Reference Guide

Basic and Short-Term Fire Behavior

1.5

Contents

WFDSS Basic Fire Behavior

The automated version of WFDSS Basic Fire Behavior (BFB) is a very simple way to get "snapshot in time" fire behavior outputs for every cell (usually 30x30 meters) on the user-defined landscape extent.

To run the analysis, you need only the following information:

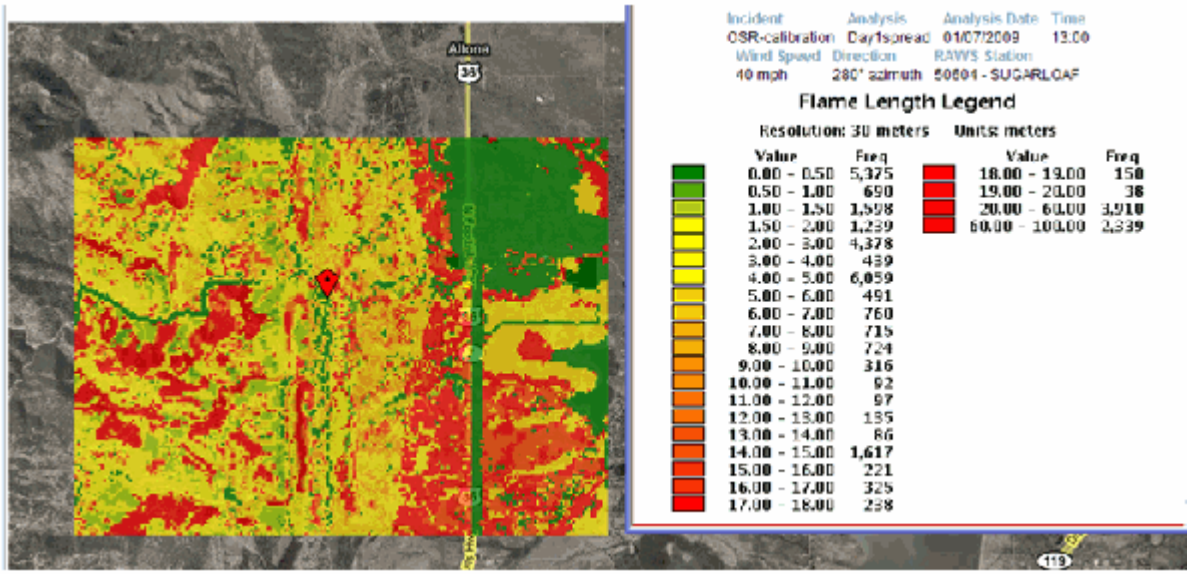
- Defined analysis area / landscape extent (normally no larger than about 5-6 miles per side)
- Start date and time for the analysis

The model retrieves historic or forecasted weather and winds for the analysis date and time. You can choose to accept the wind speed and direction provided or replace those input values with ones you choose. Within a short time (usually within a minute or so), fire behavior results will be ready for viewing.

Note: It is important to remember that the more automated the model, the less ability you have to refine the inputs. Because WFDSS BFB is highly automated (providing fuels, weather, and topography data, and requiring very few inputs from the user), *carefully critique the results* before using them for supporting wildland fire decision making.

WFDSS Basic - What it is

WFDSS Basic Fire Behavior (BFB) is a web-based fire behavior application. It gives "snapshot in time" fire behavior outputs (flame lengths, rates of spread, fireline intensities, etc.) for an entire user-defined landscape extent using one set (per cell) of wind and fuel moisture conditions. WFDSS BFB can be thought of as a "spatial BEHAVE or BehavePlus". Using fuels, topography, and weather data, fire behavior characteristics are calculated and displayed for every cell of the landscape extent.



Flame Length Example

WFDSS Basic - What it needs (inputs)

Like BEHAVE and BehavePlus, WFDSS Basic Fire Behavior (BFB) requires the following information to perform fire behavior calculations:

- fuels
- weather (winds and fuel moisture values)
- topography

WFDSS BFB automatically provides nearly all of the necessary information to perform fire behavior calculations.

Caution: The quality of the output from the analysis is only as good as the data input into the model. Before using the output results to support wildland fire decision-making, be sure that you understand the inputs: fuels data being used, the appropriateness of the RAWS from which fuel moistures are calculated, and the validity of the weather forecast data.

The following table lists the inputs required for the automated WFDSS Basic Fire Behavior model:

Input	Source	Editable Value
Landscape data	WFDSS	Can choose one of the following from the Incident Information page (HOWEVER you may NOT edit): - AK Tanana Zone - AK Yukon-Charley - CA Landscape - LANDFIRE National - LANDFIRE Rapid Refresh
Foliar Moisture Content	WFDSS default (100%)	Not Viewable or Editable
Live fuel moistures	From the WFDSS-selected RAWS and based on the standard NFDRS algorithms	Not Viewable or Editable
Weather observations (for 7-day fuel moisture conditioning of dead fuels)	Nearby RAWS*	Not Viewable or Editable
Weather forecast information for fire behavior predictions	National Digital Forecast Data (NDFD) based on the RAWS location	Not Viewable or Editable
Wind speed and direction forecast information for fire behavior predictions	National Digital Forecast Data (NDFD) based on the center of the user-defined landscape extent	Can change: - wind speed - wind direction

Input	Source	Editable Value
(wind speed and direction values are used as inputs to generate gridded winds)		
Landscape extent (extent of analysis area)	User-defined	Draw the landscape extent (normally no more than 5-6 miles per side)
Name of analysis	User-defined	Name the analysis
Analysis Date and Time	User-defined	Enter the analysis date and time

** WFDSS chooses the nearby RAWS in the following way: The center of the analysis area is used as a starting point. Then, a horizontal/vertical distance algorithm sorts the RAWS stations within a given area. Next, WFDSS iterates through the list until the first station is found with the requisite fuel moisture / weather information (continuous hourly observations).*

WFDSS Basic - What it does (outputs)

Using the analysis date, WFDSS retrieves the previous seven days of RAWS data to do fuel moisture conditioning (of dead fuels) for each cell of the landscape extent. The dead fuel moistures that have been calculated by the analysis start date and time are what are used by WFDSS Basic Fire Behavior (BFB) to provide fire behavior outputs for each cell. Wind direction and speed is provided from NDFD and, if desired, you can change those values or accept them. The wind values are then used by WindNinja to create gridded winds for the landscape extent. Using the fuel moistures and gridded winds, BFB calculates fire behavior characteristics. BFB provides many of the same fire behavior outputs as BEHAVE (and BehavePlus). Below are the outputs available in WFDSS BFB and their units:

Output	Display Units
Flame Length	meters
Fireline Intensity	kilowatts per meter (kW/m)
Rate of Spread	meters per minute (m/min)
Heat per Unit Area	kilojoules per meter squared (kJ/m^2)
Crown Fire Activity	0 (no fire), 1 (surface fire), 2 (torching), 3 (active crown fire)
Maximum Spread Direction	radians

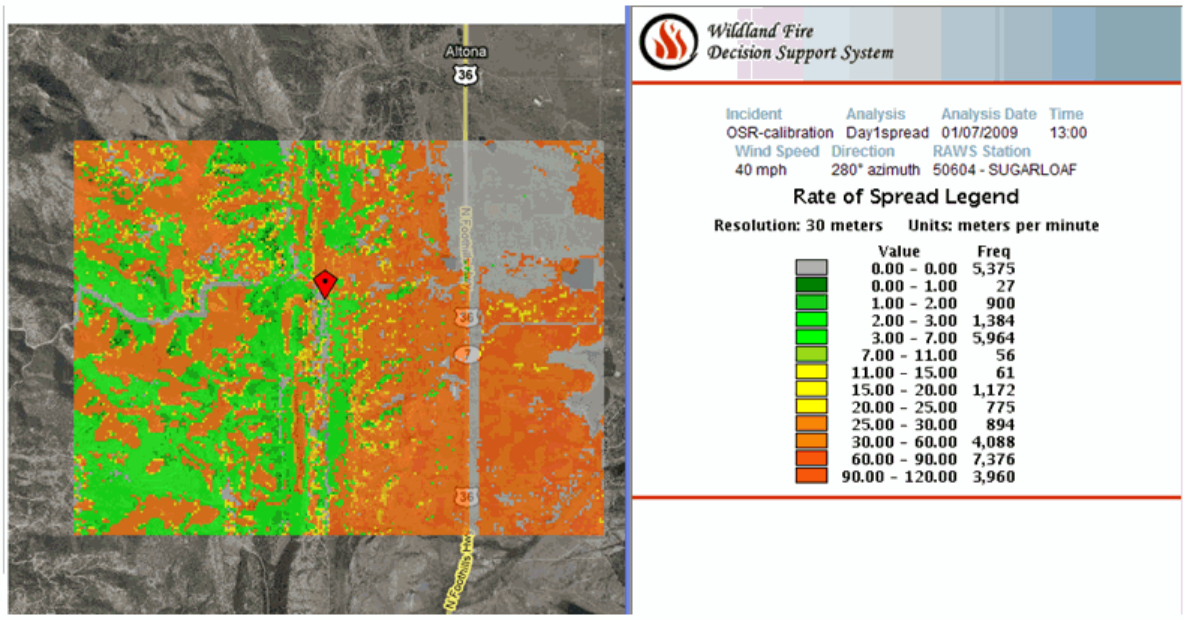
WFDSS BFB also calculates the following environmental outputs:

Output	Display Units
1 hour fuel moisture	fraction (e.g., 0.06 = 6%)
10 hour fuel moisture	fraction (e.g., 0.18 = 18%)
Solar radiation	watts per meter squared (W/m^2)

Because it is geospatial, WFDSS BFB calculates and maps the outputs for every cell on a landscape for an instant in time. In the current automated version, WFDSS BFB does not allow the user to change the units, legend or save the outputs. Currently, the outputs can only be displayed within WFDSS; however, you can save screen captures. BFB analysis results will automatically be deleted after 20 days.

WFDSS Basic - What it means (interpretation)

WFDSS Basic Fire Behavior (BFB) output results are fairly straightforward to interpret. When you choose a specific fire behavior output, BFB displays the calculated fire behavior characteristics for every cell of the landscape extent, based on the analysis start date and time. The image below shows an example of BFB analysis with the Rate of Spread output displayed.



Rate of Spread Example

The legend provides the following information:

- inputs used for the analysis, such as the Analysis Date and Time, Wind Speed and Direction, and RAWS Station used
- resolution (in this case, 30 meters)
- units (in this case, meters per minute)
- rate of spread value class that corresponds with each color
- frequency or number of cells in each value class.

When interpreting these output results, it is crucial to remember the numerous WFDSS BFB Assumptions and Limitations.

1) WFDSS Basic Fire Behavior (BFB) calculates fire behavior outputs using fuel moistures based on topographic information, forest canopy cover, and the previous seven days of weather data (for fuel moisture conditioning) from the WFDSS-selected RAWS. However, the RAWS selected by WFDSS cannot be changed by the user. In addition, RAWS data cannot be viewed or edited.
2) The wind speed and direction (from historic observations, NDFD, or supplied by the user) are used as inputs into WindNinja to create gridded winds at 200 meter resolution.
3) Fire behavior calculations are performed independently for each cell on the landscape

4) WFDSS BFB uses the same underlying fire models (Rothermel's 1972 surface fire model, Van Wagner's 1977 crown fire initiation model, Rothermel's 1991 crown fire spread model, and Nelson's 2000 dead fuel moisture model) used in other fire behavior applications, thus the assumptions and limitations of those underlying fire models are inherent within WFDSS BFB.

5) As with all models, the quality of the outputs from WFDSS BFB depends on the quality of the inputs. If the landscape data or RAWS data used are inadequate, the resulting fire behavior outputs will be questionable. It is important to be familiar with and assess the fuels data, as well as the RAWS data *before* using WFDSS BFB in support of wildland fire decision-making. If the input data are suspect, then consider the output results suspect as well.

6) WFDSS BFB does not allow the user to save the outputs, they can only be displayed within WFDSS. **In addition, after 20 days the analysis is automatically deleted by WFDSS.**

7) It is important to remember that the more automated the model, the less ability the user has to refine the inputs. Because WFDSS BFB is highly automated (providing fuels, weather, and topography data, and requiring very few inputs from the user), carefully critique the results before using them for supporting wildland fire decision-making.

WFDSS Basic - Why use it - (potential uses)

Outputs from WFDSS Basic Fire Behavior (BFB) have a variety of uses. Some examples include:

- Fire behavior outputs (Flame lengths, rates of spread, crown fire activity, etc.) can be calculated using forecasted weather and displayed in WFDSS BFB to provide insight into expected fire behavior across the landscape extent for a chosen time (e.g., the peak of the burning period for the next afternoon).
- Using forecasted weather, landscape-wide 1hour and 10hour fuel moistures could be calculated for determining likelihood of successful burnout conditions
- Using archived (historic) wind and weather observations, WFDSS BFB calculations could be used for critiquing landscape fuels data by choosing a date and time of a 2008 fire that had recorded fire behavior observations. For example, the BFB Crown Fire Activity output could be compared to actual observations of crown fire activity for a given time and location.

WFDSS Basic - Assumptions and Limitations

1) WFDSS Basic Fire Behavior (BFB) calculates fire behavior outputs using fuel moistures based on topographic information, forest canopy cover, and the previous seven days of weather data (for fuel moisture conditioning) from the WFDSS-selected RAWS. However, the RAWS selected by WFDSS cannot be changed by the user. In addition, RAWS data cannot be viewed or edited.

2) The wind speed and direction (from historic observations, NDFD, or supplied by the user) are used as inputs into WindNinja to create gridded winds at 200 meter resolution.

3) Fire behavior calculations are performed independently for each cell on the landscape

4) WFDSS BFB uses the same underlying fire models (Rothermel's 1972 surface fire model, Van Wagner's 1977 crown fire initiation model, Rothermel's 1991 crown fire spread model, and Nelson's 2000 dead fuel moisture model) used in other fire behavior applications, thus the assumptions and limitations of those underlying fire models are inherent within WFDSS BFB.

5) As with all models, the quality of the outputs from WFDSS BFB depends on the quality of the inputs. If the landscape data or RAWS data used are inadequate, the resulting fire behavior outputs will be questionable. It is important to be familiar with and assess the fuels data, as well as the RAWS data *before* using WFDSS BFB in support of wildland fire decision-making. If the input data are suspect, then consider the output results suspect as well.

6) WFDSS BFB does not allow the user to save the outputs, they can only be displayed within WFDSS. **In addition, after 20 days the analysis is automatically deleted by WFDSS.**

7) It is important to remember that the more automated the model, the less ability the user has to refine the inputs. Because WFDSS BFB is highly automated (providing fuels, weather, and topography data, and requiring very few inputs from the user), carefully critique the results before using them for supporting wildland fire decision-making.

WFDSS Short-Term Fire Behavior (STFB)

The automated version of WFDSS Short-Term Fire Behavior (STFB) is a quick way to get an idea of potential fire spread from a point location using one set of wind and fuel moisture conditions for the user-defined burn period(s).

The current automated version of STFB requires only the following information from the user:

- Name for the analysis
- Analysis Date and Time
- Fire start location (click a point on the map or enter latitude/longitude information)
- Defined analysis area/ landscape extent (normally no larger than 5-6 miles per side)
- Length of the burn period
- Number of burn periods for the analysis

The model retrieves forecasted weather and winds for the selected time, using National Digital Forecast Data (NDFD) for current simulations. For historic fires, the model can use historic weather.

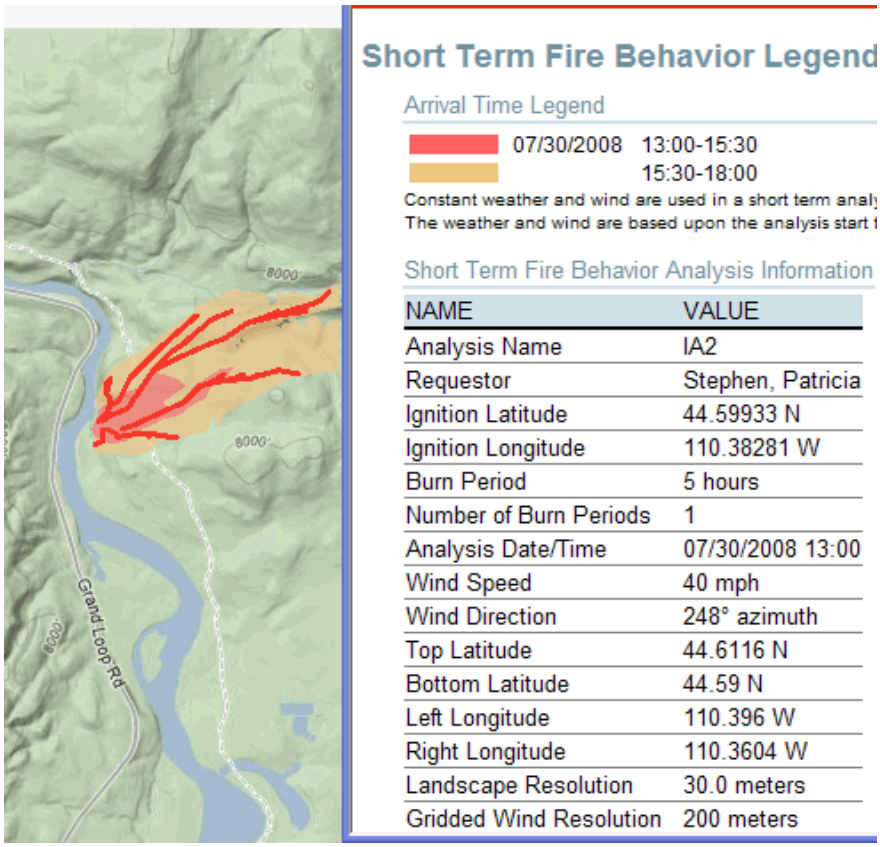
You can accept the wind speed and direction provided, or replace those values with ones you select. Within a short period of time (usually within a couple of minutes), WFDSS STFB fire spread results are ready for viewing.

Note: It is important to remember that the more automated the model, the less ability the user has to refine the inputs. Because WFDSS STFB is highly automated (providing fuels, weather and topography data, and requiring very few inputs from the user), carefully critique the results before using them for supporting wildland fire decision-making.

WFDSS STFB - What it is

WFDSS Short-Term Fire Behavior (STFB) is a two-dimensional fire growth model. This web-based application calculates spread rates and maximum spread direction at each cell. Holding all environmental conditions (wind and fuel moistures) constant for the duration of the simulation, STFB calculates fire growth and behavior by searching for the set of pathways with minimum fire spread times from an ignition (point) source.

Using one set of wind and fuel moisture conditions, STFB provides potential fire spread (arrival times and major paths) for a user-defined length of time.



NAME	VALUE
Analysis Name	IA2
Requestor	Stephen, Patricia
Ignition Latitude	44.59933 N
Ignition Longitude	110.38281 W
Burn Period	5 hours
Number of Burn Periods	1
Analysis Date/Time	07/30/2008 13:00
Wind Speed	40 mph
Wind Direction	248° azimuth
Top Latitude	44.6116 N
Bottom Latitude	44.59 N
Left Longitude	110.396 W
Right Longitude	110.3604 W
Landscape Resolution	30.0 meters
Gridded Wind Resolution	200 meters

STFB Potential Fire Spread with Arrival Times and Major Paths

WFDSS STFB - What it needs (inputs)

Like other geospatial fire models, WFDSS Short-Term Fire Behavior (STFB) requires the following data to perform fire behavior calculations:

- fuels
- weather (winds and fuel moisture values)
- topography information

STFB automatically provides (from web-based sources) most of the necessary information to perform fire behavior spread calculations.

Caution: The quality of the output from the analysis is only as good as the data input into the model. Before using the output results to support wildland fire decision-making, be sure that you understand the inputs: fuels data being used, the appropriateness of the RAWS from which fuel moistures are calculated, and the validity of the weather forecast data.

The following table lists the inputs required to make fire behavior and spread predictions in the automated version of WFDSS STFB:

Input	Source	Editable Values
Landscape data	WFDSS	Can choose one of the following from the Incident Information page (HOWEVER, you may NOT edit): - Alaska Tanana Zone - Alaska Yukon-Charley - California state data - LANDFIRE National - LANDFIRE Rapid Refresh
Foliar Moisture Content	WFDSS default (100%)	Not Viewable or Editable
Live fuel moistures	From the WFDSS-selected RAWS and based on the standard NFDRS algorithms	Not Viewable or Editable
Weather observations (for 7 day fuel moisture conditioning of dead fuels)	Nearby RAWS*	Not Viewable or Editable

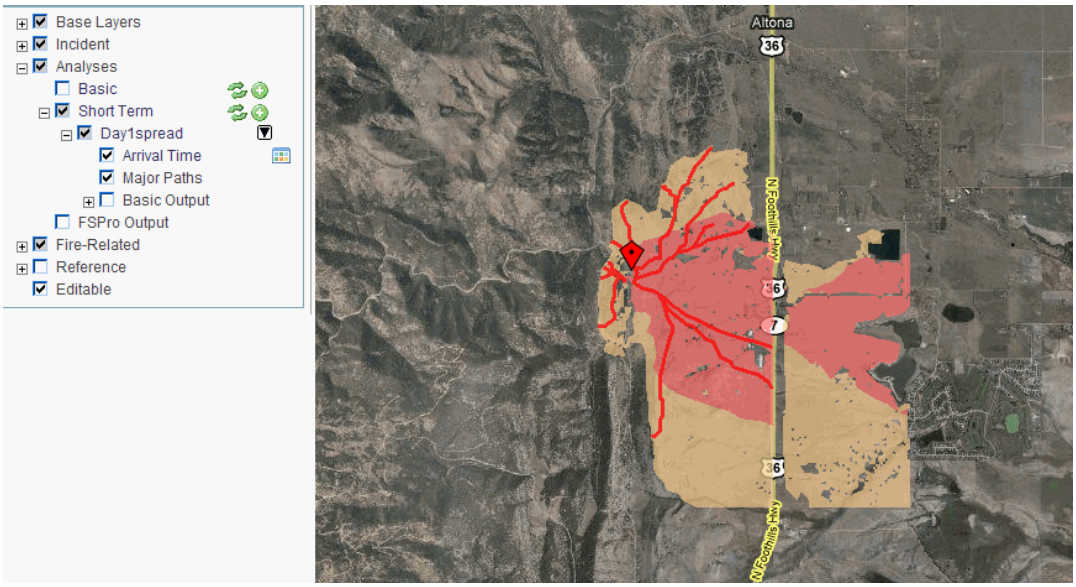
Input	Source	Editable Values
Weather forecast information for fire behavior predictions	National Digital Forecast Data (NDFD) based on the RAWS location	Not Viewable nor Editable
Wind speed and direction forecast information for fire behavior predictions (wind speed and direction values are used as inputs to generate gridded winds)	National Digital Forecast Data (NDFD) based on the center of the user-defined landscape extent	Can change: ▸ wind speed ▸ wind direction
Landscape extent (extent of analysis area)	User - defined	Draw the landscape extent (normally no more than 5-6 miles per side)
Location of fire (point)	User - defined	Enter a Latitude/Longitude or select the fire's location on a map by clicking at a point
Name of analysis	User - defined	Name the analysis
Analysis Start date and time	User - defined	Enter the analysis date and time
Number of hours in the Burn Period	User - defined	Define a burn period
Number of Burn Periods	User - defined	Define the number of burn periods (1-3)

** WFDSS chooses the nearby RAWS in the following way: The ignition location is used as a starting point. Then, a horizontal/vertical distance algorithm sorts the RAWS stations within a given area. Next, WFDSS iterates through the list until the first station is found with the requisite fuel moisture / weather information (continuous hourly observations).*

WFDSS STFB - What it does (outputs)

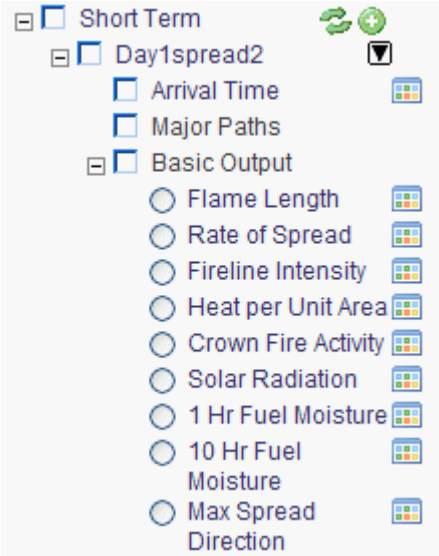
Following 7 days of fuel moisture conditioning, the WFDSS Short-Term Fire Behavior (STFB) model uses one set of gridded wind and fuel moisture conditions (based on the analysis start time) for the simulation duration to calculate and display two fire spread outputs:

- **Arrival Time:** represents the number of hours it takes the fire to reach that location on the landscape from the ignition source
- **Major Paths:** shows only the most significant fire spread pathways



STFB Outputs showing Arrival Time and Major Paths

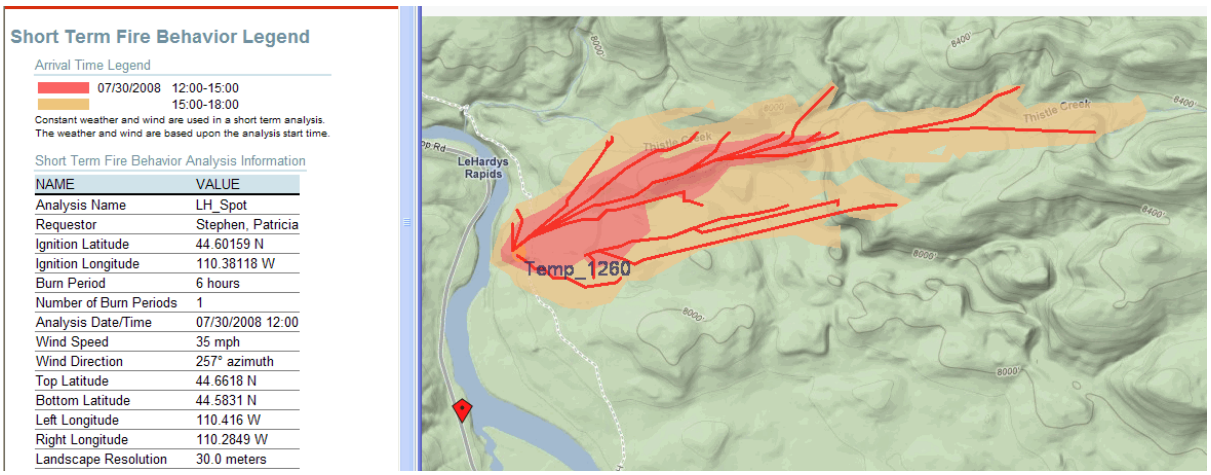
In addition to the fire spread outputs described above, when a STFB analysis is conducted, Basic Fire Behavior (BFB) "snap shot in time" outputs are also calculated for the defined landscape extent using the start date and time, and are available for display.



STFB Outputs showing BFB Calculations

WFDSS STFB - What it means (interpretation)

WFDSS Short-Term Fire Behavior (STFB) output results are fairly straightforward to interpret. In the following image can be seen a STFB analysis with both Arrival Time and Major Paths displayed. The legend provides the inputs used for the analysis and describes the hours used for the Arrival Time output. In this example, we can see the legend displays the date and hours for the Arrival Time, as well as the Short-Term Fire Behavior Analysis Information. The dark red lines depict the simulated fire's Major Paths.



STFB Outputs with Legend

When interpreting these output results it is crucial to remember the numerous WFDSS STFB Assumptions and Limitations.

WFDSS Short-Term Fire Behavior (STFB) has a number of assumptions and limitations:

1) WFDSS Short-Term Fire Behavior (STFB) calculates fire behavior outputs using fuel moistures based on topographic information, forest canopy cover, and the previous seven days of weather data (for fuel moisture conditioning) from the WFDSS-selected RAWS. However, the RAWS selected by WFDSS cannot be changed by the user. In addition, the RAWS data cannot be viewed nor edited by the user.
2) The wind speed and direction (from historic observations, NDFD or supplied by the user) are used as inputs into WindNinja to create gridded winds at 200 meter resolution.
3) Even though STFB can simulate many hours of fire spread, wind speed and direction are held constant for the duration of the simulation.
4) Fuel moisture values (as calculated at the analysis start date and time) are held constant for the duration of the STFB simulation.
5) WFDSS STFB uses most of the same underlying fire models (Rothermel's 1972 surface fire model, Van Wagner's 1977 crown fire initiation model, Rothermel's 1991 crown fire spread model, Albini's 1979 spotting from torching trees, and Nelson's 2000 dead fuel moisture model) used in other fire behavior applications; thus, the assumptions and limitations of those underlying fire models are inherent within WFDSS STFB.
6) Fire growth calculations for STFB across the landscape extent are performed assuming independence of fire behavior between neighboring cells. In other words, the travel time across a cell does not depend on the behavior in adjacent cells.
7) This automated version of STFB only allows for a single point ignition.
8) As with all models, the quality of the outputs from WFDSS STFB depends on the quality of the inputs used. If the landscape data or RAWS data used are inadequate, the resulting fire behavior outputs will be questionable. It is important to be familiar with and assess the fuels data, as well as the RAWS data before using WFDSS STFB in support of wildland fire decision-making. If the input data is suspect, then consider the output results suspect as well.

The output results from a STFB analysis cannot be saved or downloaded for use in a GIS, they can only be displayed within WFDSS. **In addition, after 20 days the analysis is automatically deleted by WFDSS.**

WFDSS STFB - Why use it - (potential uses)

The automated version of WFDSS Short-Term Fire Behavior (STFB) is a quick way to get an idea of potential fire spread from an ignition point using one set of wind and fuel moisture conditions for the user-defined burn period(s). Some potential uses of STFB (given its many limitations) include the following:

- Obtain insight into potential short-term fire spread times and locations using forecasted weather.
- Get a rough idea of short-term fire spread during a forecasted wind event.

- Run "what-if" scenarios for spot fires.
- Run several days of fire spread to help determine the size and extent needed for the Planning Area for the WFDSS Decision Process.
- Evaluate landscape and weather data using historic weather and fire perimeters.

WFDSS STFB - Assumptions and Limitations

WFDSS Short-Term Fire Behavior (STFB) has a number of assumptions and limitations:

1) WFDSS Short-Term Fire Behavior (STFB) calculates fire behavior outputs using fuel moistures based on topographic information, forest canopy cover, and the previous seven days of weather data (for fuel moisture conditioning) from the WFDSS-selected RAWS. However, the RAWS selected by WFDSS cannot be changed by the user. In addition, the RAWS data cannot be viewed nor edited by the user.
2) The wind speed and direction (from historic observations, NDFD or supplied by the user) are used as inputs into WindNinja to create gridded winds at 200 meter resolution.
3) Even though STFB can simulate many hours of fire spread, wind speed and direction are held constant for the duration of the simulation.
4) Fuel moisture values (as calculated at the analysis start date and time) are held constant for the duration of the STFB simulation.
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6) Fire growth calculations for STFB across the landscape extent are performed assuming independence of fire behavior between neighboring cells. In other words, the travel time across a cell does not depend on the behavior in adjacent cells.
7) This automated version of STFB only allows for a single point ignition.
8) As with all models, the quality of the outputs from WFDSS STFB depends on the quality of the inputs used. If the landscape data or RAWS data used are inadequate, the resulting fire behavior outputs will be questionable. It is important to be familiar with and assess the fuels data, as well as the RAWS data before using WFDSS STFB in support of wildland fire decision-making. If the input data is suspect, then consider the output results suspect as well.
9) The output results from a STFB analysis cannot be saved or downloaded for use in a GIS, they can only be displayed within WFDSS. **In addition, after 20 days the analysis is automatically deleted by WFDSS.**

Glossary of Terms

F

Fuel Moisture Conditioning

Fuel moisture conditioning is the process whereby the dead fuel moistures for each landscape cell are adjusted based on the following:

- cell's values (for aspect, elevation, slope, and forest canopy cover)
- several days of weather (precipitation, cloud cover, high and low temperatures, as well as high and low relative humidity values).

Conditioning dead fuel moistures before doing fire behavior calculations is very important. Fortunately, WFDSS Basic Fire Behavior (BFB) and Short-Term Fire Behavior (STFB) models do this fuel moisture conditioning automatically by retrieving RAWS observations for the 7 days prior to the analysis date. The models use the dead fuel moistures that have been calculated by the start date and time of the analysis to determine the fire behavior outputs.

G

Gridded Winds

Gridded winds are spatial wind field grids that are useful for examining and calculating fire spread in complex terrain where winds are modified by topography. Modeling fire behavior with complex wind and terrain interactions (through the use of gridded winds) can produce more realistic fire behavior results. For example, when using gridded winds, ridge top winds typically will be stronger than winds in the valley bottom.

Fortunately, the process of producing gridded winds is automated in WFDSS Basic Fire Behavior (BFB) and Short-Term Fire Behavior (STFB).

In WFDSS BFB and STFB, the user can choose to accept the forecasted wind speed and direction or input values of the user's choice. The model then uses these input values to calculate the gridded winds based on the landscape terrain, as well as the vegetation surface (grass, shrub or forest). The gridded wind resolution used in WFDSS BFB and STFB is 200 meters.

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