



Introduction

A primary use of the table shading for acceptable fire conditions option of BehavePlus is for prescribed fire planning. Acceptable conditions (such as 2 to 4 ft flame length) can be defined; unacceptable conditions are shaded (crossed off or left blank) on output tables. In this way conditions (such as wind speed and dead fuel moisture) that result in acceptable conditions can be identified.

The approach used in BehavePlus is different from that in the RXWINDOW program of the old BEHAVE system (Andrews and Bradshaw 1990). That program attempted to reverse the calculations to determine environmental conditions that corresponded to specified fire conditions. This is not feasible now that additional fire models (such as crown fire) are available.

Objectives

1. Practice implementation of the table shading option in BehavePlus.
2. Define acceptable fire conditions within the program.
3. Produce and interpret tables with crossed out and blank values.

Where This Lesson Fits In

This lesson is an optional lesson in the Operations Unit. Focus is on operation of the program. A lesson in the Application Unit uses the methods learned here to develop burn prescriptions.

Lesson Changes: V4.0 to V5.0

Changes to the BehavePlus program did not require changes to this lesson. The Variables paper was updated. We updated the headers and footers, but did not redo many of the screen captures labeled BehavePlus 4.0.0.

The Final Product

Following is a simple example of a worksheet and resulting 'shaded' table. We will go through the steps necessary to produce these results.

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Inputs: SURFACE

Description ➤ Example: acceptable FL = 2 to 8 ft

Administrative Unit ➤ North End

Prescribed Fire Name ➤ Blue Bird

Prepared By ➤ Mr. Smith

Fuel/Vegetation, Surface/Understory

Fuel Model ➤ 2

Fuel Moisture

Dead Fuel Moisture % ➤ 14, 13, 12, 11, 10, 9, 8, 7, 6, 5

Live Fuel Moisture % ➤ 120

Weather

Midflame Wind Speed (upslope) mi/h ➤ 0.0, 2.0, 4.0, 6.0, 8.0, 10.0

Terrain

Slope Steepness % ➤ 0

Acceptable Fire Conditions

Flame Length (ft) ☐ 2.0 ☐ 8.0

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
Example: acceptable FL = 2 to 8 ft
Flame Length (ft)

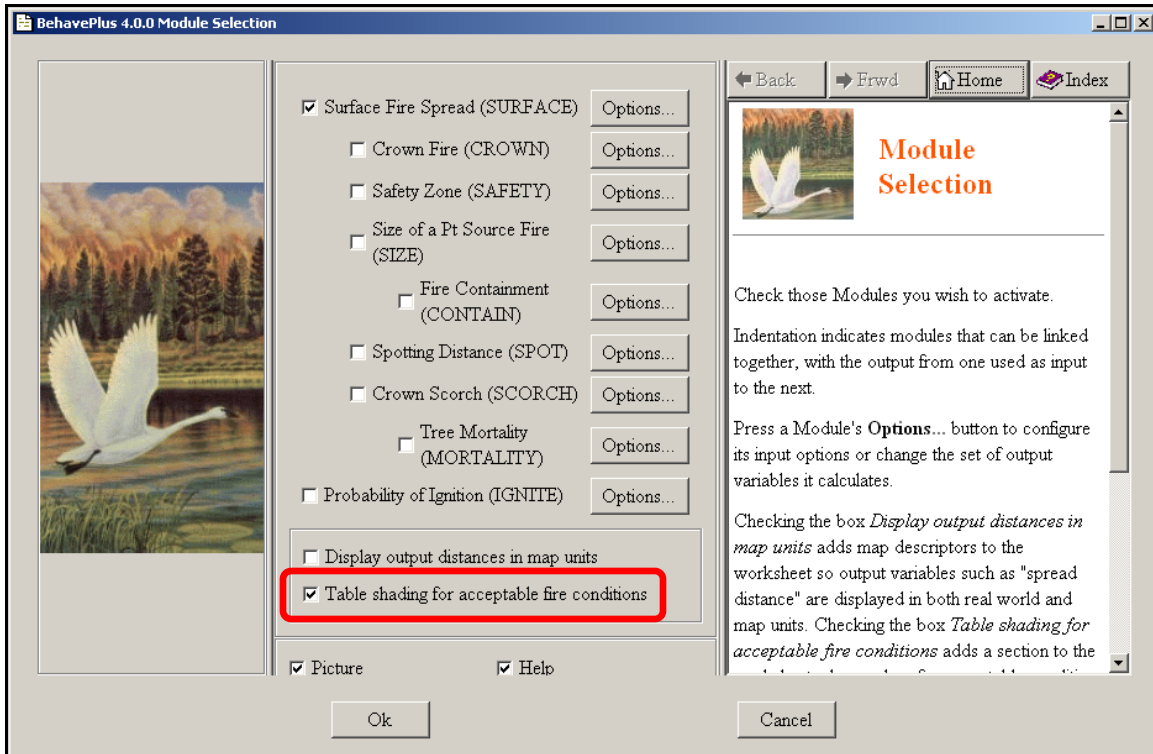
Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14					2.1	2.1
13			2.9	4.0	5.1	6.1
12		2.2	3.6	4.9	6.2	7.4
11		2.5	4.1	5.6	7.0	
10		2.7	4.4	6.1	7.7	
9		2.9	4.7	6.4		
8		3.0	4.8	6.6		
7		3.1	5.0	6.8		
6		3.1	5.1	7.0		
5		3.3	5.3	7.3		
4		3.4	5.6	7.7		
3	2.0	3.7	6.0			
2	2.2	4.1	6.6			

Creating the Worksheet

- Open the **SurfaceSimple.bpw** worksheet.

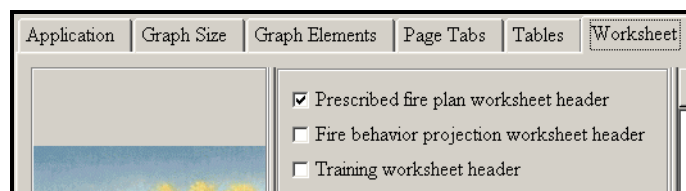
Adding Acceptable Fire Conditions

- Click the **Module Selection** button ().
- Check **Table shading for acceptable fire conditions**.
- Click **Ok** to return to the worksheet.



Add Additional Header Lines for Prescribed Fire

- To add additional header lines, click on **Configure > Appearance preferences > Worksheet**.
- Check on **Prescribed fire plan worksheet header**.
- Click **Ok**.



Change the Selected Output Variables.

- Click on **Module Selection > Surface Options... > Basic Outputs**
- Remove all output variables except Flame Length.
- Enter values on the worksheet as follows to look similar to the example at the beginning of this lesson. The worksheet will not look exactly the same as we will

be making additional changes throughout the lesson to demonstrate different techniques.

- Header lines: Whatever text you want.
- Fuel Model: 2
- Dead Fuel Moisture: 2 to 14 step 1
- Live Fuel Moisture: 120%
- Midflame Wind Speed: 0 to 10 step 2
- Slope: 0
- Acceptable Fire Conditions, Flame Length: 2 to 8
- Don't check the box by Flame Length for now.
- Click on the Calculate button.
- Remove the check for **Display graph results**.
- Click **Ok**.

A table for Flame Length is produced without shading.

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Example: acceptable FL = 2 to 8 ft
Flame Length (ft)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
2	2.2	4.1	6.6	9.1	11.5	13.8
3	2.0	3.7	6.0	8.3	10.4	12.5
4	1.9	3.4	5.6	7.7	9.7	11.7
5	1.8	3.3	5.3	7.3	9.2	11.1
6	1.7	3.1	5.1	7.0	8.9	10.7
7	1.7	3.1	5.0	6.8	8.6	10.4
8	1.6	3.0	4.8	6.6	8.4	10.1
9	1.6	2.9	4.7	6.4	8.1	9.7
10	1.5	2.7	4.4	6.1	7.7	9.2
11	1.4	2.5	4.1	5.6	7.0	8.5
12	1.2	2.2	3.6	4.9	6.2	7.4
13	1.0	1.8	2.9	4.0	5.1	6.1
14	0.4	0.8	1.2	1.7	2.1	2.1

Notice that flame length increases with increasing wind, left to right in a row. Furthermore, notice that flame length decreases with increasing moisture, top to bottom in a column.

It makes more sense to change the table so that Flame Length increases with decreasing moisture, top to bottom.

- Enter the following for dead fuel moisture, using the guide button for that variable.
You can use a negative step size to reverse the order of values on the table.

(1 - 60 %)

From

Thru

Step

- Recalculate the run to get the following table which shows increasing flame length with increasing wind and decreasing moisture.

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Example: acceptable FL = 2 to 8 ft
Flame Length (ft)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14	0.4	0.8	1.2	1.7	2.1	2.1
13	1.0	1.8	2.9	4.0	5.1	6.1
12	1.2	2.2	3.6	4.9	6.2	7.4
11	1.4	2.5	4.1	5.6	7.0	8.5
10	1.5	2.7	4.4	6.1	7.7	9.2
9	1.6	2.9	4.7	6.4	8.1	9.7
8	1.6	3.0	4.8	6.6	8.4	10.1
7	1.7	3.1	5.0	6.8	8.6	10.4
6	1.7	3.1	5.1	7.0	8.9	10.7
5	1.8	3.3	5.3	7.3	9.2	11.1
4	1.9	3.4	5.6	7.7	9.7	11.7
3	2.0	3.7	6.0	8.3	10.4	12.5
2	2.2	4.1	6.6	9.1	11.5	13.8

Enable Table Shading Option

- Add a check mark by the specified acceptable flame length values.

Acceptable Fire Conditions

Flame Length (ft) ☒ -

- Calculate the run again.

Flame Length values that are outside the acceptable range are crossed off.

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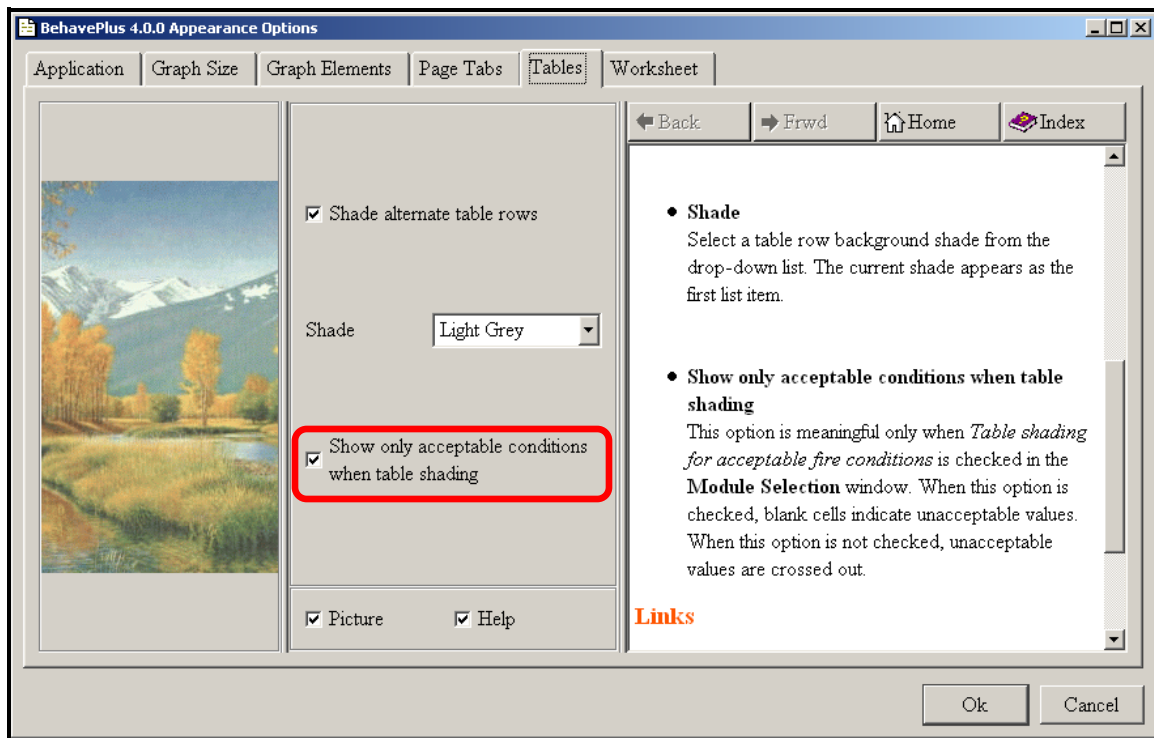
Example: acceptable FL = 2 to 8 ft
Flame Length (ft)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14	0.4	0.8	1.2	1.7	2.1	2.1
13	1.0	1.6	2.9	4.0	5.1	6.1
12	1.2	2.2	3.6	4.9	6.2	7.4
11	1.4	2.5	4.1	5.6	7.0	8.5
10	1.5	2.7	4.4	6.1	7.7	9.2
9	1.6	2.9	4.7	6.4	8.1	9.7
8	1.6	3.0	4.8	6.6	8.4	10.1
7	1.7	3.1	5.0	6.8	8.6	10.4
6	1.7	3.1	5.1	7.0	8.9	10.7
5	1.8	3.3	5.3	7.3	9.2	11.1
4	1.9	3.4	5.6	7.7	9.7	11.7
3	2.0	3.7	6.0	8.3	10.4	12.5
2	2.2	4.1	6.6	9.1	11.5	13.8

Notice that higher Midflame Wind Speeds are acceptable when the Dead Fuel Moisture is higher (wetter).

Once you get the 'prescription window' table that you want, you can produce a table with blank cells rather than with crossed off values.

- Click on **Configure > Appearance preferences > Tables Tab.**
- Check the box by **Show only acceptable conditions when table shading.**



➤ Calculate the run.

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Example: acceptable FL = 2 to 8 ft
Flame Length (ft)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14					2.1	2.1
13			2.9	4.0	5.1	6.1
12		2.2	3.6	4.9	6.2	7.4
11		2.5	4.1	5.6	7.0	
10		2.7	4.4	6.1	7.7	
9		2.9	4.7	6.4		
8		3.0	4.8	6.6		
7		3.1	5.0	6.8		
6		3.1	5.1	7.0		
5		3.3	5.3	7.3		
4		3.4	5.6	7.7		
3	2.0	3.7	6.0			
2	2.2	4.1	6.6			

Acceptable Conditions Can Be Defined for More than One Variable

- Change the table back to cross offs so that we can see the eliminated values by deselecting the **Show only acceptable conditions when table shading** box.
-

☐ Show only acceptable conditions when table shading

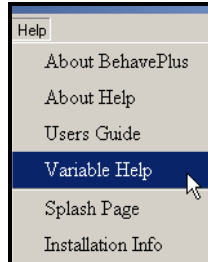
- Select the additional output variables Surface Rate of Spread and Surface Spread Distance (keep Flame Length)

While all three variables are now listed as output variables, only Surface Rate of Spread and Flame Length are found in the **Acceptable Fire Conditions** section.

Acceptable Fire Conditions			
Surface Rate of Spread (maximum)	(ch/h) <input type="checkbox"/>	0.0	- 0.0
Flame Length	(ft) <input checked="" type="checkbox"/>	2.0	- 8.0
Run Option Notes			
Maximum reliable effective wind speed limit is imposed [SURFACE].			
Calculations are only for the direction of maximum spread [SURFACE].			
Fireline intensity, flame length, and spread distance are always for the direction of the spread calculations [SURFACE].			
Wind is blowing upslope [SURFACE].			
Output Variables			
Surface Rate of Spread (maximum) (ch/h) [SURFACE]			
Flame Length (ft) [SURFACE]			
Surface Spread Distance (ch) [SURFACE]			

Variables Available for Table Shading

Not all BehavePlus variables are available for table shading. To see the variables available for table shading, open the Variables paper through the Help button.



- Click on **Output Variable Table** in the Table of Contents.

Contents	
Introduction	1
Alphabetical List of Variables	4
Input Variable Table	10
Output Variable Table	16
Variable Descriptions.....	24
Surface Fire Spread and Intensity.....	26
Surface Rate of Spread	26
Flame Length	27

- Look at the check marks in the column labeled **Table shading variable**.

Table 4—Output variables for BehavePlus version 5.0.

Output variable	Default output variable	Table shading variable	Available as map distance	English units	Metric units
SURFACE					
Basic Outputs					
Surface Rate of Spread	X	X		ch/h	m/min
Heat per Unit Area		X		Btu/ft ²	kJ/m ²
Fireline Intensity		X		Btu/ft/s	kW/m
Flame Length	X	X		ft	m
Reaction Intensity				Btu/ft ² /min	kW/m ²
Direction of Maximum Spread				degrees	degrees

Notice that both Surface Rate of Spread and Flame Length are table shading variables, but Surface Spread Distance is not.

Defining Acceptable Conditions for More than One Variable

- Remove spread distance as a selected output variable.
- Calculate the run.

Tables are produced for both Rate of Spread and Flame Length. Notice that the Rate of Spread table has values that are crossed off *even though we have not specified acceptable values for Rate of Spread*.

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Example: acceptable FL = 2 to 8 ft
Surface Rate of Spread (maximum) (ch/h)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14	0.4	1.5	4.4	8.9	14.8	14.9
13	1.1	4.0	11.5	23.0	38.2	56.9
12	1.3	5.0	14.5	28.9	48.0	71.5
11	1.6	5.8	16.8	33.6	55.7	83.1
10	1.7	6.5	18.6	37.1	61.6	81.9
9	1.9	6.9	19.9	39.8	66.0	98.4
8	1.9	7.3	20.9	41.8	69.4	103.5
7	2.0	7.6	21.8	43.6	72.4	107.9
6	2.1	7.9	22.8	45.5	75.6	112.6
5	2.2	8.3	24.0	47.9	79.6	118.6
4	2.4	8.9	25.7	51.3	85.2	127.0
3	2.6	9.8	28.1	56.2	93.3	139.0
2	2.9	11.0	31.5	63.0	104.6	155.9

The crossed-out values on the Rate of Spread table correspond to those on the Flame Length table. If moisture and wind conditions are not acceptable because of Flame Length conditions, they are crossed out on all output tables.

- Specify an acceptable range of values for Surface Rate of Spread, by checking the box next Surface Rate of Spread to apply it.
- Remove the check by Flame Length to ignore those limits for the next run.

Acceptable Fire Conditions

Surface Rate of Spread (maximum)	(ch/h)	<input checked="" type="checkbox"/>	15	-	200
Flame Length	(ft)	<input type="checkbox"/>	2.0	-	8.0

- Calculate the run.

Not both the Surface Rate of Spread and Flame Length tables have values crossed off to indicate moisture and wind conditions that result in Surface Rate of Spread that is outside the acceptable limit.

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Example: acceptable FL = 2 to 8 ft
Surface Rate of Spread (maximum) (ch/h)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) m/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14	0.4	1.5	4.4	8.9	14.8	14.9
13	1.1	4.0	11.5	23.0	38.2	56.9
12	1.3	5.0	14.5	28.9	48.0	71.5
11	1.6	5.8	16.8	33.6	55.7	83.1
10	1.7	6.5	18.6	37.1	61.6	91.9
9	1.9	6.9	19.9	39.8	66.0	98.4
8	1.9	7.3	20.9	41.8	69.4	103.5
7	2.0	7.6	21.8	43.6	72.4	107.9
6	2.1	7.9	22.8	45.5	75.6	112.6
5	2.2	8.3	24.0	47.9	79.6	118.6
4	2.4	8.9	25.7	51.3	85.2	127.0
3	2.6	9.8	28.1	56.2	93.3	139.0
2	2.9	11.0	31.5	63.0	104.6	155.9

- Now apply restrictions on both Surface Rate of Spread and Flame Length by checking both boxes.

Acceptable Fire Conditions

Surface Rate of Spread (maximum)	(ch/h)	<input checked="" type="checkbox"/>	15.0	-	200.0
Flame Length	(ft)	<input checked="" type="checkbox"/>	2.0	-	8.0

- Calculate the run.

Now conditions that fall outside the acceptable range for either the Surface Rate of Spread or Flame Length are crossed out.

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Example: acceptable FL = 2 to 8 ft
Surface Rate of Spread (maximum) (ch/h)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14	0.4	1.5	4.4	8.9	14.8	14.9
13	1.1	4.0	11.5	23.0	38.2	56.9
12	1.3	5.0	14.5	28.9	48.0	71.5
11	1.6	5.8	16.8	33.6	55.7	83.1
10	1.7	6.5	18.6	37.1	61.6	91.9
9	1.9	6.9	19.9	39.8	66.0	98.4
8	1.9	7.3	20.9	41.8	69.4	103.5
7	2.0	7.6	21.8	43.6	72.4	107.9
6	2.1	7.9	22.8	45.5	75.6	112.6
5	2.2	8.3	24.0	47.9	79.6	118.6
4	2.4	8.9	25.7	51.3	85.2	127.0
3	2.6	9.8	28.1	56.2	93.3	139.0
2	2.9	11.0	31.5	63.0	104.6	155.9

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Example: acceptable FL = 2 to 8 ft
Flame Length (ft)

Dead Fuel Moisture %	Midflame Wind Speed (upslope) mi/h					
	0.0	2.0	4.0	6.0	8.0	10.0
14	0.4	0.8	1.2	1.7	2.1	2.1
13	1.0	1.8	2.9	4.0	5.1	6.1
12	1.2	2.2	3.6	4.9	6.2	7.4
11	1.4	2.5	4.1	5.6	7.0	8.5
10	1.5	2.7	4.4	6.1	7.7	9.2
9	1.6	2.9	4.7	6.4	8.1	9.7
8	1.6	3.0	4.8	6.6	8.4	10.1
7	1.7	3.1	5.0	6.8	8.6	10.4
6	1.7	3.1	5.1	7.0	8.9	10.7
5	1.8	3.3	5.3	7.3	9.2	11.1
4	1.9	3.4	5.6	7.7	9.7	11.7
3	2.0	3.7	6.0	8.3	10.4	12.5
2	2.2	4.1	6.6	9.1	11.5	13.8

It is good practice to calculate the run by showing the numbers that are being crossed off so that you see what is happening. Change the table format to blank values only after you're sure you have the window that you want.

When you include a table in a report, it is **critical** that you also include the input worksheet.

In the example in this lesson, the results would differ for a different Fuel Model, Live Fuel Moisture, or Slope.

Summary

This lesson is a basic introduction to the BehavePlus option of table shading for acceptable fire conditions. You need more information and practice to effectively use this option for prescribed fire planning and other applications.

It important for you to understand the assumptions and limitations of the fire models and the implications for applying them to prescribed fire. The models can be used by an experienced, thoughtful, and educated user. Blind use can be trouble.

Determination of appropriate input values is a challenge. For example, what value should be used for crown base height? Foliar moisture? Surface fuel model?

There is a challenge in considering the many variables that influence fire behavior and fire effects. It is not possible to print a 10-dimensional table on a piece of paper. This lesson examined tradeoffs between the effects of two environmental variables (Midflame Wind Speed and Dead Fuel Moisture) on two fire behavior variables (Surface Rate of Spread and Flame Length). One of many questions that can be considered involves the relationship of 1-h, 10-h, and 100-h Fuel Moisture values to the Dead Fuel Moisture value.

There is a limit to the number of columns on a BehavePlus output page. You can format tables to suit your needs by exporting your results to a spreadsheet.

All of these issues, and others, are addressed elsewhere.

Exercise

Continuing with the example in this lesson, change the Acceptable Fire Conditions so there will be no transition to crown fire. The changes will result in the following worksheet.

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Inputs: SURFACE, CROWN					
Description		Example: No Transition to Crown Fire			
Administrative Unit		North End			
Prescribed Fire Name		Blue Bird			
Prepared By		Mr. Smith			
Fuel/Vegetation, Surface/Understory					
Fuel Model		2			
Fuel/Vegetation, Overstory					
Canopy Base Height	ft	15			
Fuel Moisture					
Dead Fuel Moisture	%	14, 13, 12, 11, 10, 9, 8, 7, 6,			
Live Fuel Moisture	%	120			
Foliar Moisture	%	100			
Weather					
Midflame Wind Speed (upslope)	mi/h	4.0, 6.0, 8.0, 10.0, 12.0			
Terrain					
Slope Steepness	%	0			
Acceptable Fire Conditions					
Surface Rate of Spread (maximum)	(ch/h)	<input type="checkbox"/>	15.0	-	200.0
Flame Length	(ft)	<input type="checkbox"/>	2.0	-	8.0
Transition to Crown Fire ?		<input checked="" type="checkbox"/>	No		
		<input type="checkbox"/>	Yes		