure > Language > Portuguese (Portugal) command.

BehavePlus 2.0.0 Página 1

**MÓdulos: Superfície**  
Descrição ▾

**COMBUSTÍVEL/VEGETAÇÃO**  
Modelo de combustível ▾

**HUMIDADE DOS COMBUSTÍVEIS**  
Humidade do combustível morto % ▾  
Humidade dos combustíveis vivos % ▾

**METEOROLOGIA**  
Velocidade do vento a meia chama (dir. de maior declive) mi/h ▾

**TERRENO**  
Declive da encosta % ▾

---

**OPÇÕES DE SIMULAÇÃO**  
Direcção do vento é a subir encosta.  
As simulações são somente para a direcção de propagação máxima.  
Direcção do vento e de propagação em graus na direcção de máximo declive.  
A direcção do vento é a direcção que o vento está a empurrar o fogo.

---

**VARIÁVEIS DE SAÍDA**  
Velocidade de propagação (máxima) (ch/h)  
Energia libertada por unidade de área (Btu/ft<sup>2</sup>)  
Intensidade da frente de chamas (Btu/ft/s)  
Comprimento da chama (ft)  
Direcção de máxima propagação (relativo ao maior declive) (deg)  
Velocidade máxima do vento excedida?

### 15.2. Custom language set

To develop a custom language set contact Collin Bevins at [cbevins@montana.com](mailto:cbevins@montana.com).

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## 16. Fine Dead Fuel Moisture Tool



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

Dry Bulb Temperature	10 - 29 °F
Relative Humidity	0 - 4 %
Reference Fuel Moisture	1 %
Month	May June July
Time of Day	08:00 - 09:59
Elevation Difference	Above (1000 - 2000 ft)
Slope	0 - 30%
Aspect	North
Fuel Shading	Exposed (< 50% shading)
Fuel Moisture Correction	2 %
Fine Dead Fuel Moisture	3 %

Picture       Help

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### Fine Dead Fuel Moisture Tables

#### Short Description

The fine dead fuel moisture calculation is based on the tables in *How to predict the spread and intensity of forest and range fires*. (Rothermel 1983). Only the daytime tables are provided and there is no conversion to metric.

This tool is included in BehavePlus only for completeness because the tables are used in the field by Fire Behavior Analysts. They are not

Dismiss

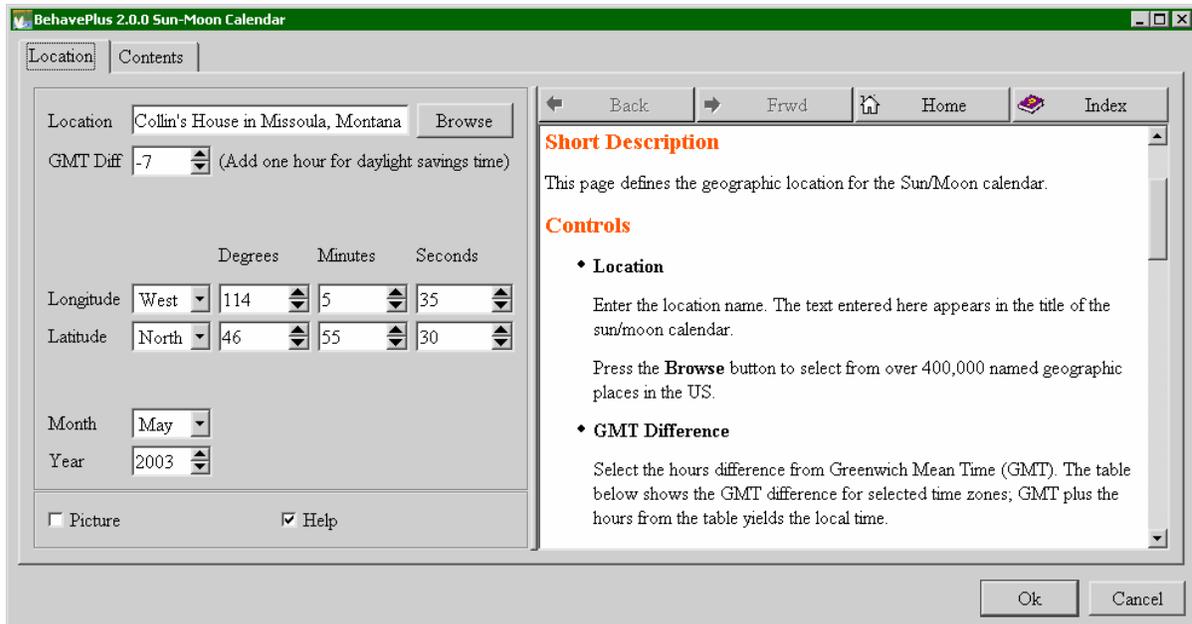
This tool is an automation of the daytime tables from Rothermel (1983). Selections are made through drop down lists. As soon as a change is made, the results are displayed. Since these tables are not based on equations, they can't effectively be incorporated as a module into BehavePlus.

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## 17. Sun-Moon Calendar Tool



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



This tool allows you to specify any month of any year at a location on the globe and generate a calendar of 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.

The calendar 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.

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## 18. File management

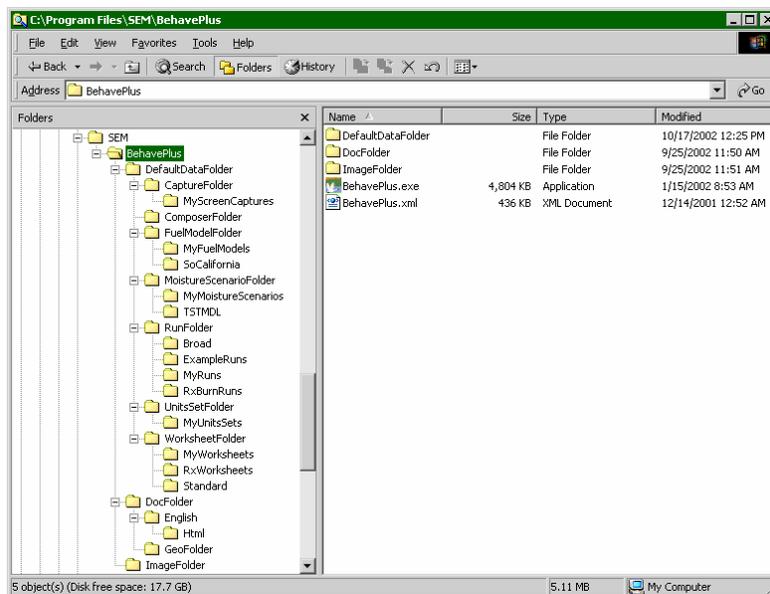


### 18.1. Workspaces

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 corresponds to a single BehavePlus project, and each BehavePlus project should have its own Workspace. 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 the “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 emailing 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

## 18.2. Load a Worksheet

A previously saved Worksheet is loaded with the File > New 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).

## 18.3. 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.

## 18.4. Save as...

A sub-menu of the File > saveAs command offers several choices of what to save from the active Worksheet:

- Run
- Worksheet
- Fuel model
- Moisture scenario

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.

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 > New command or the  toolbar button.

Before saving a fuel model make sure the SURFACE module check box is selected and the fuel parameters checkbox 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. To make custom fuel models available at a later time use the Configure > Fuel model set selection command.

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.

The following example saves a Worksheet. The process is the same for other file types. In all cases, the File > saveAs command requests input of folder name, file name, and file description in the "Save As" dialog box.

WorksheetFolder / File	Files	Description	Last Modified
Example	9	Standard BehavePlus worksheets	Thu Oct 31 16:23:30 2002
MyWorksheets	0	Default user worksheet folder	Thu Oct 31 16:23:30 2002
TestFolder	1	Users Guide Examples	Mon Jan 6 15:16:10 2003

Worksheet Folder	<input type="text" value="TestFolder"/>
Worksheet File	<input type="text" value="test1"/>
Worksheet Description	<input type="text" value="example 1 for users guide"/>

To create a new Folder simply enter a new folder name in the Worksheet Folder field and press the Ok button.

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

## 18.5. 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 creates for the Workspace.

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## 19. Help



Help features are a primary feature of BehavePlus. The Users Guide is 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.

### 19.1. 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

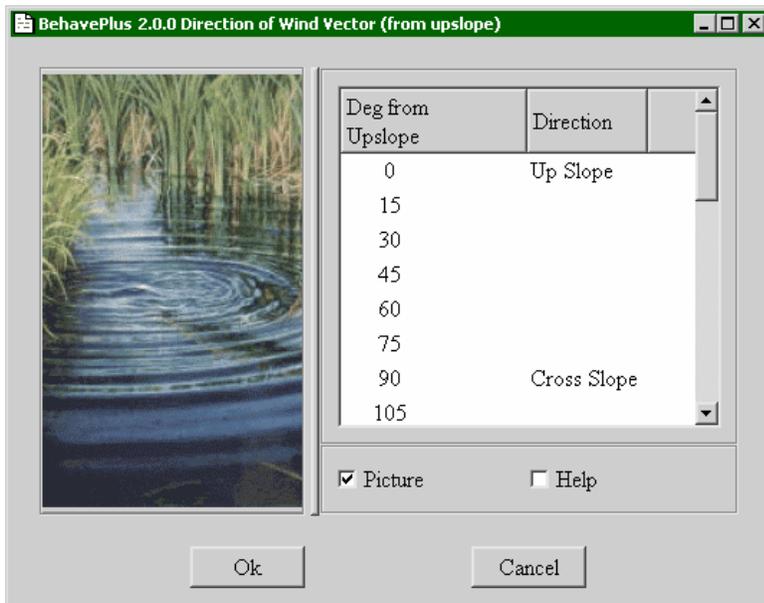
- Short description
- Input to modules
- Output from modules
- More Information
- See also
- Links

### 19.2. 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.

### 19.3. 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 BehavePlus and can be opened with the Help > Program help command. When viewed with the Adobe Acrobat Reader, the contents at the left provide access to the section in question.

## References

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- Andrews, Patricia L. 1986. BEHAVE: fire behavior prediction and fuel modeling system-BURN subsystem, Part 1. Gen. Tech. Rep. INT-194. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 130 p.
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- Burgan, Robert E.; Rothermel, Richard C. 1984. BEHAVE: fire behavior prediction and fuel modeling system-FUEL subsystem. Gen. Tech. Rep. INT-167. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 126 p.
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- Rothermel, Richard C. 1972. A mathematical model for predicting fire spread in wildland fuels. Res. Pap. INT-115. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 40 p.
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## Appendix A: Version Comparison

### Version 1 and Version 2

Following are significant differences between BehavePlus version 1.0 and version 2.0. Minor changes are not listed here.

- Safety zone size model added as a new SAFETY module
- Containment model 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 added to the IGNITE module
- Two fuel weighting, three methods added to the SURFACE module
- Dynamic palmetto-gallberry fuel model added to the SURFACE module
- Size diagram output added to SIZE
- Contain diagram output in CONTAIN
- Direction diagram added to SURFACE
- Fire characteristics chart diagram output added to SURFACE
- Fine dead fuel moisture 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' (zero) 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 the **File > New** command.
- 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-axis are now user-scalable.

### BEHAVE and BehavePlus

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 modern 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 five 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, 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 contrast, the BehavePlus SURFACE module allows users to specify the method of entry for fuel moisture, wind speed, and directions.
- In BEHAVE only continuous variables could be assigned more than one value for a maximum of seven 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 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 it is being run on a 21<sup>st</sup> century personal computer.

## Appendix B: Input and Output Variable Tables

Each input variable in BehavePlus, version 2, is listed in the table according to category. 'I' (for Input) in a Module column indicates that it is a possible input for that module. In some cases an input variable may also be an output variable, indicated by 'O' (for Output). It depends on the selected modules, input options, and output variables.

For example, note that

- Midflame wind speed is an input to SURFACE under the input option **Wind speed is entered as midflame height**. However, it is an output variable if **Wind speed is entered as 20-ft wind and wind adjustment factor** is selected.
- Rate of spread is an output from SURFACE and an input to SIZE. If both SURFACE and SIZE are selected, the rate of spread from SURFACE is automatically used in SIZE. If only SIZE is selected, then the user must input values for rate of spread.
- Temperature is used only in SCORCH and RH, it is not used for the spread rate and intensity calculations in SURFACE.
- These tables also give the English and metric units and number of decimal places and the output variables selected for display initiated by the 0Startup.bpw worksheet. (See Appendix D.)

**Input Variables and Modules**

<b>Input variable</b>	<b>SURFACE</b>	<b>SAFETY</b>	<b>SIZE</b>	<b>CONTAIN</b>	<b>SPOT</b>	<b>SCORCH</b>	<b>MORTALITY</b>	<b>IGNITE</b>	<b>RH</b>	<b>Variable Type</b>	<b>English Range/Units</b>	<b>Metric Range/Units</b>	<b>Notes</b>
<b>Fuel / Vegetation</b>													
Fuel model	I									D	N/A	N/A	
First fuel model	I									D	N/A	N/A	For two fuel models
Second fuel model	I									D	N/A	N/A	“
First fuel model coverage	I									C	0-100%	0-100%	“
1-h fuel load	I									C	0.0-30.49 ton/ac	0.0-68.35 tonne/ha	Fuel model parameter
10-h fuel load	I									C	0.0-30.49 ton/ac	0.0-68.35 tonne/ha	“
100-h fuel load	I									C	0.0-30.49 ton/ac	0.0-68.35 tonne/ha	“
Live herbaceous fuel load	I									C	0.0-30.49 ton/ac	0.0-68.35 tonne/ha	“
Live woody fuel load	I									C	0.0-30.49 ton/ac	0.0-68.35 tonne/ha	“
1-h surface area / vol ratio	I									C	109-4,000 ft <sup>2</sup> /ft <sup>3</sup>	358-13,123 m <sup>2</sup> /m <sup>3</sup>	“
Live herb surface area / vol ratio	I									C	109-4,000 ft <sup>2</sup> /ft <sup>3</sup>	358-13,123 m <sup>2</sup> /m <sup>3</sup>	“
Live woody surface area / vol ratio	I									C	109-4,000 ft <sup>2</sup> /ft <sup>3</sup>	358-13,123 m <sup>2</sup> /m <sup>3</sup>	“
Fuel bed depth	I/O									C	0.05 to 10.0 ft	0.02-3.05 m	“ output for P-G
Dead fuel moisture of extinction	I									C	5 – 100%	5 – 100%	Fuel model parameter
Dead fuel heat content	I									C	6,000-12,000 BTU/lb	13,967-27,934kJ/kg	“
Live fuel heat content	I									C	6,000-12,000 BTU/lb	13,967-27,934kJ/kg	“

## Input Variables and Modules

Input variable	SURFACE	SAFETY	SIZE	CONTAIN	SPOT	SCORCH	MORTALITY	IGNITE	RH	Variable Type	English Range/Units	Metric Range/Units	Notes
<b>Fuel / Vegetation (cont.)</b>													
Palmetto-gallberry age of rough	I									C	1-25 years	1-25 years	For dynamic palmetto-gallberry
Height of understory	I									C	1-6 ft	0 -2 m	“
Palmetto coverage	I									C	15-85 %	15-85 %	“
Overstory basal area	I									C	30-110 ft <sup>2</sup> /ac	6.8-25.3 m <sup>2</sup> /ha	“
Mean cover height					I					C	0 –300 ft	0 –91 m	
Tree height					I		I			C	10 – 300 ft.	3 – 91 m	
Crown ratio							I			C	0.1 – 1.0	0.1 – 1.0	
Mortality tree species					I		I			D	(206 species)	(206 species)	
Spot tree species					I					D	(14 species)	(14 species)	
D.B.H.					I		I			C	5 – 40 in	13 – 102 cm	
Bark thickness							I/O			C	0.1 – 2.0 in	0.3 – 5.1 cm	
Lightning ignition fuel type								I		D	PPL, PWC, PWD, PWS, LPD, DFD, ESH, PMC	PPL, PWC, PWD, PWS, LPD, DFD, ESH, PMC	
Lightning duff and litter depth								I		C	0-12 in	0-30 cm	

## Input Variables and Modules

<b>Input variable</b>	<b>SURFACE</b>	<b>SAFETY</b>	<b>SIZE</b>	<b>CONTAIN</b>	<b>SPOT</b>	<b>SCORCH</b>	<b>MORTALITY</b>	<b>IGNITE</b>	<b>RH</b>	<b>Variable Type</b>	<b>English Range/Units</b>	<b>Metric Range/Units</b>	<b>Notes</b>
<b>Fuel Moisture</b>													
Moisture scenario										D	N/A	N/A	
1-h moisture	I							I		C	1 – 60%	1 – 60%	Fuel moisture scenario parameter
10-h moisture	I									C	1 – 60%	1 – 60%	“
100-h moisture	I							I		C	1 – 60%	1 – 60%	“
Live herbaceous moisture	I									C	30 – 300%	30 – 300%	“ Live foliage for P-G
Live woody moisture	I									C	30 – 300%	30 – 300%	“ Live stemwood for P-G
Dead fuel moisture	I							I		C	1 – 60%	1 – 60%	Used for 1-h, 10-h, 100-h
Live fuel moisture	I									C	30 – 300%	30 – 300%	Used for live herbaceous and woody

## Input Variables and Modules

Input variable	SURFACE	SAFETY	SIZE	SPOT	SCORCH	MORTALITY	IGNITE	RH	CONTAIN	Variable Type	English Range/Units	Metric Range/Units	Notes
<b>Weather</b>													
Midflame wind speed	I/O				I					C	0 – 60 mi/h	0.0 – 96.6 km/h	
20-ft (or 10-m) wind speed	I			I						C	0 – 99 mi/h	0.0 – 159 km/h	
Wind adjustment factor	I									C	0.1 – 1.0	0.1 – 1.0	
Effective wind speed	O		I							C	0 – 60 mi/h	0.0 – 96.6 km/h	
Wind direction (from North) or (from upslope)	I									C	0 – 360 deg	0 – 360 deg	Reference depends on input option selections
Air temperature					I		I	I		C	-40 – 120 deg F	-40 – 49 deg C	
Wet bulb temperature								I		C	-40 – 120 deg F	-40 – 49 deg C	
Dew point temperature								I/O		C	-40 – 120 deg F	-40 – 49 deg C	
Fuel shading from the sun							I			C	0 – 100%	0 – 100%	by cloud or canopy
Lightning strike type							I			D	+, -, or unknown	+, -, or unknown	
<b>Terrain</b>													
Slope steepness	I									C	0 – 45 deg 0 – 100%	0 – 45 deg 0 – 100%	
Aspect	I									C	0 – 360 deg	0 – 360 deg	
Site elevation								I		C	-1,000-30,000 ft	-305 – 9,144 m	
Ridge-to-valley elevation difference				I						C	0 – 4,000 ft	0 – 1,219 m	
Ridge-to-valley horizontal distance				I						C	0 – 4.0 mi	0 – 6.4 km	
Spotting source location				I						D	RT, MW, VB, ML	RT, MW, VB, ML	

**Input Variables and Modules**

<b>Input variable</b>	<b>SURFACE</b>	<b>SAFETY</b>	<b>SIZE</b>	<b>CONTAIN</b>	<b>SPOT</b>	<b>SCORCH</b>	<b>MORTALITY</b>	<b>IGNITE</b>	<b>RH</b>	<b>Variable Type</b>	<b>English Range/Units</b>	<b>Metric Range/Units</b>	<b>Notes</b>
<b>Fire</b>													
Rate of spread (maximum)	O		I	I						C	0 – 500 ch/h	0.0-167.6 m/min	Head fire
Flame length	O	I			I	I				C	0 – 200 ft	0 – 61 m	Worst-case estimate of flame height for SAFETY
Fireline intensity	O					I				C	0 – 10,000 BTU/ft/s	0 – 34,641 kW/m	
Flame height from a burning pile					I					C	0 – 100 ft	0 – 30.5 m	
Spread direction (from North) or (from upslope)	I/O									C	0 – 360 deg	0 – 360 deg	Reference depends on input option selections
Number of torching trees					I					C	0 – 30	0 - 30	
Scorch height						O	I			C	0 – 200 ft	0 – 61 m	
Elapsed time	I		I							C	0.5 – 8.0 h	0.5 – 8.0 h	From ignition/start
Fire size at report			O	I						C	0.1-100 ac	0.0-40.5 ha	‘area’ from SIZE
Length-to-width ratio			O	I						C	1-7	1-7	

## Input Variables and Modules

<b>Input variable</b>	<b>SURFACE</b>	<b>SAFETY</b>	<b>SIZE</b>	<b>CONTAIN</b>	<b>SPOT</b>	<b>SCORCH</b>	<b>MORTALITY</b>	<b>IGNITE</b>	<b>RH</b>	<b>Variable Type</b>	<b>English Range/Units</b>	<b>Metric Range/Units</b>	<b>Notes</b>
<b>Map</b>													
Map representative fraction (1:x)	I		I		I					C	1,980 – 1,013,760	1,980 – 1,013,760	
Contour interval	I									C	1 - 1000 ft	0.3 – 304.8 m	
Map distance	I									C	0.1 – 100 in	0.3 – 254 cm	
Number of contour intervals	I									C	1 – 100	1 - 100	

<b>Input variable</b>	<b>SURFACE</b>	<b>SAFETY</b>	<b>SIZE</b>	<b>CONTAIN</b>	<b>SPOT</b>	<b>SCORCH</b>	<b>MORTALITY</b>	<b>IGNITE</b>	<b>RH</b>	<b>Variable Type</b>	<b>English Range/Units</b>	<b>Metric Range/Units</b>	<b>Notes</b>
<b>Suppression</b>													
Suppression tactic				I						D	Head or Rear	Head or Rear	
Line construction offset				I						C	0-100 ch	0-2012 m	0 = direct attack else parallel attack
Resource name				I						D	N/A	N/A	Entry for each resource
Resource line production rate				I						C	1-200 ch/h	20.1-4023.4 m/h	“
Resource arrival time				I						C	0-8 h	0-8 h	“
Resource duration				I						C	0.0-10 h	0.0-10 h	“
Resource base cost				I						C	0-500,000	0-500,000	“
Resource hourly cost				I						C	0-500,000	0-500,000	“
Number of personnel		I								C	1-200	1-200	Integer
Area per person		I								C	10-100 ft2	.93-9.3 m2	
Number of heavy equipment		I								C	0-10	0-10	Integer
Area per heavy equipment		I								C	100-500 ft2	9.3-46.5 m2	

I = Input

O = Output

I/O = Input or Output depending on the selected modules and options

C = Continuous variable

D = Discrete variable

## Output Variables and Modules

Output variable	Default output variable	English Units	Metric Units	Notes
<b>SURFACE</b>				
Rate of spread	X	ch/h	m/min	
Heat per unit area	X	BTU/ft <sup>2</sup>	KJ/m <sup>2</sup>	
Fireline intensity	X	BTU/ft/s	KW/m	
Flame length	X	ft	m	
Reaction intensity		BTU/ft <sup>2</sup> /min	KW/m <sup>2</sup>	
Direction of maximum spread	X	degrees	degrees	
Spread distance		ch	m	Can be map distance
Midflame wind speed		mi/h	km/h	
Effective wind speed		mi/h	km/h	
Maximum reliable wind speed		mi/h	km/h	
Maximum wind exceeded?	X	Yes or No	Yes or No	
Slope steepness		percent	percent	
Slope elevation change		ft	m	
Slope horizontal distance		ft	m	
Wind/slope/fire direction diagram		N/A	N/A	
Fire characteristics chart		N/A	N/A	
P-G dead fine fuel load		ton/ac	tonne/ha	
P-G dead medium fuel load		ton/ac	tonne/ha	
P-G dead foliage fuel load		ton/ac	tonne/ha	
P-G live fine fuel load		ton/ac	tonne/ha	
P-G live medium fuel load		ton/ac	tonne/ha	
P-G live foliage fuel load		ton/ac	tonne/ha	
P-G litter fuel load		ton/ac	tonne/ha	
Fuel bed depth		ft	m	

## Output Variables and Modules

Output variable	Default output variable	English Units	Metric Units	Notes
<b>SAFETY</b>				
Safety zone separation distance	X	ft	m	
Safety zone size	X	ac	ha	
Safety zone radius		ft	m	
<b>SIZE</b>				
Area	X	ac	ha	
Perimeter	X	ch	m	
Length-to-width ratio		N/A	N/A	Real number
Forward spread distance		ch	m	Can be map distance
Backing spread distance		ch	m	Can be map distance
Fire length		ch	m	Can be map distance
Maximum fire width		ch	m	Can be map distance
Fire shape diagram		N/A	N/A	
<b>CONTAIN</b>				
Time from report	X	h	h	To containment or escape
Contain status	X	Contained, Withdrawn, or Exhausted	Contained, Withdrawn, or Exhausted	Either withdrawn or exhausted is escaped
Contained area	X	ac	ha	At containment. If escape, area = 0
Fireline constructed	X	ch	m	
Number of resources used	X	N/A	N/A	Integer
Cost of resources used		N/A	N/A	
Containment diagram		N/A	N/A	

## Output Variables and Modules

Output variable	Default output variable	English Units	Metric Units	Notes
<b>SPOT</b>				
Spotting distance from torching trees	X	mi	km	
Spotting distance from a burning pile		mi	km	
Spotting distance from a wind-driven surface fire		mi	km	
<b>SCORCH</b>				
Scorch height	X	ft	m	
<b>MORTALITY</b>				
Bark thickness		in	cm	
Tree crown length scorched		ft	m	
Tree crown volume scorched		percent	percent	
Probability of mortality	X	percent	percent	
<b>IGNITE</b>				
Probability of ignition from a firebrand	X	percent	percent	
Probability of ignition from lightning		percent	percent	
<b>RH</b>				
Relative humidity	X	Percent	Percent	
Dew point temperature		deg F	deg C	

## Appendix C: Units Editor

Variable	English units	No. Dec.	Metric units	No. Dec.
<b>Fuel and Vegetation Units</b>				
Fuel Load <ul style="list-style-type: none"> <li>• 1-h fuel load</li> <li>• 10-h fuel load</li> <li>• 100-h fuel load</li> <li>• Live herbaceous fuel load</li> <li>• Live woody fuel load</li> <li>• Palmetto-gallberry dead fine fuel load</li> <li>• Palmetto-gallberry dead medium fuel load</li> <li>• Palmetto-gallberry dead foliage fuel load</li> <li>• Palmetto-gallberry live fine fuel load</li> <li>• Palmetto-gallberry live medium fuel load</li> <li>• Palmetto-gallberry live foliage fuel load</li> <li>• Palmetto-gallberry litter fuel load</li> </ul>	ton/ac	2	tonne/ha	2
Surface Area/Vol Ratio <ul style="list-style-type: none"> <li>• 1-h surface area/volume ratio</li> <li>• Live herb surface area/volume ratio</li> <li>• Live woody surface area/volume ratio</li> </ul>	ft <sup>2</sup> /ft <sup>3</sup>	0	m <sup>2</sup> /m <sup>3</sup>	0
Understory Fuel Depths <ul style="list-style-type: none"> <li>• Fuel bed depth</li> <li>• Palmetto-gallberry height of understory</li> </ul>	ft	2	m	2
Ground Fuel Depth <ul style="list-style-type: none"> <li>• Lightning duff and litter depth</li> </ul>	in	1	cm	0

<b>Variable</b>	<b>English units</b>	<b>No. Dec.</b>	<b>Metric units</b>	<b>No. Dec.</b>
Fuel Moisture & Extinction Moisture <ul style="list-style-type: none"> <li>• Dead fuel moisture of extinction</li> <li>• 1-h moisture</li> <li>• 10-h moisture</li> <li>• 100-h moisture</li> <li>• Live herbaceous moisture</li> <li>• Live woody moisture</li> <li>• Dead fuel moisture</li> <li>• Live fuel moisture</li> </ul>	percent	0	percent	0
Fuel Heat Content <ul style="list-style-type: none"> <li>• Dead fuel heat content</li> <li>• Live fuel heat content</li> </ul>	Btu/lb	0	kJ/kg	0
Tree Height & Mean Cover Height <ul style="list-style-type: none"> <li>• Mean cover height</li> <li>• Tree height</li> <li>• Tree crown length scorched</li> </ul>	ft	0	m	0
Tree D.b.h. and Bark Thickness <ul style="list-style-type: none"> <li>• D.b.h.</li> <li>• Bark thickness</li> </ul>	in	0	cm	0
Coverage <ul style="list-style-type: none"> <li>• First fuel model coverage</li> <li>• Palmetto coverage</li> </ul>	percent	0	percent	0
Basal Area <ul style="list-style-type: none"> <li>• Palmetto-gallberry overstory basal area</li> </ul>	ft <sup>2</sup> /ac	0	m <sup>2</sup> /ha	0
<b>Weather Units</b>				
Wind Speed <ul style="list-style-type: none"> <li>• Midflame wind speed</li> <li>• 20-ft wind speed</li> <li>• 10-m wind speed</li> <li>• Effective wind speed</li> <li>• Maximum reliable wind speed</li> </ul>	mi/h	1	km/h	1
Temperature <ul style="list-style-type: none"> <li>• Air (dry bulb) temperature</li> <li>• Wet bulb temperature</li> <li>• Dew point temperature</li> </ul>	°F	0	°C	0
Relative Humidity <ul style="list-style-type: none"> <li>• Relative humidity</li> </ul>	percent	0	percent	0
Shading from sun	percent	0	percent	0

Variable	English units	No. Dec.	Metric units	No. Dec.
<b>Terrain &amp; Spotting Units</b>				
Slope Steepness <ul style="list-style-type: none"> <li>Slope steepness</li> </ul> (Note: these units only apply when the SURFACE Module option Slope is specified as percent is selected. When Slope is specified as degrees is selected, all slope units are degrees.)	percent	0	percent	0
Site Elevation & Ridge-to-Valley Elevation Difference <ul style="list-style-type: none"> <li>Site elevation</li> <li>Ridge-to-valley elevation difference</li> <li>Elevation change (slope rise)</li> <li>Horizontal distance (slope reach)</li> </ul>	ft	0	m	0
Spotting Distance & Ridge-to-Valley Horizontal Distance <ul style="list-style-type: none"> <li>Spotting distance from torching trees</li> <li>Spotting distance from a burning pile</li> <li>Spotting distance from a wind-driven surface fire</li> <li>Ridge-to-valley horizontal distance</li> </ul>	mi	1	km	1
<b>Fire &amp; Effects units</b>				
Rate of Spread	ch/h	1	m/min	1
Fire Heat Per Unit Area	Btu/ft <sup>2</sup>	0	kW/s/m <sup>2</sup>	0
Fireline Intensity	Btu/ft/s	0	kW/m	0
Flame Length & Scorch Height <ul style="list-style-type: none"> <li>Flame length</li> <li>Flame height of a burning pile</li> <li>Scorch height</li> </ul>	ft	1	m	1
Fire Reaction Intensity	Btu/ft <sup>2</sup> /min	0	kW/m <sup>2</sup>	0
Spread Distance <ul style="list-style-type: none"> <li>Spread distance</li> <li>Forward spread distance</li> <li>Backing spread distance</li> <li>Fire length</li> <li>Maximum width of fire</li> </ul>	ch	1	m	1

<b>Variable</b>	<b>English units</b>	<b>No. Dec.</b>	<b>Metric units</b>	<b>No. Dec.</b>
Fire Area <ul style="list-style-type: none"> <li>• Area</li> <li>• Contained area</li> <li>• Fire size at report</li> </ul>	ac	1	ha	1
Fire Perimeter	ch	0	m	0
Probability of Mortality & Crown Volume Scorched <ul style="list-style-type: none"> <li>• Tree crown volume scorched</li> <li>• Probability of mortality</li> </ul>	percent	0	percent	0
Probability of Ignition <ul style="list-style-type: none"> <li>• Probability of ignition from a firebrand</li> <li>• Probability of ignition from a lightning strike</li> </ul>	percent	0	percent	0
<b>Time &amp; Map Units</b>				
Time <ul style="list-style-type: none"> <li>• Elapsed time</li> <li>• Resource Arrival Time</li> <li>• Resource Duration</li> <li>• Time from Report</li> </ul>	h	1	h	1
Contour Interval <ul style="list-style-type: none"> <li>• Map contour interval</li> </ul>	ft	0	m	1
Map Distance <ul style="list-style-type: none"> <li>• Map distance (for slope calculation)</li> <li>• Fire spread map distances</li> <li>• Fire length and width map distances</li> <li>• Spotting map distance from torching trees</li> <li>• Spotting map distance from a burning pile</li> <li>• Spotting map distance from a wind-driven surface fire</li> </ul>	in	2	cm	1

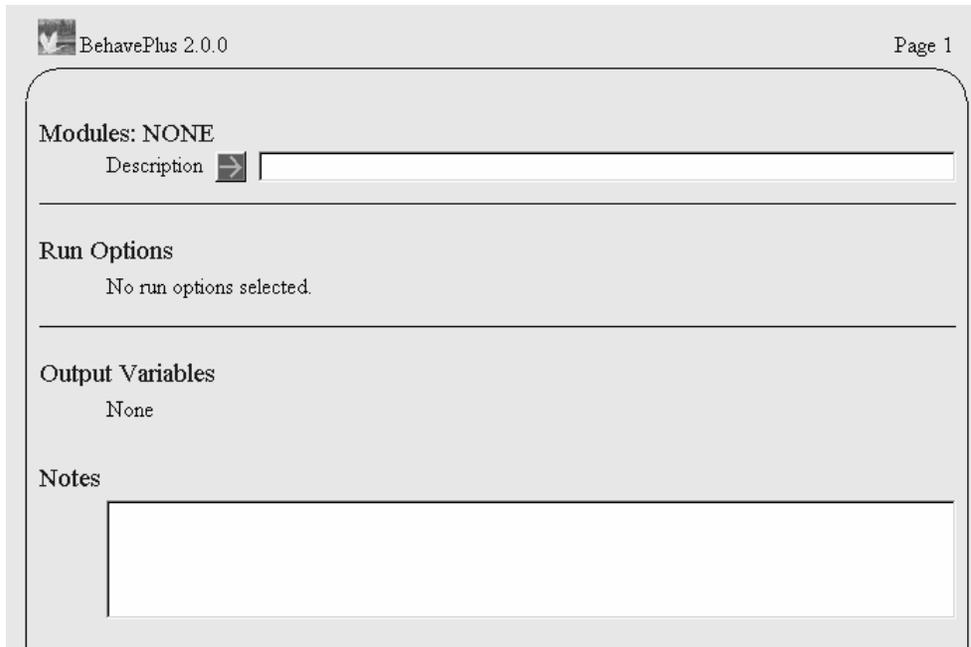
<b>Variable</b>	<b>English units</b>	<b>No. Dec.</b>	<b>Metric units</b>	<b>No. Dec.</b>
<b>Contain &amp; Safety Units</b>				
Rate <ul style="list-style-type: none"> <li>Resource Line Production Rate</li> </ul>	ch/h	1	m/h	1
Distance, Containment <ul style="list-style-type: none"> <li>Fireline Constructed</li> <li>Line Construction Offset</li> </ul>	ch	1	m	0
Distance, Safety Zone <ul style="list-style-type: none"> <li>Safety Zone Radius</li> <li>Safety Zone Separation Distance</li> </ul>	ft	0	m	0
Area, Safety Zone <ul style="list-style-type: none"> <li>Safety Zone Size</li> </ul>	ac	2	ha	0
Area, Personnel and Equipment <ul style="list-style-type: none"> <li>Area per person</li> <li>Area per heavy equipment</li> </ul>	ft <sup>2</sup>	0	m <sup>2</sup>	0

## Appendix D: The 0Startup.bpw worksheet, defaults

The 0Startup.bpw worksheet is generally the starting place for selection of calculation modules. Therefore, upon initiation, the BehavePlus program automatically loads that worksheet. You have the option of ignoring or closing it and loading a previously saved worksheet loaded through the **File > New** command.

The 0Startup.bpw worksheet doesn't look like much on the screen, but it carries with it all of the 'default' selections for calculation modules and displays. Any of those selections can be changed, of course. The 0Startup.bpw worksheet can be reloaded at any time to reset the defaults. The 0 (zero) is the first character in the file name to assure that it is listed first in the list of Example Worksheets for easy selection.

If you want to use a different set of 'defaults', simply develop and save a similar startup worksheet in your own folder. For example, if you generally use metric units or if you prefer to display graphs as full screen rather than 50%, then you can define an alternate appropriate startup worksheet. The program will, however, continue to load our 0Startup.bpw worksheet when the program is initiated. You will need to load your own using the **File > New** command.



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Modules: NONE  
Description

---

Run Options  
No run options selected.

---

Output Variables  
None

Notes

Following are the 'default' selections that come with the 0Startup.bpw worksheet.

<b>Module</b>	<b>Input option</b>	<b>0Startup.bpw selection</b>	<b>Other options</b>
SURFACE	Fuel is entered as	<ul style="list-style-type: none"> <li>• Fuel models</li> </ul>	<ul style="list-style-type: none"> <li>• Fuel parameters</li> <li>• Dynamic palmetto-gallberry</li> <li>• Two fuel models, two-dimensional expected spread</li> <li>• Two fuel models, harmonic mean</li> <li>• Two fuel models, area weighted</li> </ul>
	Moisture is entered by	<ul style="list-style-type: none"> <li>• Individual size class</li> </ul>	<ul style="list-style-type: none"> <li>• Dead and live category</li> <li>• Moisture scenario</li> </ul>
	Wind speed is entered as	<ul style="list-style-type: none"> <li>• Midflame height</li> </ul>	<ul style="list-style-type: none"> <li>• 20-ft wind and wind adjustment factor</li> <li>• 10-m wind and wind adjustment factor</li> </ul>
	Wind direction is	<ul style="list-style-type: none"> <li>• Specified on the worksheet</li> </ul>	<ul style="list-style-type: none"> <li>• Upslope</li> </ul>
	Rate of spread is calculated	<ul style="list-style-type: none"> <li>• Only in the direction of maximum spread</li> </ul>	<ul style="list-style-type: none"> <li>• In directions specified on the worksheet</li> </ul>
	Wind & spread directions are	<ul style="list-style-type: none"> <li>• Degrees clockwise from upslope (direction the wind is pushing the fire)</li> </ul>	<ul style="list-style-type: none"> <li>• Degrees clockwise from north (direction from which the wind is blowing)</li> </ul>
	Slope is specified as	<ul style="list-style-type: none"> <li>• Percent</li> </ul>	<ul style="list-style-type: none"> <li>• degrees</li> </ul>
	Slope steepness is	<ul style="list-style-type: none"> <li>• Specified on the worksheet</li> </ul>	<ul style="list-style-type: none"> <li>• Calculated from map measurements</li> </ul>
SCORCH	Fire intensity is entered as	<ul style="list-style-type: none"> <li>• Flame length</li> </ul>	<ul style="list-style-type: none"> <li>• Fireline intensity</li> </ul>
MORTALITY	Bark thickness is	<ul style="list-style-type: none"> <li>• Specified on the worksheet</li> </ul>	<ul style="list-style-type: none"> <li>• Estimated from species and d.b.h</li> </ul>
RH	Relative humidity is derived from	<ul style="list-style-type: none"> <li>• Dew point and dry bulb temperature</li> </ul>	<ul style="list-style-type: none"> <li>• Dry and wet bulb temperature and elevation</li> </ul>

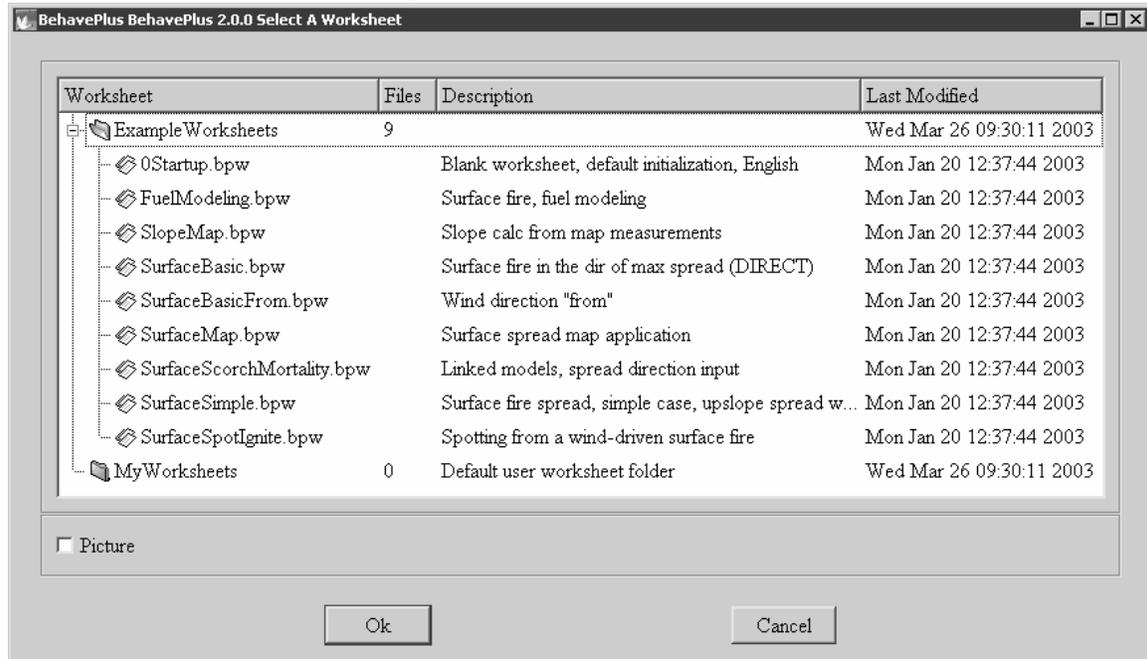
Module	Startup.bpw output variable selection	Other output variables
SURFACE	<ul style="list-style-type: none"> <li>• Rate of spread</li> <li>• Heat per unit area</li> <li>• Fireline intensity</li> <li>• Flame length</li> <li>• Direction of maximum spread</li> <li>• Maximum wind exceeded?</li> </ul>	<ul style="list-style-type: none"> <li>• Reaction intensity</li> <li>• Spread distance</li> <li>• Midflame wind speed</li> <li>• Effective wind speed</li> <li>• Maximum reliable wind speed</li> <li>• Slope steepness</li> <li>• Slope elevation change</li> <li>• Slope horizontal distance</li> <li>• Wind/slope/spread direction diagram</li> <li>• Fire characteristics chart</li> <li>• For Palmetto-gallberry dynamic fuel: <ul style="list-style-type: none"> <li>• P-G dead fine fuel load</li> <li>• P-G dead medium fuel load</li> <li>• P-G dead foliage fuel load</li> <li>• P-G live fine fuel load</li> <li>• P-G live medium fuel load</li> <li>• P-G live foliage fuel load</li> <li>• P-G litter fuel load</li> </ul> </li> <li>• Fuel bed depth</li> </ul>
SAFETY	<ul style="list-style-type: none"> <li>• Safety zone separation distance</li> <li>• Safety zone size</li> </ul>	<ul style="list-style-type: none"> <li>• Safety zone radius</li> </ul>
SIZE	<ul style="list-style-type: none"> <li>• Area</li> <li>• Perimeter</li> </ul>	<ul style="list-style-type: none"> <li>• Length-to-width ratio</li> <li>• Forward spread distance</li> <li>• Backing spread distance</li> <li>• Fire length</li> <li>• Maximum fire width</li> <li>• Fire shape diagram</li> </ul>
CONTAIN	<ul style="list-style-type: none"> <li>• Time from report</li> <li>• Contain status</li> <li>• Contained area</li> <li>• Fireline constructed</li> <li>• Number of resources used</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of resources used</li> <li>• Containment diagram</li> </ul>
SPOT	<ul style="list-style-type: none"> <li>• Spotting distance from torching trees</li> </ul>	<ul style="list-style-type: none"> <li>• Spotting distance from a burning pile</li> <li>• Spotting distance from a wind-driven surface fire</li> </ul>
SCORCH	<ul style="list-style-type: none"> <li>• Scorch height</li> </ul>	
MORTALITY	<ul style="list-style-type: none"> <li>• Probability of mortality</li> </ul>	<ul style="list-style-type: none"> <li>• Bark thickness</li> <li>• Tree crown length scorched</li> <li>• Tree crown volume scorched</li> </ul>
IGNITE	<ul style="list-style-type: none"> <li>• Probability of ignition from a firebrand</li> </ul>	<ul style="list-style-type: none"> <li>• Probability of ignition from lightning</li> </ul>
RH	<ul style="list-style-type: none"> <li>• Relative humidity</li> </ul>	<ul style="list-style-type: none"> <li>• Dew point temperature</li> </ul>

<b>Menu item</b>	<b>0Startup.bpw selection</b>	<b>Other options</b>
View	100%	50, 67, 75, 83, 117, 133, 150, 167, 200%
Configure > Module selection	None	SURFACE, SAFETY, SIZE, CONTAIN, SPOT, SCORCH, MORTALITY, IGNITE, RH
	Display output distances in map units. Off	On
Configure > Units	English	Metric Custom
Configure > Language	English (US)	Portuguese (Portugal)
Configure > Fuel model set selection	None	No other options. Fuel model set selection must be done every time a Worksheet or Run is loaded
Configure > Moisture scenario set selection	None	No other options Moisture scenario set selection must be done every time a Worksheet or Run is loaded

<b>Configure &gt; Appearance Tab</b>	<b>Option</b>	<b>0Startup.bpw selection</b>	<b>Other options</b>
Application	Show help pane	On	Off
	Show picture pane	On	Off
	Border color	Black	Other colors
	Border width	1	0 = no border 2-9= thicker border
Graph size	Graph size	50%	25-100%
	Graph title	Short	Long
	X axis origin	Zero	Min value
	Y axis origin	Zero	Min value
Graph elements	Background	White	Other colors
	Rainbow colors	3	4-18
	Bar color	Red	Other colors
	Curve points	20	4-100
	Curve color	Rainbow colors	Single color
	Curve width	3	0-9
	Axis color	Black	Other colors
	Axis width	1	2-9
	Gridline color	Yellow	Other colors
	Gridline width	1	0=no gridlines 2-9=thicker gridlines
Page tabs	Display page tab	Off	On
	Tabs per page	4	0 = no tabs 1-10
	Tab position	1	0=no tabs 1- #tabs per page
	Tab text	Blank	User defined
	Tab text color	Black	Other color
	Tab font size	12	8-24
Tables	Shade alternate table rows	On	Off
	Shade	Light grey	Other colors
Worksheet	Fire projection documentation	Off	On
	Training documentation	Off	On
	Show input codes for all discrete variables	Off	On
	Show output variables to be calculated	On	Off
	Show notes section	On	Off
	Notes lines	4	1-10

## Appendix E: Example Worksheets

BehavePlus allows the user to define and save a worksheet for later use. A set of Example Worksheets is provided with the program. Those worksheets are described in this appendix. A worksheet is selected through **File > New**. Clicking on the  by the Example Worksheets folder displays the following list. A double click on the selection or a single click and **Ok** loads the worksheet.



It is important to recognize that these are only examples. We expect that people will set up their own folder of commonly used worksheets.

### 0Startup.bpw

This worksheet is a special case. It is used as the starting place for selecting calculation modules. It shows no input or output variables, but it sets defaults for all run settings as described in Appendix D. The 0Startup.bpw worksheet was used to initialize all of the following example worksheets.

### SurfaceSimple.bpw

This worksheet is the ultimate simplification of the setup for a surface fire spread and intensity calculation. It can be used to examine relationships among the basic variables (fuel, moisture, wind, and slope) on surface fire spread. For specific fire behavior prediction, more information would be used.

- Fuel moisture is entered as dead and live category. A single value is used for 1-h, 10-h, and 100-h moisture content and another for live herbaceous and live woody fuel moisture.
- Calculations are for maximum spread rate, upslope spread with the wind.

### SurfaceBasic.bpw

This worksheet is similar to the DIRECT module in the old BEHAVE. This method of specifying directions is used to show the relative effects of wind and slope by vectoring. Reference is to upslope, so there is no need to define aspect or reference directions with respect to north.

- A fuel moisture value is required for each size class.
- Calculations are only for the direction of maximum spread
- Wind and spread directions are specified as degrees clockwise from upslope
- Wind direction is specified as the direction the wind is pushing the fire

### **SurfaceBasicFrom.bpw**

This worksheet is like SurfaceBasic.bpw except the other option for specifying directions is selected. This method of specifying directions is suited for onsite calculations for a specific location on the landscape. The wind direction is that used in weather forecasts.

- A fuel moisture value is required for each size class.
- Calculations are only for the direction of maximum spread.
- Wind and spread directions are specified as degrees clockwise from north.
- Wind direction is the direction from which the wind is blowing.

### **FuelModeling.bpw**

This is the SURFACE module set up to examine the effect of changing fuel parameters, part of the process of developing a custom fuel model.

- Fuel is entered as fuel parameter.
- Fuel moisture is entered as moisture scenario.
- Wind is blowing upslope.
- Calculations are only for the direction of maximum spread.
- Only rate of spread (maximum) and flame length are selected as output.

### **SurfaceMap.bpw**

This worksheet might be used when using maps in projecting fire growth.

- The header includes those for 'fire projection documentation'.
- Output distances are displayed as map units.
- Calculations are only for the direction of maximum spread.
- Wind and spread directions are degrees clockwise from north.
- Wind direction is the direction from which the wind is blowing.
- Direction of maximum spread and spread distance are selected as additional output variables.
- Slope steepness is calculated from map measurements.

### **SlopeMap.bpw**

This simple worksheet is used to calculate slope steepness from map measurements. It is available from the SURFACE module.

- Slope steepness is specified to be calculated from map measurements.
- Only the slope output variables are selected.

### **SurfaceScorchMortality.bpw**

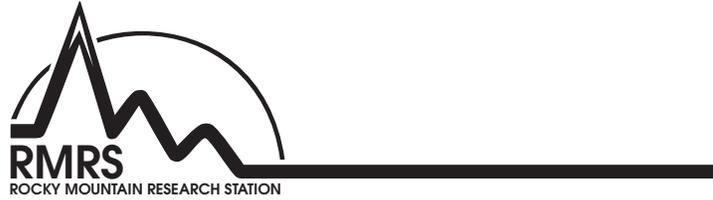
This worksheet enables the three modules SURFACE, SCORCH, and MORTALITY.

- Calculations are for specified spread directions (rather than for the direction of maximum spread).
- Wind and spread directions are degrees clockwise from upslope.
- Wind direction is the direction the wind is pushing the fire.

### **SurfaceSpotIgnite.bpw**

This worksheet enables the three modules; SURFACE, SPOT, and IGNITE

- Spotting distance is calculated from a wind-driven surface fire, which is the only spotting distance output option that makes sense for a link to SURFACE.
- Wind is entered as 20-ft wind speed and wind adjustment factor (rather than as midflame wind speed).
- Wind direction is upslope.
- Calculations are only for the direction of maximum spread (the only option that is valid for this spotting option).



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