Advanced Wildland Fire Behavior Calculations, S-490

Pre-Course Study Material

Part 5: Automated Fire Behavior – Use of BehavePlus

Materials Needed:
S-490 Student CD or S-490 Pre-Course Online
BehavePlus User Guide
BehavePlus software

Introduction:
BehavePlus fire behavior modeling system is a very complex, yet user friendly program. You can set up BehavePlus to do very complicated "runs" with numerous variables of input and output information. The key to successful use of BehavePlus is to configure the "runs" so that you are asking the program to do only the calculation you need, and not have to put in lots of extra input and produce more output than you need.

Become familiar with the operation of BehavePlus by reading through the User Guide and reviewing the Self-Study lessons (the User Guide and the Self-Study lessons can be accessed through fire.org, navigating to BehavePlus, and going to the training page). Concentrate on the portions dealing with configuration of the inputs and outputs, the Surface Module, and file management.

Directions:
Read the following information on using BehavePlus and then complete the practice tests. Review your answers with those given. Remember, before taking S-490 you need to be very comfortable using BehavePlus. Thoroughly review the User Guide and other resources and take the time to make lots of BehavePlus runs. Take the pre-selection assessment only when you feel comfortable using BehavePlus.

Using BehavePlus
This study material focuses on "Configuration of Inputs and Outputs," "Spotting Distance Module," and "File Structure" in BehavePlus. It is important that you understand how to format your input to get the most out of each run. One of the keys to this will be understanding how and when to enter more than one input variable.

Input variables are one of two types, discrete and continuous. Discrete values are those that are whole numbers only, with no values of meaning in between. An example of a discrete input value is fuel model. Fuel model 4 means one thing and fuel model 5 means another. There is no value between them (there is no value for a fuel model four and a half). Continuous values on the other hand do have values between the whole numbers. Wind speed can be 4 mph and it can be 5 mph, it can also be four and a half.

With BehavePlus you can input a single value very easily, such as entering a "7" for fuel model 7. You can also enter several values directly, such as 4, 5, 8 for fuel models 4, 5 and 8. For continuous values you can enter a set of numbers separated by commas or spaces, or you can use the Guide Button to bring you to the Input Guide Screen. There you will see places for starting and stopping values as well as the interval step value.

It is important to remember (but if you don't, BehavePlus will remind you) that you can only have 2 inputs per run that are entered as multiple values. The rest of your inputs will need to be individual numbers.

Configuration of Inputs and Outputs

BehavePlus can be configured to need only very limited input to produce very specific outputs (flame length and rate of spread) or BehavePlus can be configured to require extensive input to produce fire behavior prediction outputs dealing with:

- Rate of Surface fire spread, intensity, flame length
- Area and perimeter of a point source fire
- Spread distance
- Spotting distance
- Probability of ignition
- Scorch height
- Tree Mortality
- Relative humidity determination
- Mid-flame wind speed
- Effective wind speed
- Slope steepness
- Length-to-width ratio
- Map length for all distances

Typically, the more outputs you ask for, the more inputs you will need to enter. In order to ensure you are asking BehavePlus to produce only what you need for output, and therefore are not being asked for more input than you need, or have, you should always start your operation of a run with a trip to the *Module Selection Screen*.

It is a good idea to always use this page and specifically check and un-check which inputs and outputs you want selected (at least until you are <u>VERY</u> familiar with the many intricacies of the inputs and outputs).

The starting point for most BehavePlus predictions will be to complete a "Surface Fire Spread" (SURFACE) run. To do this, start with a blank worksheet. Next, configure the worksheet to give just the outputs you want, and to make sure the inputs required will be in the format that you want. To do this, press the configure button, check the box for Surface Fire Spread, and click on the Options button.

Fire Spread Module – Options
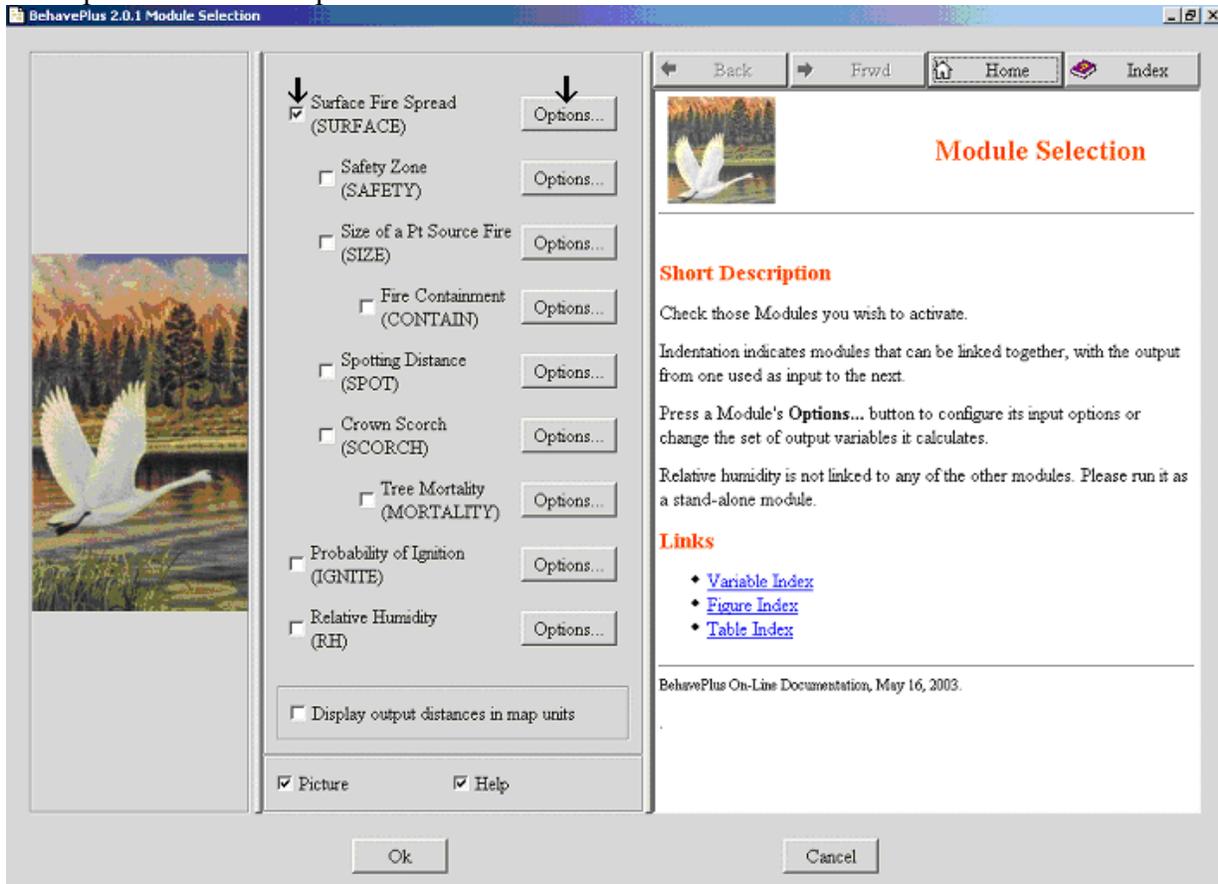
NOTE: One of the most often overlooked "boxes" is found on this page. If you need to have your outputs include map units (Fire moved .54 inches) you must check the "Display output distances in map units." If you do check this box you will need to have input indicating elapsed time and map representative fraction.

When the options button is activated you will access the above page. You can then move to each input and output page of Fuel and Moisture, Wind, Directions, Slope, Outputs, and P-G outputs (which will be discussed during S-490). Each of these pages will be discussed.

Fuel and Moisture
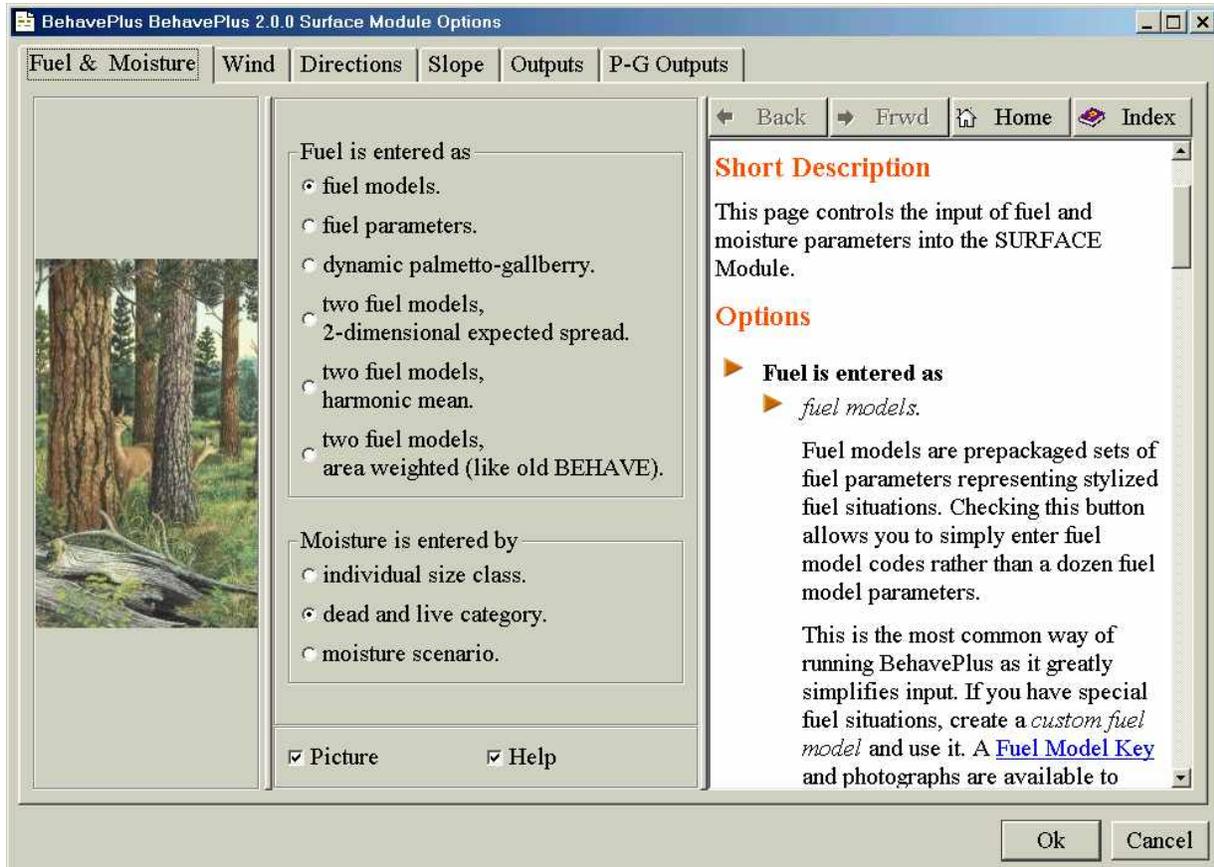
On the Fuel and Moisture page you need to specify that the fuel model will be entered as either one of the 13 fuel models, a custom fuel model, the palmetto-gallberry, or two fuel models. For now we will just use the 13 fuel models.

Also on this page, you will need to choose how the fuel moisture will be entered. It can be entered by individual size class, dead and live category, or a custom moisture scenario.
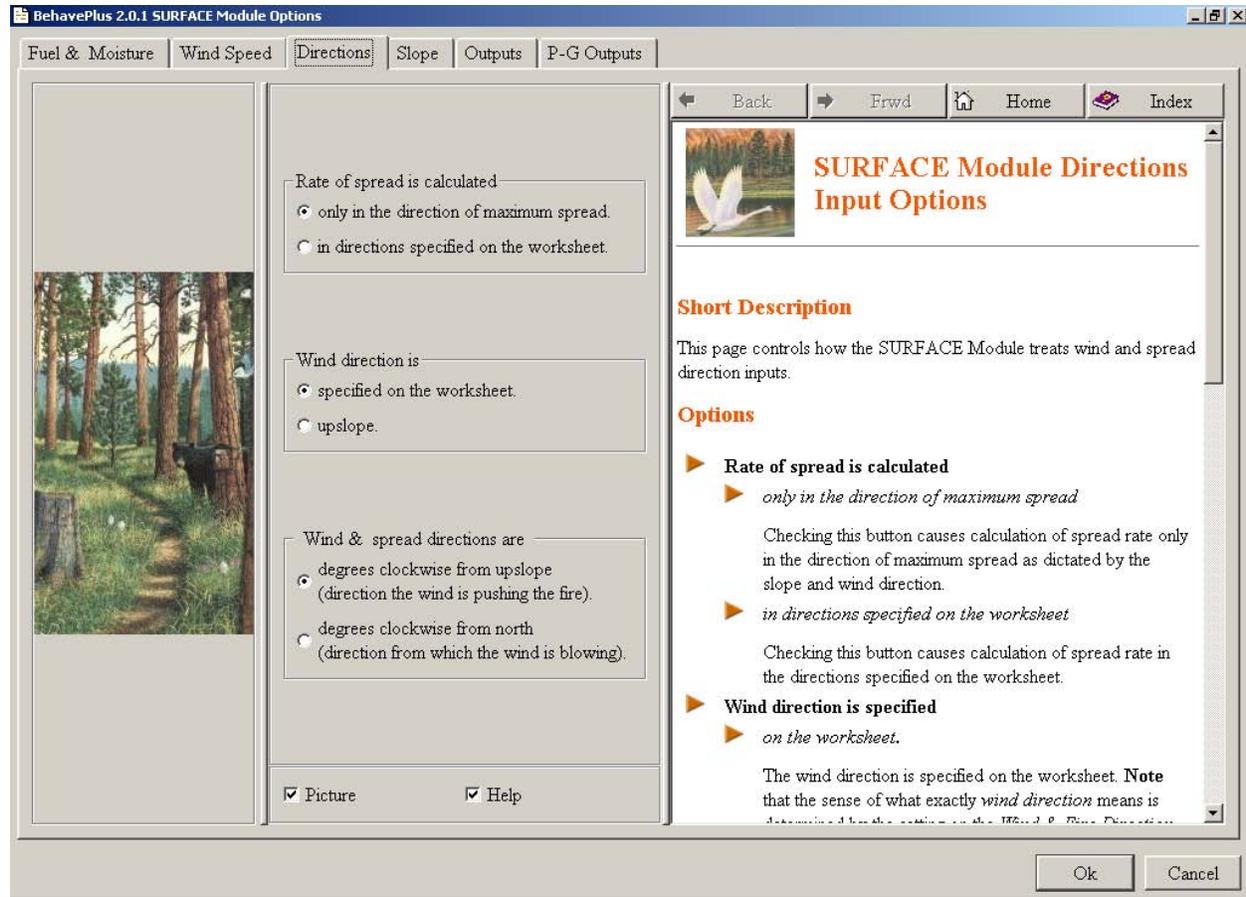
The next tab is for Wind Speed.

Wind Speed
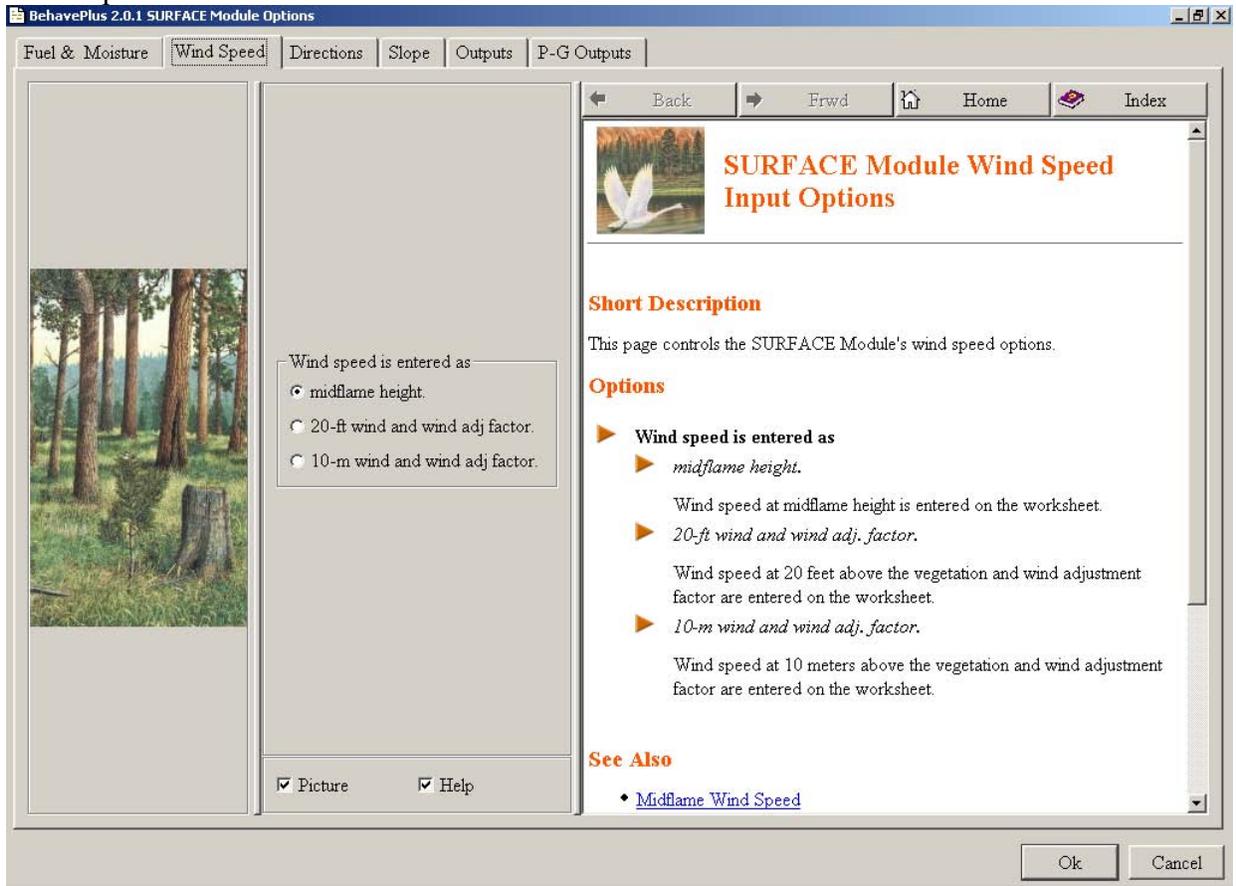
Wind speed will need to be entered as either midflame height, or as a 20 ft or 10 meter wind and a wind adjustment factor.

In BehavePlus the wind direction will be specified on the Directions page.

Directions

On the Directions page, the direction of the rate of spread needs to be chosen (direction of maximum spread or a direction as specified on the worksheet). The "in directions specified on the worksheet" would be used if wanting to calculate the rate of spread in a specific direction (east or north for example) or on a specific portion of the fire (flank or backing for example).

Also, wind direction is specified as specified on the worksheet or upslope. If upslope is chosen, wind direction will not be needed as an input.

Wind direction and spread of the fire will need to be indicated as being either, clockwise from upslope or from north.

Slope
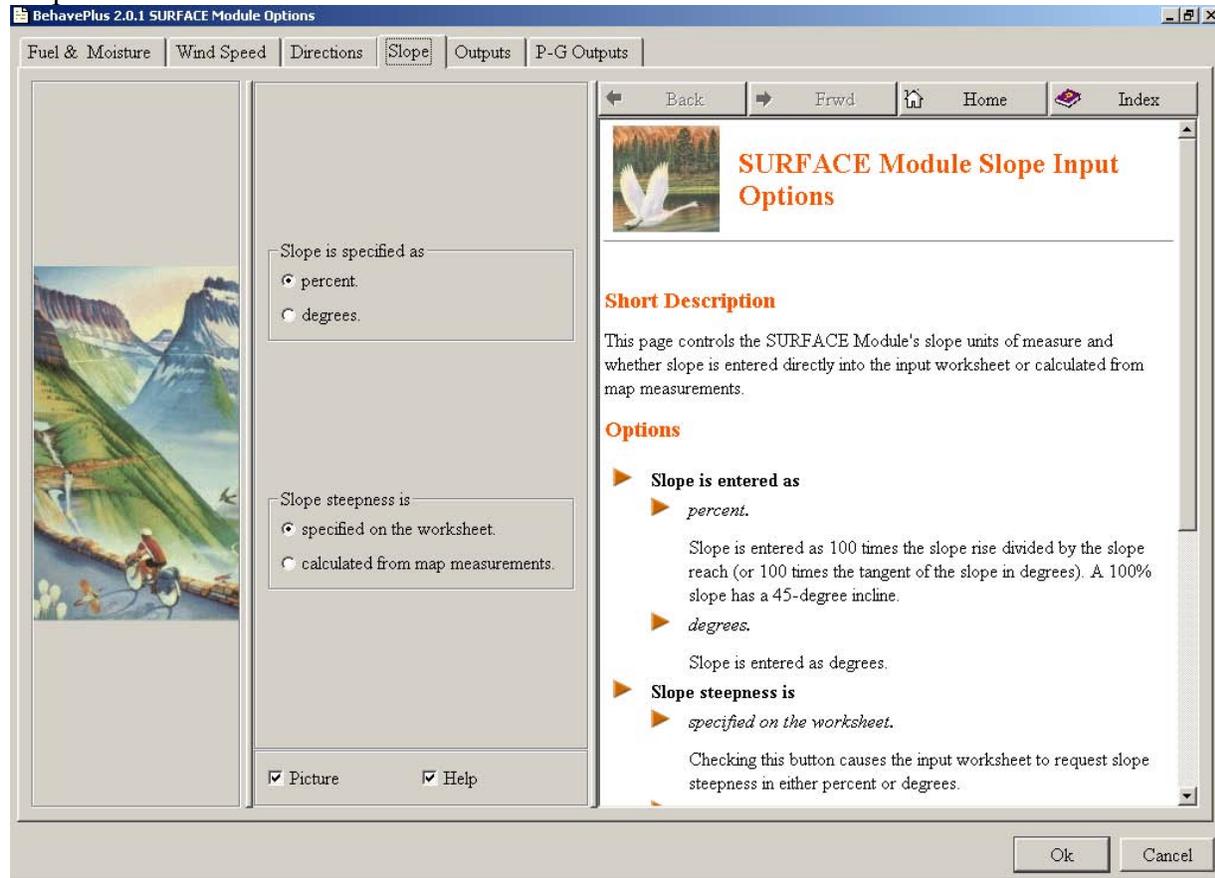
On the Slope page you need to indicate if you have slope in percent or degrees. Also, you can choose to have BehavePlus help calculate the slope by entering map measurements. Choosing to have BehavePlus calculate the slope will require you enter more inputs, dealing with map scale, map distance, contour interval, and number of contour lines.

Outputs
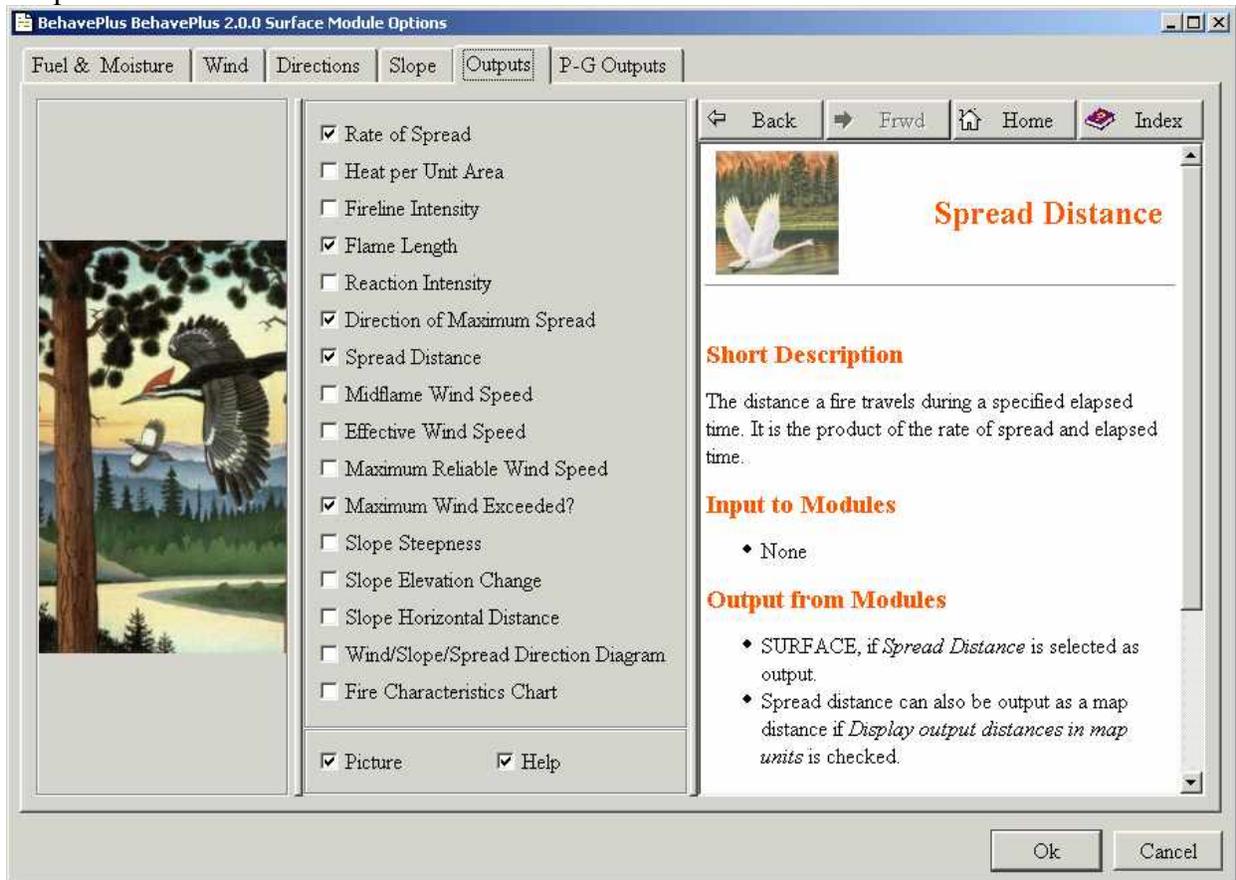
The Outputs page is very important to ensure that the proper output needed will be displayed after the calculations are made. The list of possible outputs from the Surface Fire Module are:

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

(X) *indicates the default output*

It is important to make sure that the outputs you need are checked and those that you do not want are not checked. If outputs you don't want stay checked you may be asked for inputs you don't have. For example if you check "spread distance" you will be asked for an "elapsed time."

It is important for you to become familiar with all of the other Modules of BehavePlus, by reviewing them, checking in the User Guide and other resources. These are:

> Safety Zone
> Size of a Point Source Fire
>> Fire Containment
> Spotting Distance
> Crown Scorch
>> Tree Mortality
> Probability of Ignition
> Relative Humidity

Each of these Modules has options for outputs and some have input options.

Practice Test #1

Figure out how to configure the following example to yield just the following output.

> Rate of Spread
> Flame Length
> Direction of Maximum Spread
> Spread Distance after 2 hours
> Map Distance of spread

On August 15 a fire is burning on a west facing slope of 40%. The fire is burning in a partly sheltered fuel model 10 with a wind reduction factor of 0.3. The weather forecast for the fire area calls for 70% cloudy skies, temperature 89 degrees, relative humidity 19%, and 20' wind of 12 mph from the north. One hour fuel moisture was given as 6% (there is no data on 10 hour or 100 hour) and the live fuel moisture was 120%. The map you are using has a scale of 2" equals one mile.

Practice Test #1 Answer

Modules: SURFACE

Description → `Proficiency Check - Unit 5 -BehavePlus`

Fuel/Vegetation

Fuel Model → `10`

Fuel Moisture

Dead Fuel Moisture % → `6`

Live Fuel Moisture % → `120`

Weather

20-ft Wind Speed mi/h → `12`

Wind Adjustment Factor → `.3`

Direction of Wind Vector (from upslope) deg → `90`

Terrain

Slope Steepness % → `40`

Fire

Elapsed Time h → `2`

Map

Map Representative Fraction (1:x) → `31680`

Proficiency Check - Unit 5 -BehavePlus

Rate of Spread (maximum)	5.4 ch/h
Flame Length	4.1 ft
Direction of Maximum Spread (from upslope)	65 deg
Spread Distance	10.8 ch
Spread Map Distance	0.27 in

To get this set up you need to go to the Module Selection page and choose the Surface Fire Spread Module. On this page towards the bottom you need to check that you will want to "Display output distances in map units." Then go to the options page.

Fuel and Moisture Page –
Under fuel moistures you needed to choose "Moisture is entered by dead and live category" because we have no data for the 10 and 100 hour fuels.

Wind Speed Page –
You need to click the "20-ft wind and wind adjustment factor" button.

Directions Page –
You did not need to make any changes but it is good to make sure you understand the wind is set to "wind specified on the worksheet" because the wind is not blowing upslope. Also, check to see that you understand the wind will be entered as "degrees clockwise from upslope" (direction the wind is pushing the fire).

Slope Page –
Make sure the slope is entered as percent, as it was given in the problem. Since slope was given, you do not need to "calculate from map measurements."

Output Page –
Ensure the requested output is checked. In this problem it should be Rate of Spread, Flame Length, Direction of Maximum Spread, and Spread Distance.

When the inputs page asked for "Map Representative Fraction (1:x) you can use the Guide Button to access the Input Guide Screen. There you can use the "Choices" button to find the representative fraction that goes with 2" /mi. which is 1:31680.

Practice Test #2

For the following situation, calculate just the following outputs in table format in BehavePlus.

> Rate of Spread, at the head and on the flank
> Heat per Unit Area
> Flame Length, at the head and on the flank
> Slope (in degrees)

In an unsheltered (wind adjustment factor of 0.4) fuel model 7, a fire is being pushed by an upslope wind. An automated weather station in the area is recording upslope winds of 14 mph at the 10 meter level. This weather station gives the 1 hour fuel moisture as 8%, and the 10 hour and 100 hour are 9% and 10%, respectively. A sample of the live woody vegetation has been cut, dried and weighed, and had a fuel moisture of 150%. The map being used has a scale of 4"/mile and contour interval of 20 feet. A measurement of the slope in the area of the fire was 2.4" in length and crossed over 13 contour lines.

Practice Test #2 Answer

Modules: SURFACE

Description → Proficiency #2-unit5

Fuel/Vegetation

Fuel Model → 7

Fuel Moisture

1-h Moisture % → 8
10-h Moisture % → 9
100-h Moisture % → 10
Live Herbaceous Moisture % →
Live Woody Moisture % → 150

Weather

10-m Wind Speed (upslope) mi/h → 14
Wind Adjustment Factor → .4

Fire

Spread Direction (from upslope) deg → 0 90

Map

Map Representative Fraction (1:x) → 15840
Contour Interval ft → 20
Map Distance in → 2.4
Number of Contour Intervals → 13

Run Options

Wind direction is upslope.

Calculations are for the specified spread directions.

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.

Outputs for Practice Test #2 Answers

Proficiency #2-unit 5

Spread Dir	Rate of Spread	Heat per Unit Area	Flame Length	Slope
deg	ch/h/Btu/ft2	ft	deg	
0 Head Fire	20.5	485	4.9	5
90 Flank Fire	2.2	485	1.8	5

To set this up you needed to review the configuration of the Surface Fire Spread Module in the following ways:

Fuel and Moisture –
In this example the default choices will work, but they should be reviewed to make sure.

Wind Speed –
The wind speed needs to be changed to reflect the 10-meter wind with adjustment factor.

Directions –
To get the flank fire characteristics we needed to change the "Rate of spread is calculated" to "in directions specified on the worksheet" because we are looking for more than just the maximum spread. Also, the wind direction should be changed to upslope. No other changes were needed.

Slope –
Slope needs to be specified as being in degrees and we need to change the "slope steepness" to "calculated from map measurements."

Outputs –
Here we need to make sure just the required outputs are being checked (Rate of Spread, Heat per Unit Area, Flame Length, and Slope Steepness).

When calculating this "run" you should have selected the "display table results" for the options of output display.
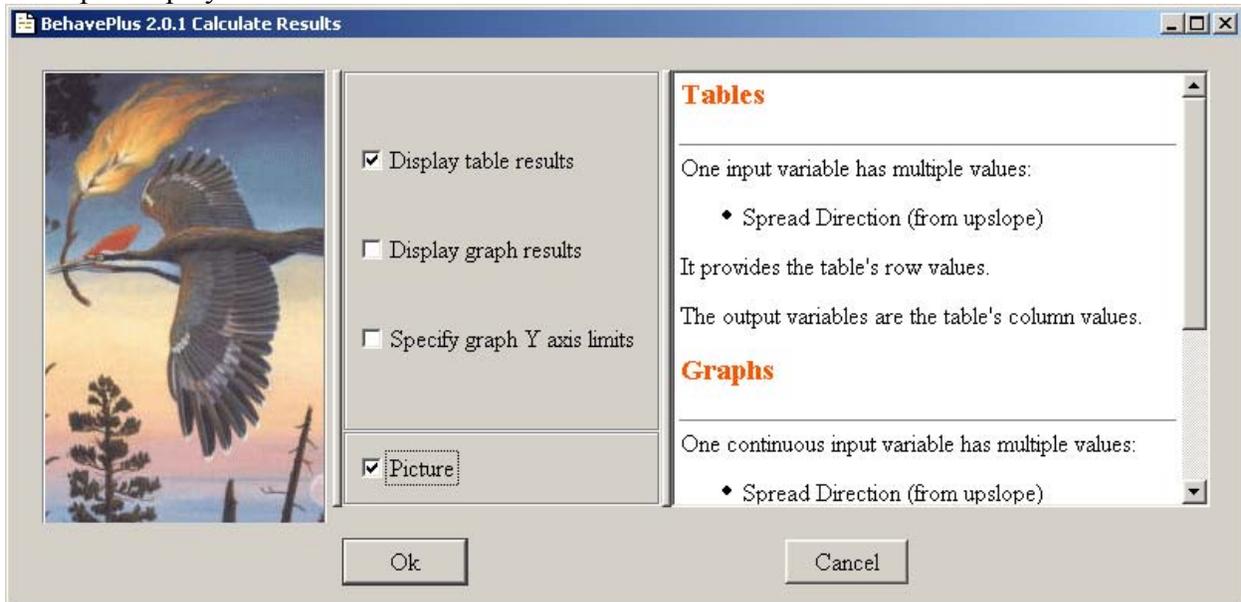
Spotting Distance Module - BehavePlus

One of the major fire behavior prediction model assumptions is that it predicts fire progress through surface fire burning at the flaming front. Fires spread not only through the surface fuels but also by torching and spotting. Creation of spot fires is the result of embers being lofted by the main fire, being carried downwind, and landing on receptive, flammable fuels.
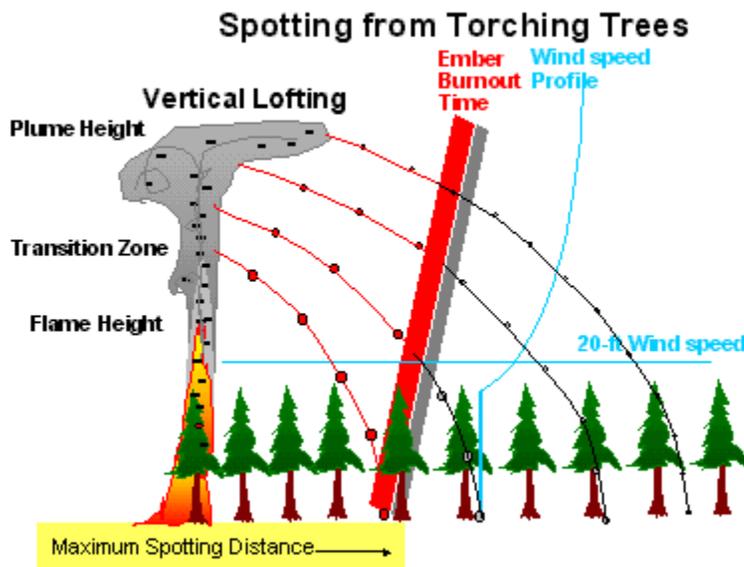
This section discusses predicting the spotting distance using BehavePlus. When using BehavePlus you can activate the SPOT module from the configuration page. Under the SPOT module, you need to select the source of the spot fires. The three choices are torching trees, burning piles or wind driven surface fire.

You will need to identify a number of inputs that are used only in the SPOT module and some that are used in other modules.

Inputs that are needed for calculating spotting distance from <u>torching trees</u> are:

      Mean (Tree) Cover Height – Trees in the downwind direction from the spotting source (NOTE: if forest stand is open, divide mean cover height by 2, otherwise, retain full height.)
      Tree Height
      Tree Species
      D.B.H. (Diameter at Breast Height)
      20 foot wind speed
      Ridge-to-Valley Elevation Difference
      Ridge-to-Valley Horizontal Distance
      Spotting Source Location (on the topography)
      Number of Torching Trees

Inputs that are needed for calculating spotting distance from a <u>burning pile</u>:

      Mean (Tree) Cover Height – Trees in the downwind direction from the spotting source
(NOTE: if forest stand is open, divide mean cover height by 2, otherwise, retain full height.)
      20 foot wind speed
      Ridge-to-Valley Elevation Difference
      Ridge-to-Valley Horizontal Distance
      Spotting Source Location (on the topography)
      and
      Flame Height from a Burning Pile

Inputs needed for calculations of the spotting distance from <u>wind driven surface fires</u> are:

      Mean (Tree) Cover Height – Trees in the downwind direction from the spotting source
(NOTE: if forest stand is open, divide mean cover height by 2, otherwise, retain full height.)
      20 foot wind speed
      Ridge-to-Valley Elevation Difference
      Ridge-to-Valley Horizontal Distance
      Spotting Source Location (on the topography)
      and
      Flame Length (can be entered independently or "linked" from a Surface run)

When SPOT module has been selected and the output (which spotting source/s) has been
selected, entering the needed input will allow BehavePlus to produce the spotting distance for
your prediction.

Practice Test - BehavePlus SPOT Module

Problem 1: Determine the spotting distance for the following scenario. On July 22 at 14:00 three 50 foot tall, 24 inch DBH, Ponderosa pines are torching mid-slope, on the leeward side of a ridge. The average height of trees downwind is 70 feet in a closed canopy. The valley bottom 700 feet below the ridge top. The ridge top is located .4 miles from the valley bottom. The air temperature is 85 degrees, and the relative humidity is 32%. The 20' wind speed is 12 mile per hour, and eye level winds are observed at 4 mph. Cloud cover is greater than 50%.

What is the spotting distance?

Problem 2: Determine the spotting distance from a burning pile. On December 24 at 08:00, a pile burn located on a ridge top. The pile is burning with 15 foot flame heights. The weather observed is, clear skies, 73 degrees, 45% humidity, 20 foot winds are 17 mph. The valley located .5 miles downwind is 500 feet lower than the ridge top. The trees located down wind are 65 feet tall on average, in a closed canopy.

What is the spotting distance?

After you have determined the spotting distance for these two problems, read the answers on the following page and work out any difficulties.

Practice Test Answers – BehavePlus SPOT Module

Problem 1, Spotting Distance = 0.2 miles

Fuel/Vegetation

Mean Cover Height	ft	→	70
Tree Height	ft	→	50
Spot Tree Species		→	PINPON
D.B.H.	in	→	24

Weather

20-ft Wind Speed	mi/h	→	12

Terrain

Ridge-to-Valley Elevation Difference	ft	→	700
Ridge-to-Valley Horizontal Distance	mi	→	.4
Spotting Source Location		→	ML

Fire

Number of Torching Trees		→	3

Problem 2, Spotting Distance = 0.1 miles

Fuel/Vegetation

Mean Cover Height	ft	→	65

Weather

20-ft Wind Speed	mi/h	→	17

Terrain

Ridge-to-Valley Elevation Difference	ft	→	500
Ridge-to-Valley Horizontal Distance	mi	→	.5
Spotting Source Location		→	RT

Fire

Flame Height from a Burning Pile	ft	→	15

Behave File Locations and File Management

Read the User Guide in BehavePlus dealing with section 18, File Management. The User Guide can be found by hitting the help button. The key to proper file management is the same for BehavePlus as it is with any filing system, be sure to follow as consistent, scientific naming structure. BehavePlus suggests you use their system based on Workspaces. The workspace is a file location that holds all of the files pertaining to a specific project. The workspace will hold all the required BehavePlus files plus any additional Worksheet, Run, Fuel Model, Moisture Scenario, Units Set, or Screen Capture files saved by the user.

Workspaces
It is recommended to make a new Workspace folder in Windows Explorer for each project. Projects can be fires, training classes, planned prescribed fires, or other examples. You should make a new folder under the BehavePlus2 folder and giving the new folder an appropriate name. Then in BehavePlus go to File > Workspaces > New Workspace command and choose that new workspace. BehavePlus will copy the file structure to your new folder and ask if you want to use this new folder as your new default. You should indicate yes to this question.

The benefits of using the Workspace Concept are:

- 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.

Saving Runs
Using the File > SaveAs > Run command will save a run to the run files in the current Workspace. Saving a Run saves the worksheet and the entered input values. Saving the worksheet means saving the options selected under the different modules, such as what inputs are needed and what outputs are produced.

Saving Worksheets
Using the File > SaveAs > Worksheet command saves only the worksheet, not any of the inputs of the run.

Saving Fuel Models
This option saves any custom fuel models you have created. The parameters of these fuel models will be saved in the current workspace.

Saving Moisture Scenario
This option saves any custom fuel moisture scenarios that you have created. They will be saved in the current workspace.

Practice Test - File Management

1. Which file saving is used to save the worksheet <u>and</u> the input data?
    A.   File > Workspace > New Workspace
    B.   File > SaveAs > Run
    C.   File > SaveAs > Worksheet
    D.   File > SaveAs > Fuel Models

2. Which command saves a complete subdirectory tree containing all required BehavePlus files, plus additional files saved by the user?
    A.   File > Workspace > New Workspace
    B.   File > SaveAs > Run
    C.   File > SaveAs > Worksheet
    D.   File > SaveAs > Fuel Models

3. Which command saves the worksheet but not the included input values?
    A.   File > Workspace > New Workspace
    B.   File > SaveAs > Run
    C.   File > SaveAs > Worksheet
    D.   File > SaveAs > Fuel Models

<u>Practice Test Answers - File Management</u>

1. B
2. A
3. C