Summary of changes from the old BEHAVE through each version of BehavePlus

The BEHAVE fire behavior prediction and fuel modeling system was first available to the field in 1984. JFSP funded a much-needed redesign and update to the BehavePlus fire modeling system version 1.0, which was released in 2002. Version 2.0 was released in 2003, Version 3.0 in 2005, and Version 4.0 in 2008. Each version update has offered additional features and fire modeling capabilities. The most significant changes are given here.

BehavePlus version 1 compared to the old BEHAVE

The old BEHAVE fire behavior prediction and fuel modeling system is a set of five DOS programs, three of which were first available in 1984. The whole look and feel of the BehavePlus fire modeling system is different, using updated user interface technology. Following are some specific differences that will be of interest to users of the old BEHAVE system:

- BehavePlus is one program. The old BEHAVE was 5 programs (FIRE1, FIRE2, RXWINDOW, NEWMDL, TSTMDL). The separation was due to computer limitations at the time and an extended development period.
- BehavePlus gives the user control of input options that were fixed on the old BEHAVE. For example, in the old BEHAVE:
    - The DIRECT module required direct input of fuel moisture by size class, midflame wind speed, and direction of wind and spread with respect to upslope.
    - The SITE module calculated fine fuel moisture and requested input of 20-ft wind speed, exposure to the wind, and direction of wind and spread.
    - The DISPATCH module requested dead and live fuel moisture, 20-ft wind speed and wind adjustment factor. Calculations were for upslope spread with the wind.
    - In the TSTMDL program, fuel moisture was specified by category.

  In contrast, the BehavePlus SURFACE module allows users to specify the method of entry for fuel moisture, wind speed, and directions.
- In BEHAVE only continuous variables could be assigned more than one value for a maximum of 7 values. For example, wind speed could be assigned a range of values, but fuel model could not. BehavePlus allows multiple input values for every variable and there is essentially no limit to the number of values. Table output is carried over to multiple pages if necessary.
- BehavePlus produces graphs and diagrams as well as tables. The primary output of the old BEHAVE was tables. Crude graphs were produced using characters.
- The fuel modeling portion of the old BEHAVE consisted of the NEWMDL and TSTMDL programs. The features in NEWMDL are not in BehavePlus. The TSTMDL fuel model testing methods are in BehavePlus.

- BehavePlus does not include the fine dead fuel moisture model in MOISTURE and SITE modules in the FIRE2 program of BEHAVE. A better moisture model based on hourly weather data has been developed and is used in FARSITE and is being incorporated into the National Fire Danger Rating System (NFDRS) and the FireFamily Plus program. Eventually it will be available for fire behavior calculations in BehavePlus. BehavePlus offers the fuel moisture tables as a tool.
- The CONTAIN module of BehavePlus is different from that used in BEHAVE. The old model had a mathematical problem that occasionally surfaced. BehavePlus uses a model by Fried and Fried (1996) that offers the application of multiple resources with various productivity rates and arrival times, and direct or parallel attack at either the fire head or rear. BehavePlus does not offer the option of reverse calculation that was in the old BEHAVE (i.e. given a final fire size, what is the required line production rate).
- The RxWindow program is not and will not be part of BehavePlus. Reverse calculation becomes more difficult (essentially impossible) as models are added. The plan is to provide a new method of table shading to aid in prescribed fire planning.
- The equations in the MORTALITY module in BehavePlus have been updated to match those of FOFEM. Many new tree species have been added.
- BehavePlus lists input values by category (Fuel/Vegetation, Weather, …) rather than by module (DIRECT, SIZE, …) as was done in the old BEHAVE.
- In BehavePlus users select the output variables to be displayed. In BEHAVE the output list was fixed.
- Map distance calculation was a stand-alone feature in BEHAVE. It is integrated into BehavePlus.
- BEHAVE asked users whether they were using a computer with a screen. The program could be run in either WORDY or TERSE mode. BehavePlus assumes that it is being run on a 21st century personal computer.

BehavePlus version 2 compared to version 1

- Safety zone size model is added as a new SAFETY module.
- Containment model is added as a new CONTAIN module. This is a new model that allows multiple resources to make direct or parallel attack.
- Probability of ignition by lightning model is added to the IGNITE module.
- Three methods of weighting two fuel models for rate of spread calculations is added to the SURFACE module.
- Dynamic palmetto-gallberry fuel model (Hough and Albini 1978) is added to the SURFACE module.
- Size diagram output is added to SIZE.
- Contain diagram output is in CONTAIN.
- Direction diagram is added to SURFACE.
- Fire characteristics chart diagram output is added to SURFACE.
- Fine dead fuel moisture is added as a new tool.
- A Run Option section is added to the worksheets for clarification.

- The contents of the Notes section on example worksheets is blank. The description of the worksheet that was there for version 1 is not necessary, especially with the addition of the Run Options section.
- The 'Standard' worksheet folder that was supplied with version 1 of the program is called the ExampleWorksheets folder in version 2 to better reflect what it is. The worksheets in that folder are just some that the developers put together. The term 'standard' gave them significance that they didn't deserve.
- The Blank.bpw Worksheet that was in version 1 is called the 0Startup.bpw Worksheet in version 2 to better reflect what it is—the worksheet to use as a startup in selecting calculation modules. (The '0' as a first character of the file name puts it as the first item on the list for easy selection.)
- The program now automatically loads the 0Startup.bpw worksheet upon initiation. This saves some steps if the worksheet is set up by module selection. If a previously saved worksheet is desired, it is selected and loaded as before with File > New.
- The Fuel model guide button gives you access to the photographs and descriptions in Anderson (1982) "Aids to selecting fuel models" and to the selection key in Rothermel (1983) "How to predict the spread and intensity of forest and range fires".
- The Program Help and the Users Guide for version 1 have been replaced by a single, new document—a users guide in PDF format that can be both printed and accessed online for specific help.
- A Language option has been added. Portuguese is provided as an example.
- Additional Workspace options aid in file management.
- Graph y-axes are now user-scalable.

BehavePlus version 3 compared to version 2

- A new CROWN module to calculate transition to crown fire and crown fire spread rate is added.
- Calculation of wind adjustment factor (WAF) for fuel sheltered by overstory trees is added to SURFACE.
- Table shading according to user-specified ranges of acceptable conditions for prescribed fire planning is available.
- A CONTAIN option is added for single resource dispatch so tables and graphs can be produced for ranges of line construction rate, etc.
- The ability to export table output to a spreadsheet for further analysis or custom display is available.
- RH module is replaced by an RH tool.
- The step function from the calculation of probability of ignition by a firebrand is resolved and removed.
- Forty new surface fuel models, some with dynamic herbaceous live-to-dead fuel load transfer as a function of live fuel moisture are available in SURFACE.
- A new moisture scenario set (named "FuelModeling") that was used to develop the new fuel models is added.
- Custom fuel models can be exported in the file format required by FARSITE, FlamMap, and NEXUX.

- When the program starts up, a new "BasicStart.bpw" example worksheet is automatically loaded.
- Module names are included on the Output Variables and Run Options lists for added clarity.
- The "Fuel/Vegetation" worksheet section has been split into "Surface/Understory" and "Overstory" sections.
- The Worksheet Appearance Dialog has a new option "show descriptions only for entered variable codes" as well as the "show descriptions for all discrete variable codes". The new option is the default for example worksheets.
- A "SurfaceCrown.bpm" worksheet has been added to the set of example worksheets.
- An updated User's Guide reflects operational changes. An index has been added.
- In-program help screens are updated with variable definitions and explanations.
- Tutorials 1-4 are updated and reorganized.
- New tutorials focus on new modeling capabilities.

BehavePlus version 4 compared to version 3

- The User's Guide is updated to reflect operational changes.
- A new Variables paper includes variable descriptions from the help windows and input/output tables (Andrews 2008). The pdf document is available through the help system and includes many internal linkages to make is a useful reference guide.
- As part of a JFSP funded project, the tutorials were updated, new lessons are available, and a plan for future training material development was prepared.
- The BehavePlus program and supporting material has been moved to a new web site: www.firemodels.org, for fire behavior and fire danger software.
- Photographs and values for canopy cover, stand height, canopy bulk density, and canopy base height are available in help windows. The information is taken from Scott and Reinhardt (2005) ‘Stereo photo guide for estimating fuel characteristics in conifer stands.’
- The user has the option of identifying a worksheet to open at startup, rather than the BasicStart.bpw worksheet.
- A tool was added to calculate horizontal map distance from ground map distance and direction with respect to upslope.
- The option was added to not impose the maximum reliable wind speed limit for the Rothermel surface fire spread model. Spread rate increases with increasing wind speed rather than being constant for high wind speeds.
- The option was added to input curing level (fuel load transfer portion) for dynamic fuel models rather than calculating curing from live herbaceous fuel moisture.
- A special case fuel model was added for western aspen (Brown and Simmerman 1986).
- If bark thickness is a user input for MORTALITY, ‘mortality equation’(spruce or not-spruce) is an input. This clarifies that the 206 species available for ‘mortality species’ is used only to calculate bark thickness.
- Additional output variables are available for SURFACE. ‘Intermediate’ output values will aid understanding of the Rothermel surface fire spread model.

- Fuel model names were changed to specifically mention short and long needle litter and to clarify that the fuel models are for surface fuel, not for the overstory.
    - 8—'Closed timber litter' to 'Short needle litter'
    - 9—'Hardwood litter' to 'Long needle or hardwood litter'
    - 10—'Timber with litter & understory' to 'Timber litter & understory'
    - TU4—'Dwarf conifer with understory' to 'Dwarf conifer understory'
- Output variables were added to help understanding of calculated Wind Adjustment Factor: Crown fill portion and WAF calculation (sheltered or unsheltered).
- Crown fire area and perimeter output variables were added, using the equations in Rothermel (1991).
- 'Conditional crown fire' was added as a 'fire type'. In version 3 if Transition to crown fire? was 'no', then the fire type was 'surface', whether 'Active crown fire? was 'yes' or 'no'.
- Changes to the main menu are more logical. For example, File > New is now File > Open worksheet.
- File > saveAs > Results > Spreadsheet or Html is now File > Export results. In version 3, save as spreadsheet save the output table without input values as a .txt file. In version 4, only html files are exported. These files can be viewed in a browser, or they can be opened with spreadsheet software and then saved in spreadsheet format.
- An ExportFolder has been added as the default location for Export results.
- For the option 'Table shading for acceptable fire conditions,' the option is added to produce tables with blank cells rather than crossed out values. The option is available in Configure > Appearance preferences > Tables tab.
- Values entered in the 'Fine dead fuel moisture' tool are remembered the next time the tool is used for the current session.
- Another option has been added for worksheet header lines, for prescribed fire planning.
- The Language option was eliminated. Portuguese was available in version 3, as an example of how a translated version of BehavePlus could be developed. Due to lack of interest, the option has been disabled for now.
- In version 3.0.2, the program sometimes ran slowly or not at all, particularly when installed in the default directory of 'C:/SEM'. This has been fixed in version 4.0.