Help, More Help, and Desperate for Help Lesson

Introduction

The BehavePlus fire modeling system offers many options for the user to obtain help, many of which are listed below. However, the Help system is not designed to explain fire behavior. The user must understand fire behavior prior to using BehavePlus.

Objectives

By the end of this lesson, you will be able to do the following.

1. Explore the Features Paper.
2. View the contents of the Variables Paper.
3. Identify additional publications about components of the BehavePlus fire modeling system.
4. Tour the BehavePlus Help system.
5. Find help on the website: www.frames.gov/behaveplus.

Where This Lesson Fits In

This is a lesson in the **Operation Unit**, which provides users with specific topics about operating the BehavePlus fire modeling system (button-pushing). Lessons in the **Operation Unit** can be done in any order, based on the interests of the student. We assume that you have skill in basic program operation. Basic fire behavior modeling using BehavePlus is covered in the four lessons of the **Introduction Unit**.

Note: *Many of the BehavePlus documents are provided in PDF format. You can use any PDF reader to view them. However, if you are using Adobe products, information provided in the Appendix provides guidance on setting up Adobe DC (Reader and Pro) for maximum flexibility.*

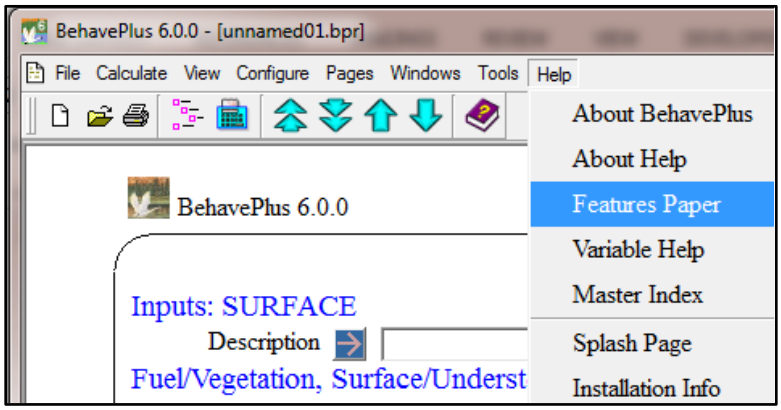
Note: There are questions (in blue) located throughout this lesson. The answers can be found at the end of the lesson starting on page 15.

The Design and Features Guide

The report titled *BehavePlus fire modeling system, version 5.0: Design and Features*, hereafter called the Features Paper describes operation of the BehavePlus fire modeling system. The models, associated variables, and application are described elsewhere. The Features Paper is currently being updated for version 6.

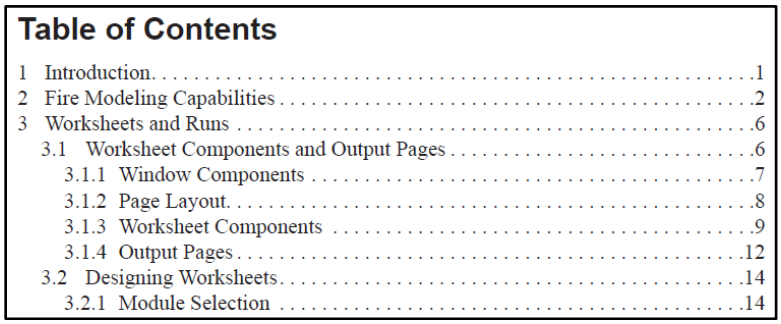
The Features Paper is available from several sources, including the website. It is also a central part of the Help system within BehavePlus.

- The Features Paper can be accessed by clicking on **Help > Features Paper** via the menu at the top of the program. The Features Paper will open in a new window and can be either printed or accessed interactively using a PDF viewer.



The Features Paper includes both technical details about the system as well as the design and features of BehavePlus. It explains the program's design to help users understand what the program can do and why the program behaves the way it does.

The Table of Contents is a clickable menu, allowing you to access specific content when you need it.



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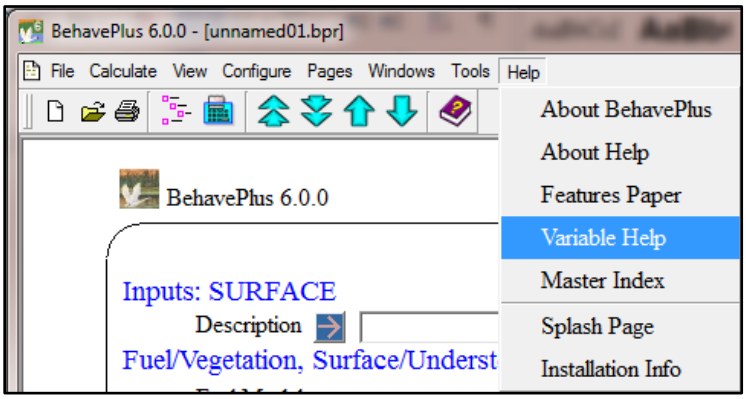
1. *Looking at the Table of Contents, which chapter describes Table Shading for Acceptable Fire Conditions?*
2. *How do you activate table shading?*

The Variables Paper

The *BehavePlus fire modeling system, version 5.0: Variables* paper, hereafter called the Variables Paper, is a reference guide describing the many input and output variables available in the BehavePlus fire modeling system. It is based on information that was previously available only in the Help system. The

information in the Variables Paper and the Help system is largely the same, although the help files do contain additional information such as tables and graphs. The Help system has been completely revised for version 6. The Variables Paper is currently being updated for version 6.

- If it is still open, close the Features Paper.
- To access the Variables Paper, click on **Help > Variable Help**. The Variables Paper will open in a new window and can be accessed interactively using a PDF viewer.

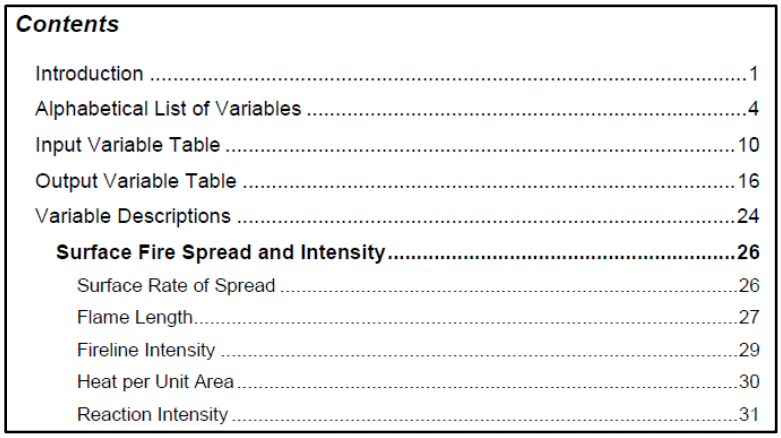


Note: *While the Variables Paper can be printed, there are links between variables within the document. Therefore, it is most useful when viewed digitally.*

The Variables Paper is also available from several other sources, including the website.

Contents

As with the Features Paper, you can navigate through the Variables Paper using both interactive content and bookmarks. The **Contents** list contains more than 180 input and output variables within BehavePlus, along with their relationships to each other. Variables are listed by topic.



You can click on any of the variables within the **Contents** to access a description of that variable.

- Scroll down to the section entitled **Surface Fuel** and click on **Fuel Model Type**.

3. *Which other variables does Fuel Model Type link to?*
4. *Under what condition is Fuel Model Type an input to the SURFACE module?*

- Click on the link to **Dead Herbaceous Fuel Load**.

5. *Is Dead Herbaceous Fuel Load an input to or an output from the SURFACE module? Under which condition does that occur?*

- Click on the button to return to **Fuel Model Type**. See the Appendix if this button is missing.

Alphabetical list of variables

In addition, the Variables Paper provides an alphabetical list of variables in Table 2. The name of each variable links to a description of that variable. Each variable is defined as an input variable (--**I**--), an output variable (--**O**--), or both. The --**I**-- link takes you to an Input Variable Table. The --**O**-- link will take you to the Output Variable Table, each of which provides slightly different information as described in more detail below.

Table 2—Alphabetical list of all input and output variables and an indication of whether each serves as input and/or output.

Variable name	Input and/or output	
1-h Fuel Load	--I--	--O--
1-h Moisture	--I--	
1-h Surface-Area-to-Volume Ratio	--I--	--O--
10-h Fuel Load	--I--	
10-h Moisture	--I--	

- Using the bookmarks or Contents page, navigate to the **Alphabetical List of Variables**.
- Click on the link for **20-ft Wind Speed**.

6. *What happens if you select both Midflame Wind Speed for the SURFACE module and 20-ft Wind Speed for either the CROWN or SPOT module?*

- Click on the button to return to the **Alphabetical List of Variables**.

Input variable table

The Input Variable Table can be accessed from the Contents page or the Alphabetical list of Variables.

- From the Alphabetical List of Variables, click on the --**I**-- next to 1-h Surface-Area-to-Volume Ratio. This takes you to the Input Variable Table. You may need to scroll up slightly to view the header row.

Input variable	SURFACE	SAFETY	SIZE	CONTAIN	SPOT	SCORCH	MORTALITY	IGNITE	CROWN	Variable type	English range and units	Metric range and units
1-h Surface-Area-to-Volume Ratio	I/O									C	109 to 4,000 ft^2/ft^3	358 to 13,123 m^2/m^3

7. *Return to the previous view ( ). Scroll down and click on the --I-- next to Canopy Base Height. Is this a continuous (C) or discrete (D) variable? What is the valid input range in English Units?*

➢ Return to the Alphabetical List of Variables.

Output variable table

The Output Variable Table can be accessed from the Contents page or the Alphabetical List of Variables.

➢ From the Alphabetical List of Variables, click on the --**O**-- next to 1-h Surface-Area-to-Volume Ratio. This takes you to the Output Variable Table. You may need to scroll up slightly to view the headers.

8. *Is 1-h Surface-Area-to-Volume Ratio a default output variable? What are the default English units?*

The models in each BehavePlus module

The Variables Paper contains a list of all of the models included in each BehavePlus module, including the primary references for each one. This can be found in Appendix A. The same table can be found in the BehavePlus Help system by going to **Help > Master Index > Table of References**.

➢ Click on the Bookmark icon ( ) next to **Appendix A**.

Click on the icon to go to page 2 of Table A1.

Table A1 (continued)

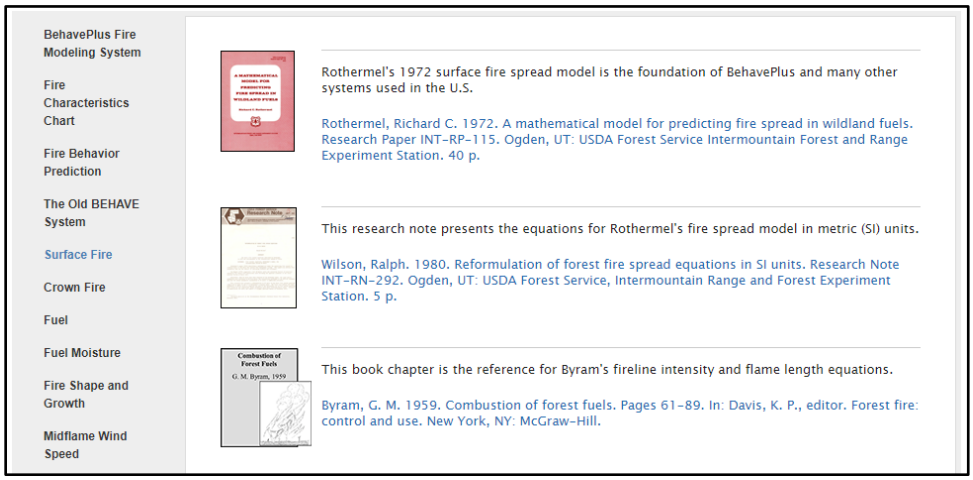
BehavePlus Module	Model	Reference and Notes
CROWN	Critical surface intensity needed for transition from surface to crown fire	(Van Wagner 1977)
	Transition to crown fire, relationship of surface fire intensity and critical surface fire intensity	(Finney 1998) (Scott and Reinhardt 2001)
	Crown fire rate of spread, area, and perimeter	(Rothermel 1991)
	Critical crown fire rate of spread, needed for an active crown fire	(Van Wagner 1993)
	Active crown fire, relationship of crown fire rate of spread and critical crown fire rate of spread	(Finney 1998) (Scott and Reinhardt 2001)
	Fire type: surface, torching, conditional crown, crowning	(Finney 1998) (Scott and Reinhardt 2001)
	Crown fire flame length	(Thomas 1963)
	Crown fire intensity	(Rothermel 1991)
	Power of the fire, power of the wind	(Byram 1959)

There are several models within the CROWN module, beginning with the Critical surface intensity needed for transition from surface to crown fire. This model was developed by Van Wagner (1977).

9. *Who developed the spotting distance models used in the SPOT module?*

Other Publications

There are numerous publications related to the BehavePlus fire modeling system. A list of these publications can be found on the website (www.frames.gov/behaveplus) under **Publications**. The publications are sorted by topic; select a general topic on the left to show a list of related publications.



Rothermel's fire spread model

Rothermel's (1972) original paper entitled *A mathematical model for predicting fire spread in wildland fuels* (under Surface Fire) is the foundation of BehavePlus and many other fire modeling systems used in the US. Rothermel's surface fire spread model is a model of steady-state fire conditions in uniform fuels using fuel and weather parameters that can be measured in the field. Understanding the strengths and weaknesses of Rothermel's surface fire spread model is essential for correctly interpreting results obtained from BehavePlus.

10. *Why does Rothermel say in the abstract that the surface fire rate of spread model is complete?*

Predicting the spread and intensity of forest and range fires

In 1983, Rothermel published *How to predict the spread and intensity of forest and range fires* (under Fire Behavior Prediction), describing the basics of fire behavior prediction as related to surface fire rate of spread, intensity, flame length, and size of fires burning in forests and rangelands. This document contains instructions for obtaining fuel and weather data, calculating fire behavior, and interpreting the results for application to actual fire problems. Potential uses include fire prediction, fire planning, dispatching, prescribed fires, and monitoring managed fires. Included are sections that deal with fuel model selection, fuel moisture, wind, slope, calculations with nomograms, point source, line fire, interpretations of outputs, and growth predictions.

11. *What does Rothermel state are considerations in selecting a fuel model?*
12. *What is the Two-Fuel-Model Concept?*
13. *What other information is included in this document?*

Verification and adjustment of fire behavior predictions

The document *Field procedures for verification and adjustment of fire behavior predictions* (Rothermel and Rinehart, 1983; under Fire Behavior Prediction) discusses the problems associated with verifying fire predictions at the operational level. The intent of these verification procedures is not to validate the fire spread model itself, but rather to verify the complete fire modeling system, which includes the fire spread model and any associated models and data. Opportunities and problems associated with prescribed and

wildfires (planned and unplanned) are discussed as are procedures for collecting and analyzing data for both accessible and inaccessible fires. Analyses for choosing the appropriate fuel model, for evaluating prediction capability, and for improving predictions by the use of simple linear regression techniques are explained and illustrated with examples from the field. For example, this paper includes an excellent discussion of the effects of fire spread and wind direction on flame shape. The paper also explains how it is possible to adjust the results from BehavePlus using site-derived multipliers and fine-tune models to obtain more accurate estimates using the 13 original fuel models (p. 12-19 of the document).

14. *Look at Figure 4. What impact does wind direction have on flame shape?*
15. *What note of caution do Rothermel and Rinehart write on page 20?*

Fuel models

The original 13 fuel models, developed by Rothermel and Albini are described by Anderson (1982) in a paper entitled *Aids to determining fuel models for estimating fire behavior*. This paper includes photos of vegetation typical for the given fuel model.

16. *For what conditions were the 13 fuel models developed?*
17. *How is each fuel model described?*

Forty additional standard fuel models are described by Scott and Burgan (2004) in *Standard fire behavior fuel models: A comprehensive set for use with Rothermel's surface fire spread model*. None of the 13 fuel models are repeated in this set. The original 13 fire behavior models were developed "for the severe period of the fire season when wildfires pose greater control problems…." However, use of the BehavePlus fire modeling system has extended beyond the prediction of spread rate and fire intensity at peak of fire season. Therefore, Scott and Burgan (2004) developed 40 additional fuel models that seek to:

- improve the accuracy of fire behavior prediction outside of the peak fire season,
- increase the number of models available in areas of high humidity,
- increase the number of fuel models containing forest litter or litter with a grass or shrub understory, and
- increase the number of fuel model choices for modeling changes in fire behavior resulting from fuel treatments.

18. *Describe the impact of selecting a dynamic fuel model (page 6 of the report) in your own words.*
19. *How many timber understory fuel models are included in the original 13 fuel models? In the additional 40 fuel models described by Scott and Burgan?*

All 53 standard fuel models are described in detail in the Help system in addition to the above papers.

- Open the BehavePlus fire modeling system.
- Click on the **Guide** button ( ) next to **Fuel Model**.
- Scroll down in the help file to see links to descriptions for the 53 original models.
- Click on **Fuel Model 2**. The description is the same as that on page 5 of the report by Anderson (1982), including the images.
- Click the **Back** button (Back) to return to the description of **Fuel Model**.
- Click on **Fuel Model GR7**. The description is the same as that on page 32 of the report by Scott and Burgan (2004).

Estimating overstory fuel characteristics in conifer stands

Another very helpful paper is the General Technical Report entitled *Stereo photo guide for estimating fuel characteristics in conifer stands* by Scott and Reinhardt (2005). This paper includes stereo photographs, hemispherical photos, and stand data for Canopy Bulk Density and Canopy Base Height for five Interior West conifer stands. These data are used in crown fire modeling.

This information is also available in the Help system in a simplified form.

- In BehavePlus, click on **Help > Master Index**.
- Click on the **Guide Index**.
- Scroll down and click on **Canopy Bulk Density -- Ponderosa pine**.
- Expand the **Help** window. Look at the values for Canopy Base Height and Canopy Bulk Density in the column for 75% of initial basal area.

20. *Look up the Ponderosa pine @ 75% of initial basal area on page 34 of the paper by Scott and Reinhardt. What is the canopy base height of the stand in feet? What is the canopy fuel bulk density in lb/ft^3?*

This information can also be accessed using the **Guide** button for Canopy Bulk Density as described later in this lesson.

Other publications

As mentioned earlier, there are a number of papers associated with the models used within BehavePlus. Many of these are listed in the **Variables Paper, Appendix A**. The Variables Paper can be accessed via the BehavePlus Help system as mentioned previously.

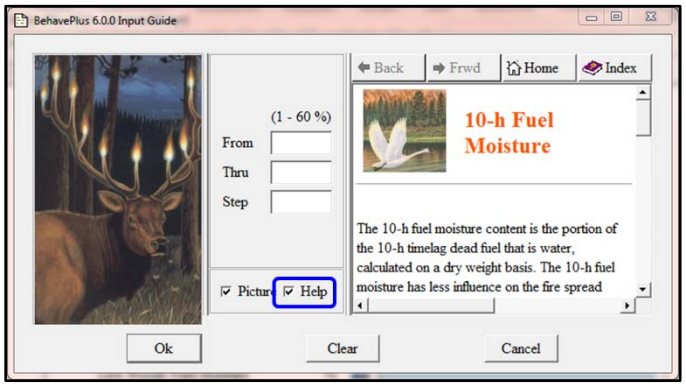
The BehavePlus Help Window

The BehavePlus Help window is available during program operation to provide context-sensitive help. Every variable in the input section of the worksheet is accompanied by a **Guide** button ( ).

- Open BehavePlus if necessary. The startup Worksheet is **BasicStart.bpw**, unless you have changed it.

Input variables

You can most easily access the Help system for input variables via the Worksheet. An **Input Guide** window opens that includes a help file as shown below for 10-h Fuel Moisture. You can turn the help pane on and off by (un)checking the box next to **Help**. However, we *strongly* recommend that you always keep help files available for viewing.



- Open the help file for **Midflame Wind Speed**.

21. What is the technical definition for Midflame Wind Speed?

Output variables

Information about output variables is obtained differently.

- Click on the **Module Selection** ( ) button to open the **Module Selection** window.

Clicking on the **Options…** button for any module will open another window related specifically to the models and options contained in that module.

- Click on the **SURFACE Options…** tab.
- Under the **Output Variables** tab, click on **Basic**.
- Hover over any output variable to see the definition.

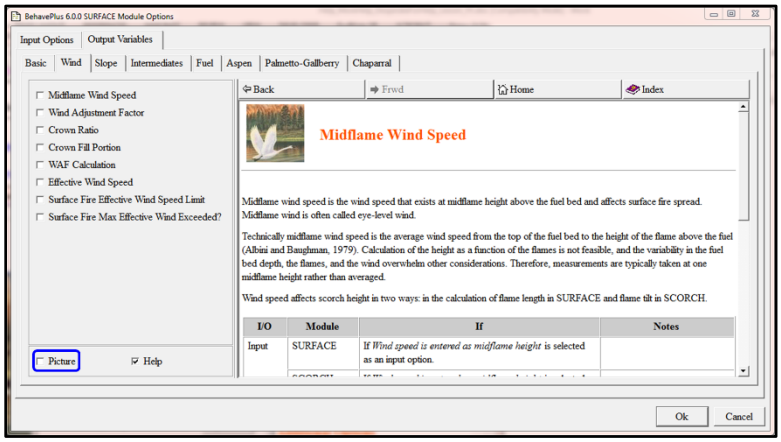
*22. On the **CROWN Options…** tab, click on **Basic Outputs**. What two general categories of crown fire behavior are listed?*

This is the primary location for viewing outputs. General information will appear on each tab before you hover over a variable. You can view the general information again by clicking on the tab or **Home** while the tab is active.

- Returning to the **SURFACE Options…** tab, click on **Output Variables > Wind**.
- Hover over **Midflame Wind Speed**.

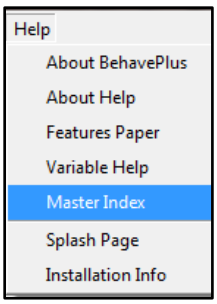
Since Midflame Wind Speed can be either an input to or an output from the SURFACE module, the same help file can be accessed both ways depending on your needs.

You can remove the **Picture** from any tab by clicking on the **Picture** button at the bottom of any window. This selection applies only to the current tab.



Master index

If you want to find information about a specific variable without navigating through the program, you can view an Index, which can be access in two ways. The easiest method is to click on **Help > Master Index**.



This will open a Master Index, which contains five links to more specific indices:

- **Variable Index:** Descriptions of all BehavePlus input and output variables as help files (e.g., Fuel Model and Surface Rate of Spread).
- **Figure Index:** All figures appearing in the BehavePlus Help system (e.g., Beaufort Scale for Estimating 20-ft Wind Speed from 0 to 7 m.p.h. (in 20-Foot Wind Speed)).
- **Table Index:** All tables appearing in the BehavePlus Help system (e.g., Area Required by Heavy Equipment (in Area per Heavy Equipment)).
- **Guide Index:** All guides appearing in the BehavePlus Help system (e.g., Western Aspen Details).
- **Table of References:** All of the models used in BehavePlus, including references.

While the tables and figures are listed separately here, they are also included with all relevant variables. In fact, these indices link you to the figure within the appropriate variable description so that you can view the description at the same time.

➢ In the **Master Index**, click on the blue **Variable Index**, which shows all of the variables within BehavePlus. Much of the information is the same as is in the Variables Paper, but the **Help** window may provide additional information.

The four indices and the table of references can also be accessed at the bottom of every Help page under **Links**. You can navigate through the Help system using the **Back**, **Frwd** (Forward), **Home**, and **Index** buttons at the top of the window.

The **Back** and **Frwd** buttons are self-explanatory and allow you to move through the system. The **Home** button will take you to the main Help window for the section you are in. For example, if you are on an

output page, **Home** will take you to the help file for Select Output Variables. If you are on an input options page, **Home** will take you to the help file for that particular tab, regardless of how many times you have jumped through the Help system. If you are in the **Master Index**, the **Home** button will take you back to the **Master Index**. The **Index** button will return you to the **Master Index**, regardless of where you are in the program. Therefore, the second method for finding the **Master Index** is to click on the **Index** button in an open Help window.

- Open **Module Selection** > **SURFACE > Options…**.

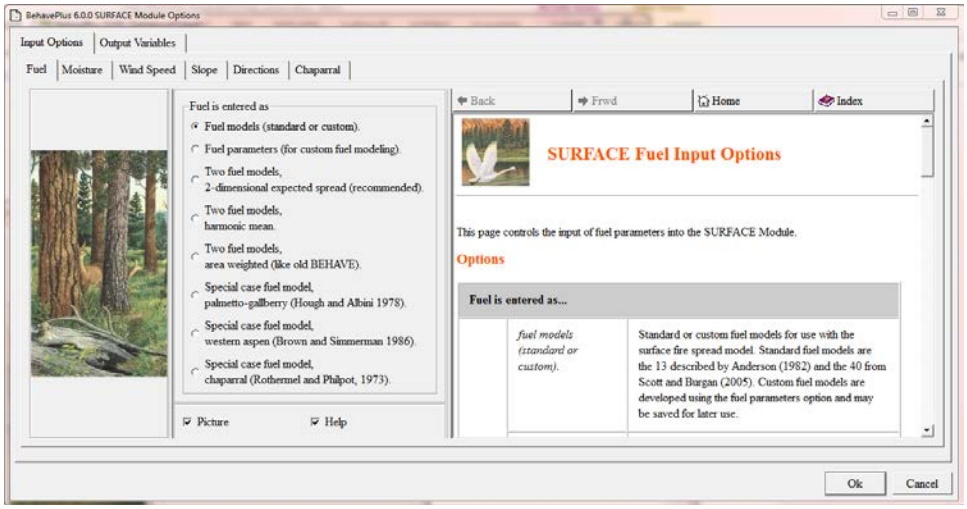
By default, you are viewing the **Output Variables > Basic** tab.

- Notice that **Select Output Variables** is located in the **Help** window.

- Now, hover over **Surface Fireline Intensity** to view the associated help file.
- Click on **Home**.

23. What do you see?

- Click on the **Input Options > Fuel** tab.



The **Help** window shows the numerous options available in this tab.

- Uncheck the **Picture** box to increase the size of the help pane.
- Scroll down in the help file and click on the link for **Western Aspen Details**.

- Scroll to the bottom of the Western Aspen Details page, and click on **Variable Index**.
- Click the **Home** button.

24. What is showing in the Help window?

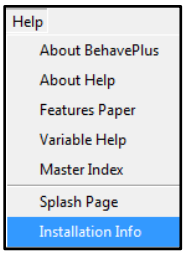
- Check the **Picture** box to show the picture again.
- Click **Cancel** twice to return to the worksheet.

BehavePlus Installation Info

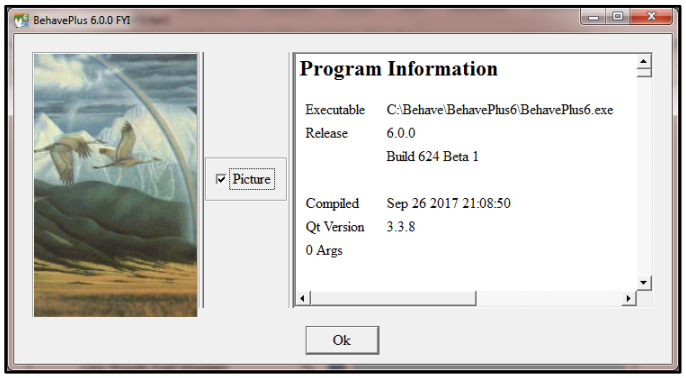
Program information

In the **Program Information** section, you can view the location of the BehavePlus executable file, the release number, and the date and time it was compiled. This information can help you determine if you have the latest version of the program. In the event that you have a pre-release or a Beta copy of BehavePlus, you will know which copy you are currently using. This information is helpful when you contact the Help Desk.

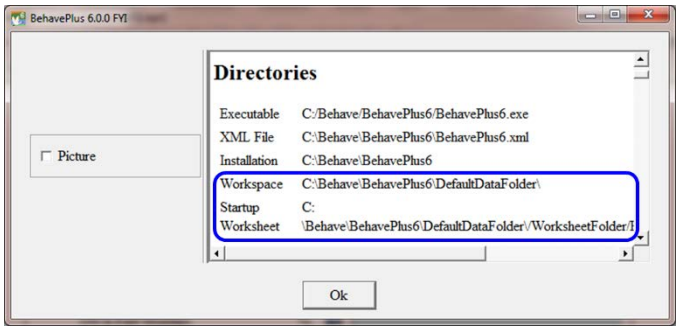
- Click on **Help > Installation Info** to open the BehavePlus **Program Information** screen.



- Scroll through the **FYI** window, looking at the wealth of information included in each section listed below.



- **Directories:** The Directories section provides the locations of the executable file again, as well as where the current Workspace is located. Since you may develop many Workspaces over time, you will want to know which Workspace is currently active. Refer to the **Operation Unit** *File Management Lesson* to learn more. You may also set up a different Startup Worksheet for your Workspace. The Directories section shows the file name and location of the file.



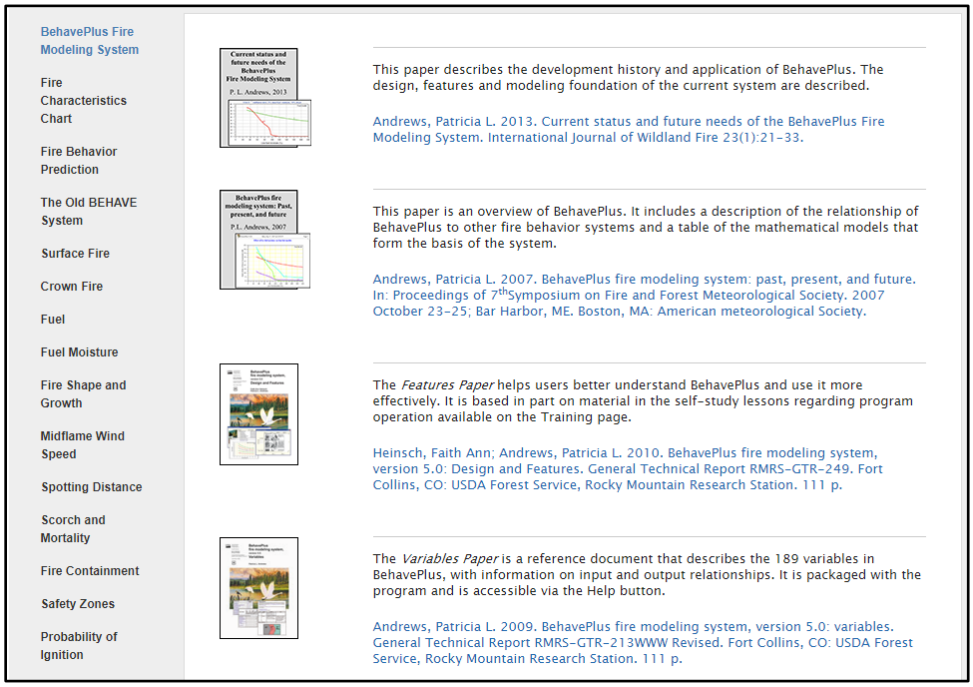
- **Environment Variables:** The Environment Variables section shows the current BehavePlus settings on your computer. The $PATH environment variable, in particular, shows the order in which Microsoft Windows searches directories to find applications. This may be useful in determining exactly which BehavePlus executable file is being run, or why one version (e.g., version 6) is being run in preference over another (e.g., version 5).
- **Display Metrics:** This information tells you the current resolution of your BehavePlus window on the Desktop and the number of colors in use. This information is changed by changing the Desktop preferences of your Windows-based PC.
- **Image Files, Documentation Files, Geographic Files:** These sections will let you know if any relevant files are missing from your program. If there are no missing files, the text will read "All [image, documentation, geographic location] files are present." Reinstalling the program will fix any problems that you have.
- **Custom Fuel Model Files (x):** Over time, you may develop custom fuel models of your own. These are saved separately from the 53 standard fuel models and are listed here. The **x** indicates how many custom fuel models you have developed and/or installed in the program.
- **Moisture Scenario Files (x):** Moisture scenarios are sets of fuel moisture values representing the moisture condition of the surface fuel. Fuel moisture scenarios are included with the program, or you may create scenarios of your own. Regardless of origin, all possible moisture scenario files are listed in this section, and the **x** indicates the number of available moisture scenario files.
- **Units Set Files (x):** This section lists custom units set files that you have created and saved. For more information on custom units sets, refer to the **Operation Unit** *Units and Decimals Lesson*.
- **Worksheet Files (x):** Worksheet files are created to provide a template for the settings that you use most often. For example, when BehavePlus first opens, the **BasicStart.bpw** worksheet opens. You can change the startup worksheet. Several sample worksheets are installed with the program. You can create as many individual worksheets as you wish. All worksheets in the **WorksheetFolder** of the current Workspace, regardless of origin, are listed in this section of **Program Information**.
- **Run Files (x):** While Worksheets provide the blank template for running BehavePlus, you may want to save individual runs. This will save the values that you have entered, although it will not save the calculations. The run files that you have created and stored in the **RunFolder** of the current Workspace are listed in this section.

The BehavePlus Website

The website www.frames.gov/behaveplus provides additional assistance and updated information that may not be included with the BehavePlus program. The website provides a wealth of information about BehavePlus. We will only look at a few of the most relevant sections of the website here.

Publications

As mentioned in a previous section, there are a number of BehavePlus publications available for download on the BehavePlus website, including papers about the current and past BehavePlus fire modeling systems and models within BehavePlus.



Known bugs

We maintain a list of the known bugs on the website for each release of BehavePlus. If you think you have found a bug in the program, please check the Known Bugs page to see if the problem (and an associated fix) has been identified. If it hasn't been identified, please document *exactly* what the problem is, when it occurs, and any error messages you receive and contact the Help Desk.

FAQs

If you have problems with *technical aspects* of the program (e.g., installation, printing, or running the program), visit the FAQs on the website *before* contacting the Help Desk.

Tips and training

As we develop tips for use with BehavePlus, we will post them on the website. If you have developed a tip that you would like to share, please contact the Help Desk, and they will direct you to the proper contact.

A number of lessons such as this one have been developed for use with the BehavePlus modeling system. You can download the lessons from the same location.

Summary

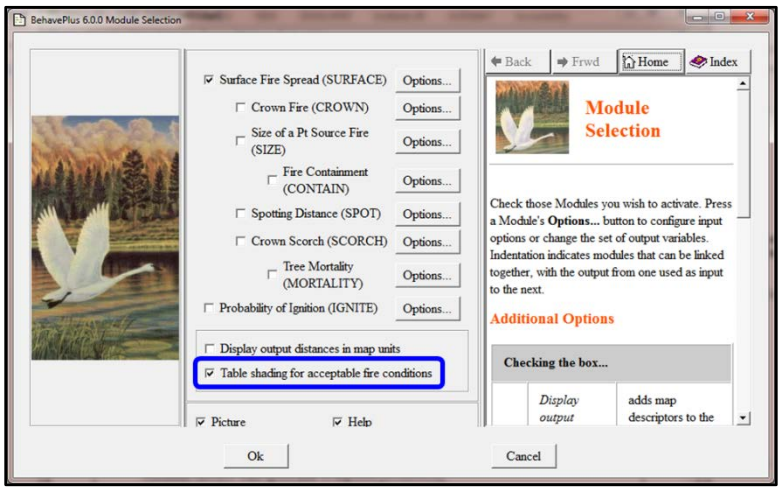
This tutorial provides an overview of the various help options available for BehavePlus, including publications, the internal Help system, and the website. While there is a lot of information available, it is strictly designed to assist you in operating the BehavePlus fire modeling system. Interpretation of the results requires a thorough understanding of fire behavior.

There are exercises associated with this lesson. They start on page 18, after the answers to the questions in the lesson.

Answers to Questions in the Lesson

1. *Looking at the Table of Contents, which chapter describes Table shading for acceptable fire conditions?*
   Chapter 12 describes this option.

2. *How do you activate table shading?*
   Table shading is activated by checking the box next to **Table Shading for Acceptable Fire Conditions** in the **Module selection** window. You must then check the boxes next to the variables of interest on the Worksheet.



3. *Which other variables does Fuel Model Type link to?*
   The description of Fuel Model Type links to both Dead Herbaceous Fuel Load and Fuel Load Transfer Portion.

4. *Under what condition is Fuel Model Type an input to the SURFACE module?*
   Fuel Model Type is an input to the SURFACE module If *Fuel is entered as fuel parameters* is selected as an input option.

5. *Is Dead Herbaceous Fuel Load an input to or an output from the SURFACE module? Under which condition does that occur?*
   It is an output from the SURFACE module if a fuel model is *dynamic*.

6. *What happens if you select both Midflame Wind Speed for the SURFACE module and 20-ft Wind Speed for either the CROWN or SPOT module?*
   If Wind speed is entered as midflame height is selected as an input option for SURFACE, and if either SPOT or CROWN is also selected, the initial version of the worksheet will request both Midflame Wind Speed and 20-ft Wind Speed. This triggers an error in the program. BehavePlus then offers a choice of how to resolve the conflict.

7. *Return to the previous view (). Scroll down and click on the --I-- next to Canopy Base Height. Is this a continuous (C) or discrete (D) variable? What is the valid input range in English Units?*
   Canopy Base Height is a continuous variable that ranges from 0 to 100 feet.

8. *Is 1-h Surface-Area-to-Volume Ratio a default output variable? What are the default English units?*
   No, it is not a default variable. The default English units are ft^2/ft^3.

9. *Who developed the spotting distance models used in the SPOT module?*
   Albini developed the spotting models and the original spotting nomograms, while Chase created equations for use with pocket calculators. The equations for pocket calculators are used in BehavePlus.

10. *Why does Rothermel say in the abstract that the surface fire rate of spread model is complete?*
    Rothermel (1972) writes, "The model is complete in the sense that no prior knowledge of a fuel's *burning* characteristics is required. All that is necessary are inputs describing the physical and chemical makeup of the fuel and the environmental conditions in which it is expected to burn."

11. *What does Rothermel state are considerations in selecting a fuel model?*
    Rothermel (1983), listed the following considerations.
    a. Identify the general vegetation type.
    b. Determine which surface fuel is carrying the fire.
    c. Calculate the general depth and compactness of the fuel.
    d. Find out which fuel classes are *present* and which fuel classes are *absent*.
    e. Use the fuel model key as well as descriptions by Anderson (1982) to select a fuel model.

12. *What is the Two-Fuel-Model Concept?*
    The Two-Fuel-Model Concept enables users to enter two fuel models for an area, taking into account the proportion of each. This was more commonly used when there were only 13 fuel models.

13. *What other information is included in this document?*
    Other information in this document includes nomograms and methods for calculating the necessary inputs and outputs for them.

14. *Look at Figure 4. What impact does wind direction have on flame shape?*
    Wind causes the flame to tilt in the direction of wind. If wind is blowing upslope (downslope) and the fire is burning upslope (downslope), the flame will tilt towards the unburned fuel. If wind is blowing upslope (downslope) and the fire is burning downslope (upslope), the flame will tilt towards the burned area. Flames tilt most when wind is blowing upslope and fire is spreading upslope.

15. *What note of caution do Rothermel and Rinehart write on page 20?*
    They write, "Observations of fire behavior under severe conditions in remote areas can be very difficult. Under no circumstances should safety be compromised for the purpose of collecting data."

16. *For what conditions were the 13 fuel models developed?*
    The 13 fuel models were developed for the peak of fire season when conditions are most severe.

17. *How is each fuel model described?*
    Each fuel model includes a description of fire spread, typical vegetation in the area, fuel load values for dead and live fuel, and fuel bed depth, and three photos showing sample sites.

18. *Describe the impact of selecting a dynamic fuel model (page 6 of the report) in your own words.*
    When live herbaceous fuel moisture is greater than 120%, all live herbaceous fuel is in the live class. When it is less than 30%, all live herbaceous fuel is in the dead class (maintaining the live herbaceous surface area-to-volume ratio). If the moisture is between 30% and 120%, a portion of the live herbaceous load is transferred to the dead class. Once live herbaceous fuel moisture is greater than 120%, fire behavior drops off for the dynamic fuel models.

19. *How many timber understory fuel models are included in the original 13 fuel models? In the additional 40 fuel models described by Scott and Burgan?*
    There are no timber understory fuel models in the original 13. Fuel model 2, which could be described as a timber understory model, is classified as a grass model. There are five timber understory models in the 40.

20. *Look up the Ponderosa pine @ 75% of initial basal area on page 34 of the paper by Scott and Reinhardt. What is the canopy base height of the stand in feet? What is the canopy fuel bulk density in lb/ft^3?*
    Canopy base height is 20 feet. Canopy Bulk Density is 0.0092 lb/ft^3.

21. *What is the technical definition for Midflame Wind Speed?*
    Midflame Wind Speed is defined as the *average* wind speed from the top of the fuel bed to the height of the flame above the fuel (Albini and Baughman, 1979).

22. *On the* ***CROWN Options…*** *tab, click on* ***Basic Outputs****. What two general categories of crown fire behavior are listed?*
    The two general categories are Active crown fire behavior and Passive crown fire behavior. Active crown fire behavior is used in both the Rothermel (1991) and Scott and Reinhardt (2001) crown fire methods. Passive crown fire behavior can only be calculated using the Scott and Reinhardt (2001) crown fire method. The method for calculating fire behavior is determined on the **Input Options** tab.

23. *What do you see?*
    The **Select Output Variables** file appears when you click on the **Home** button on the **Output Variables > Basic** tab.

24. *What is showing in the* ***Help*** *window?*
    The SURFACE Fuel Input Options file appears, which is the file associated with that tab.

Exercises

You can use any of the above resources to answer the questions in the following exercises. In many cases, the answer can be found in multiple places.

1. What is the relationship between 10-m and 20-ft Wind Speed?

2. In which calculations is Air Temperature used in BehavePlus?

3. Find the Canopy Bulk Density, Stand Height and Canopy Cover for Lodgepole pine at the initial condition.

4. What input values are used in the special case Western Aspen fuel model?

5. How does one calculate Surface Fire Rate of Spread? Surface Fire Rate of Spread is an input to which module(s)?

6. Which models are included in the CONTAIN module?

7. What is Fuel Shading from the Sun used for? In which module(s) is it used? Is it an input or an output?

8. What are the range and units for 1-h Fuel Load?

9. Is Critical Surface Intensity a default output? Is it a table shading variable?

10. What are the units for Cost of Resources Used? Why?

11. How can you estimate 20-ft wind speed using the Beaufort Scale? How many wind classes are there?

12. Where can you find information about Known Bugs in BehavePlus?

13. What are the possible sources of help for using BehavePlus?

Answers to these exercises can be found in the accompanying PDF file.

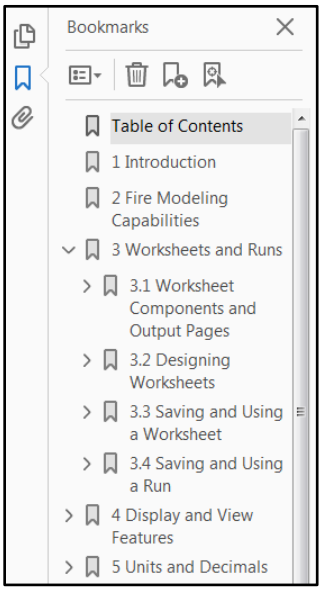
Appendix: Using Adobe PDF Products Effectively with BehavePlus Documents

Many of the documents related to BehavePlus are provided as PDF documents. They can be either printed or viewed via a PDF viewer. You can download a free copy of Acrobat Reader DC from the Adobe website.

Note: *The following guidelines work for Adobe Acrobat Pro DC version 2018.009.20044 and Reader DC version 2018.009.20044 and later.*

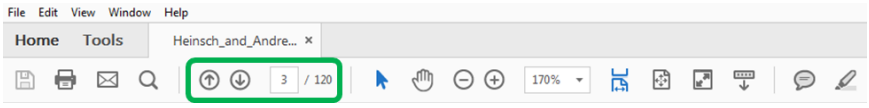
Bookmarks

The Features Paper and Variables Paper both contain bookmarks for easy navigation. The content menu on the left-hand side of either Acrobat product contains bookmarks, which provide easy access to individual sections and subsequent sections of a document, allowing users to quickly find the needed information. If the bookmarks are not visible, click on the Bookmark icon ( ) to open them. The sections can be expanded by clicking on the **>** sign next to the section header. Click on the ∨ to condense the section again.



Page navigation toolbar

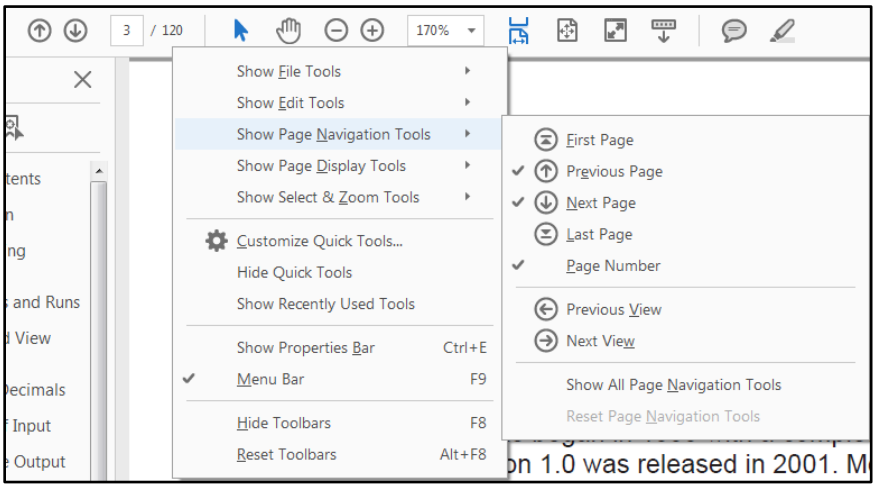
The **Page Navigation Toolbar** allows you to move easily through a document. Only a few options are normally shown as part of the default setup as shown in the green box below.



The typical setup includes arrows for the **Previous Page** ( ) and **Next Page** ( ) as well as the **Page Number** ( ). If you right-click on the toolbar, you can add additional options.

- Select **Show Page Navigation Tools** to show a list of possible views.
- If you want to add all of them, select **Show All Page Navigation Tools**.

- If you only want a few of them, click on a tool you would like to add.
- Repeat until all the tools you want to add are showing.
- Reset to the default view by clicking on **Reset Page Navigation Tools**.



Additional options include the **First Page** ( ) and **Last Page** ( ) of the document. You can also select the **Previous View** ( ) and **Next View** ( ) options. These buttons are particularly helpful if you click on links within a document and want to return to the page you were viewing originally.