Introduction

BehavePlus provides a number of tools that are stand-alone utilities, meaning they are not linked with any of the calculation modules. They allow for easy calculation of certain variables. Functions range from converting units to calculating slope and relative humidity to finding the fine dead fuel moisture. There is even a tool to determine the sunrise/sunset times for a given area. Results from these tools are independent of the BehavePlus worksheet and must be entered manually if needed.

Objectives

1. Describe the six tools found in BehavePlus: Units Converter, Relative Humidity, Fine Dead Fuel Moisture, Slope from Map Measurements, Slope vs. Horizontal Map Distance, and Sun-Moon Calendar.
2. Describe why outputs from tools are not integrated with BehavePlus worksheets.
3. Demonstrate proficiency in exporting results from tools.
4. Describe the assumptions and limitations associated with the Fine Dead Fuel Moisture tool.
5. Describe the relationship between the Slope from Map Measurements tool and the SURFACE module of BehavePlus.

Where This Lesson Fits In

This is an optional lesson in the Operation Unit, which describes the six stand-alone tools in BehavePlus. There are no prerequisites. Additional lessons referenced in this document can be found in the BehavePlus Training section of www.FireModels.org.

Lesson Changes: V4.0 to V5.0

This lesson is new to Version 5.0.

Introduction

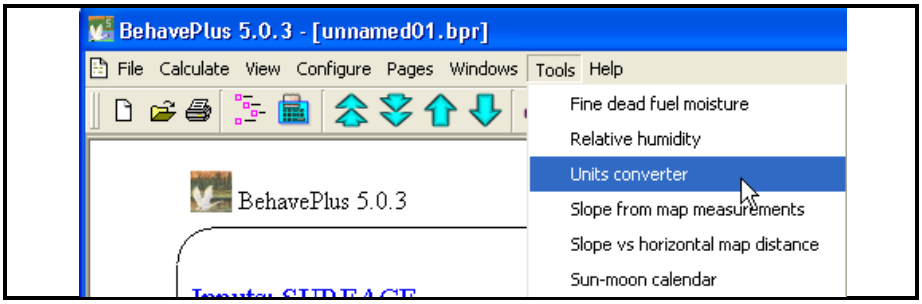
The BehavePlus tools are designed to make life easier, so their use is optional. They are independent of the BehavePlus Worksheet. Some of them, such as the Fine Dead Fuel Moisture tool do not contain equations. Therefore, they cannot be integrated into the Worksheet. The Relative Humidity Tool provides a quick way to find values otherwise available in tables. The Slope from Map Measurements tool (a.k.a. the Slope Tool) is new in version 5.0. It duplicates functionality within the SURFACE module, but allows for easy calculation when slope is the only variable of interest, such as when needed for calculating Fine Dead Fuel Moisture. Others tools such as the Units Converter, Slope vs. Horizontal Map Distance, and Sun-Moon Calendar tools provide additional information not necessarily needed for *calculating* fire behavior. The six BehavePlus tools are summarized in the Features paper (Heinsch and Andrews 2010), and are found on the **Tools** menu. They are also discussed in several other topic-specific BehavePlus lessons. Here, we'll examine each tool in detail, providing examples, limitations, and assumptions as appropriate.

The Units Converter Tool

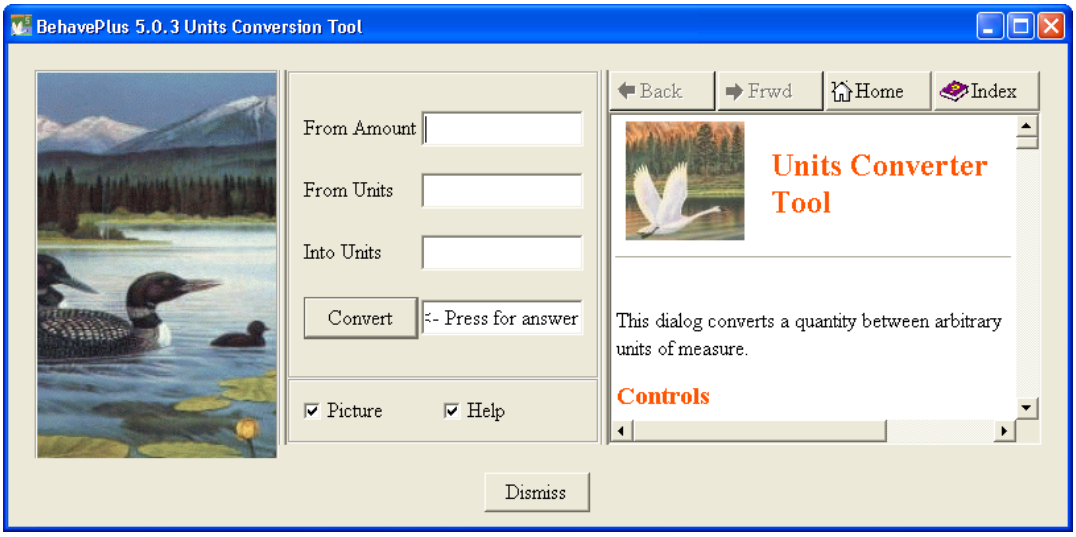
How often do you need to convert Btu/ft/s into kW/m or vice versa? Perhaps not often, but when you do, you could be working with fireline intensity calculations. If you consistently use metric units, you can, of course, change the units of your Worksheet so that the fireline intensity is always generated in kW/m (see Operation Unit > Units and Decimals Lesson for more details). However, you can make a quick conversion using the Units Converter Tool as well. This tool will also come in handy for many more common conversions if you don't have access the handy conversion tools from Google.

With 272 different variables, almost any units you can think of are found in this tool – from drams, hogsheads, and furlongs to feet, kilograms, and BTUs. Units can be combined into any meaningful combination you require. You might never need to convert from furlongs per fortnight to chains per hour, but you could. And, you can quickly convert from chains per hour to feet per second, from feet per second to meters per second, or from kilometers per hour to miles per hour.

- To access the Units Converter Tool, go to **Tools > Units converter**.



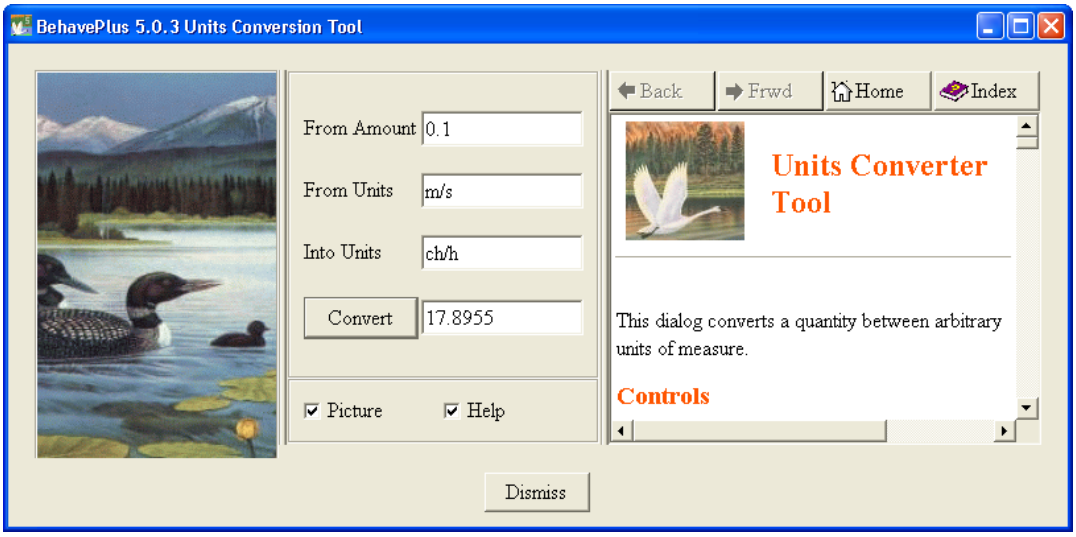
A Units Conversion Tool window will pop up.



In this window, you enter the number you want to convert (**From Amount**), the starting units (**From Units**), and the units you desire (**Into Units**). Press the **Convert** button, and the answer will appear to the right.

You are given a Surface fire Fate of Spread of 0.1 m/s. What is the Surface Rate of Spread in ch/h?

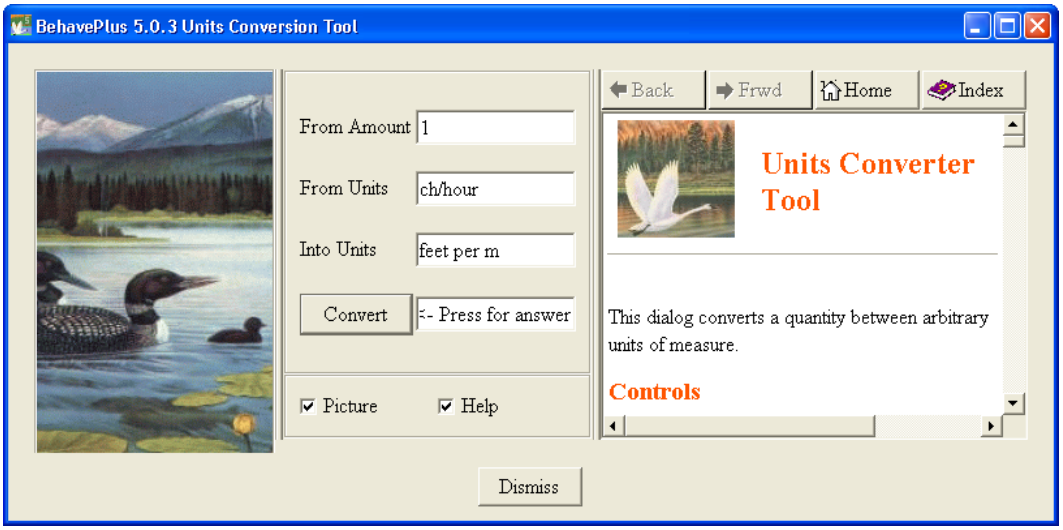
- Go to **Tools > Units Converter**.
- Enter '0.1' in the box next to **From Amount**.
- Enter 'm/s' in the box next to **From Units**.
- Enter 'ch/h' in the box next to **Into Units**.
- Press **Convert**.



The Units Converter is very forgiving about how you enter units, and it understands most common abbreviations. You could have entered m/s as we did above, or any of the following: meters per second, meter per s, m per second, meters/second, m/second, or m/second. All of them would have generated the same answer.

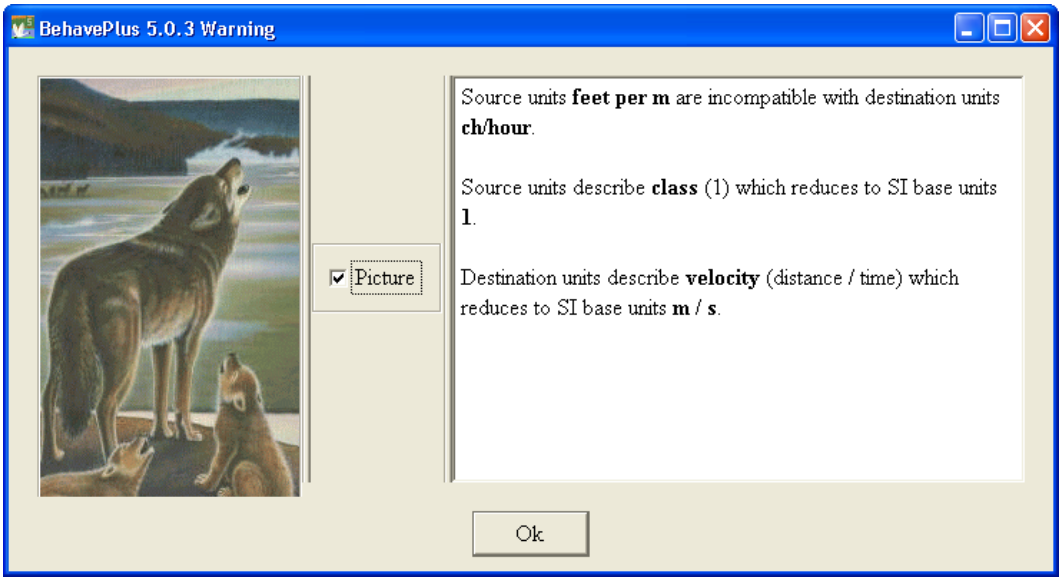
You know that ft/min and ch/h are very similar, but how similar are they?

- Click on **Tools > Units converter**.
- Enter '1' in the box next to **From Amount**.
- Enter 'ch/hour' in the box next to **From Units**.
- Enter 'feet per m' in the box next to **Into Units**.



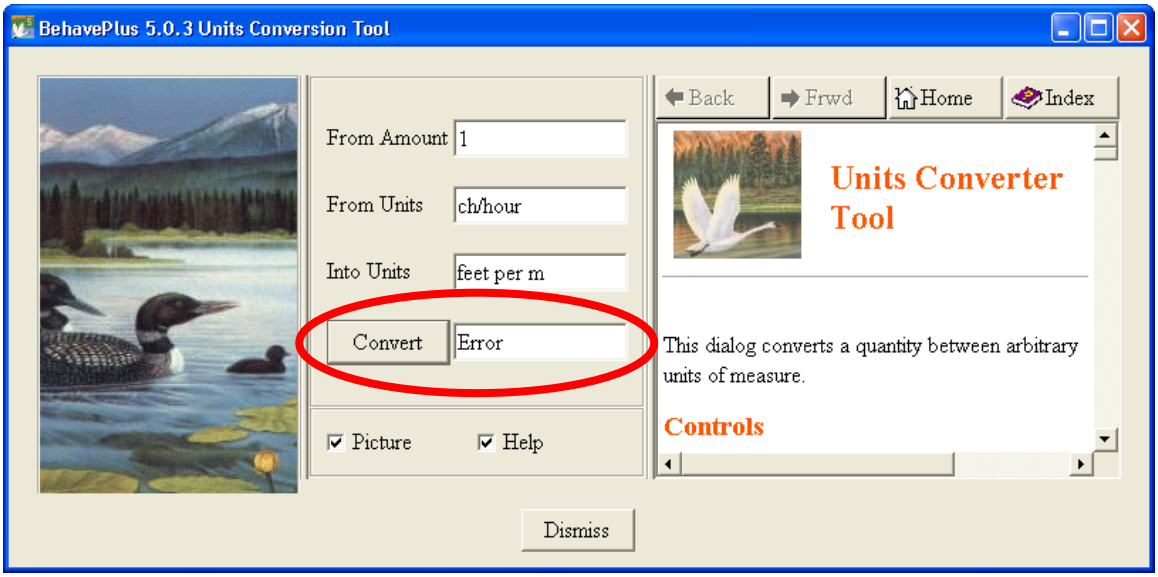
- Press **Convert**.

An error message should appear.



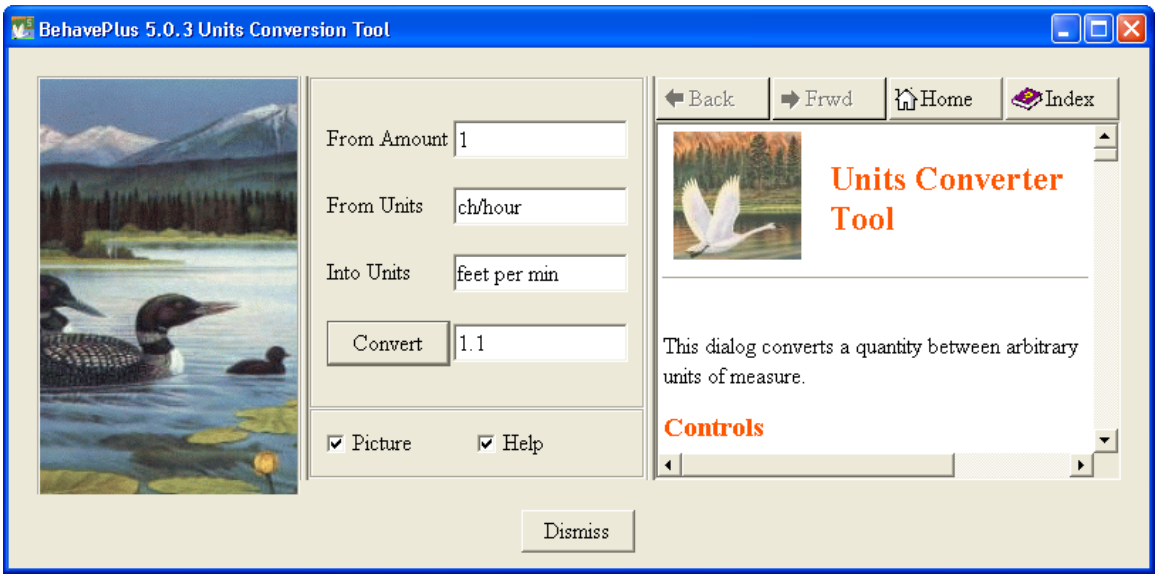
While the Units Converter is very forgiving, it can't read our minds. It assumes that the 'm' stands for meters, because that is the most common use of the abbreviation. Feet and meters are both measures of length, so they "cancel out," leaving us with the SI base units of **1** in the **Warning** window. The "Destination units" are velocity units. This mismatch causes an error.

- Click **Ok**.



The answer box next to **Convert** contains the word **Error**, indicating that the calculation failed.

- In the **Units Conversion Tool** window, change "feet per m" to "feet per min".
- Click on the **Convert** button again.



This time, the Units Converter was able to complete the conversion. The result indicates that for "slow" Rates of Spread, you can probably consider ch/h and ft/min to be the same, but the difference between them will become larger as the rates increase.

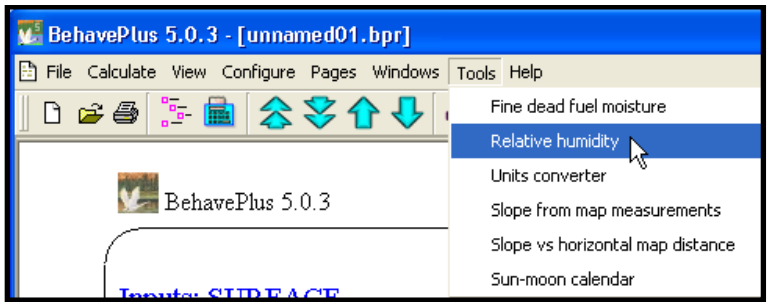
The Units Converter is not limited to fire behavior variables. Looking in the **Help** window, you can see the 272 variables supported by this tool. Remember, you can combine the variables in meaningful combinations. As long as the **From Units** and **Into Units** are compatible, the Units Converter will convert them for you.

- Click on **Dismiss** to close the **Units Converter** tool.

Relative Humidity

Relative humidity is required for the calculation of the Fine Dead Fuel Moisture. While it is not required as a direct input for any other fire behavior calculation in BehavePlus, it is useful for many applications beyond BehavePlus, and so it is included with the program.

- Click on **Tools > Relative humidity**.

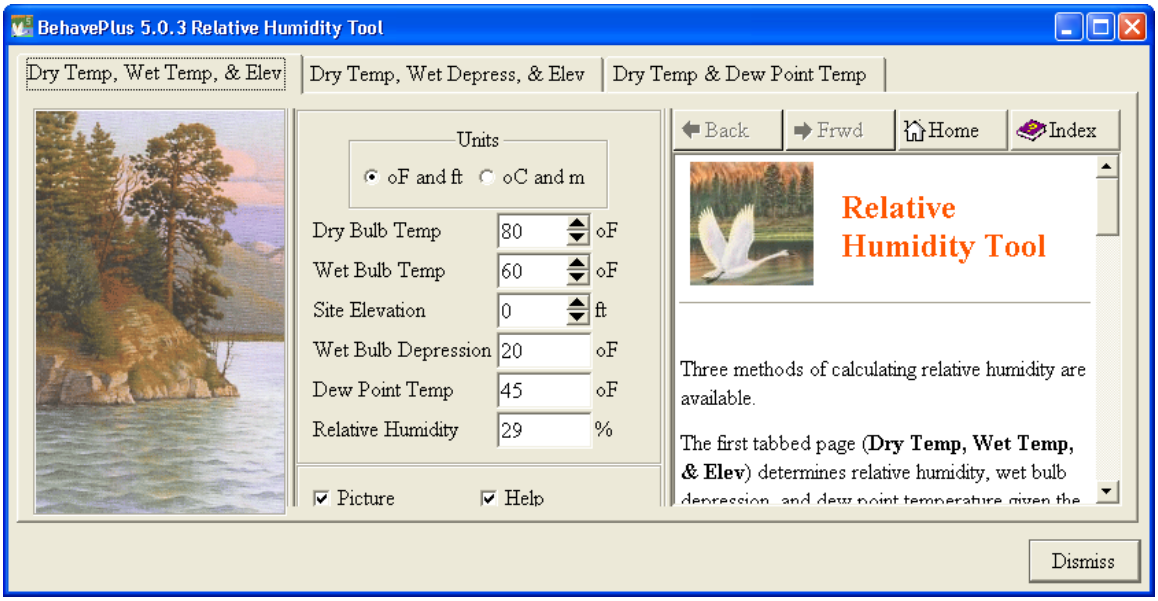


The Relative Humidity Tool will open. Notice that there are three tabs at the top of the window. There are three methods for calculating the Relative Humidity, each with different inputs:

1. Dry Temp, Wet Temp, & Elev
   - Dry Bulb Temperature, Wet Bulb Temperature, and Elevation are used to calculate Dew Point Temperature.
   - Relative Humidity is calculated from Dry Bulb Temperature and Dew Point Temperature.
2. Dry Temp, Wet Depress, & Elev
   - Wet Bulb Depression is the difference between the Dry Bulb Temperature and the Wet Bulb Temperature.
   - Dry Bulb Temperature, Wet Bulb Temperature, and Elevation are used to calculate Dew Point Temperature.
   - Relative Humidity is calculated from Dry Bulb Temperature and Dew Point Temperature.

3. Dry Temp & Dew Point Temp
    - Relative Humidity is calculated from Dry Bulb Temperature and Dew Point Temperature.

Common mistakes made when calculating Relative Humidity are (a) to confuse the Web Bulb *Temperature* and the Wet Bulb *Depression* or (b) to confuse *Wet Bulb* Temperature with *Dew Point* Temperature. Make sure you know what inputs you have, and use the correct tab for those inputs.



The first tab is the one to use if you have "slung the weather" using a sling psychrometer. There are tables for calculating Relative Humidity that come with the belt weather kit, and you can order them for the Fire Behavior Field Reference Guide. Of course, you can download tables from the internet. However, you can easily calculate Relative Humidity using this tool as well. As a bonus, since the tool asks for the elevation, you don't have to remember to pick the right table!

You've just slung the weather at your location on the fireline at 3500 feet. The Dry Bulb Temperature is 98°F and the Wet Bulb Temperature is 63°F. What is the Relative Humidity?

- If need be, open the Relative Humidity Tool.
- Make sure the **Dry Temp, Wet Temp, and Elev** tab is active.

Values can either be typed directly into the boxes, or you can use the up and down arrows on the side to change the values.

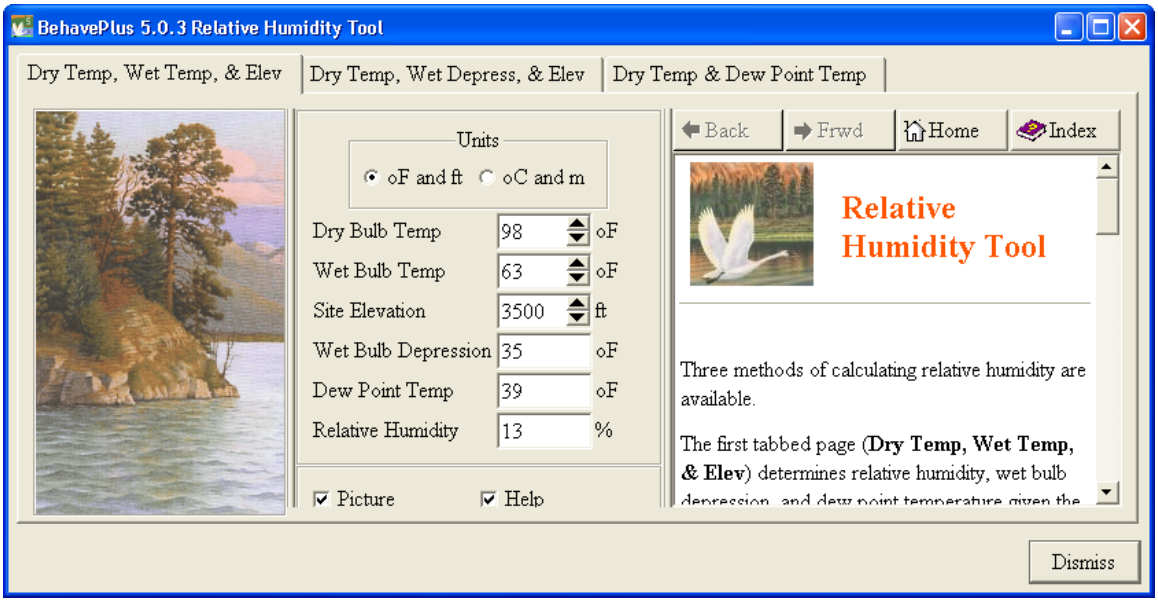
You can either tab between boxes or use the mouse to navigate.

If you type your answer into the box, you MUST click outside the final input box; the answer is then calculated automatically.

- Enter '98' in the box next to **Dry Bulb Temp**.
- Use the arrows to change the **Wet Bulb Temp** to '63'.

Notice that the output variables change as you click on the arrows.

- Enter '3500' in the box next to **Site Elevation**.
- If you typed in the elevation, click somewhere else in the Relative Humidity window to calculate the result.



The Relative Humidity is **13%**.

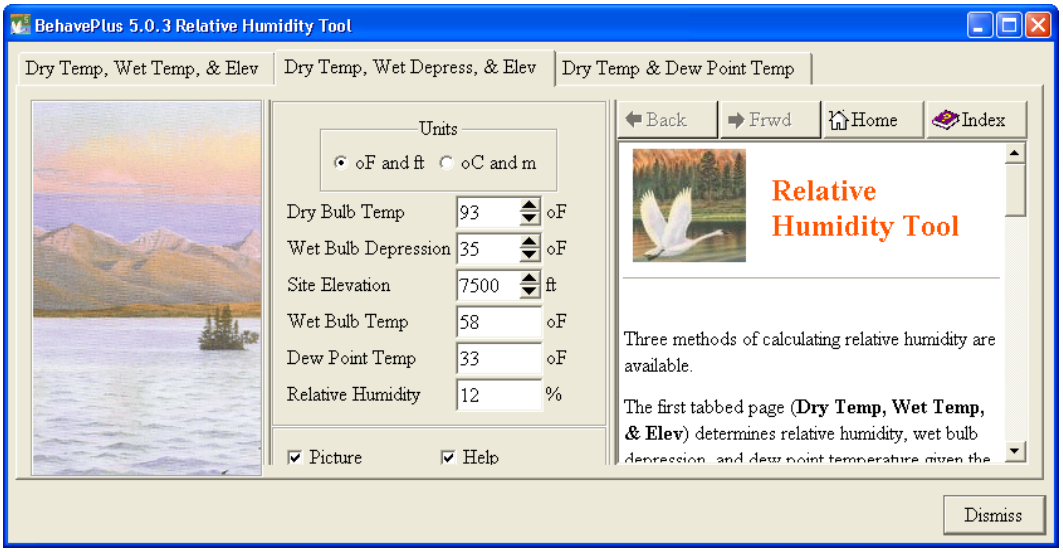
You are given a Dry Bulb Temperature of 93°F and a Wet Bulb Depression of 35°F. The elevation is 7500 ft. What is the Relative Humidity?

Let's look at this problem two different ways.

First, you are given a Dry Bulb Temperature and Wet Bulb Depression.

- If necessary, open the Relative Humidity Tool.
- Activate the second tab – **Dry Temp, Web Depress & Elev**.

- Enter the values as shown below.

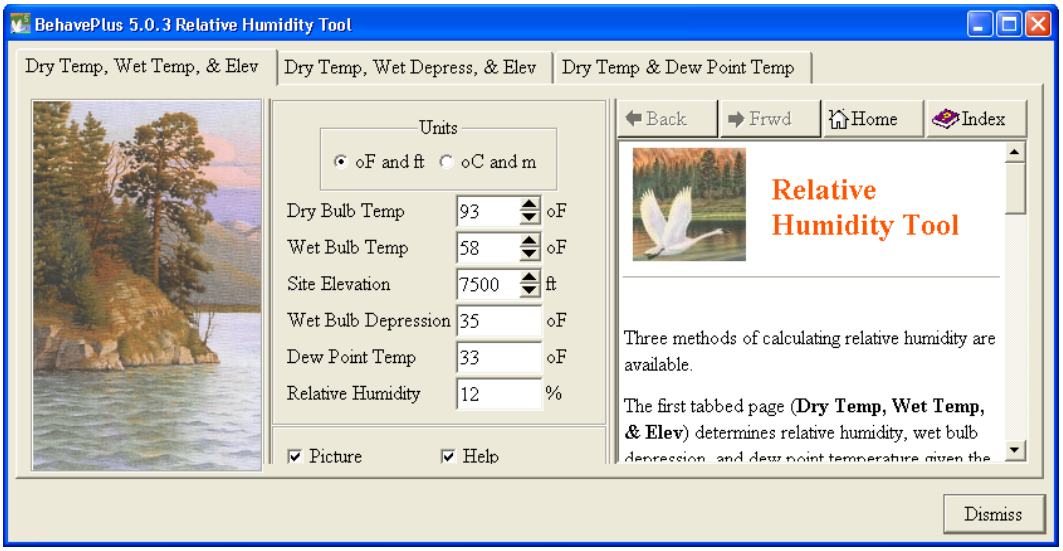


The Relative Humidity is **12%**.

Now, let's do some quick math. The Wet Bulb Depression is the difference between the Dry Bulb Temperature and the Wet Bulb Temperature. So, we can figure out the Wet Bulb Temperature as follows:

Wet Bulb Temperature = Dry Bulb Temperature – Wet Bulb Depression
Wet Bulb Temperature = 93°F - 35°F = 58°F

- Activate the **Dry Temp, Wet Temp, & Elev** tab.
- Enter the values as shown below.



The Relative Humidity is the same: **12%**.

The answer to this question can be found at the end of the tutorial.
Question 1: What impact does elevation have on the calculation of Relative Humidity? Use the following information to determine the answer.

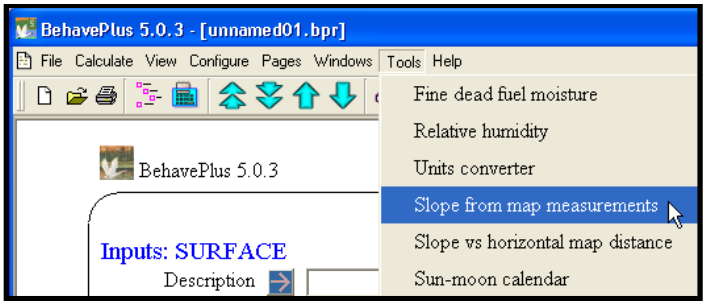
- Dry Bulb Temperature = 78°F
- Wet Bulb Temperature = 39°F
- Elevation ranges from 1000 – 11,000 feet

➢ Click on **Dismiss** to close the **Relative Humidity** tool.

Slope from Map Measurements

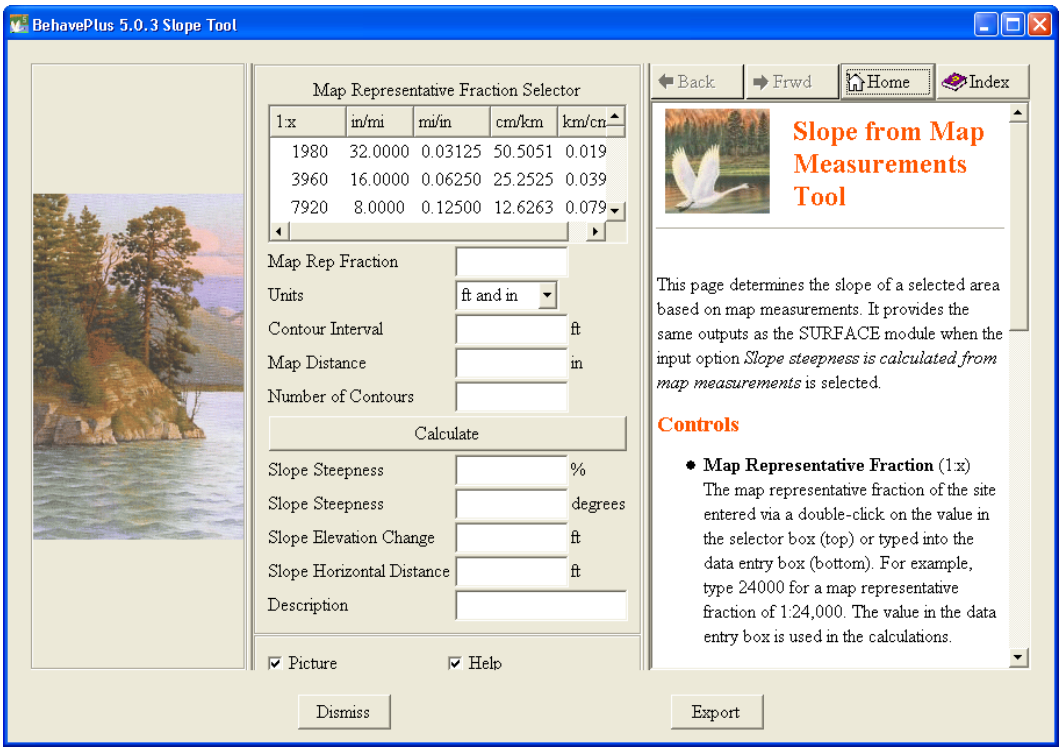
The Slope from Map Measurements tool (a.k.a. the Slope Tool) is new for version 5.0. It was designed to provide a quick calculation of slope for use with the Fine Dead Fuel Moisture tool. This tool provides the same outputs as the SURFACE module when the input option *Slope steepness is calculated from map measurements* is selected (see the Modeling Unit > Slope Lesson for more details).

➢ Click on **Tools > Slope from map measurements**.

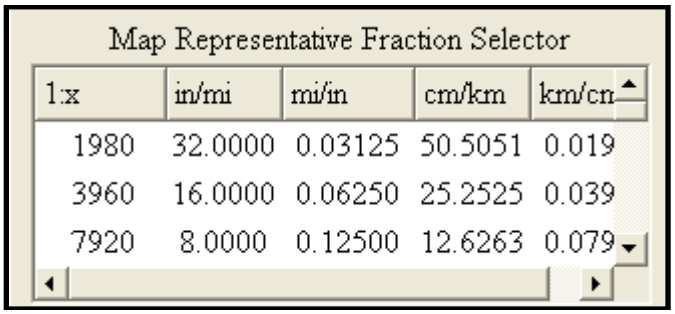


There are three sections to the Slope Tool:

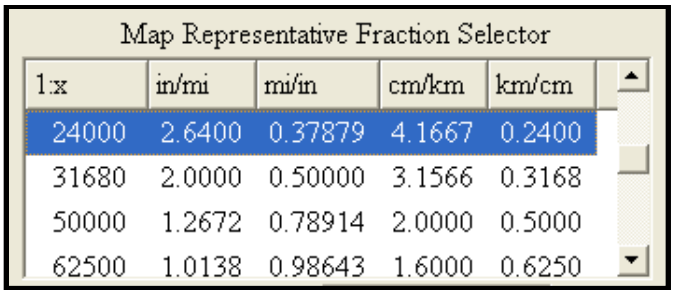
- Inputs
  - Map Representative Fraction (select or type in)
  - Units
  - Contour Interval
  - Map Distance
  - Number of Contours
- Calculate
- Outputs
  - Slope Steepness (% and degrees)
  - Slope Elevation Change
  - Slope Horizontal Distance
  - Description (for export)



The **Help** window contains information on inputs. Map Representative Fraction is the ratio of the distance measured on a map to the actual distance on the group. For example, a Map Representative Fraction of 1:24000 means that 1 unit (e.g., inch) on the map equals 24,000 units (e.g., inches) on the ground. The **Map Representative Fraction Selector** box contains many of the most commonly used Map Representative Fractions as well as conversions to other units.

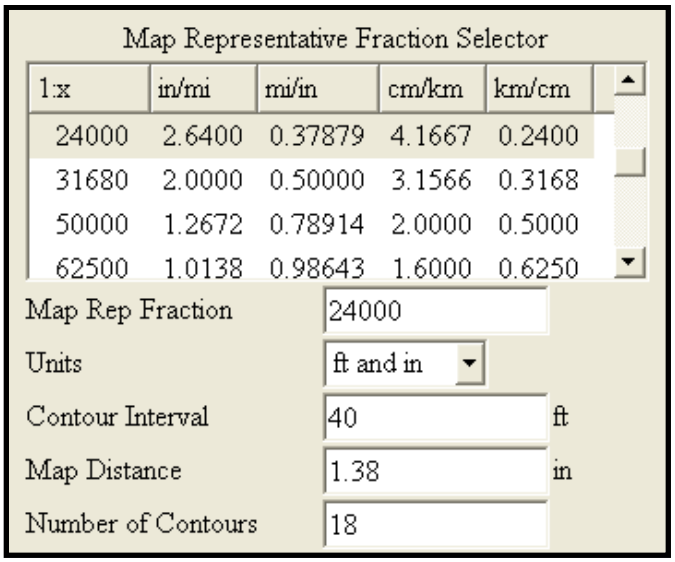


- Scroll down in the **Map Representative Fraction Selector** box to the row that begins with 24000.

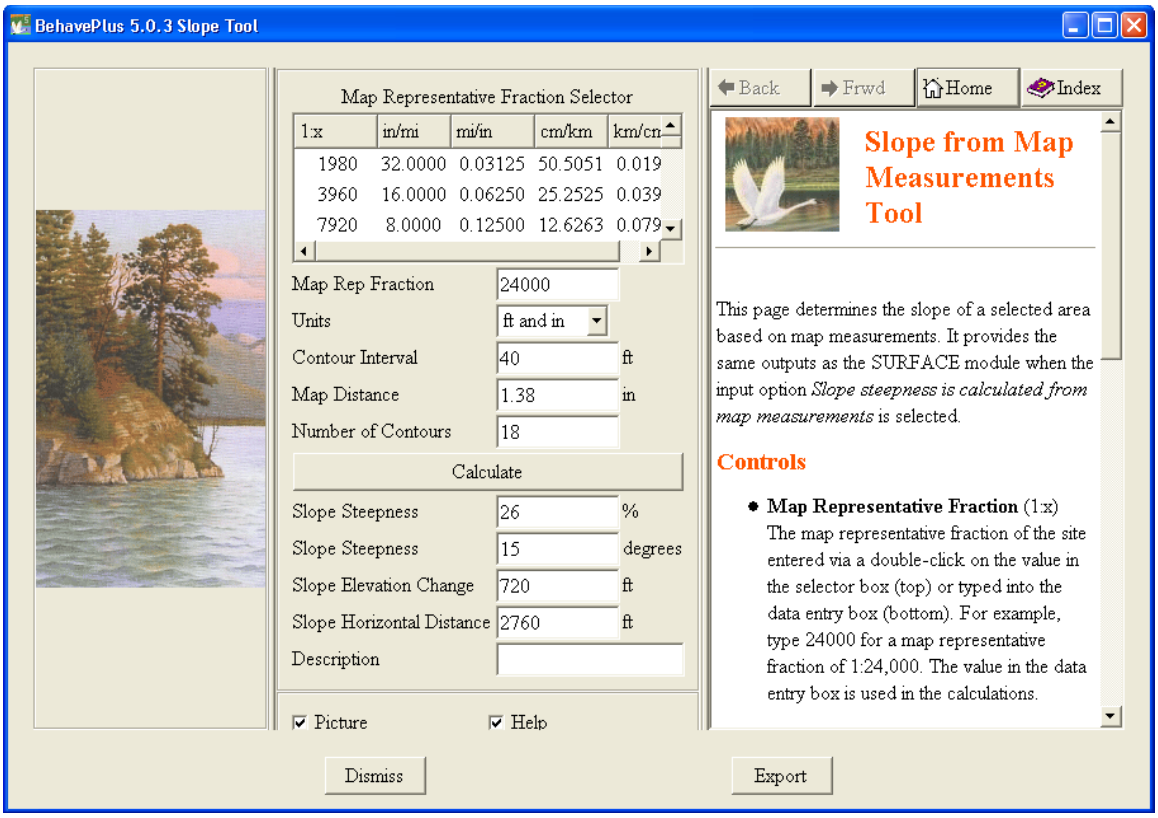


The information provided shows that a Map Representative Fraction of 1:24000 is equivalent to 2.64 inches/mile or 4.1667 cm/km. When using this map, of course, this means that 2.64 inches on the map represents 1 mile on the ground.

- Double-click on '24000' to insert that value in the **Map Rep Fraction** box.
  - You could also type the number '24000' directly into the **Map Rep Fraction** box.
- Continue filling in the inputs as below.



- Click **Calculate**.



The slope is **26% or 15 degrees**.

Metric units can also be used by selecting the appropriate **Units** from the drop-down menu.

Results from the Slope Tool can be exported as an HTML file for documentation purposes.

- Enter the **Description** 'Sample Slope Calculation'.

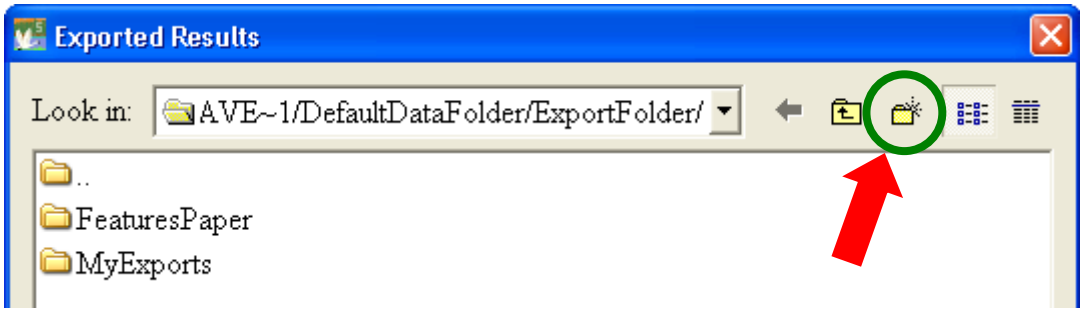
The **Description** becomes the title of your exported file.

- Click **Export**.

You can save this file anywhere on your computer. By default, it will be saved in the **ExportFolder** located in your current Workspace. A Workspace is a specific file structure that contains all of the files necessary for BehavePlus to run. For more information on Workspaces, please see the Operation Unit > File Management Lesson.

For now, I am going to use the default file structure.

- Create a new directory by clicking on the folder with the star located in the upper right-hand corner of the screen.



- Name the Folder 'BehavePlusTools'; we'll use it again later in this lesson.
- Double-click on the folder.
- Name the file 'SampleSlopeCalculation' and click **Save**.
- The **FYI** window reminds you where the file is located and that you can open this HTML file using Excel.
- Click **Ok**.

Now, let's take a look at the HTML file that we exported.

- Open Windows® Explorer (**Start > My Computer**).

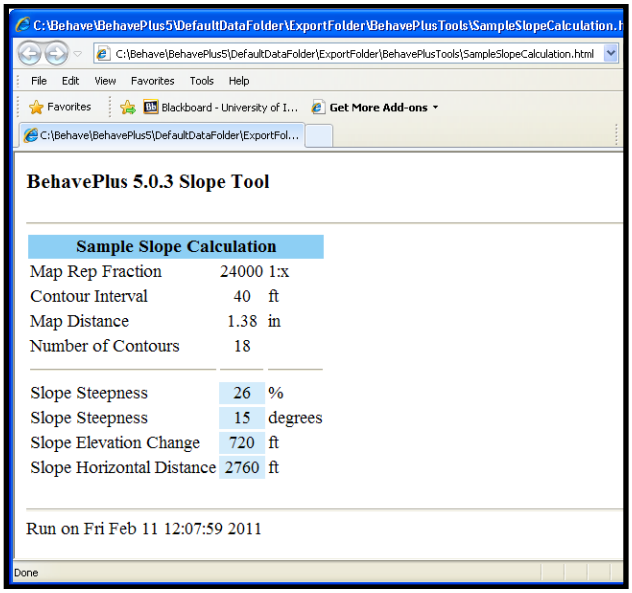
I installed BehavePlus version 5 in the default location. Therefore, BehavePlus is installed in the folder **C:\Behave\BehavePlus5** on my computer. It may differ on your computer, depending on where you installed the program.

- Navigate to the BehavePlus folder.

I am also using the default Workspace, which is called **DefaultDataFolder**. If you don't know about Workspaces yet, don't worry; you are likely using the default Workspace.

- Double-click on **DefaultDataFolder** and then on **ExportFolder** and then **BehavePlusTools** (or, if you saved it elsewhere, the folder where you saved the file).
- Double-click on **SampleSlopeCalculation.html**; it will open in your default internet browser.

Your file should look similar to the one below.



All of the inputs and outputs necessary for calculating slope are documented in this file. Notice that the **Description** you entered (p. 13) is the title of the table.

- Click on **Dismiss** to close the **Slope from Map Measurements** tool.

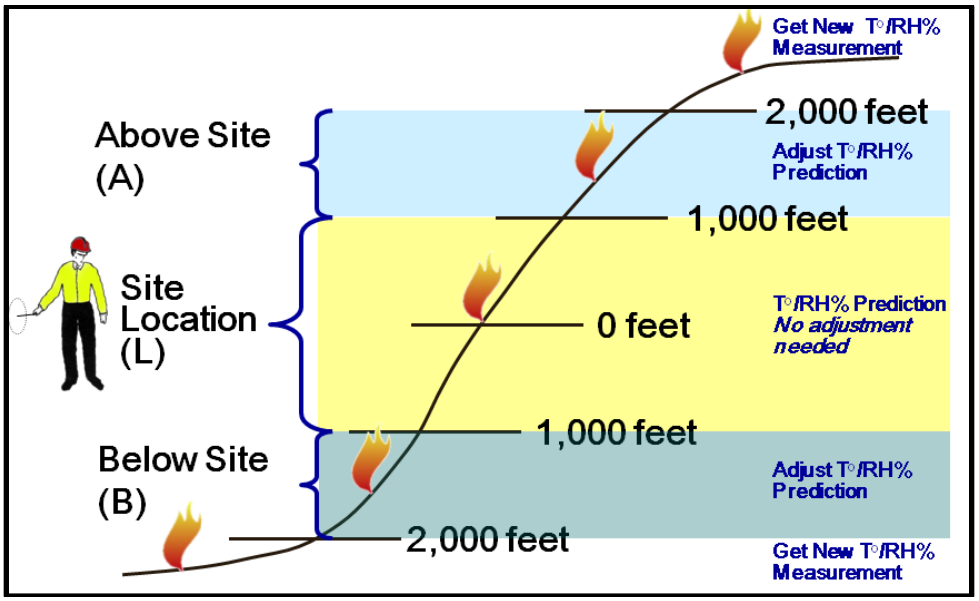
Fine Dead Fuel Moisture

The fine dead fuel moisture calculation is based on the look-up tables found in *How to predict the spread and intensity of forest and range fires* (Rothermel 1983). These tables are also printed in the Fireline Handbook, Appendix B (NWCG 2006), and in the help window associated with the Fine Dead Fuel Moisture tool in BehavePlus. Because this is a reproduction of existing tables, metric equivalents are not available. Further, since the determination of Fine Dead Fuel Moisture is not based on equations, it could not be readily linked with the calculation modules SURFACE, CROWN, and IGNITE. Any results from this tool must be typed into the BehavePlus Worksheet.

Temperature and Relative Humidity are used to calculate a Reference Fuel Moisture; they are "assumed to have been measured according to standard procedures for a weather shelter, or received in a forecast" (Rothermel 1983). The Fuel Moisture Correction accounts for the effects of solar heating, including elevation changes, slope, aspect, day length, and fuel shading from the sun. The Fine Dead Fuel Moisture is the sum of the Reference Fuel Moisture and the Fuel Moisture Correction.

The location at which the Temperature and Relative Humidity are measured (the measurement site) may be different from the location for which the Fine Dead Fuel Moisture calculation is made (the projection point), resulting in the sometimes confusing but necessary Elevation Difference variable indicating if the projection is 1000-2000 feet

above (Above), within 1000 feet of (Level), or 1000-2000 feet below (Below) the measurement site. Remember, if the projection point is **more than 2000 feet** above or below the measurement site, you *must* obtain a new forecast or reading. The time period of the reading must match the time period for which the projection is needed.

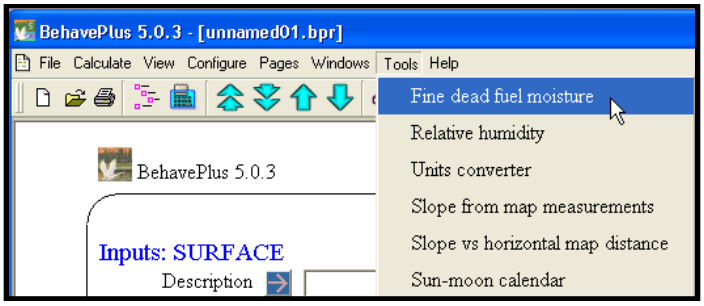


From S-290

Watch out for inversions. Do not take measurements below an inversion (for example in a valley bottom) and apply them to a projection site above the inversion; the results will be meaningless.

Only the daytime Fine Dead Fuel Moisture can be calculated as only the daytime tables were included in the BehavePlus tool. Caution should be used when using the nighttime Fine Dead Fuel Moisture tables, especially during the transition between using daytime and nighttime values.

- Click on **Tools > Fine dead fuel moisture**.

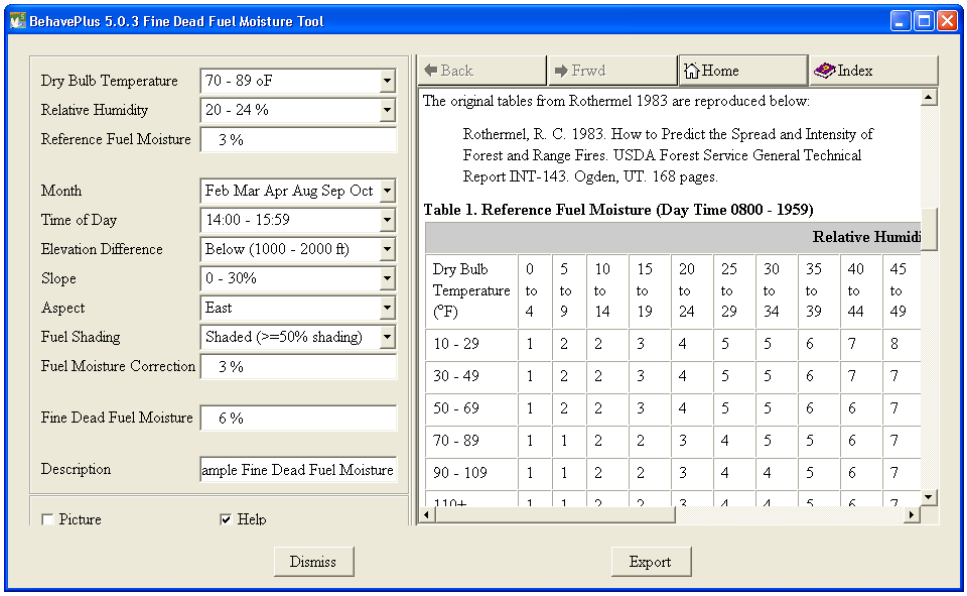


- Uncheck the **Picture** pane to temporarily hide the picture and expand the **Help** window.
  - Remember, you can always hide the picture in this manner.

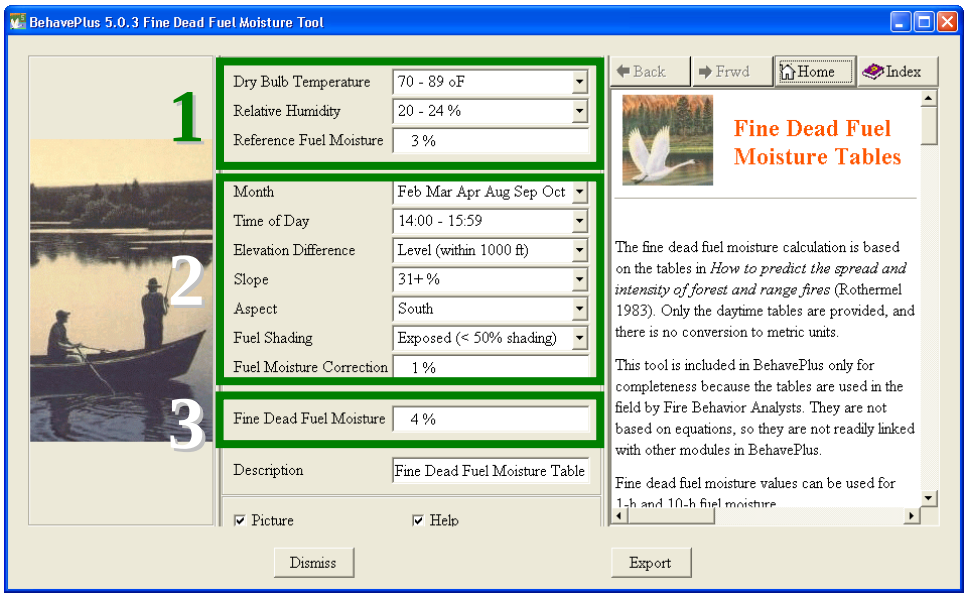
- To permanently hide the Picture, go to **Configure > Appearance preferences > Application** and uncheck the box next to **Show picture pane**.

➢ Scroll down in the **Help** window to view the tables.

- Table 1 contains the Reference Fuel Moisture.
- Tables 2-4 contain the Fuel Moisture Correction factors.



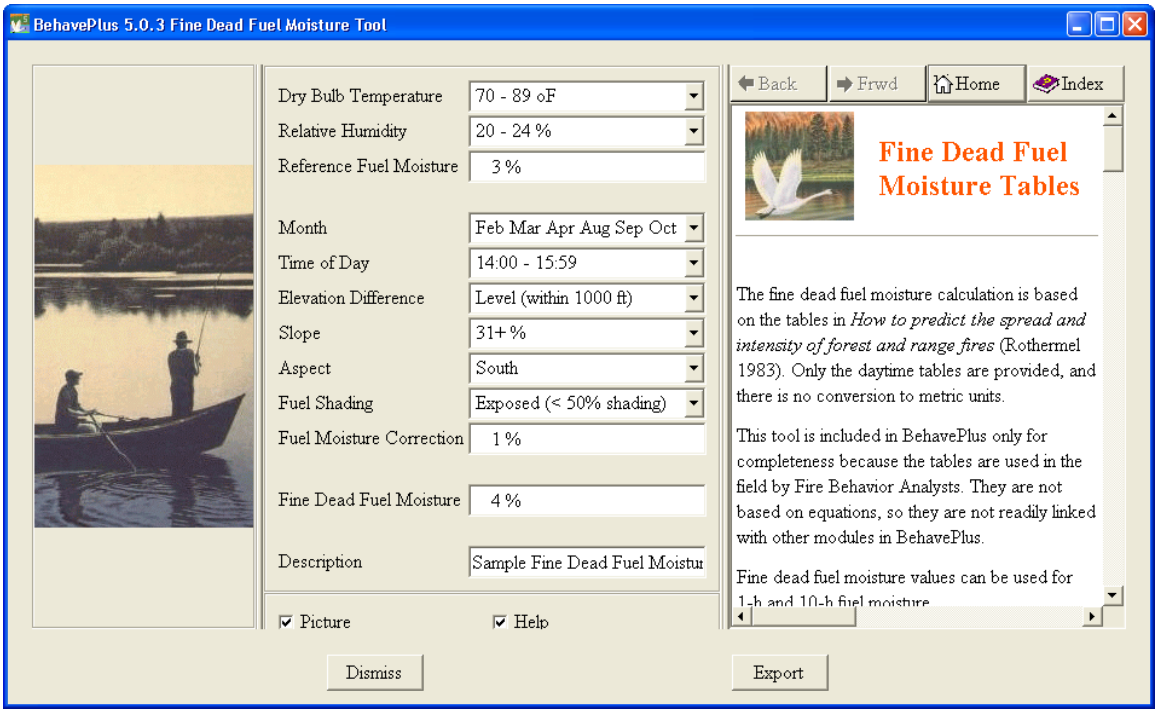
Like Relative Humidity, Fine Dead Fuel Moisture is calculated automatically as information is changed in the tool. Use the drop-down menu to select the correct inputs.



Box 1 contains the calculation of the Reference Fuel Moisture. Box 2 contains the calculation of the Fuel Moisture Correction. And, Box 3 contains the final Fine Dead Fuel Moisture.

Given the following conditions, calculate the Fine Dead Fuel Moisture. Assume the weather measurement was taken near the fire perimeter at 5,000 feet elevation.

Dry Bulb Temperature	80°F
Relative Humidity	20%
Slope	35%
Aspect	South
Site Exposure	Open
Month	August
Time	1500
Sky	Clear



In this example, the Fine Dead Fuel Moisture is **4%**.

Like Slope Tool outputs, Fine Dead Fuel Moisture can be exported for documentation.

- Type ‘Sample Fine Dead Fuel Moisture’ in the Description box.
- Click on the **Export** button.

You can save this file anywhere on your computer. We will save it in the default location.

- Double-click on the folder we created earlier (p. 15) called ‘BehavePlusTools’.
- Name the file ‘SampleFDFM’.
- Click **Save**.

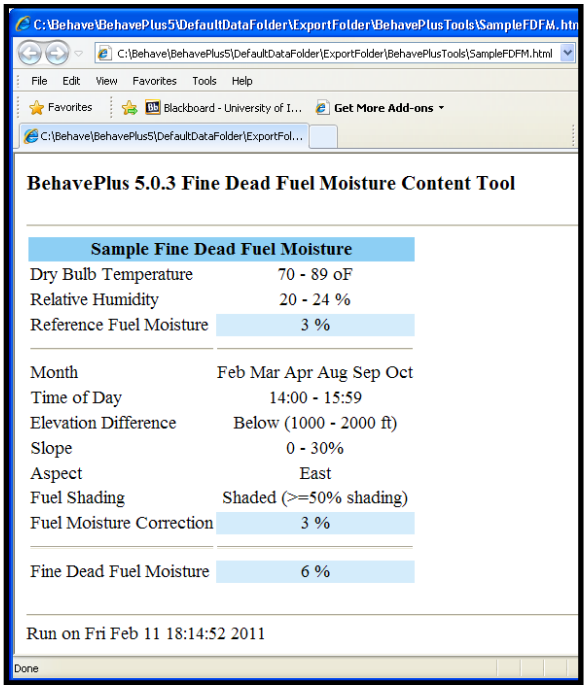
An **FYI** window opens telling you where the file has been saved and reminding you that you can open this file with Excel. While Excel is not as effective when used with a single value generated by the BehavePlus Tools, it can be very useful for table output from the BehavePlus modules. Please see the Operation Unit > Export to Spreadsheet Lesson for more details.

- Click **Ok**.
- Open Windows® Explorer (**Start > My Computer**).

BehavePlus is installed in the folder **C:\Behave\BehavePlus5** on my computer. It may differ on your computer, depending on where you installed the program.

- Navigate to the location you saved the file. In my example, that would be **C:\Behave\BehavePlus5\DefaultDataFolder\ExportFolder\BehavePlusTools**.
- Double-click on **SampleFDFM.html**; it will open in your default internet browser.

Your file should look similar to the following.



The **Description** you entered above becomes the title of the output. Inputs and outputs of the Fine Dead Fuel Moisture tool are included in the HTML file.

- Close Windows® Explorer.
- Click on **Dismiss** to close the **Fine Dead Fuel Moisture** tool.

The answer to this question can be found at the end of the tutorial.
Question 2: Using the information from the example above, what is the Fine Dead Fuel Moisture on a shaded east-facing slope 1,500 feet below you? The slope is 22%.

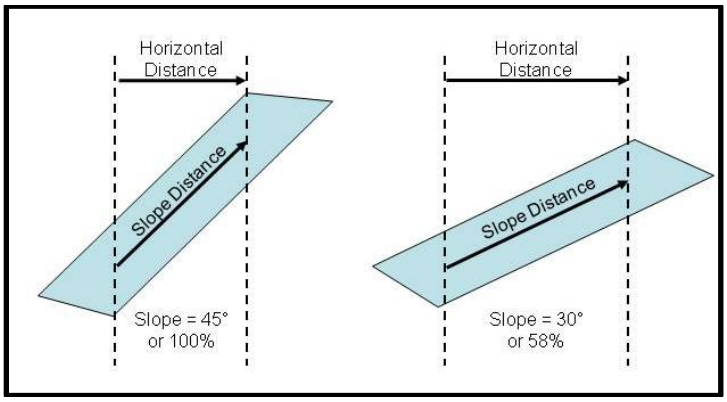
Slope vs. Horizontal Map Distance

After calculating fire behavior outputs, you may want to add them to a map. You can do this by selecting **Display output distances in map units** from the **Module Selection** window.

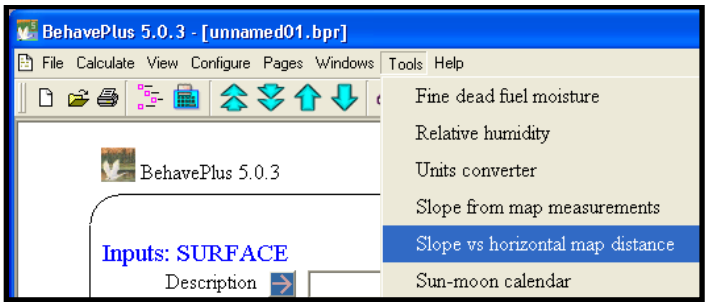
When you select the option **Display output distances in map units** from the **Module Selection** window, the following slope distances (the distance along the ground) are converted to map distances:

- Surface spread distance [SURFACE]
- Crown spread distance [CROWN]
- Forward spread distance [SIZE]
- Backing spread distance [SIZE]
- Fire length [SIZE]
- Maximum fire width [SIZE]
- Spotting distance [SPOT]

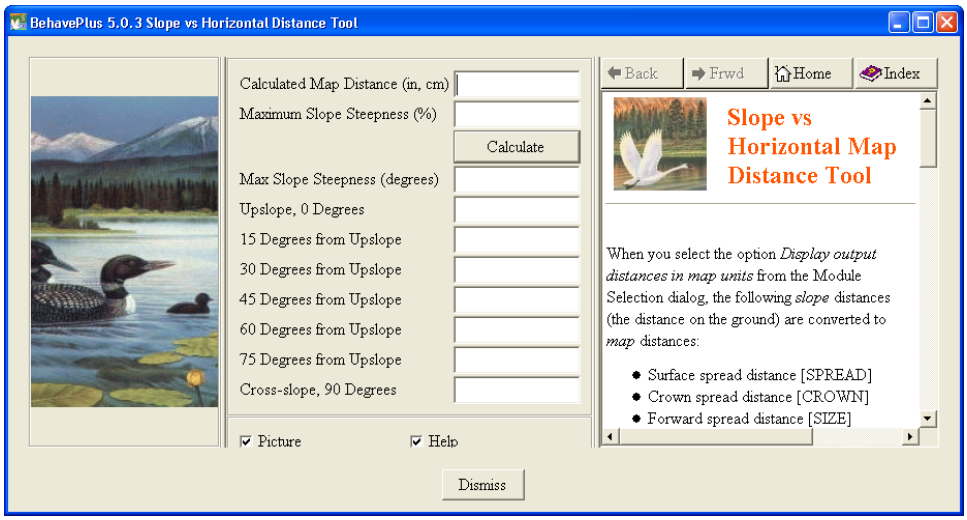
The **Slope vs. Horizontal Map Distance Tool** converts calculated map distances to actual map distance by correcting for slope. Map distance is often found by multiplying ground distance (distance along the slope [slope distance] shown below) by the map scale, which is not technically correct. Because a map is a two-dimensional surface, the actual distance that should be plotted on the map is the horizontal distance. The difference between slope distance and horizontal distance increases as slope increases. While the difference between slope distance and horizontal distance is not critical given all of the other variability within fire behavior modeling, we include this tool in case you want to make the correction before you plot a distance on a map.



➢ Click on **Tools > Slope vs horizontal map distance**.



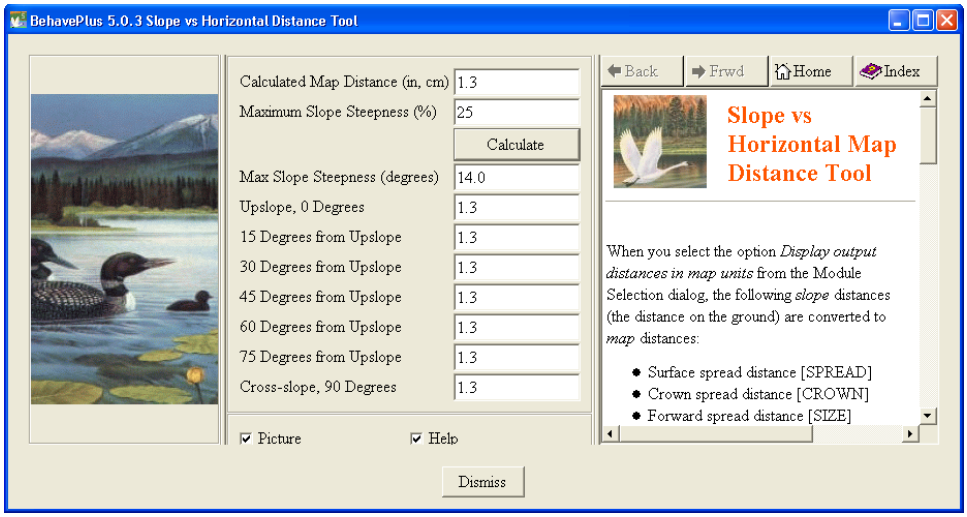
There are only two inputs required for this calculation—Calculated Map Distance and Maximum Slope Distance, both from your BehavePlus Worksheet.



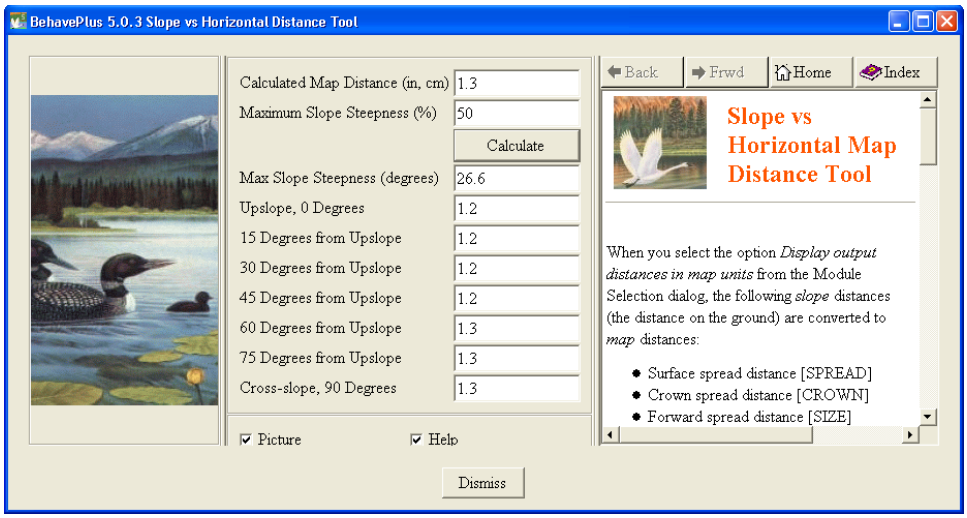
The Slope vs. Horizontal Map Distance Tool will calculate corrected horizontal distances for directions ranging from upslope (0 Degrees) through cross-slope (90 Degrees from Upslope). You can interpolate between these values as necessary to estimate the map distance in the direction of maximum spread.

- Enter a Calculated map Distance of '1.3 inches'.
- Enter a Slope Steepness of '25%'.
- Click **Calculate**.

Your answers should look like those shown below.



- Change the Slope Steepness to '50%'.



The answer to this question can be found at the end of the tutorial.
Question 3: Try a range of Slope Steepness values from '100%' to '500%'. How much difference is there for the terrain typically found in your area?

Horizontal Map Distance (Calculated Map Distance = 1.3 inches)							
	Maximum Slope Steepness						
	25%	**50%**	**100%**	**200%**	**300%**	**400%**	**500%**
Slope Steepness, degrees	**14**	**26.6**					
Upslope, 0°	**1.3**	**1.2**					
15° from Upslope	**1.3**	**1.2**					
30° from Upslope	**1.3**	**1.2**					
45° from Upslope	**1.3**	**1.2**					
60° from Upslope	**1.3**	**1.3**					
75° from Upslope	**1.3**	**1.3**					
Cross-slope, 90° from Upslope	**1.3**	**1.3**					

- Click on **Dismiss** to close the **Slope vs Horizontal Map Measurements** tool.

Sun-Moon Calendar

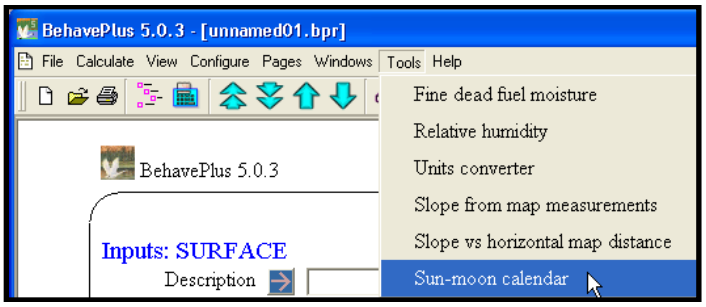
The Sun-Moon Calendar provides site-specific dates and times for

- Phases of the moon,
- Seasons (solstice and equinox dates and times),
- Sunrise / sunset,
- Moonrise / moonset, and
- Civil dawn / dusk

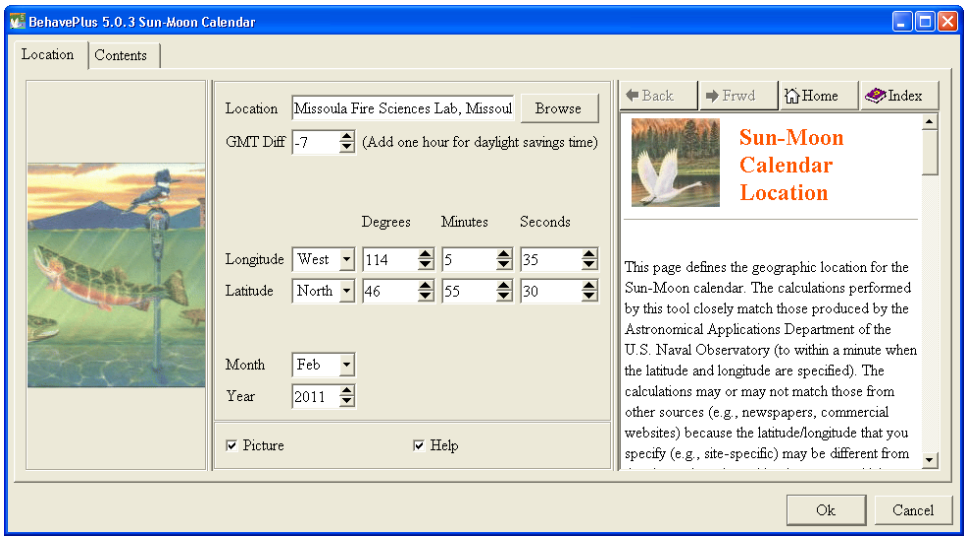
Outputs can be displayed in a table or calendar.

The calculations in this tool closely match those produced by the Astronomical Applications Department of the U.S. Naval Observatory (http://aa.usno.navy.mil/) – to within a minute when the latitude and longitude are specified. The times generated by this tool may not match those from other sources (such as newspapers and commercial websites) because the latitude and longitude used to denote a given location may be differ. For large, extended cities (such as New York City, NY) or airports that are some distance from the city (such as Denver International), calculations can differ by several minutes, depending upon the time of year.

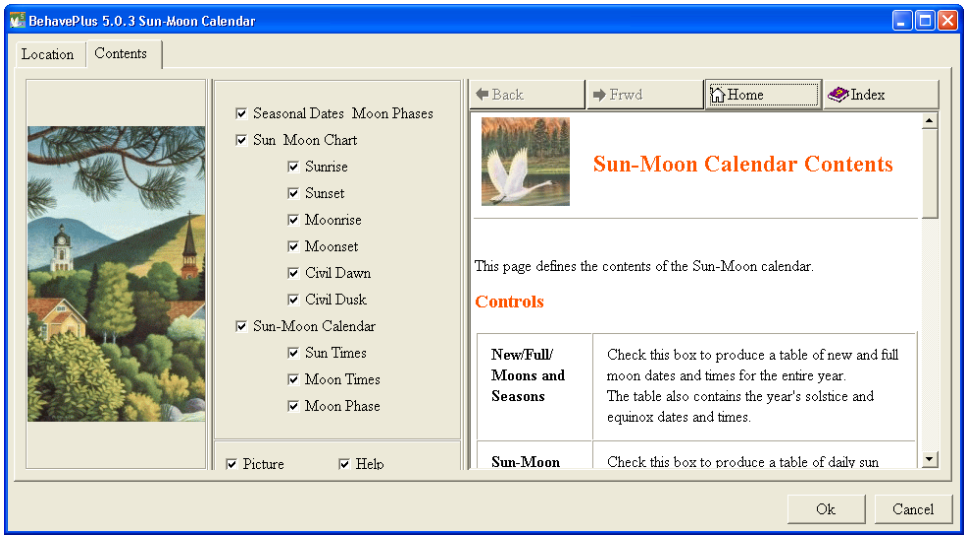
- To access the Sun-Moon Calendar Tool, go to **Tools > Sun-moon calendar**.



The tool contains two tabs. On the first tab (**Location**), you enter the location and month and year of interest. The current Month and Year will be displayed.



Choose your outputs on the second tab (**Contents**); by default, all outputs are selected.



Outputs from the Sun-Moon Calendar are produced on pages similar to Worksheets; each output is a separate page. Click on the blue arrows in the menu bar ( ) to navigate between pages. Pages can be printed or saved as images (see Operation Unit > Lesson for more details). The location and date will be produced at the top of each page.

The first set of outputs – Seasonal Dates Moon Phases –produces a table of dates/times for the new and full moon *for the entire year*, which is specified on the **Location** tab.

Seasonal Dates & Moon Phases
Missoula Fire Sciences Lab, Missoula, Montana
2011
(Lon 114.093, Lat 46.925, GMT -7.0)

Spring Equinox	Sun, Mar 20	16:21
Summer Solstice	Tue, Jun 21	10:26
Fall Equinox	Fri, Sep 23	02:14
Winter Solstice	Wed, Dec 21	22:33
Easter Sunday	Sun, Apr 24	

New Moon		1st Quarter		Full Moon		3rd Quarter	
Jan 04	02:06	Jan 11	12:29	Jan 18	22:52	Jan 26	09:15
Feb 02	19:38	Feb 10	06:11	Feb 17	16:44	Feb 25	03:17
Mar 04	13:50	Mar 12	00:15	Mar 19	10:39	Mar 26	21:04
Apr 03	07:28	Apr 10	17:33	Apr 18	03:37	Apr 25	13:42
May 02	23:46	May 10	09:21	May 17	18:56	May 25	04:30
Jun 01	14:05	Jun 08	23:03	Jun 16	08:01	Jun 23	17:00
Jul 01	01:58	Jul 08	10:23	Jul 15	18:48	Jul 23	03:13
Jul 30	11:39	Aug 06	19:44	Aug 14	03:50	Aug 21	11:56
Aug 28	20:02	Sep 05	04:06	Sep 12	12:09	Sep 19	20:12
Sep 27	04:16	Oct 04	12:30	Oct 11	20:44	Oct 19	04:58
Oct 26	13:12	Nov 02	21:45	Nov 10	06:18	Nov 17	14:50
Nov 24	23:23	Dec 02	08:20	Dec 09	17:17	Dec 17	02:14
Dec 24	11:11	Dec 31	20:34	Jan 08	05:56	Jan 15	15:18

The second set of outputs – Sun Moon Chart – produces a table of daily sun and moon events for the *month* of interest, including sunrise / sunset, moonrise / moonset, civil

dawn and civil dusk. According to the Astronomical Applications Department, sunrise and sunset refer to "times when the upper edge of the disk of the sun is on the horizon" (http://aa.usno.navy.mil/faq/docs/RST_defs.php). Moonrise and moonset are determined in a similar manner, but can occur at any time of the day or night. Civil dawn and dusk are defined as the times when the center of the sun is 6° below the horizon; there is no darkness in any direction. In all cases, the calculations assume the observer is at sea level with a level, unobstructed horizon.

Sun & Moon Chart

Missoula Fire Sciences Lab, Missoula, Montana

July 2011

(Lon 114.093, Lat 46.925, GMT -7.0)

Day	Sunrise	Sunset	Moonrise	Moonset	Civil Dawn	Civil Dusk
Fri 1	04:45	20:34	05:08	20:50	04:05	21:14
Sat 2	04:46	20:34	06:19	21:24	04:06	21:13
Sun 3	04:46	20:33	07:34	21:54	04:07	21:13
Mon 4	04:47	20:33	08:49	22:20	04:08	21:13
Tue 5	04:48	20:33	10:05	22:45	04:08	21:12
Wed 6	04:48	20:32	11:21	23:10	04:09	21:12
Thu 7	04:49	20:32	12:37	23:36	04:10	21:11
Fri 8	04:50	20:31	13:54	-----	04:11	21:10
Sat 9	04:51	20:31	15:11	00:05	04:12	21:10
Sun 10	04:51	20:30	16:24	00:40	04:13	21:09
Mon 11	04:52	20:30	17:33	01:22	04:14	21:08
Tue 12	04:53	20:29	18:33	02:13	04:15	21:08
Wed 13	04:54	20:28	19:23	03:13	04:16	21:07
Thu 14	04:55	20:28	20:02	04:19	04:17	21:06
Fri 15	04:56	20:27	20:35	05:29	04:18	21:05
Sat 16	04:57	20:26	21:02	06:38	04:19	21:04
Sun 17	04:58	20:25	21:25	07:46	04:20	21:03
Mon 18	04:59	20:24	21:46	08:51	04:21	21:02
Tue 19	05:00	20:23	22:06	09:56	04:23	21:01
Wed 20	05:01	20:22	22:27	10:59	04:24	21:00
Thu 21	05:02	20:21	22:49	12:01	04:25	20:59
Fri 22	05:04	20:20	23:13	13:04	04:26	20:57
Sat 23	05:05	20:19	23:42	14:07	04:28	20:56
Sun 24	05:06	20:18	-----	15:10	04:29	20:55
Mon 25	05:07	20:17	00:16	16:11	04:30	20:54
Tue 26	05:08	20:16	00:58	17:09	04:31	20:52
Wed 27	05:09	20:15	01:50	18:00	04:33	20:51
Thu 28	05:11	20:13	02:50	18:44	04:34	20:49
Fri 29	05:12	20:12	03:59	19:22	04:35	20:48
Sat 30	05:13	20:11	05:14	19:55	04:37	20:47
Sun 31	05:14	20:10	06:30	20:23	04:38	20:45

The third set of outputs – Sun-Moon Calendar – provides the sunrise / sunset, moonrise / moonset, and phases of the moon in calendar format.

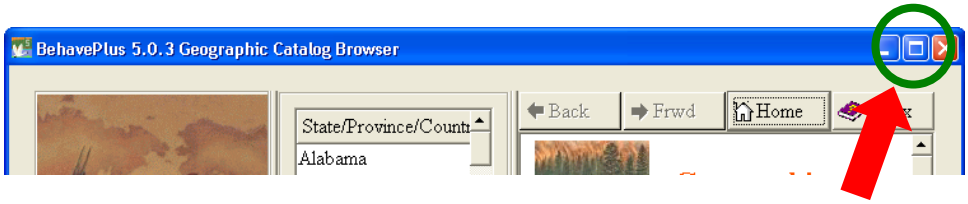
Missoula Fire Sciences Lab, Missoula, Montana
July 2011
(Lon 114.093, Lat 46.925, GMT -7.0)

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					New 1 05:08 - 20:50 04:45 - 20:34	2 06:19 - 21:24 04:46 - 20:34
3 07:34 - 21:54 04:46 - 20:33	4 08:49 - 22:20 04:47 - 20:33	5 10:05 - 22:45 04:48 - 20:33	6 11:21 - 23:10 04:48 - 20:32	7 12:37 - 23:36 04:49 - 20:32	1st 8 - 20:31 04:50 - 20:31	9 15:11 - 00:05 04:51 - 20:31
10 16:24 - 00:40 04:51 - 20:30	11 17:33 - 01:22 04:52 - 20:30	12 18:33 - 02:13 04:53 - 20:29	13 19:23 - 03:13 04:54 - 20:28	14 20:02 - 04:19 04:55 - 20:28	Full 15 20:35 - 05:29 04:56 - 20:27	16 21:02 - 06:38 04:57 - 20:26
17 21:25 - 07:46 04:58 - 20:25	18 21:46 - 08:51 04:59 - 20:24	19 22:06 - 09:56 05:00 - 20:23	20 22:27 - 10:59 05:01 - 20:22	21 22:49 - 12:01 05:02 - 20:21	22 23:13 - 13:04 05:04 - 20:20	3rd 23 23:42 - 14:07 05:05 - 20:19
24 - 15:10 05:06 - 20:18	25 00:16 - 16:11 05:07 - 20:17	26 00:58 - 17:09 05:08 - 20:16	27 01:50 - 18:00 05:09 - 20:15	28 02:50 - 18:44 05:11 - 20:13	29 03:59 - 19:22 05:12 - 20:12	New 30 05:14 - 19:55 05:13 - 20:11
31 06:30 - 20:23 05:14 - 20:10						

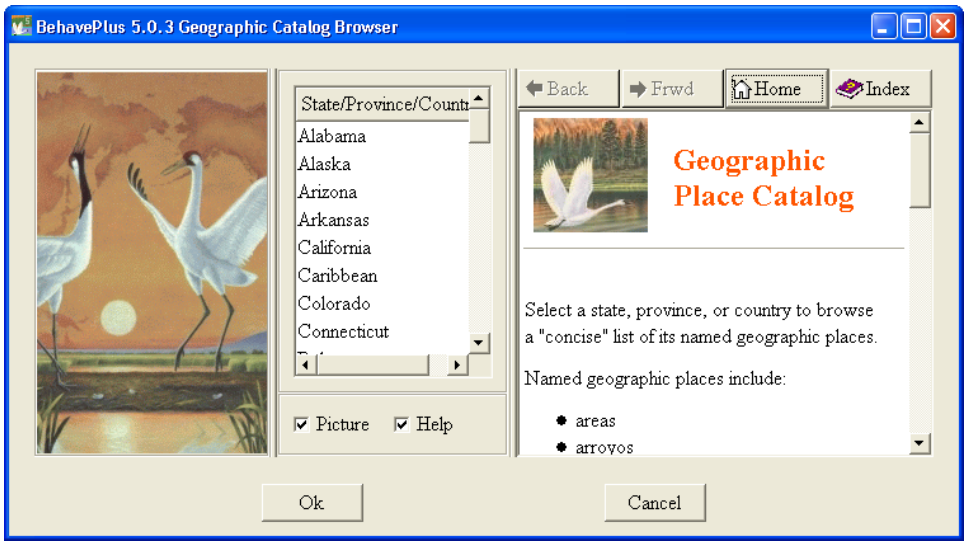
Moonrise - Moonset
Sunrise - Sunset

- To select a site, go to the **Location** tab.
  - The Location can be typed in, or you can **Browse** through a list of sites.

- Click on the **Browse** button next to the location.
- Expand the window by clicking on the square in the upper right hand corner of the window.



- Double-click on a U.S. State or a geographic area that contains a U.S. Territory (Caribbean or Oceania); they are listed in alphabetical order.



Pre-defined geographic areas are listed for each state and territory; you can sort the list by any available column.

State	County	Geographic Place Name	Type	Longitude	Latitude	Elev	GMT
Pennsylvania	Adams	Adams County	civil	0771400W	395200N		-5
Pennsylvania	Adams	Aspers	ppl	0771323W	395846N	651	-5
Pennsylvania	Adams	Biglerville	ppl	0771454W	395549N	636	-5
Pennsylvania	Adams	Fairfield	ppl	0772208W	394714N	531	-5
Pennsylvania	Adams	Gettysburg (county seat)	ppl	0771353W	394951N	520	-5
Pennsylvania	Adams	Gettysburg National Military Park	park	0771400W	394900N		-5
Pennsylvania	Adams	Littlestown	ppl	0770518W	394440N	619	-5
Pennsylvania	Adams	New Oxford	ppl	0770322W	395149N	687	-5
Pennsylvania	Adams	York Springs	ppl	0770657W	400032N	606	-5

- Double-click to select a **Geographic Place Name**. This will be entered into the Location box in the Sun-Moon Calendar Tool window.

Note: If you enter a specific location yourself, you will need to know the following:

- **GMT Diff** – the difference between Greenwich Mean Time and local time (based on time zone; add one hour for daylight savings time)
- **Longitude** and **Latitude**
  - Select the direction (east/west of the Prime Meridian; north/south of the equator) using the drop-down menu.
  - Numbers can be typed n directly, or you can use the arrows to change them.
- **Month** and **Year**
  - Select the month using the drop-down menu.
  - The year can be typed in directly, or you can use the arrows to change it.

- Switch to the **Contents** tab.
- Select the outputs you wish to view.
    - You can select / unselect entire categories, or entries within the category to personalize your outputs.

- Click on the **Ok** button to generate the outputs.
    - The Sun-Moon Calendar will close when you click **Ok**; you will need to open it again if you wish to change your location and/or outputs.

Answers to this question will vary; outputs should look similar to those shown in the example for the Fire Lab above.

Question 4: Using the information provided above, create outputs for the Sun-Moon Calendar for a site of interest.

Summary

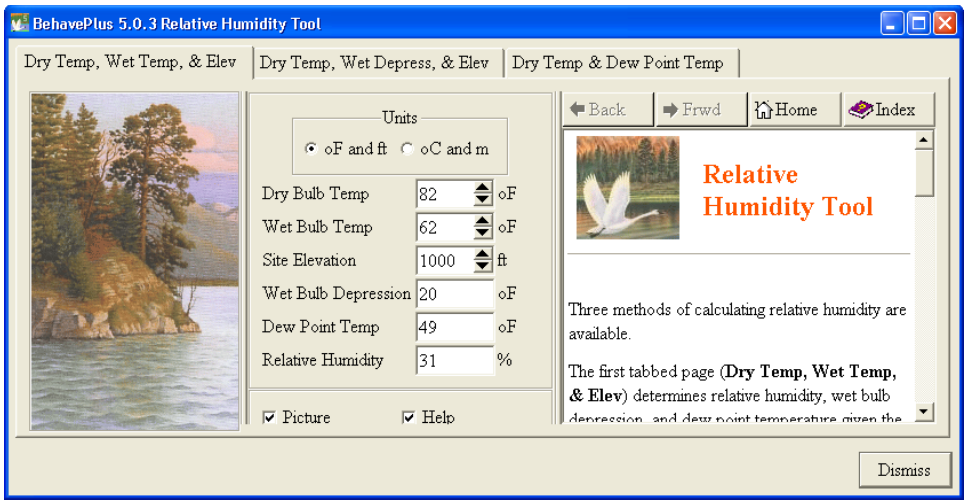
In this lesson, we examined all six of the BehavePlus tools. All of the tools are stand-alone tools, and they cannot be integrated with the BehavePlus Worksheet. Results from two tools (Fine Dead Fuel Moisture and Slope from Map Measurement) can be exported as HTML files. Results from the Sun-Moon Calendar tool can be printed or saved as an image. Three of the tools may be used in concert to determine the Fine Dead Fuel Moisture (Relative Humidity, Slope from Map Measurements, and Fine Dead Fuel Moisture). The Slope vs. Horizontal Map Distance tool can be used to correct the map distances calculated in BehavePlus for slope. However, at the slopes typically found on the landscape, this *may* be artificial precision. The Sun-Moon Calendar tool can be used to determine the sunrise and sunset of your present location, which may be useful for planning purposes.

Answers to Tutorial Questions

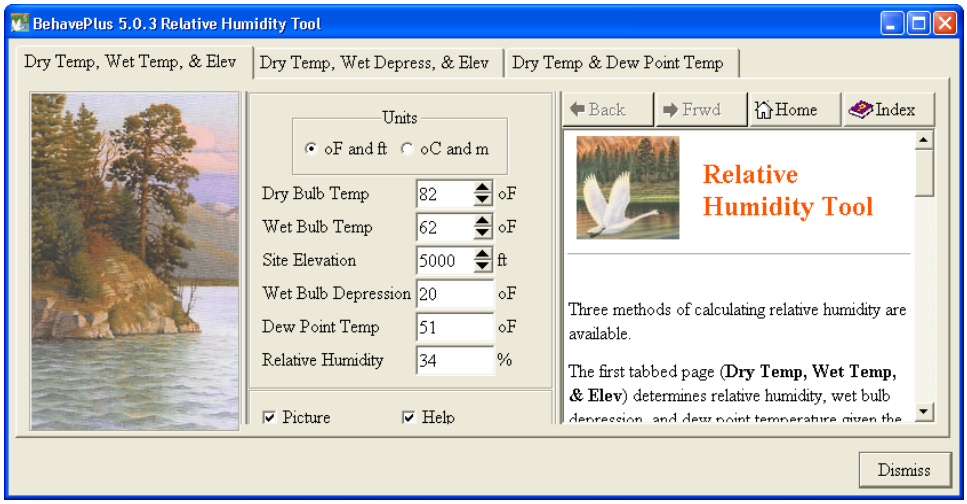
Question 1: What impact does elevation have on the calculation of relative humidity? Use the following information to determine the answer.

- Dry Bulb Temperature = 82°F
- Wet Bulb Temperature = 62°F
- Elevation ranges from 1000 – 11,000 feet

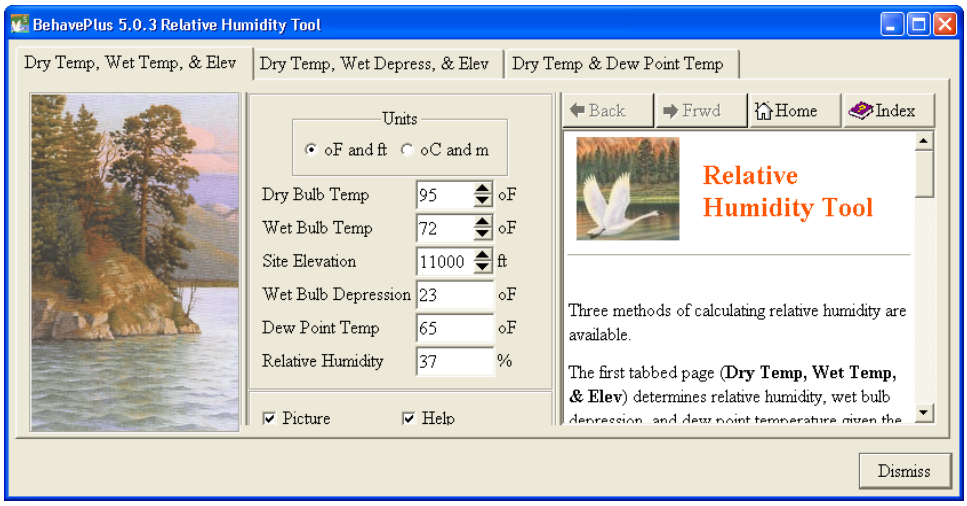
At 1000 feet, the Relative Humidity is 31%.



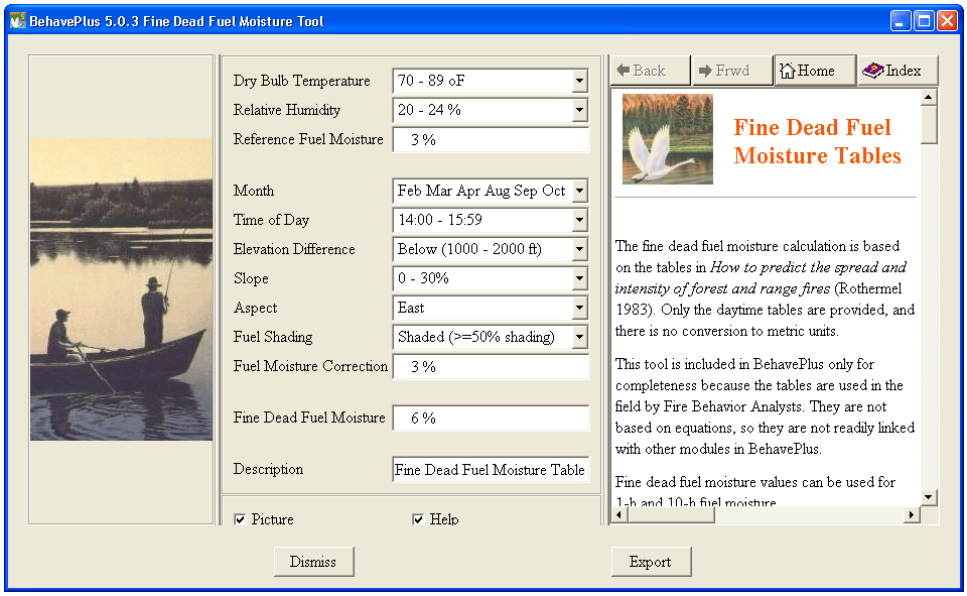
At 5000 feet, the Relative Humidity = 34%.



At 11,000 feet, the Relative Humidity = 37%. The Relative Humidity changes by about 0.6% every 1000 feet *under these conditions*.



Question 2: What is the Fine Dead Fuel Moisture on a shaded east-facing slope 1,500 feet below you? The slope is 22%.



The Reference Fuel Moisture will not change, because the measurement point information is the same. The Fuel Moisture Correction value has increased to 3%, so the final Fine Dead Fuel Moisture is **6%**.

Question 3: Try a range of Slope Steepness values from '100%' to '500%'. How much difference is there for the terrain typically found in your area?

Horizontal Map Distance (Calculated Map Distance = 1.3 inches)							
	Maximum Slope Steepness						
	25%	**50%**	**100%**	**200%**	**300%**	**400%**	**500%**
Slope Steepness, degrees	14.0	26.6	45.0	63.4	71.6	76.0	78.7
Upslope, 0°	1.3	1.2	0.9	0.6	0.4	0.3	0.3
15° from Upslope	1.3	1.2	0.9	0.7	0.5	0.5	0.4
30° from Upslope	1.3	1.2	1.0	0.8	0.7	0.7	0.7
45° from Upslope	1.3	1.2	1.1	1.0	1.0	0.9	0.9
60° from Upslope	1.3	1.3	1.2	1.2	1.1	1.1	1.1
75° from Upslope	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Cross-slope, 90° from Upslope	1.3	1.3	1.3	1.3	1.3	1.3	1.3

Arguably, for most areas, the difference between the slope distance and horizontal map distance is minor, well within the level of uncertainty of the fire model. You will need to determine if the terrain in your area is steep enough for corrections to be made.