BehavePlus Tech Tips

We have developed a number of tips for using BehavePlus more effectively.

Contents

1. Tricks and Tips List 1
2. Dead Fuel Moisture = 1-h = 10-h = 100-h 3
3. Create Moisture Scenarios in BehavePlus 6
4. Export HTML Files from BehavePlus 7
5. BehavePlus Results in Reports and Documentation 7
6. Print HTML Files with Shading 11
7. Accessing BehavePlus Version 5 Files from Version 6 13
8. Using Adobe PDF Products Effectively with BehavePlus Documents 14
9. Selecting a Grass Fuel Model for Prescribed Fire Planning 16

1. Tricks and Tips List

Following is a list of BehavePlus tips and tricks. The**y** are discussed in more detail in the referenced section in the following report.

Heinsch, Faith Ann; Andrews, Patricia L. 2010. BehavePlus fire modeling system, version 5.0: Design and Features. Gen. Tech. Rep. RMRS-GTR-249. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 111 p.

Worksheet setup

- Add additional **Description** lines to the Worksheet header. (Section 3.1.3)
- Change the size of or remove the **Notes** section. (Section 3.1.3)
- Add tabs to the edge of pages to add space for additional documentation. (Section 3.1.2)
- All selections are stored as part of a Worksheet or Run, including those not visible on the current Worksheet. Selections include module selection; input options; output variables; appearance of graphs, tables, and Worksheets; and units and decimal settings. (Section 3 and Appendices D-H)
- Use Worksheets designed explicitly for fuel modeling because the additional decimal display for fuel load reduces round off problems. (Section 3.3.1 and 5.2)

Enter input

- Enter values on a Worksheet separated by commas, spaces, or any combination of commas and spaces. (Section 6.1)
- Pick from a list of selected values for some continuous variables using the **Choices** button. (Section 6.4)
- Check the range of valid values for a continuous variable using the **Guide** button. (Section 6.3)
- Use the **Guide** button input fields to enter one value, two values (e.g., minimum and maximum plot values), as well as the more common three values (**From**, **Thru**, **Step**). (Section 6.3)
- Look in the **Help** window for additional aid in determining input values. (Section 6.5 and 15.3)

Format output

- Enter a negative step size to format tables so that variables range from larger to smaller values (for example, fuel moisture). (Section 6.3)
- Table shading of every other line of output tables can be removed or the color can be changed. (Section 7.2)
- Using the option **Table shading for acceptable fire conditions** will create tables in which unacceptable values are crossed off or left blank. (Section 12)
- Graph appearance can be changed, including colors, size, grid, etc. All of these selections are saved with the Worksheet or Run. (Section 7.3.1)
- Set graph minimum values to either zero or the minimum calculated values. Y-axis maximum can be determined by the maximum calculated value or set to a maximum value. (Section 7.3.3)
- Change the order of input values on Worksheets to change the position of curve labels. (Section 7.3.1)
- Decimal display of input variables on output tables is determined by the precision of values entered on the Worksheet. (Section 5.1)
- Change units and output decimal display for the current Run without saving a custom units set. (Section 5.4)

View

- Look at fuel model parameters or moisture scenario values by right-clicking on the selection in the **Guide** button window and selecting **View Parameters**. (Section 10.2 and 11)
- Use the **View** command to zoom in for presentations or zoom out to show the show the whole page. (Section 4.1)
- Jump directly to the page you want to view using the **Pages** command. (Section 4.3)
- If you prefer not to see the pictures by Dolack in the left-hand window, you can turn them all off. That option will remain in effect until you turn this feature back on. (Section 3.2.5)
- Temporarily close the Dolack **Picture** pane to give more space to the **Help** window. (Section 3.2.5)
- View multiple Worksheets/Runs at a time. (Section 4.2)
- Scroll down to see if there is additional helpful information in the **Help** window. (Section 6.5 and 15.3)
- Look at variable descriptions, tables, diagrams, and additional guides in the **Help** system using the **Master Index**. (Section 15.4)

Export and print

- Table results can be exported to an HTML file and opened with a browser. Long and wide tables are not split to fit on 8½-inch x 11-inch paper. (Section 8.5 and Section 8.6)
- Open HTML files with spreadsheet software to do additional analysis and formatting. The file must be saved as a spreadsheet. (Section 8.6)
- Export moisture values calculated with the fine dead fuel moisture tool to an HTML file for documentation. (Section 8.5 and Section 13)
- Print any help window by a right-click on the window. (Section 15.3)
- Capture and if necessary, modify a BehavePlus window or image using the Snipping Tool and insert into a document.

Personalization

- Set the Worksheet that opens when BehavePlus starts. (Section 3.3.3)

- Example Worksheets that come with the program have selections that we call ‘defaults.’ A user can define alternate sets of ‘defaults’ for various applications. (Section 3.3.2)
- Use workspaces for documentation and to share BehavePlus Worksheets, Runs, etc. (Section 9.2)

2. Dead Fuel Moisture = 1-h = 10-h = 100-h

The BehavePlus fire modeling system offers three options for defining the moisture content for surface fuel components.

1. When **Moisture is entered by individual size class** is selected, a moisture value is entered for each size class: 1-h, 10-h, 100-h, live woody, and live herbaceous fuel.
2. When **Moisture is entered by dead and live categories** is selected, the dead fuel moisture value is then used for 1-h, 10-h and 100-h fuel moisture and the live fuel moisture value is used for live herbaceous and live woody fuel moisture.
3. When **Moisture is entered by dead, live herbaceous, and live woody categories** is selected, the value used for dead fuel moisture is used for 1-h, 10-h, and 100-h fuel. The moisture content for live herbaceous and live woody fuel are entered separately.
4. When **Moisture is entered by moisture scenario** is selected, a set of five moisture values can be defined, saved, and specified by name.

A rule of thumb that is commonly used is to specify a 1-h moisture value is as follows.

- In the western U.S., assign 10-h = 1-h +1% and 100-h = 1-h + 2%, an approximation was suggested by Rothermel (1983, p.14).
- In the eastern U.S., where climate is generally more humid, assign 10-h = 1-h + 2% and 100-h = 10-h + 4%.

How much difference does it make to select **Moisture is entered by individual size class** or **Moisture is entered by dead and live categories** when specifying dead fuel moisture? BehavePlus includes intermediate values to facilitate understanding of the underlying models. Characteristic dead fuel moisture is the value that is calculated from the weighting factors based on the loading of each size class and the moisture content of each size class.

Fifteen moisture scenarios were built and saved for each combination of 1-h, 10-h, and 100-h fuel moisture. All 53 fuel models and all of the new moisture scenarios were used to build the table. Moisture Scenario names and descriptions are listed at the end of the Run along with the fuel model names. For this table, 1-h fuel moisture ranged from 2 to 30 in steps of 2, while 10-h = 1-h +1% and 100-h = 1-h +2%. In only one case is there a difference between the 1-h and characteristic dead fuel moisture: fuel model TL7/187 (large downed logs). There is effectively no benefit to using the +1% and +2% relationships over using the same value for all dead fuel size classes.

Characteristic Dead Fuel Moisture (%)
(Live fuel moisture = 100%)
Columns include fuel moisture calculated as follows:
Dead fuel moisture, 1-h, 10-h = 1-h + 1%, 100-h = 1-h + 2%

Fuel Model	02-03-04	04-05-06	06-07-08	08-09-10	10-11-12	12-13-14	14-15-16	16-17-18	18-19-20	20-21-22	22-23-24	24-25-26	26-27-28	28-29-30	30-31-32
1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
5	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30

Fuel Model	02-03-04	04-05-06	06-07-08	08-09-10	10-11-12	12-13-14	14-15-16	16-17-18	18-19-20	20-21-22	22-23-24	24-25-26	26-27-28	28-29-30	30-31-32
6	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
7	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
8	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
9	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
10	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
11	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
12	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
13	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr5	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr6	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr7	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr8	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gr9	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gs1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gs2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gs3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
gs4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh5	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh6	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh7	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh8	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sh9	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tu1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tu2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tu3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tu4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tu5	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl5	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl6	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl7	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
tl8	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
tl9	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sb1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sb2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sb3	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
sb4	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30

This does not mean that the moisture content of 10-h and 100-h fuels doesn't matter. What follows are two tables that show characteristic dead fuel moisture for ranges of 1-h and 10-h fuel moisture. The effect of 10-h and 100-h moisture depends on how much different they are from 1-h moisture and on the distribution of fuel in the fuel model.

Bottom line: If you don't have moisture values for each size class, just use the same value for all of them using the option *Moisture is entered by dead and live category*.

Characteristic dead fuel moisture is different than the 1-h fuel moisture in the yellow cells. For this analysis, we examined two fuel models and a range of 1-h and 10- fuel moisture values. Fuel model 12 has relatively more 10-h and 100-h fuel than fuel model 2 does.

Characteristic Dead Fuel Moisture (%)

Fuel Model 2, 100-h fuel moisture = 6%, Live fuel moisture = 75%

1-h Moisture	10-h Moisture (%)														
%	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
28	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28
30	29	29	30	30	30	30	30	30	30	30	30	30	30	30	30

Characteristic Dead Fuel Moisture (%)

Fuel Model 12, 100-h fuel moisture = 6%, Live fuel moisture = 75%

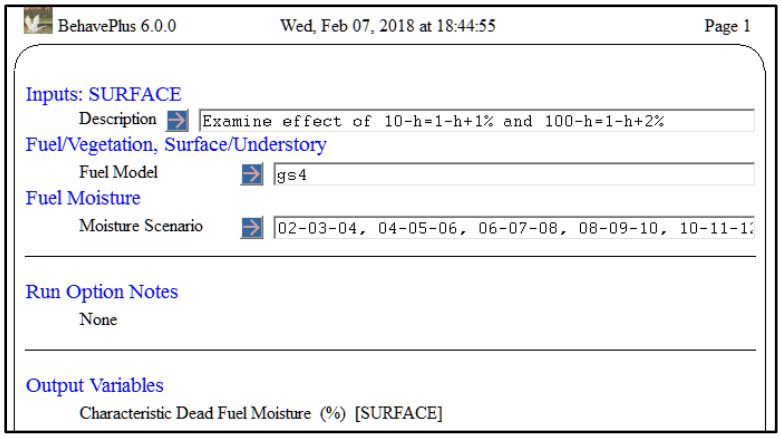
1-h Moisture	10-h Moisture (%)														
%	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
2	2	3	3	3	4	4	4	5	5	6	6	6	7	7	8
4	4	4	4	5	5	6	6	6	7	7	7	8	8	9	9
6	5	6	6	6	7	7	7	8	8	9	9	9	10	10	11
8	7	7	7	8	8	9	9	9	10	10	10	11	11	12	12
10	8	9	9	9	10	10	10	11	11	12	12	12	13	13	13
12	10	10	10	11	11	12	12	12	13	13	13	14	14	15	15
14	11	12	12	12	13	13	13	14	14	15	15	15	16	16	16
16	13	13	13	14	14	15	15	15	16	16	16	17	17	18	18
18	14	15	15	15	16	16	16	17	17	18	18	18	19	19	19
20	16	16	16	17	17	18	18	18	19	19	19	20	20	21	21
22	17	18	18	18	19	19	19	20	20	21	21	21	22	22	22
24	19	19	19	20	20	21	21	21	22	22	22	23	23	24	24
26	20	21	21	21	22	22	22	23	23	24	24	24	25	25	25
28	22	22	22	23	23	24	24	24	25	25	25	26	26	27	27
30	23	24	24	24	25	25	25	26	26	27	27	27	28	28	28

Suggestion: *Try similar Runs with 100-h fuel moisture = 10%.*

Something to think about: *Can live fuel moisture affect characteristic dead fuel moisture?*

3. Create Moisture Scenarios in BehavePlus

Fifteen moisture scenarios were built and saved for each of the combinations of 1-h, 10-h, and 100-h fuel moisture in Section 2. All of the fuel models and all of the new moisture scenarios were selected to build the table. The Moisture Scenario names and descriptions are listed at the end of the Run along with the fuel model names.



BehavePlus 6.0.0 Wed, Feb 07, 2018 at 18:44:55 Page 1

Inputs: SURFACE

Description: Examine effect of 10-h=1-h+1% and 100-h=1-h+2%

Fuel/Vegetation, Surface/Understory

Fuel Model: gs4

Fuel Moisture

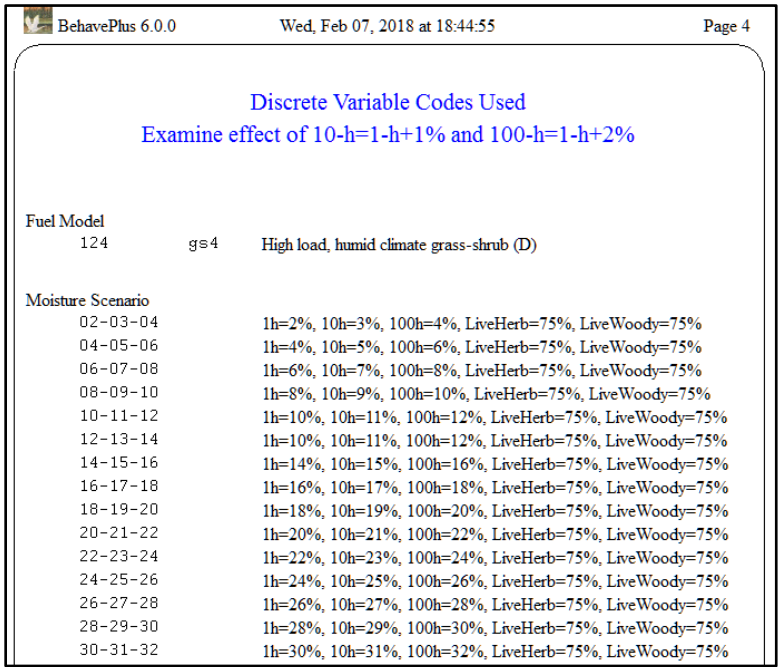
Moisture Scenario: 02-03-04, 04-05-06, 06-07-08, 08-09-10, 10-11-1

Run Option Notes

None

Output Variables

Characteristic Dead Fuel Moisture (%) [SURFACE]



BehavePlus 6.0.0 Wed, Feb 07, 2018 at 18:44:55 Page 4

Discrete Variable Codes Used

Examine effect of 10-h=1-h+1% and 100-h=1-h+2%

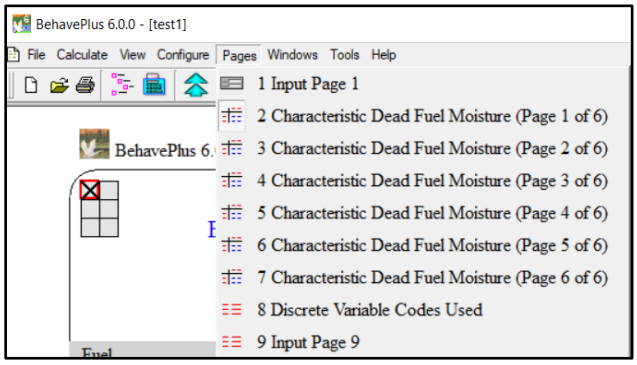
Fuel Model

124	gs4	High load, humid climate grass-shrub (D)

Moisture Scenario

02-03-04	1h=2%, 10h=3%, 100h=4%, LiveHerb=75%, LiveWoody=75%
04-05-06	1h=4%, 10h=5%, 100h=6%, LiveHerb=75%, LiveWoody=75%
06-07-08	1h=6%, 10h=7%, 100h=8%, LiveHerb=75%, LiveWoody=75%
08-09-10	1h=8%, 10h=9%, 100h=10%, LiveHerb=75%, LiveWoody=75%
10-11-12	1h=10%, 10h=11%, 100h=12%, LiveHerb=75%, LiveWoody=75%
12-13-14	1h=10%, 10h=11%, 100h=12%, LiveHerb=75%, LiveWoody=75%
14-15-16	1h=14%, 10h=15%, 100h=16%, LiveHerb=75%, LiveWoody=75%
16-17-18	1h=16%, 10h=17%, 100h=18%, LiveHerb=75%, LiveWoody=75%
18-19-20	1h=18%, 10h=19%, 100h=20%, LiveHerb=75%, LiveWoody=75%
20-21-22	1h=20%, 10h=21%, 100h=22%, LiveHerb=75%, LiveWoody=75%
22-23-24	1h=22%, 10h=23%, 100h=24%, LiveHerb=75%, LiveWoody=75%
24-25-26	1h=24%, 10h=25%, 100h=26%, LiveHerb=75%, LiveWoody=75%
26-27-28	1h=26%, 10h=27%, 100h=28%, LiveHerb=75%, LiveWoody=75%
28-29-30	1h=28%, 10h=29%, 100h=30%, LiveHerb=75%, LiveWoody=75%
30-31-32	1h=30%, 10h=31%, 100h=32%, LiveHerb=75%, LiveWoody=75%

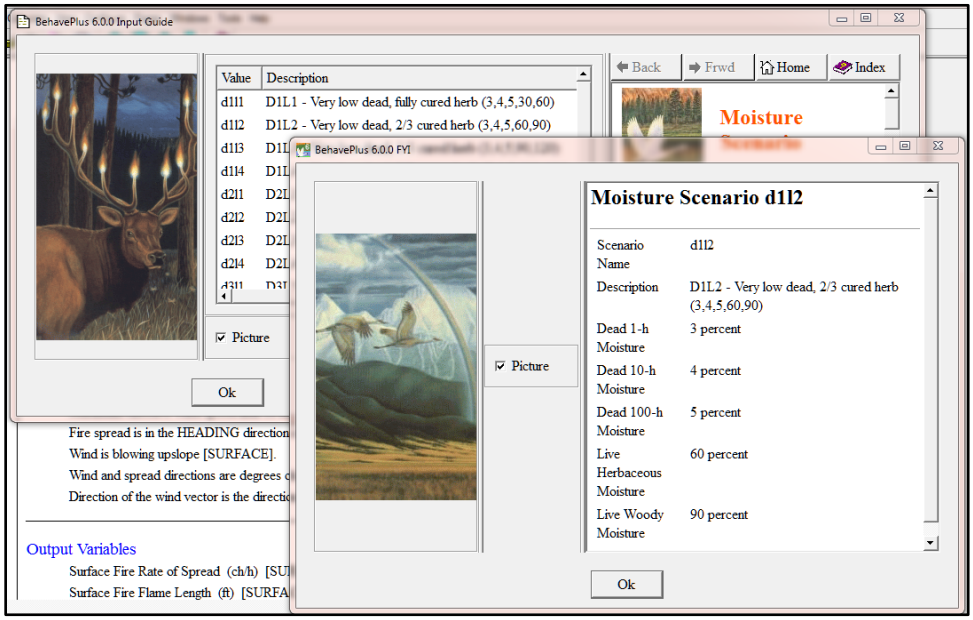
In section 2, the table was made up of more than 53 rows and more than 15 columns, which created nine pages of outputs. The **Pages** menu button becomes much more valuable when you have so many pages of outputs.



4. Export HTML Files from BehavePlus

The results from Section 2 were saved in HTML format, putting all of the values into a single table. The file was opened with Excel. The data table was then copied into a Word document where shading was added, and spacing/headings were adjusted to improve readability.

To see the moisture values for a moisture scenario, right-click on the selected scenario in the **Input Guide** window and select **View Parameters**.



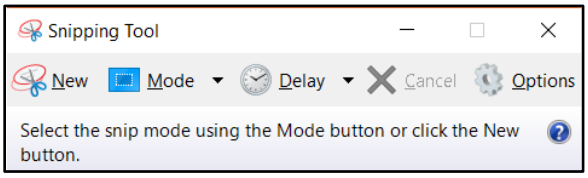
5. BehavePlus Results in Reports and Documentation

Following are some tips you can use to effectively include BehavePlus results in reports, such as prescribed fire plans.

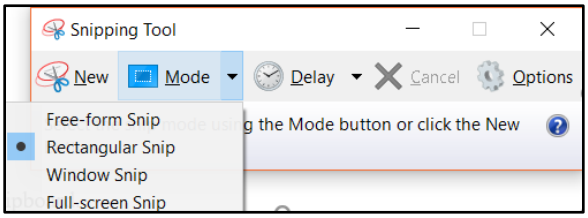
Capture and insert into a Word document

The following method works better than using the BehavePlus **File > Save as an image** feature. The following is available on every computer and doesn't require an additional capture program.

- Click on the **Snipping Tool** if it is already present on your taskbar.
  ***Note**: If the **Snipping Tool** is not already installed on your taskbar, click on the **Start** button, search for **snipping tool**, and then select it.*
- Go to the selection you would like to copy and click on **New** as shown below.

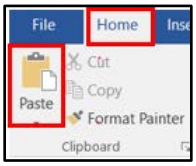


- Drag the cursor around the area you would like to copy. (Or, alternatively, choose the type of snip you want, select **Mode** (or, in older versions of Windows, the arrow next to **New**), and then choose **Free-form Snip**, **Rectangular Snip**, **Window Snip**, or **Full-screen Snip**.

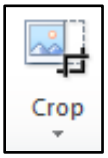


- Select **File > Save** at the top of the toolbar to save your image to the clipboard.
- Name your file and save it as a .PNG, .GIF, or .JGP, in a convenient location

- In Word, click **Ctrl-V** (or right-click and select **Paste**, or click the **Paste** button in the **Clipboard** group on the **Home** tab of the main ribbon) to insert into a Word document.



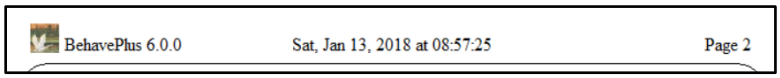
- Click once on the inserted image in the Word document to activate the **Picture Tools** tab.
- Click on **Format** in the **Picture Tools** tab, and then click on the **Crop** icon.



- Crop the window to leave only the part you want in the report.

Include the Header on each BehavePlus output page

The header includes the program version number and the date and time of the Run. The time stamp helps you match input to output pages if things get confused.

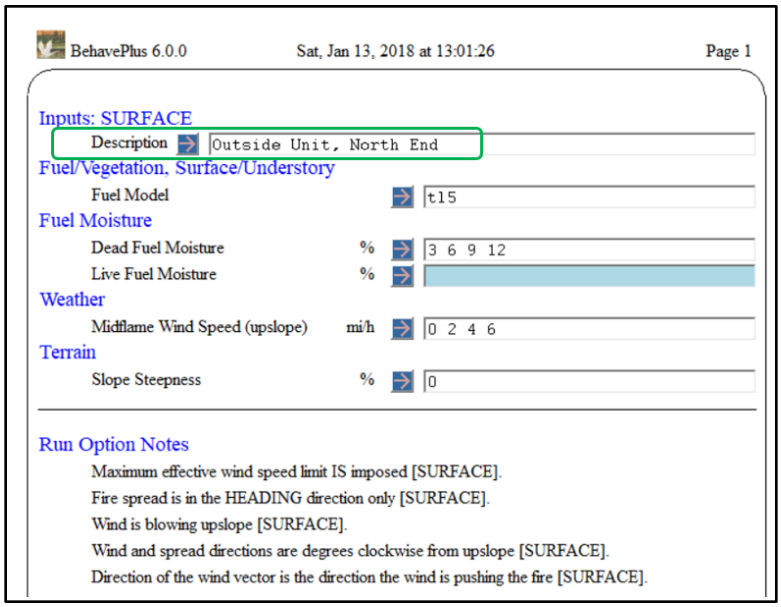


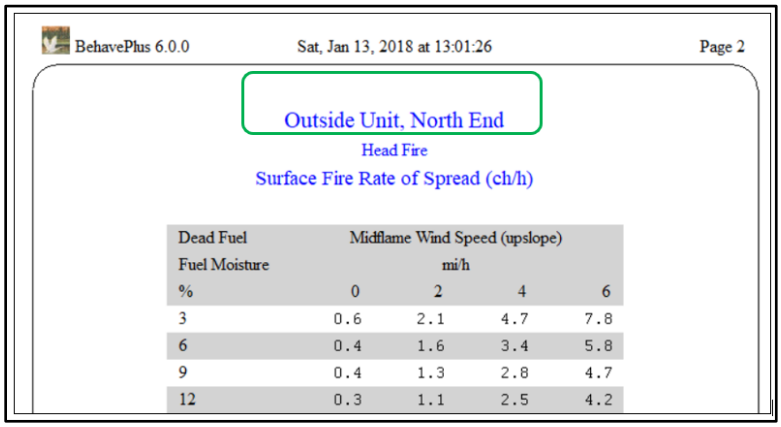
Include Worksheet with results

The Worksheet provides information necessary to correctly interpret the outputs. It makes no sense to include tables of flame length or plots of spotting distance if the inputs used to get those values are not provided.

Description Line is used in headings of output pages

The description provided in the BehavePlus Worksheet will be included at the top of every output page. Additional headers, such as the Prescribed Fire Header described in Description Line is used in headings of output pages are only shown on the Worksheet. Notes at the bottom of the Worksheet page are only found on the Worksheet.





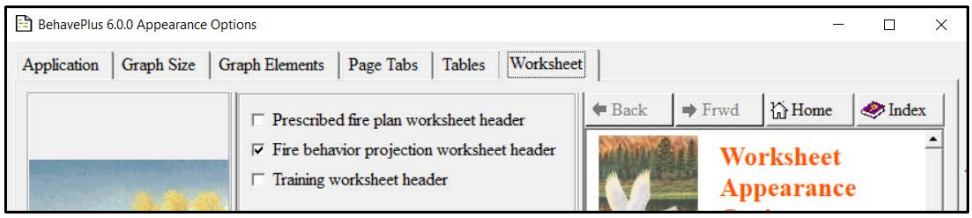
Dead Fuel Fuel Moisture %	Midflame Wind Speed (upslope) mi/h 0	2	4	6
3	0.6	2.1	4.7	7.8
6	0.4	1.6	3.4	5.8
9	0.4	1.3	2.8	4.7
12	0.3	1.1	2.5	4.2

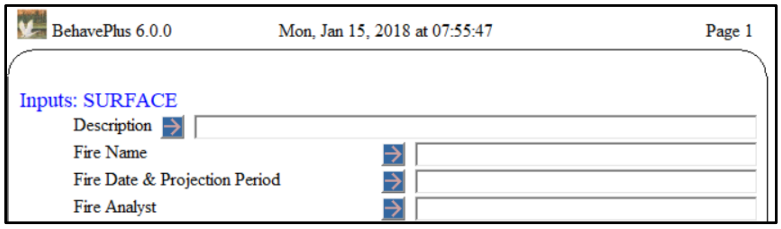
Add lines to the heading to document a Run

The following three additional headers have been created for BehavePlus.

- Prescribed fire plan
- Fire behavior projection
- Training

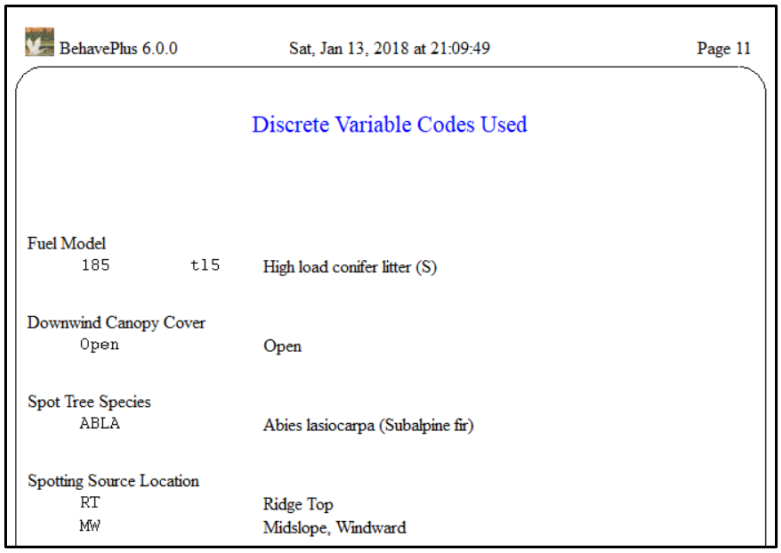
Select **Configure > Appearance preferences > Worksheet**.





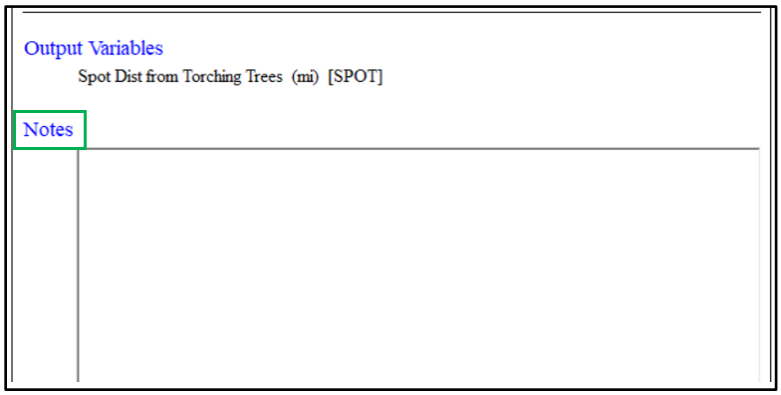
Discrete Variable Codes are described on the last page of a Run

For completeness, consider including these descriptions in a report. It will help technical reviewers better interpret and understand the inputs you have selected.

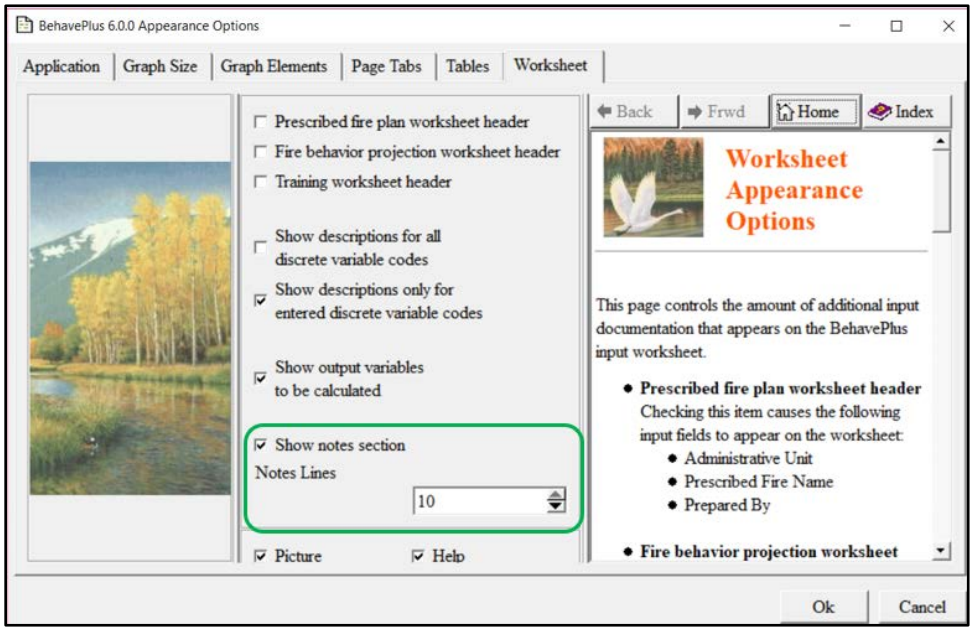


Use the Notes Section at the bottom of the Worksheet for additional description of the Run

The size of the **Notes** section can be increased from the default of four lines up to ten.



- Click on **Configure > Appearance preferences > Worksheet**.

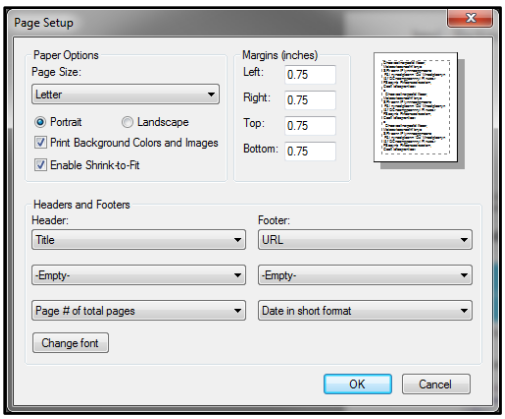


6. Print HTML Files with Shading

You can export BehavePlus tables in HTML format. The shading in the HTML document looks good on the screen. In order for the shading to show in a printed copy, you may need to change your browser settings. This tip describes how to set up your browser to display HTML table shading on printed output.

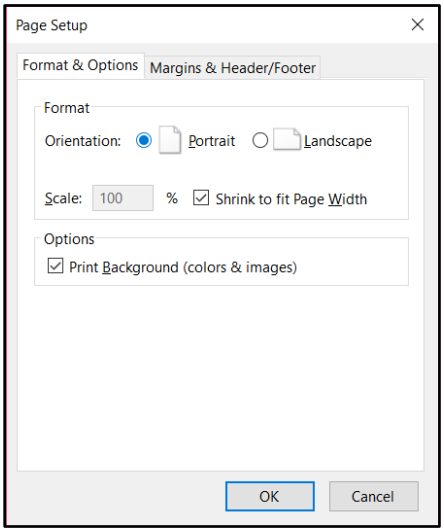
Using Internet Explorer (IE11):

- Select **File > Print > Print Preview**.
- Click on the **Page Setup** button (**)**
- Click in the box next to **Print Background Colors and Images**.
- Click **OK**.



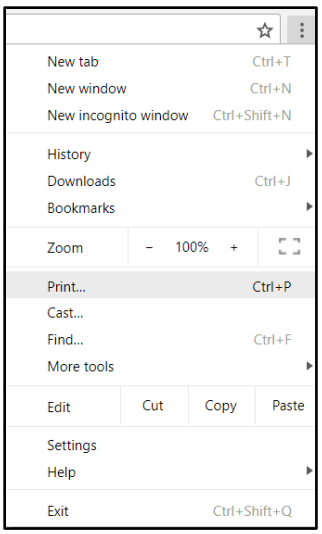
Using Mozilla Firefox:

- Select **File > Page Setup**.
- Select the **Format & Options** tab.
- Enable the check box titled **Print Background (colors & images)**.
- Click **OK**.

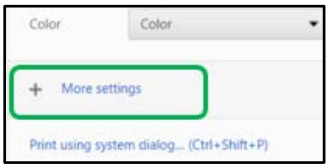


Using Google Chrome:

- Select **Customize and Control Google Chrome > Print**.



- Select **+ More settings**.



- Check **Background graphics**.

- Click **Print**.

7. Accessing BehavePlus Version 5 Files from Version 6

BehavePlus Version 5 files (BehavePlus5) are completely compatible with Version 6 (BehavePlus6). There are two methods for accessing BehavePlus5 files in BehavePlus6: (1) using Windows Explorer® and (2) Setting a Workspace. We recommend using the Windows Explorer® method unless you are familiar with using workspaces. You can learn more about Workspaces in the **Operation Unit**, *File Management Lesson*.

Using Windows Explorer®

To access Worksheet, Run, fuel model, units set, and moisture scenario files created under BehavePlus5, copy the BehavePlus5 folders you need to the BehavePlus6 directory. It is easier to copy the entire folder rather than individual files.

1. Open Windows Explorer®.
2. Browse to your BehavePlus5 folders.
3. Copy the entire folder (e.g., **C:\Behave\BehavePlus5\DefaultDataFolder\RunFolder\MyRuns**) to the new data structure (e.g., **C:\Behave\BehavePlus6\DefaultDataFolder\RunFolder\MyRuns_From5**).

> ***Note:*** *You must include the small (1 KB) file (e.g.,* ***MyRuns****) found in the folder for BehavePlus6 to recognize the folder structure.*

Setting a Workspace

To access Worksheet, Run, fuel model, units set, and moisture scenario files created under Version 5, open the Version 5 **DefaultDataFolder** as a workspace from BehavePlus6.

> ***Note:*** *Once you have opened a file with Version 6, you can no longer open it in version 5.*

1. Select **File > Workspaces > Open Workspace** to display a folder selection dialog.
2. Click on **My Computer** and browse to the location of your BehavePlus Version 5 files (e.g., **C:/Behave/BehavePlus5**.)
3. Highlight **DefaultDataFolder**, and press **OK**.

Better yet,

1. Open Windows Explorer®.
2. Browse to your BehavePlus5 folders.
3. Copy the entire Workspace (e.g., **C:\Behave\BehavePlus5\DefaultDataFolder**) somewhere else on your computer.
4. Browse to the *new* location (e.g., **C:\Behave\BehavePlus6\DefaultDataFolder**) and press **Ok**.

The Version 5 files are now available to use in Version 6. You may repeat this procedure for any other workspaces you may have created under Version 5.

For more information on copying files, please read the **Operation Unit**, *File Management Lesson* located at on the BehavePlus website's **Tips/Training** page under **Training Materials: Operation**.

8. Using Adobe PDF Products Effectively with BehavePlus Documents

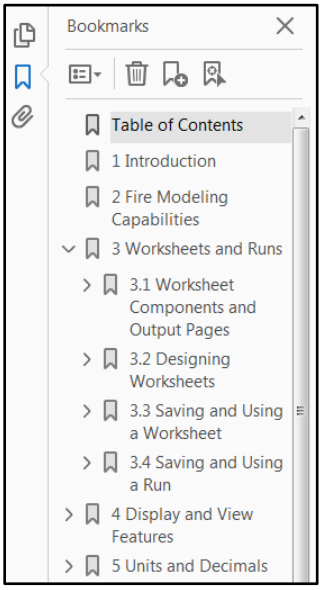
Many of the documents related to BehavePlus are provided as PDF documents. They can be either printed or viewed via a PDF viewer. You can download a free copy of Acrobat Reader DC from the Adobe website.

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

Bookmarks

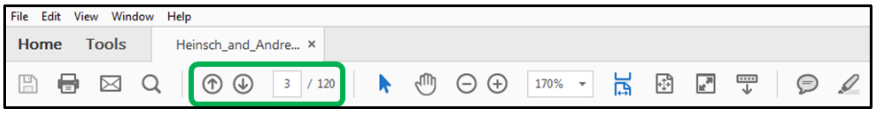
The Features Paper and Variables Paper both contain bookmarks for easy navigation. The content menu on the left-hand side of either Acrobat product contains bookmarks, which provide easy access to individual sections and subsequent sections of a document, allowing users to quickly find the needed information. 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

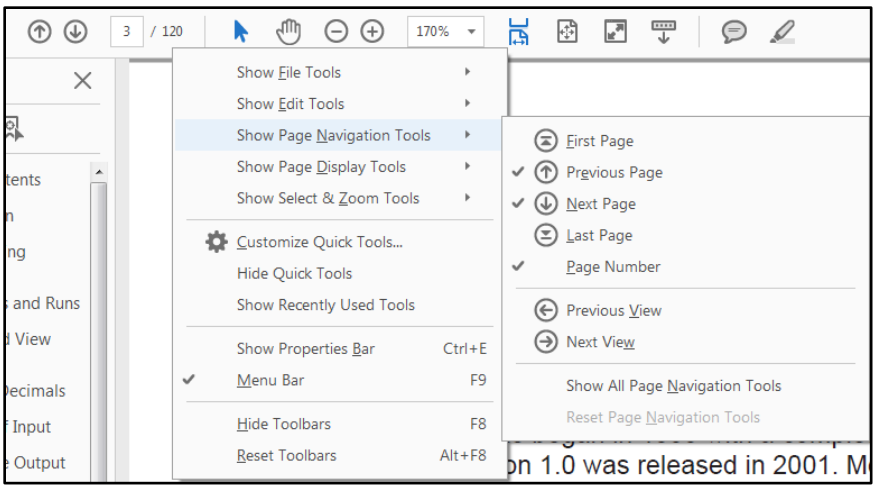
The **Page Navigation Toolbar** allows you to move easily through a document. Only a few options are normally shown as part of the default setup as shown in the green box below.



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.

9. Selecting a Grass Fuel Model for Prescribed Fire Planning

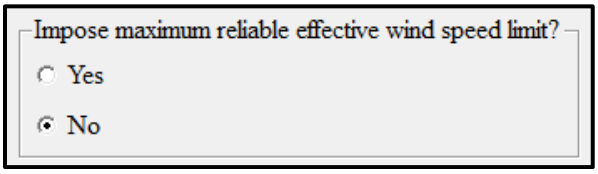
This example uses data from a National Park Service prescribed fire project in North Dakota. We use predicted and observed data to select a standard fuel model, which will prove useful in future prescribed fire planning.

Options in BehavePlus

There are two options available in BehavePlus for enhanced fire modeling. Both of these options are available only in BehavePlus. They are not available in the spatial fire behavior modeling systems.

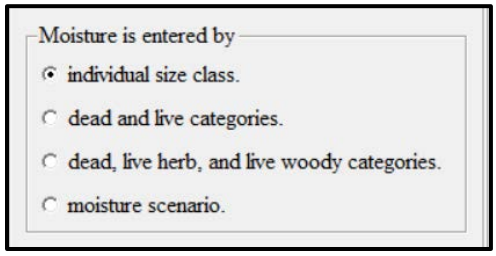
1. Users can elect to impose the maximum reliable wind speed or not.
2. User entry of fuel load transfer is allowed for dynamic fuel models rather than calculation from live herbaceous fuel moisture.

The first option is to elect not to impose the maximum reliable wind speed. This option is found in the **Module Selection > SURFACE Options… > Wind Speed**. The **Maximum reliable wind speed** value is calculated from the reaction intensity. When the wind limit is imposed (the default), surface fire rate of spread and flame length remain constant for winds above that value. The wind limit is reached more often for low intensity fuels, like grass. Dynamic grass fuel models have very low wind limits for high values of live fuel moisture. The user has the option of deciding whether that limit is appropriate. More information on the wind limit function is available in the paper by Andrews et al. (2013)



The second option discussed relates to dynamic curing load transfer found in Module Selection **>SURFACE > Options… > Moisture**. The default is to calculate the amount of fuel transferred from the

live to the dead fuel category from the live herbaceous fuel moisture content. The user has the option of direct entry of curing (fuel load transfer portion) if that information is available.



Fuel and fire behavior observations

Data from two fires (April and September) were used in this example. Each fire had two observations of head fire rate of spread and flame length. Monitoring data included wind speed, fuel loading, live and dead fuel moisture, and portion of live fuel. Table 1 provides a summary of observed values.

Table 1. Measured or observed conditions and fire behavior for the Big Hidatsa and Artifact prescribed fires.

Fire Location	Big Hidatsa Youess, N	Big Hidatsa Poly, N	Big Hidatsa Average	Artifact Youess, N	Artifact Poly, N	Artifact Average
Date	April 28, 2005			Sept. 28, 2005		
Time	1115	1200		1230	1400	
Fuel Model	X			X		
Dead Fuel Moisture %	9.6	10.0	10	13.7	11.6	12.7
Live Fuel Moisture %	218.2	221.0	220	60	79	70
Wind Speed, mi/h	10-12 G 19 NW (1100)	10-12 G 18 WNW (1200)	10-12 G 19	5 G 8-10 WNW (1230)	6 G 8-10 WNW (1315)	5-6 G 10
Portion Live Fuel %	40-50	40-50	40-50	20-30	20-30	20-30
Fuel Load Transfer %	50-60	50-60	50-60	70-80	70-80	70-80
Fuel Load, ton/ac	2.68	1.89	2.28	2.51	1.21	1.86
Direction	Head	Head		Head	Head	
ROS, ch/h	40	40	40	43.6	90.6	
Flame Length, ft	2-5	2-5	2-5	2-5	1.5-4.5	

Fuel Models

There are three grass fuel models in the original 13 (1, 2, and 3) and nine in the set of 40 fuel models (GR1 through GR9). Five of those nine models are categorized as 'humid' types and were eliminated from consideration. Table 2 gives the fuel parameters for the remaining seven grass fuel models. Fuel loading and the portion of live fuel is also provided for the two prescribed fires.

Table 2. Fuel model parameters for standard grass fuel models and observed values for the two burn sites.

Fuel Model	1	2	3	GR1	GR2	GR4	GR7	Big Hidatsa	Artifact
Dynamic or Static	S	S	S	D	D	D	D		
1-h Load, ton/ac	0.74	2.0	3.0	0.1	0.1	0.25	1.0		
10-h Load, ton/ac	--	1.0	--	--	--	--	--		
100-h Load, ton/ac	--	0.5	--	--	--	--	--		
Live Herbaceous Load, ton/ac	--	0.5	--	0.3	1.0	1.9	5.4		
Live Woody Load, ton/ac	--	--	--	--	--	--	--		
Fuel Bed Depth, ft	1.0	1.0	2.5	0.4	1.0	2.0	3.0		
Dead Fuel Moisture of Extinction, %	12	15	25	15	15	15	15		
Total Load, Dead and Live	1.74	4.0	3.0	0.4	1.1	2.15	6.4	2.28 (2.68, 1.89)	1.86 (2.51, 1.21)
% Load Transfer at 220% Live Fuel Moisture	0	0	0	0	0	0	0		
% Dead Fuel at 220% Live Fuel Moisture	100	87.5	100	25.0	9.1	11.6	15.6	50	XX
% Live Fuel at 220% Live Fuel Moisture	0	12.5	0	75.0	90.9	88.4	84.4	50	XX
% Load Transfer at 70% Live Fuel Moisture	0	0	0	56	56	56	56		
% Dead Fuel at 70% Live Fuel Moisture	100	87.5	100	66.7	59.6	60.8	62.5	XX	75
% Live Fuel at 70% Live Fuel Moisture	0	12.5	0	33.3	40.4	39.2	37.5	XX	25

A comparison provides guidance on which fuel models to consider.

- Fuel model 1 load and depth are appropriate, but fuel model 1 includes no live fuel. The new 40 fuel models were developed in part because the original 13 represent dry conditions and don't cover the range of conditions experienced in prescribed fire, or at times outside of the hot and dry portion of the fire season.
- Fuel model 2 includes live fuel, as well as 10-h and 100-h fuels, which are not appropriate for this project area. Also, the total fuel load of 4 tons/acre is higher than the measured values.
- Fuel model 3 includes only dead fuel. The fuel bed depth is 2.5 feet and the load is higher than that measured in the burn units.
- Fuel models GR1, GR2, GR4, and GR7 all contain 1-h dead and live herbaceous fuel. The moisture of extinction for each is 15%. GR1 total load is low while GR7 total load is very high.
- Fuel models GR2 and GR4 parameters most closely match the data collected for the prescribed fire units. Thus, these two fuel models will be considered for further analysis.

Compare calculations for different Fuel Models

Following is a calculation for conditions on the Big Hidatsa prescribed fire, for fuel models 1, GR2, and GR4. (Fuel model 1 is included for demonstrating the difference in models.)

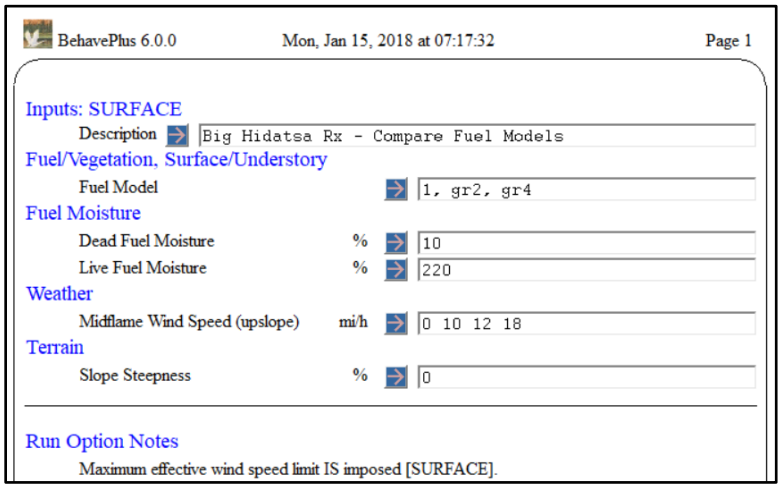
The initial Run uses the **SurfaceSimple.bpw** Worksheet with the default input options:

- The maximum reliable wind speed is imposed.
- Dynamic curing load transfer is calculated from live herbaceous fuel moisture.

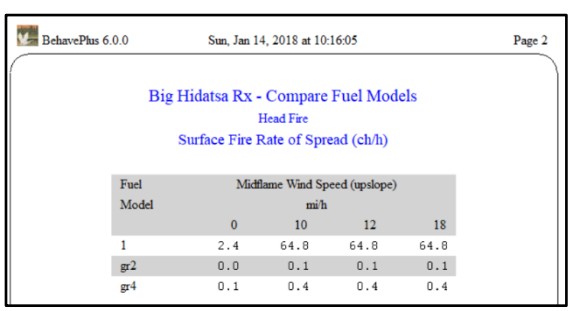
The output variables selected are

- Surface Fire Rate of Spread
- Surface Fire Flame Length
- Effective Wind Speed Limit

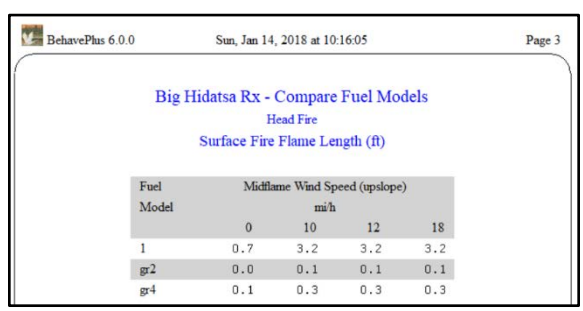
The input values for dead and live fuel moisture and wind speed are taken from Table 1.



Notice that the surface fire rate of spread and flame length values are the same for midflame wind speed values of 10, 12, and 18 mi/h.



Fuel Model	Midflame Wind Speed (upslope) mi/h			
	0	10	12	18
1	2.4	64.8	64.8	64.8
gr2	0.0	0.1	0.1	0.1
gr4	0.1	0.4	0.4	0.4



Fuel Model	Midflame Wind Speed (upslope) mi/h			
	0	10	12	18
1	0.7	3.2	3.2	3.2
gr2	0.0	0.1	0.1	0.1
gr4	0.1	0.3	0.3	0.3

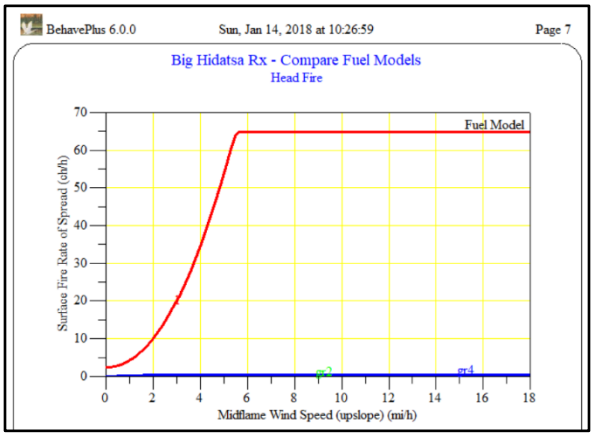
The reason that calculated fire behavior doesn't keep increasing with increasing wind is that the maximum effective wind limit has been imposed. For the moisture values in this Run, the wind limit is 5.5 mi/h for fuel model 1, 0.9 mi/h for fuel model GR2, and 2.2 mi/h for fuel model GR4.

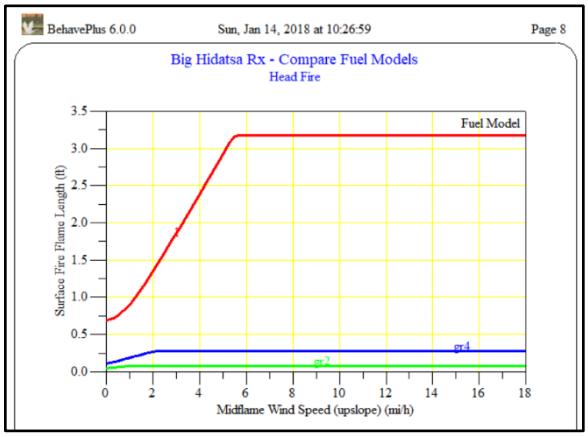
BehavePlus 6.0.0 Sun, Jan 14, 2018 at 10:26:59 Page 5

Big Hidatsa Rx - Compare Fuel Models
Head Fire
Surface Fire Effective Wind Speed Limit (mi/h)

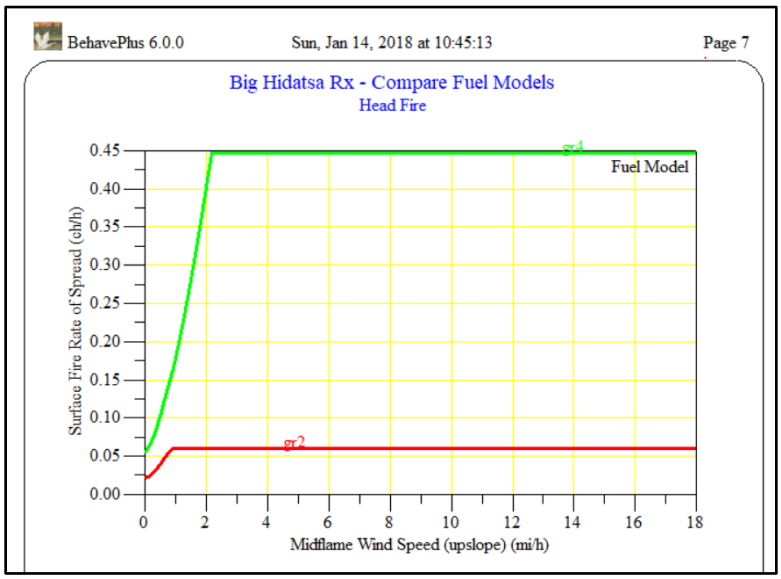
Fuel Model	Midflame Wind Speed (upslope) mi/h			
	0	10	12	18
1	5.5	5.5	5.5	5.5
gr2	0.9	0.9	0.9	0.9
gr4	2.2	2.2	2.2	2.2

The plots clearly show the effect of the wind limit.





We now remove fuel model 1 and look at the plots for only GR2 and GR4.



It seems unrealistic that the wind limit would be so low for fuel models GR2 and GR4. The wind limit is so low because the live fuel moisture of 220% is high, leading to a low reaction intensity for those fuel

models. Field observations (Table 3 and 4) show rate of spread and flame length that are higher than these predictions.

Effect of not imposing wind limit

The following Run is the same as above, with the option changed to **Maximum reliable effective wind speed limit is NOT imposed**.

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 11:01:49 Page 2

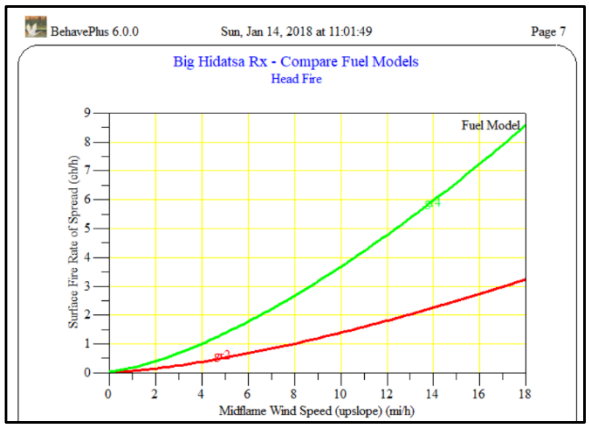
Big Hidatsa Rx - Compare Fuel Models
Head Fire
Surface Fire Rate of Spread (ch/h)

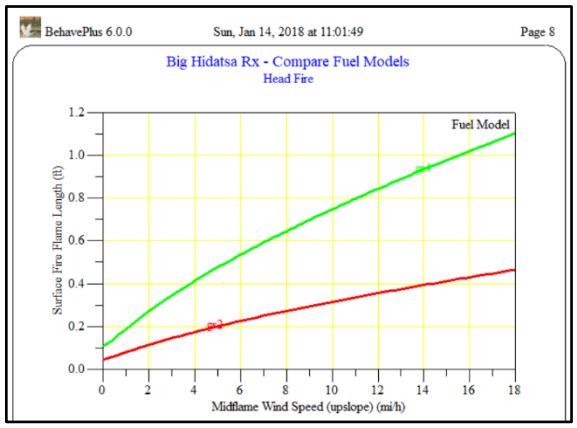
Fuel Model	Midflame Wind Speed (upslope) mi/h			
	0	10	12	18
gr2	0.0	1.4	1.8	3.2
gr4	0.1	3.7	4.8	8.6

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 11:01:49 Page 3

Big Hidatsa Rx - Compare Fuel Models
Head Fire
Surface Fire Flame Length (ft)

Fuel Model	Midflame Wind Speed (upslope) mi/h			
	0	10	12	18
gr2	0.0	0.3	0.4	0.5
gr4	0.1	0.7	0.8	1.1





Calculated values are still less than observed. In the next section we will see if we can improve the results using the option to specify dynamic curing.

Dynamic Fuel Models

The original 13 fuel models are all static, meaning fuel model parameters do not change. Seventeen of the 40 fuel models are dynamic, including all of the grass (GR) fuel models. The fuel loads listed for 1-h and for live herbaceous fuel are the values before fuel is transferred from the live to the dead category as a representation of the curing process. The original formulation of dynamic fuel models uses live herbaceous fuel moisture to calculate the fuel load transfer portion. For live herbaceous fuel moisture greater than 120%, no live fuel is transferred to the dead category. BehavePlus offers the option of specifying the portion of load transfer rather than using the calculated value.

Table 2 shows the calculated and observed portion of live fuel. For fuel model GR4 and live fuel moisture of 70%, the calculated portion of live fuel is 39.2% compared to an observed value of 40-50% (Table 1), which is close. There is a very large difference at 220% live fuel moisture. At this moisture value, 0% of the fuel would be transferred from live to dead, meaning that fuel model GR4 contains 88.4% live fuel, or double the observed value. (There is dead fuel in the fuel model even at 0% curing.)

The previous Runs use the default option of automatic calculation of load transfer portion (curing). We now select the option of user entry of a value for fuel load transfer portion and enter a value of 50% fuel load transfer portion rather than accepting the calculated value of 0%.

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 17:25:58 Page 1

Inputs: SURFACE

Description: Big Hidatsa Rx - Compare Fuel Models

Fuel/Vegetation, Surface/Understory

Fuel Model: gr2, gr4

Fuel Load Transfer Portion %: 50

Fuel Moisture

Dead Fuel Moisture %: 10

Live Fuel Moisture %: 220

Weather

Midflame Wind Speed (upslope) mi/h: 10 12 18

Terrain

Slope Steepness %: 0

Run Option Notes

Maximum effective wind speed limit is NOT imposed [SURFACE].

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 11:33:53 Page 2

Big Hidatsa Rx - Compare Fuel Models

Head Fire

Surface Fire Rate of Spread (ch/h)

Fuel Model	Midflame Wind Speed (upslope) mi/h		
	10	12	18
gr2	14.6	18.9	34.0
gr4	30.7	39.9	71.6

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 11:33:53 Page 3

Big Hidatsa Rx - Compare Fuel Models

Head Fire

Surface Fire Flame Length (ft)

Fuel Model	Midflame Wind Speed (upslope) mi/h		
	10	12	18
gr2	2.1	2.4	3.1
gr4	4.1	4.6	6.0

GR4 now produces values close to the observed fire behavior (ROS 40 ch/hr and flame length 2–5 ft).

Next, let's produce a table of values using the GR4 fuel model.

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 17:25:58 Page 1

Inputs: SURFACE

Description: Big Hidatsa Rx - Compare Fuel Models

Fuel/Vegetation, Surface/Understory

Fuel Model: gr4

Fuel Load Transfer Portion %: 50

Fuel Moisture

Dead Fuel Moisture %: 10

Live Fuel Moisture %: 220

Weather

Midflame Wind Speed (upslope) mi/h: 10 12 18

Terrain

Slope Steepness %: 0

Run Option Notes

Maximum effective wind speed limit is NOT imposed [SURFACE].

BehavePlus 6.0.0 Sun, Jan 14, 2018 at 17:55:09 Page 2

Big Hidatsa Rx - Compare Fuel Models

Head Fire

Midflame Wind Speed mi/h	Surface Fire Rate of Spread ch/h	Surface Flame Length ft	Fuel Load Transferred %	Dead Fuel Load Portion %
10	30.7	4.1	50	55.81
12	39.9	4.6	50	55.81
18	71.6	6.0	50	55.81

Following are calculations for the Artifact Rx burn, with lower live fuel moisture, more dead fuel, and lower wind speeds.

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 07:07:13 Page 1

Inputs: SURFACE

Description: Artifact Research Rx

Fuel/Vegetation, Surface/Understory

Fuel Model: gr4

Fuel Load Transfer Portion %: 75

Fuel Moisture

Dead Fuel Moisture %: 12

Live Fuel Moisture %: 70

Weather

Midflame Wind Speed (upslope) mi/h: 5 6 10

Terrain

Slope Steepness %: 0

Run Option Notes

Maximum effective wind speed limit is NOT imposed [SURFACE].

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 07:07:13 Page 2

Artifact Research Rx

Head Fire

Midflame Wind Speed mi/h	Surface Fire Rate of Spread ch/h	Surface Flame Length ft	Fuel Load Transferred %	Dead Fuel Load Portion %
5	47.2	6.1	75	77.91
6	61.0	6.9	75	77.91
10	126.4	9.6	75	77.91

The rates of spread are in the range of observed values, but the flame lengths are higher than observed.

It is worth noting that under essentially the same conditions the observed rate of spread on one plot was 43.6 ch/h and 90.9 ch/h on the other (Table 1). Variations in fuel, moisture, and wind speed must be recognized as they change across the landscape and over time. In addition, it is difficult to accurately measure fuel moisture, wind, rate of spread, and flame length in the field.

With a limited data set, the objective cannot be to precisely match predicted and observed values, but rather to use the observations to guide selection of a fuel model that performs reasonably well under the conditions associated with the prescribed fires.

A summary of observations and calculations is provided in Table 3 and Table 4.

Table 3. Calculated fire behavior

	Big Hidatsa	**Big Hidatsa**	**Big Hidatsa**	**Big Hidatsa**	**Artifact**	**Artifact**	**Artifact**
Fuel Model	GR4	GR4	1	1	GR4	GR4	1
Curing	Calculated Curing	Input Curing	Static	Static	Calculated Curing	Input Curing	Static
Dead Fuel Moisture, %	10	10	10	10	12	12	12
Live Fuel Moisture, %	220	220			70	70	
Wind Speed, mi/hr	10-18	10-18	10-18	10-18	5-10	5-10	5-10
Input Fuel Load Transfer, %	X	50			X	75	
Calculated Dead Fuel Portion, %	X	56			X	78	
Calculated Fuel Load Transfer, %	0	X			56	X	
Surface ROS, ch/hr	4-9	31-72	217-729	65-65	35-94	47-126	0
Flame Length, ft	0.5-1.0	4-6	5.5-9.7	3.2-32.0	5-8	6-9	0
Wind Limit Imposed?	No	No	No	Yes	No	No	No

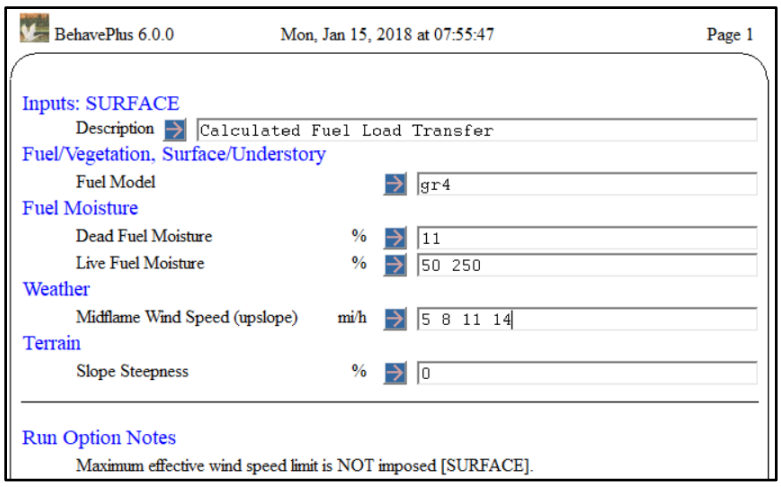
.
Table 4. Observed fire behavior

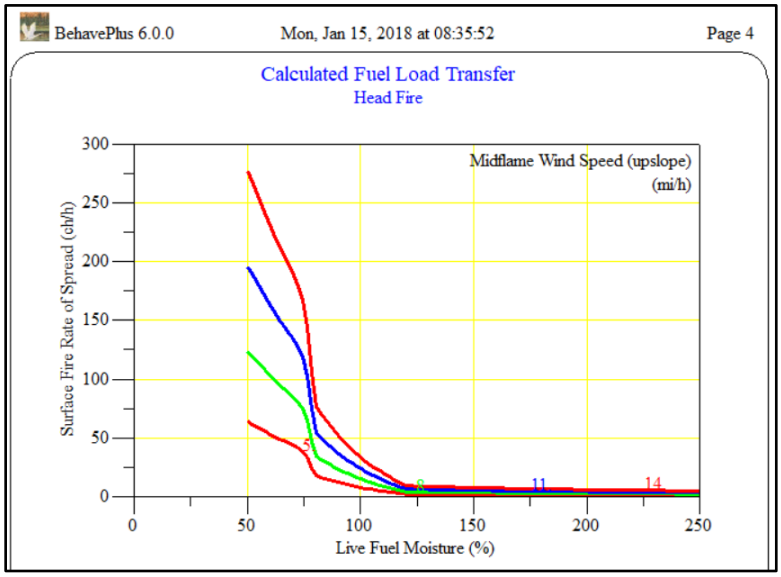
	Big Hidatsa	**Artifact**
Observed Surface ROS, ch/h	40	67.2 (43.6-90.9)
Observed Flame Length, ft	2-5	2-5 (1.5-4.5)

Direct entry of fuel load transfer for dynamic fuel models

The increased flexibility of dynamic fuel models comes with the added responsibility for users to understand how they work. It takes some effort to fully understand them.

Next, we do some additional Runs to illustrate the difference in calculated load transfer versus direct entry for this example. The two prescribed fires had live fuel moisture values of 70% and 220%. Let's look at the Surface Fire Rate of Spread for a range of Live Fuel Moistures from 50 to 250% and Midflame Wind Speeds from 5 to 14 mi/h.





The graphs show that there is essentially no spread when the live fuel moisture is greater than 120%. However, the prescribed fire conducted with live fuel moisture of 220% did burn. There is a large drop in calculated spread rate at about 75%. A look at a subset of values in a table shows the large change in spread rate for a little change in live fuel moisture.

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 08:41:23 Page 2

Calculated Fuel Load Transfer

Head Fire

Surface Fire Rate of Spread (ch/h)

Live Fuel Fuel Moisture %	Midflame Wind Speed (upslope) mi/h 5	8	11	14
70	44.1	85.8	135.4	191.7
72	42.0	81.7	129.0	182.6
74	39.0	75.9	119.8	169.6
76	34.2	66.4	104.9	148.5
78	25.8	50.2	79.2	112.1
80	17.8	34.7	54.7	77.5
82	16.6	32.2	50.8	72.0
84	15.4	29.9	47.1	66.7

At a midflame wind of 8 mi/h, spread rate is 34.7 ch/h at 80% moisture, and 66.4 ch/h at 76% moisture. This is close to a doubling of spread rate for a 4% drop in live fuel moisture. This sensitivity of the model to changes in live fuel moisture is unrealistic. It is not possible to know the live fuel moisture to that level of precision. These results are due to the combined effect of live fuel moisture in the rate of spread calculations and the use of live fuel moisture to change the dynamic fuel model.

The following Run uses the option of calculated fuel load transfer portion, an 8 mi/h wind, and additional output variables. We will compare these results to those obtained using the option of direct entry of fuel load transfer portion.

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 08:41:23 Page 1

Inputs: SURFACE

Description: Calculated Fuel Load Transfer

Fuel/Vegetation, Surface/Understory

Fuel Model: gr4

Fuel Moisture

Dead Fuel Moisture %: 11

Live Fuel Moisture %: 50 60 70 80 90 200 220 250

Weather

Midflame Wind Speed (upslope) mi/h: 5 8 11 14

Terrain

Slope Steepness %: 0

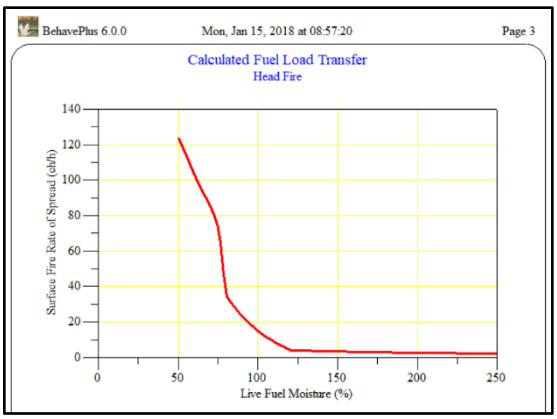
Run Option Notes

Maximum effective wind speed limit is NOT imposed [SURFACE].

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 08:57:20 Page 2

Calculated Fuel Load Transfer
Head Fire

Live Fuel Fuel Moisture %	Surface Fire Rate of Spread ch/h	Surface Flame Length ft	Fuel Load Transferred %	Dead Fuel Load Portion %
50	123.8	10.3	78	80.38
60	103.4	9.3	67	70.57
70	85.8	8.5	56	60.76
80	34.7	4.0	44	50.95
90	23.6	3.0	33	41.14
200	2.7	0.6	0	11.63
220	2.5	0.6	0	11.63
250	2.2	0.6	0	11.63



We now change the option to direct entry of fuel load transfer portion.

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 20:40:45 Page 1

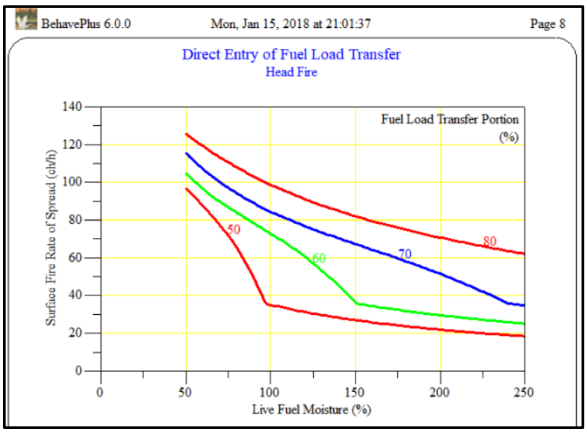
Inputs: SURFACE
Description: Direct Entry of Fuel Load Transfer
Fuel/Vegetation, Surface/Understory
Fuel Model: gr4
Fuel Load Transfer Portion %: 50, 60, 70, 80
Fuel Moisture
Dead Fuel Moisture %: 11
Live Fuel Moisture %: 50 60 70 80 90 200 220 250
Weather
Midflame Wind Speed (upslope) mi/h: 8
Terrain
Slope Steepness %: 0

Run Option Notes
Maximum effective wind speed limit is NOT imposed [SURFACE].

BehavePlus 6.0.0 Mon, Jan 15, 2018 at 20:57:48 Page 2

Direct Entry of Fuel Load Transfer
Head Fire
Surface Fire Rate of Spread (ch/h)

Live Fuel Fuel Moisture %	Fuel Load Transfer Portion % 50	60	70	80
50	97.1	105.1	115.6	125.9
60	87.7	96.6	107.1	119.2
70	77.5	89.7	100.1	113.3
80	65.0	83.8	94.1	107.9
90	49.3	78.3	88.9	103.1
200	21.9	29.6	51.4	70.7
220	20.4	27.6	44.1	67.0
250	18.4	25.2	34.8	62.0



Note the difference in spread rate for live fuel moisture over 120%. Compare this graph to the previous graph. It demonstrates the differences in fire behavior predictions using the automatic calculation of fuel load transfer and the direct entry of estimated curing.

Summary

It is useful to compare predicted and observed rates of spread and flame lengths to choose the most appropriate fuel model for a project or incident under similar conditions. Even data from two fires is worthwhile. Additional data can be used to confirm or revise the selection.

It is not just a matter of selecting a fuel model. Two modifications in BehavePlus (removal of maximum effective wind speed and direct entry of fuel load transfer portion) can improve predictions for prescribed and wildland fire management. Note however, that these modifications are not included in the spatial fire behavior modeling systems.

Variation in both time and space and the difficulty of recording observations in both conditions and fire behavior must be recognized when comparing predicted and observed values.