Basic Start Lesson

Introduction

The BehavePlus fire modeling system is a computer program based on mathematical models that describe wildland fire behavior and effects using information about the fire environment. It is a flexible system that produces tables, graphs, and simple diagrams. It can be used for a host of fire management applications, including projecting behavior of an ongoing fire, planning prescribed fire, assessing fuel hazard, training, and exploring model sensitivity since these same models are used in a suite of fire behavior modeling systems.

While BehavePlus offers many options, you can use it for the most basic fire behavior calculations. This first lesson introduces you to the default Worksheet, entering data, and calculating results.

Objectives

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

1. Enter values on a Worksheet.
2. View information available in the Help window.
3. Calculate a Run to produce tables and graphs.
4. Change inputs and produce new tables and graphs.
5. Use BehavePlus to examine the effects of fuel model selection, fuel moisture, wind speed, and slope on surface fire rate of spread and flame length for a head fire.

Where This Lesson Fits In

This is a lesson in the **Introduction Unit**, which teaches you basic program operation. These lessons should be completed in order.

This is the first of four lessons that introduce you to the BehavePlus fire modeling system.

1. **Basic Start – simple entry of input to get answers in the form of tables and graphs**
2. Worksheets – how the Worksheet is developed from user selections
3. Input Methods – various ways of entering input values
4. Calculations – table and graph output options

Lessons in other units cover the many features and fire modeling capabilities offered by BehavePlus. Those lessons can be done in any order unless otherwise specified in the lesson.

Note: There are questions (in blue) located throughout this lesson. The answers can be found at the end of the lesson starting on page 9.

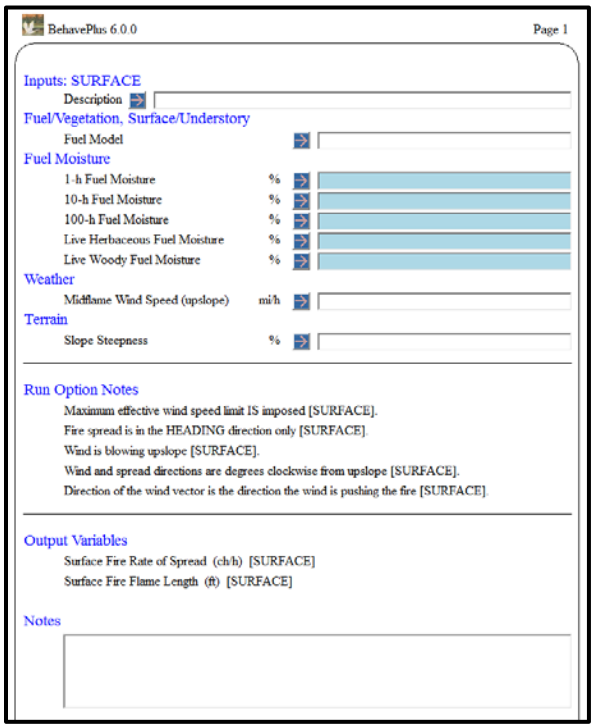
The Worksheet

The Worksheet is critical to fire behavior analyses. It includes an input variable list, a description of the Run, notes about Run Options selected, and a list of the Output Variables that you selected. A **Guide** button associated with each input variable opens a Help window with a description and aid in selecting appropriate values. Let's get started.

- Open BehavePlus.

When you open BehavePlus, the **BasicStart.bpw** Worksheet opens. This Worksheet contains one of the most commonly used configurations. There are four main sections of the Worksheet.

- **Inputs** lists the variables required to calculate fire behavior for the selected output variables.
- **Run Option Notes**, for clarification and documentation, lists relevant options currently in effect.
- **Output Variables** lists output variables that will be calculated in this Run.
- **Notes** is space where you can document additional information for the Run.



Module names currently selected are listed at the top of every Worksheet. You know at a glance what the primary purpose of the Run is. The Module name at the top of this example is SURFACE. This module contains code necessary to calculate surface fire spread and intensity. Outputs from this module can be used as inputs into almost every other module.

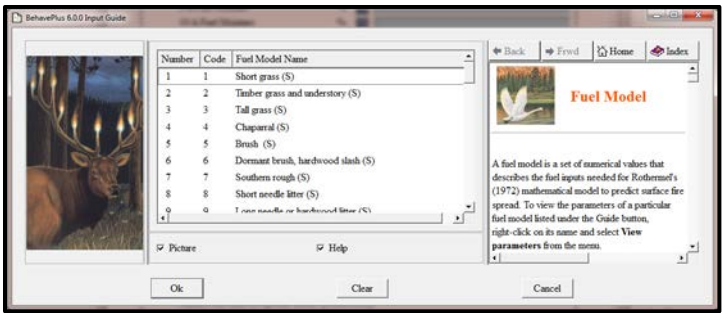
After you verify **Module names**, it is best to start from the *bottom* of the Worksheet with the **Output Variables**. BehavePlus only asks for inputs needed to calculate selected outputs. In this Worksheet, Surface Fire Rate of Spread and Surface Fire Flame Length are selected. All listed inputs are needed to calculate these variables along with the units currently required (e.g., fuel moisture in percent). After each output variable, there are also units of measurement and the MODULE used to calculate it. This section includes any additional **Notes** that you want to store with a saved Run. Continuing *up* the Worksheet, the next section is the **Run Option Notes**. These Run Option Notes describe the assumptions and limitations associated with the current Run, which can include both your outputs and the inputs used.

Finally, there is the list of **Inputs**. As mentioned before, only those inputs necessary to calculate outputs are included on a Worksheet. By setting the outputs first, you ensure that you know which inputs are required for a Run. You can then examine available data to determine the best way to enter the inputs.

Entering inputs

Let's get started. For this example, the outputs remain the same: Surface Fire Rate of Spread and Surface Fire Flame Length. You will enter values for each Input section: Fuel/Vegetation, Surface/Understory, Fuel Moisture, Weather, and Terrain.

- Place your cursor in the **Description** field. Type Lesson 1 – Basic Start Example.
- Press **Enter** or **Tab** to move to the next input field. The cursor should be in the **Fuel Model** field.
- Click the blue arrow, known as the **Guide** button (), to the left of the fuel model input field. An **Input Guide** window will open.



The **Input Guide** window is divided into three parts. On the left-hand side, there is a picture. The center pane shows a list of the currently available Fuel Models. The 53 standard fire behavior fuel models are always included in this list. These include the original 13 fuel models described by Anderson (1983) and the 40 developed by Scott and Burgan (2005). On the right is a **Help** window that contains information defining the variable (Fuel Model in this case) and provides help with selecting an input value.

- Scroll down in the **Help** window to see a list of all 53 standard fuel models separated into fuel types. The first group is the Grass Fuel Types, containing 12 fuel models.

- Click on **Fuel Model 2** in the **Help** window to see the description and photos taken from the original publication. Fuel Model 2 represents a combination of long needle dead fuels, scattered larger fuels, and live grasses.

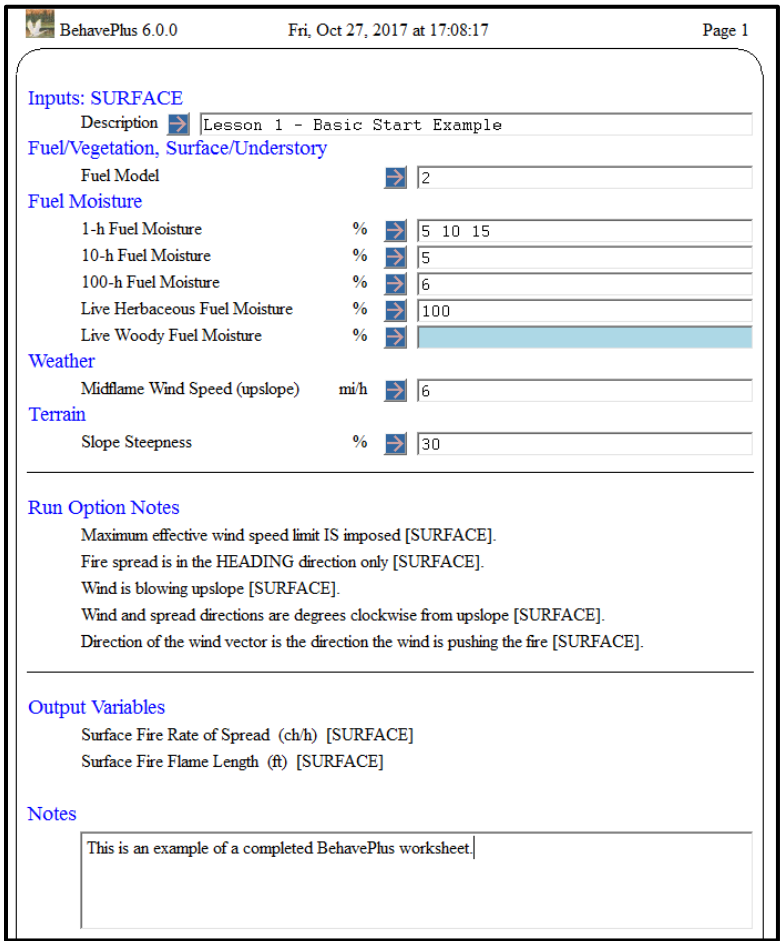
1. *Which two ecosystems are provided in the Help window as examples of a Fuel Model 2?*

- Select **Fuel Model 2** from the center pane. It will be highlighted in blue.
- Click on the **Ok** button to close the **Input Guide**. The Fuel Model field on the Worksheet should contain the number 2.
- Press the **Enter** or **Tab** key to advance to the **1-h Fuel Moisture** field (or click in the field).
- Type the following values (with or without commas) into the field: 5, 10, 15.
  - Values can be entered using spaces, commas, or some combination of the two.
- Type the appropriate number into each of the following fields:
  - **10-h Fuel Moisture**: 5
  - **100-h Fuel Moisture**: 6
  - **Live Herbaceous Fuel Moisture**: 100
  - Tab through the **Live Woody Fuel Moisture** field, leaving it blank.

The Live Woody Fuel Moisture field is shaded blue because Fuel Model 2 does not contain a live woody fuel component. Any fuel moisture field that is shaded is not required for the fuel model(s) listed.

- Continue to type the appropriate number into each of the following fields:
  - **Midflame Wind Speed**: 6
  - **Slope Steepness**: 30
  - Enter any comments you would like in the **Notes** section.

Your Worksheet should now look like the following.


BehavePlus 6.0.0 Fri, Oct 27, 2017 at 17:08:17 Page 1

Inputs: SURFACE

Description: Lesson 1 - Basic Start Example

Fuel/Vegetation, Surface/Understory

Fuel Model: 2

Fuel Moisture

1-h Fuel Moisture	%	5 10 15
10-h Fuel Moisture	%	5
100-h Fuel Moisture	%	6
Live Herbaceous Fuel Moisture	%	100
Live Woody Fuel Moisture	%	

Weather

Midflame Wind Speed (upslope) mi/h: 6

Terrain

Slope Steepness %: 30

Run Option Notes

Maximum effective wind speed limit IS imposed [SURFACE].
Fire spread is in the HEADING direction only [SURFACE].
Wind is blowing upslope [SURFACE].
Wind and spread directions are degrees clockwise from upslope [SURFACE].
Direction of the wind vector is the direction the wind is pushing the fire [SURFACE].

Output Variables

Surface Fire Rate of Spread (ch/h) [SURFACE]
Surface Fire Flame Length (ft) [SURFACE]

Notes

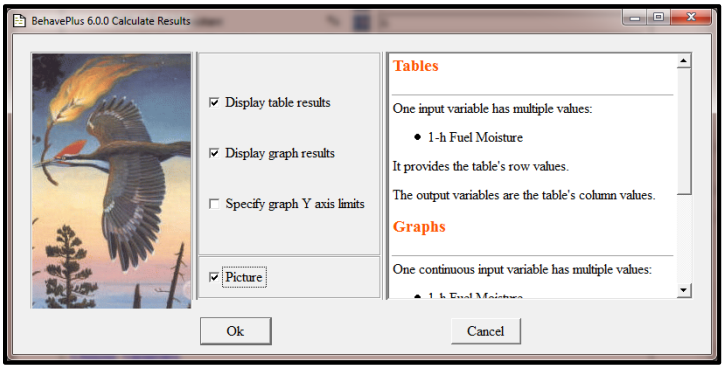
This is an example of a completed BehavePlus worksheet.

Producing outputs (tables and graphs)

Finally, it is time to calculate the surface fire behavior.

- On the top toolbar menu, select **Calculate > Calculate** command or click on the **Calculate** toolbar button (). After this, we will use "**Calculate** the Run" to indicate this command.

The **Calculate Results** dialog window appears. Make sure both **Display table results** and **Display graph results** are selected, and click on the **Ok** button.



The following table is displayed. Each output variable (Surface Fire Rate of Spread and Surface Fire Flame Length) is calculated for each of the three 1-h fuel moisture values that you entered on the Worksheet. The heading for each page of tables and graphs is the same as the **Description** field on the Worksheet. The subheading "Head Fire" indicates that this Run is calculated for a head fire – fire behavior in the direction of maximum spread.

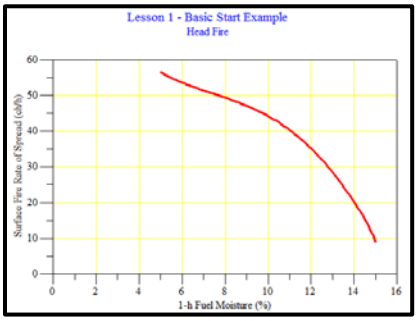
Lesson 1 - Basic Start Example

Head Fire

1-h Fuel Moisture %	Surface Fire Rate of Spread ch/h	Surface Flame Length ft
5	56.4	7.9
10	44.3	6.7
15	8.7	1.6

Notice that a 5% increase in 1-h Fuel Moisture from 5% to 10% reduces the Surface Fire Flame Length by 1.2 ft (7.9 ft – 6.7 ft), while a 5% increase in 1-h Fuel Moisture from 10% to 15% reduces the Surface Fire Flame Length by 5.1 ft (6.7 ft – 1.6 ft).

- Click on the **Next page** () toolbar button on the top menu to view the next output page. This graph shows the change in Surface Fire Rate of Spread as affected by 1-h Fuel Moisture.



- Click on the **Next page** () toolbar button on the top menu to view the next output page. This graph shows a similar drop in Surface Fire Flame Length as 1-h Fuel Moisture increases.

Changing input values

Let's change the input values and see what the resulting effect is on the outputs.

- Click on the **First page** () toolbar button to return to the Worksheet.

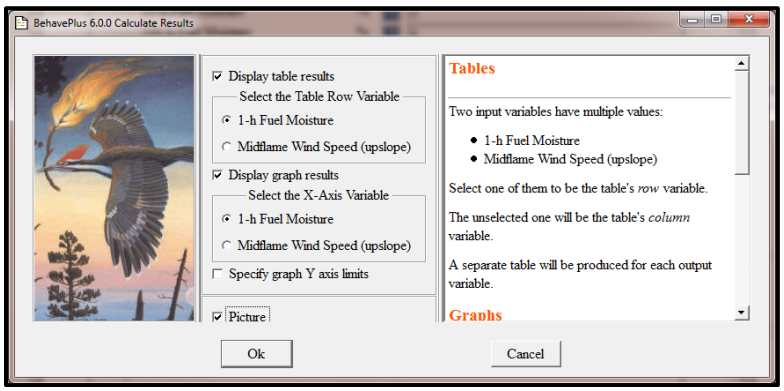
Add a range of Midflame Wind Speed values to see the combined effects of wind and fine dead fuel moisture on the Surface Fire Rate of Spread and Surface Fire Flame Length.

- In the **Midflame Wind Speed** field, replace the current value of **6 mi/h** with the values 0, 3, 6, 9.

Producing new output tables and graphs

- **Calculate** the Run.

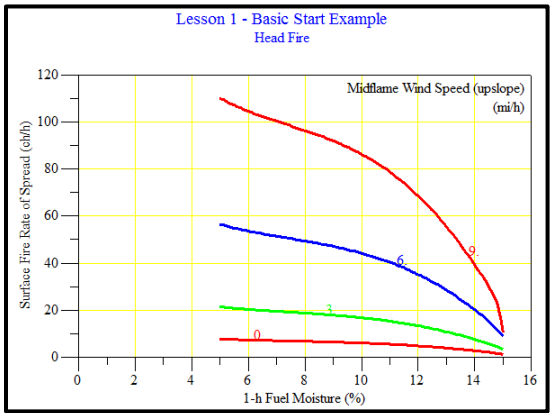
Additional options are available in the **Calculate Results** dialog window since there are two input variables with data ranges. Display options allow you to choose the orientation of tables and graphs.



- Accept the default options for now by clicking **Ok**.

Adding a range of values for a second input variable increases the number of output pages. A separate table is produced for each output variable showing results for each combination of 1-h Fuel Moisture and Midflame Wind Speed specified on the Worksheet. Use the **Next page** and **Previous page** () toolbar buttons to view each page of this Run and answer the question below.

- Look at the Surface Fire Rate of Spread graph. There is a curve for each of the input wind values.

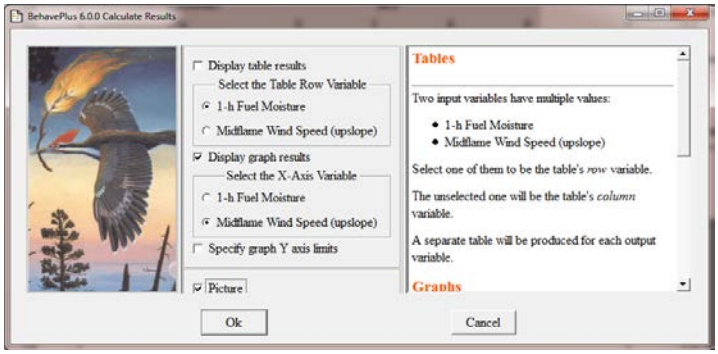


2. *For both Surface Fire Rate of Spread and Surface Fire Flame Length, what is the effect of changes in Midflame Wind Speed when the 1-h Fuel Moisture is 5%? When it is 15%?*

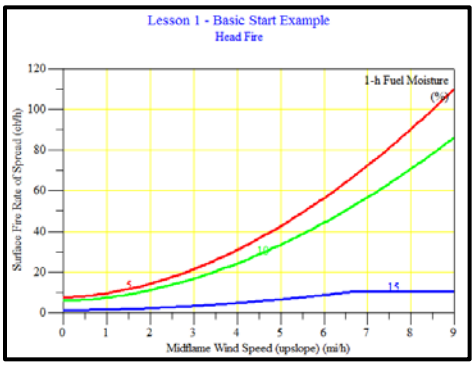
Now, view the same results in a different way by changing the options in the **Calculate Results** dialog window

- **Calculate** the Run again.
- Uncheck the box next to **Display table results**.
- In the **Display graph results** section, change **Select the X-Axis Variable** to **Midflame Wind Speed (upslope)**.

The **Calculate Results** dialog window should look the following image.



- Click **Ok** to view the results.



Since there is no table output, the Surface Fire Rate of Spread graph is the first output page. The second graph is Surface Fire Flame Length. There are now three lines – one for each value of 1-h Fuel Moisture. Midflame Wind Speed is now the X-Axis variable.

3. *What is the impact of 1-h Fuel Moisture on fire behavior in this example?*

Summary

By now you have gotten a feel for the operation of BehavePlus. The skills you learned in this **Basic Start** lesson allow you to produce tables and graphs to examine the influence of fuel model, fuel moisture, wind, and slope on head fire surface rate of spread and flame length. It is useful not just for calculating fire behavior characteristics, but also to help you better understand more complex fire behavior and modeling concepts. BehavePlus can help you gain a solid understanding of the basics, which is important when working with spatial modeling tools such as FARSITE; FlamMap; WFDSS Short-Term and Near-Term; and FSPro. It can also help you understand fire behavior outputs generated by more complex modeling systems such as FVS-FFE.

There are exercises associated with this lesson. They start on page 10, after the answers to the questions in the lesson.

You have completed the first lesson in the **Introduction Unit**.

1. **Basic Start – simple entry of input to get answers in the form of tables and graphs**

Continue in order with the next three lessons to gain a basic understanding of program operation.

2. Worksheets – how the Worksheet is developed from user selections
3. Input Methods – various ways of entering input values
4. Calculations – table and graph output options

References

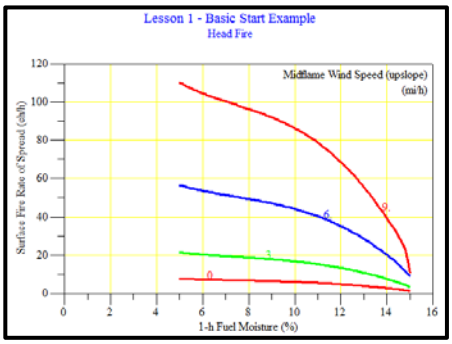
Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. Gen. Tech. Rep. INT-122. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p. https://www.fs.usda.gov/treesearch/pubs/6447

Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p. https://www.fs.usda.gov/treesearch/pubs/9521

Answers to Questions in the Lesson

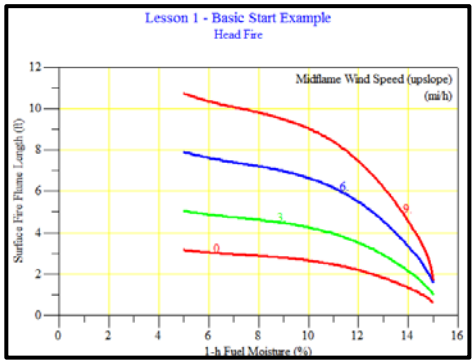
1. *Which two ecosystems are provided in the Help file as examples of a Fuel Model 2?*
   Anderson provides two examples of fuels that may fit this fuel model: open ponderosa pine stand with annual grass understory and scattered sage within grasslands. Remember, however, that this is only a *guide*. You should base your final fuel model selection on its ability to capture the fire behavior seen on the landscape.

2. *For both Surface Fire Rate of Spread and Surface Fire Flame Length, what is the effect of changes in Midflame Wind Speed when the 1-h Fuel Moisture is 5%? When it is 15%?*



Lesson 1 - Basic Start Example
Head Fire
Surface Fire Rate of Spread (ch/h)

1-h Fuel Moisture %	Midflame Wind Speed (upslope) mi/h 0	3	6	9
5	7.7	21.4	56.4	110.1
10	6.0	16.8	44.3	86.3
15	1.2	3.3	8.7	10.3



Lesson 1 - Basic Start Example
Head Fire
Surface Fire Flame Length (ft)

1-h Fuel Moisture %	Midflame Wind Speed (upslope) mi/h 0	3	6	9
5	3.2	5.1	7.9	10.7
10	2.7	4.3	6.7	9.0
15	0.6	1.0	1.6	1.7

When the 1-h Fuel Moisture is 5%, the Midflame Wind Speed has a much greater effect on Surface Fire Rate of Spread and Flame Length. When the Midflame Wind Speed is minimal, the fire behavior is also small, with Surface Fire Rate of Spread of about 8 ch/h and a Surface Fire Flame Length of about 3 ft. When the Midflame Wind Speed is 9 mi/h, however, Surface Fire Rate of Spread is about 110 ch/h and flame lengths are nearly11 feet.

When 1-h Fuel Moisture is 15%, however, Midflame Wind Speed has a much smaller effect. When Midflame Wind Speed is 0 mi/h, the Surface Fire Rate of Spread is about 1 ch/h, and the Flame Length is less than 1 ft. When the Midflame Wind Speed is 9 mi/h, the rate of spread is about 10 ch/h, and the flame length is less than 2 ft.

3. *What is the impact of 1-h Fuel Moisture on fire behavior in this example?*
   There is not a large difference in fire behavior between 5% and 10% fuel moisture in this example. Midflame wind speed has a larger influence on outputs. However, fire behavior changes dramatically at a 1-hr Fuel Moisture value of 15%. At this moisture value, Midflame Wind Speed has much less of an impact on fire behavior.

Exercises

1. Open a new **BasicStart.bpw** Worksheet.
   a. To open a Worksheet, go to **File > Open worksheet** or click on the  icon. Double-click on **ExampleWorksheets**. Select **BasicStart.bpw** and click **Ok**.
   b. Enter the following inputs.
      - The fire is burning in a hardwood stand late in the fall after leaf-off (Fuel Model 9).
      - **1-h Fuel Moisture** is 7%; **10-h Fuel Moisture** is 8%; and **100-h Fuel Moisture** is 10%.
      - **Midflame Wind Speed** is 4 mi/h, and it is blowing upslope.
      - Average **Slope Steepness** is 40%.
   c. Calculate Surface Fire Rate of Spread and Surface Fire Flame Length.
   d. Answer the following questions.
      - Why are no graphs produced for this Run?
      - Describe the fire behavior that you see.

2. Modify the Run from Exercise 1.
   a. Change the **10-h Fuel Moisture** to a range of values: 4, 8, 12).
   b. How does 10-h Fuel Moisture affect the calculated Surface Fire Rate of Spread and Flame Length?

3. Modify the Run from Exercise 2. Reverse the values of 1-h Fuel Moisture and 10-h Fuel Moisture.
   a. Reverse the values of 1-h Fuel Moisture and 10-h Fuel Moisture.
      - Change **1-h Fuel Moisture** to 4, 8, 12%.
      - Change **10-h Fuel Moisture** to 7%.
   b. How do changes in 1-h Fuel Moisture affect calculated Surface Fire Rate of Spread and Flame Length differently than 10-h Fuel Moisture does?

4. Modify the Run from Exercise 3.
   a. Change the inputs as follows.
      - **1-h Fuel Moisture** is 7%.
      - **10-h Fuel Moisture** is 8%
      - **100-h Fuel Moisture** is 10%.
      - Enter a range of values for **Midflame Wind Speed** of 0, 5, 10 mi/h.
      - Change **Slope Steepness** to 0, 10, 40, 60%.
   b. **Calculate** the Run.
   c. How much does the change in Slope Steepness from 0% to 10% change the fire behavior? From 40 to 60%?

5. Repeat Exercise 4, changing the graph display so that the **X-Axis Variable** is **Slope Steepness**.
   a. Comparing the graphs from Question 4 and Question 5, does wind or slope have a greater effect on fire behavior?
   b. How do the graphs help you reach that conclusion?

6. Try Exercises 1-5 with other fuel models, such as Fuel Model 13. How do the results differ?

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