Comparing the Fire Behavior Tools in WFDSS

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There are currently four fire behavior models available to analysts in WFDSS, automated Short-Term, analyst assisted Short-Term, Near-Term and the Fire Spread Probability model. In the following scenario all four models were run on the same ignition perimeter using identical burn start and stop dates. This is a virtual scenario so no real outcome comparisons can be made. It is however, interesting to review the four outputs and theorize on the different inputs and inner model workings that affect the final results.

Scenario Parameters

Setting – South side of Glenwood Canyon
Start Date – July 1, 2010 @ 14:00
Ignition File – 2 acres
Barrier File – I-70
Burn Period – 3 days @ 6hr/day
RAWS – Gypsum
Fuels – Landfire Refresh 2008
Fuel Moistures: 1hr=2, 10hr= 3, 100hr=5, lhfm=60, lwfm=90 with a 7-Day conditioning period
Winds – 10 mph @270 degrees
Crown Fire Model - Finney

Landfire Landscapes

Landfire National

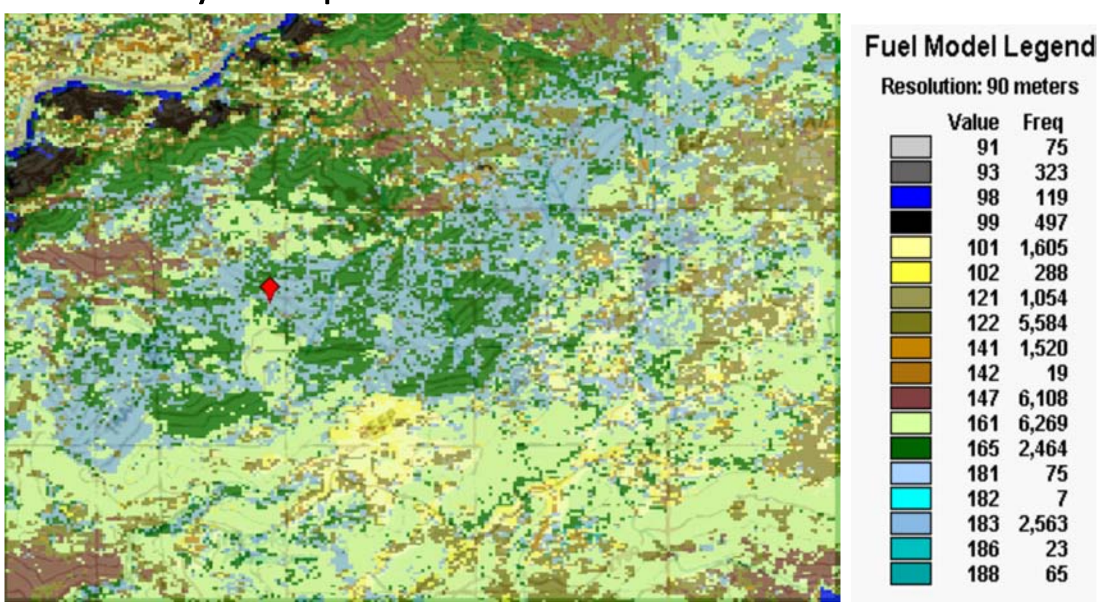
Two landfire datasets are available in WFDSS, Landfire National and Landfire Refresh 2008. Landfire National is the original Landfire data developed from satellite imagery circa 1999-2001. Large fire perimeters and other landscape scale disturbance sites prior to 1999 have been captured in the imagery. Rock is not well represented in areas with steep terrain or high elevation alpine ecosystems. In addition, if using the Finney Crown Fire Model (the crown fire model utilized in FSPro), canopy fuels will commonly need to be adjusted as follows: decrease canopy cover by 25-33% to allow higher eye-level winds, double crown bulk density to facilitate more active crown fire, and reduce crown base height by 50% to facilitate transfer from surface to crown fire. Using the Scott and Reinhardt Crown Fire Model (an option available in the STFB and NTFB models) should result in more predicted active crown fire without the canopy adjustments.

Landfire Refresh 2008

The Landfire Refresh 2008 data incorporates updates to surface and canopy fuels based on feedback from the field. If your unit provided data for disturbances or fuels treatment work post-1999 the Refresh 2008 landscape files should reflect these changes. In the Rocky Mountain Region several surface fuel models have been updated in this version, you will need to do a thorough check of the landscape to determine whether the updates are appropriate. Some canopy characteristics have been adjusted in this version as well. In general, canopy cover is still fairly high which will affect the wind adjustment factor and may limit surface to crown fire transition. Canopy base height and canopy bulk density have been adjusted for use with the Finney Crown Fire Model in this version. A quick and easy way to evaluate surface and canopy fuels is to download a Landscape Critique, a landscape summary recently available in WFDSS. See attached critique for the Glenwood Canyon example.

If the landscape critique indicates changes to surface fuel model or canopy characteristics are needed to better reflect the type of fire behavior being observed on the incident, a Landscape Editor tool is available to Fire Behavior Analysts. Information on how to use the Landscape Editor tool is available in the WFDSS Help section.

Glenwood Canyon Example Landfire Refresh 2008



The Landfire Refresh 2008 surface fuel model layer captures the vegetation type and fuels in this section of Glenwood Canyon fairly well. The light green pixels representing fuel model 161 are in fact aspen stands. The dark green, fuel model 165 and the medium blue fuel model 183 are an adequate characterization of the steep timbered walls in the canyon. The mauve fuel model 147 depicting the Gambel's oak stands in the area will likely over predict fire behavior in most non-extreme situations. No changes were made to the landscape file in the following fire behavior modeling examples.

Short-Term Fire Behavior - STFB

Short-Term fire behavior is a two-dimensional fire growth model that calculates spread rates and maximum spread direction in each 30m cell. Holding all environmental conditions (wind and fuel moisture) 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 source. Several spatial outputs are generated from a STFB run; an arrival time grid, major pathways, and multiple fire behavior characteristics grids.

Inputs

Like other fire models, STFB requires fuels, weather (wind and fuel moisture), and topography information. In WFDSS much of the required information is automatically provided. Fuel moisture and weather information is derived from a representative RAWS and the NDFD point forecast. Fuels and topography are derived from the landscape extent.

Outputs

Basic Fire Behavior – The Basic feature creates raster maps of potential fire behavior characteristics (spread rate, flame length, fireline intensity, and crown fire activity) and environmental conditions (dead fuel moistures, mid-flame wind speeds, and solar irradiance) over an entire landscape. Think of these as BehavePlus outputs completed for each 30 meter pixel in the landscape.

Arrival Time Grid – Represents the extent of spread that can be expected from the ignition source for the user defined time frame (i.e. length of burn period multiplied by the number of burn periods). Each color band represents a time frame that is one half of the burn period. For example, if the length of the burn period is six hours, each color band will represent a three hour time frame.

Major Pathways – Indicate the fastest vector of travel from cell node to cell node. Major pathways typically indicate areas on the landscape where wind, slope and/or available fuels align.

BE AWARE – Due to the 'snapshot in time' input parameters, STFB results are automatically deleted from WFDSS after 20 days. Be sure to capture the images you need to support your decision document in a timely manner.

Automated STFB

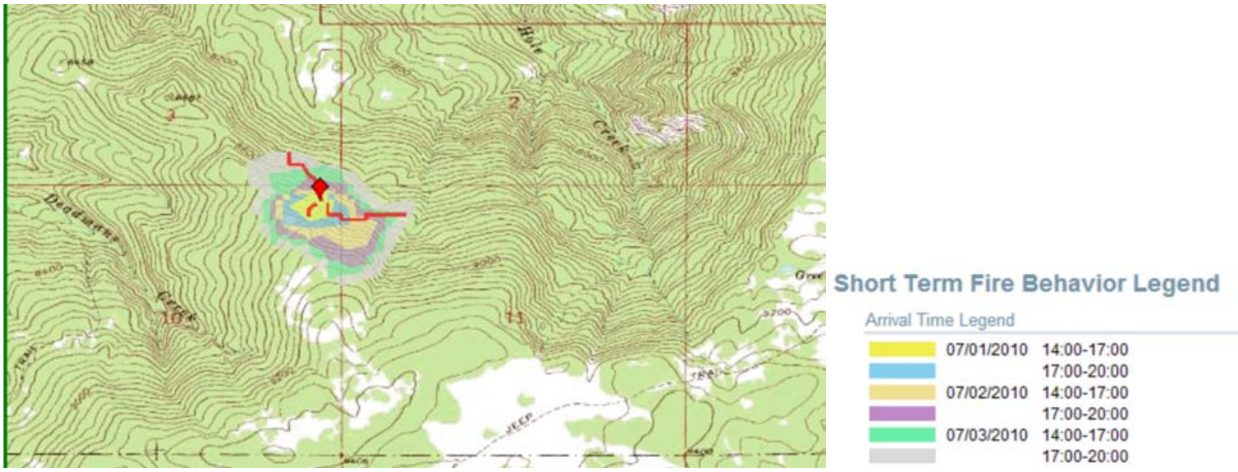
Automated Short-Term fire behavior can be run by a Dispatcher, Author, Owner or anyone with incident privileges. Because this version is designed to be run by non-fire behavior specialists very few user defined inputs are available. Carefully critique the results before using them to support the decision.

Scenario Inputs

Weather and fuel moisture inputs are automatically populated from data generated at the closest RAWS and the NDFD point forecast. The automated RAWS selection accounts for both elevation and horizontal distance from the incident. The landscape is constructed from the user defined Landfire setting in the System Preferences option on the WFDSS homepage. See discussion of Landfire 2008 Refresh above.

The limited user defined inputs in the automated option include; start date and time, wind speed and direction, number and length of burn periods, and an ignition **point** location.   Because the Glenwood Canyon Example was run on a previous date in time WFDSS picked the Storm King RAWS to generate the fuel moisture information rather than a NDFD forecast. Default fuel moistures from the Storm King RAWS were; 1hr=3,10hr= 4, 100hr=6, live herbaceous moisture=6, live woody moisture=90.

Automated STFB Results



The results produced a fire 96 acres in size that is tending to move cross-slope to the SE. Acreage estimates are found in the Values Inventory on the Results tab.

BE AWARE

Automated STFB results cannot be downloaded for use in GIS applications.

When using the Scott and Burgan 40 fuel models live herbaceous and live woody fuel moistures will significantly influence fire behavior. The live herbaceous and live woody fuel moistures that are generated from a RAWS are typically inaccurate, usually on the low end. Hence, the automated STFB will over predict fire spread in the dynamic fuel models if the real fire is burning in an area where the live and woody fuels are not fully cured.

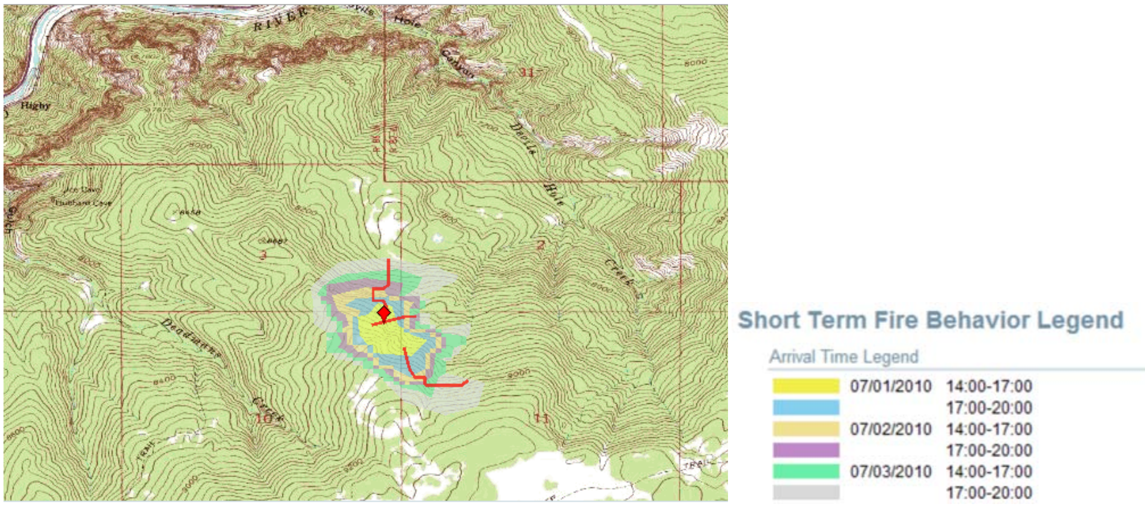
Analyst Assisted STFB

The analyst assisted option for modeling short-term fire behavior requires the analyst to have a Fire Behavior Analyst role in WFDSS. In the analyst assisted option many of the inputs required in the model can be customized to better fit the true fire environment.

Scenario Inputs

In the Glenwood Canyon example, the analyst chose to use the wind, weather and fuels information given in the Scenario Parameters section on page one (i.e. Gypsum RAWS for a warmer, drier weather scenario).

Analyst Assisted STFB Results



The results depict a larger fire, 176 acres, with stronger up/down slope pathways. The increase in final perimeter area is due in part to the use of a 2 acre polygon as the ignition source rather than a single point as is used in the automated version and the drier fuels modeled at the Gypsum RAWS (see scenario parameters on page one).

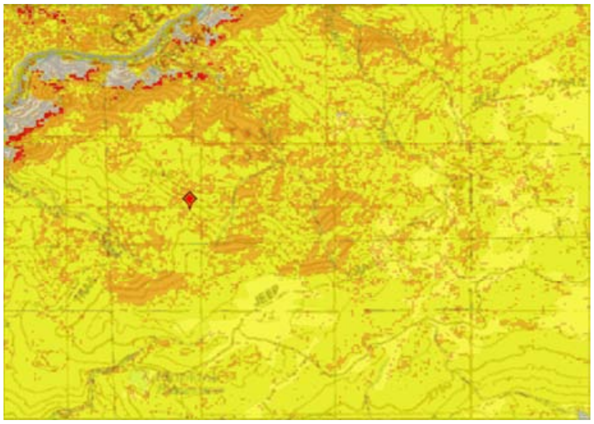
BE AWARE – If no inputs are adjusted in an analyst assisted run and the same point ignition is used, the results will be identical to the Automated output. In addition, both versions of STFB have the 'snapshot in time' limitation where in the fuel moistures and wind speed and direction are held constant through all hours and all burn periods. Hence, STFB is best used to model short-term weather events such as cold front passages, thunder cell down drafts, foehn winds etc. that will only last a few hours.

Short-Term Fire Behavior Characteristics – Basic

All of the common fire behavior characteristics (ROS, FL etc.) can be viewed across the entire landscape. Think of this as a 2-dimensional Behave Plus run modeling static fire behavior conditions on each 30-meter pixel in the analysis landscape. The Basic Grid can be a useful tool for gaming and explaining fuel treatment effects on fire behavior.

In the Glenwood Canyon Example the Basic Fire Behavior Grid indicates passive crown fire should be expected in the TU5 fuel model under the given wind and weather conditions. A few areas of active crown fire can be expected in the denser canopy in the riparian areas along the river bottom.

Basic Fire Behavior Grid



Near-Term Fire Behavior - NTFB

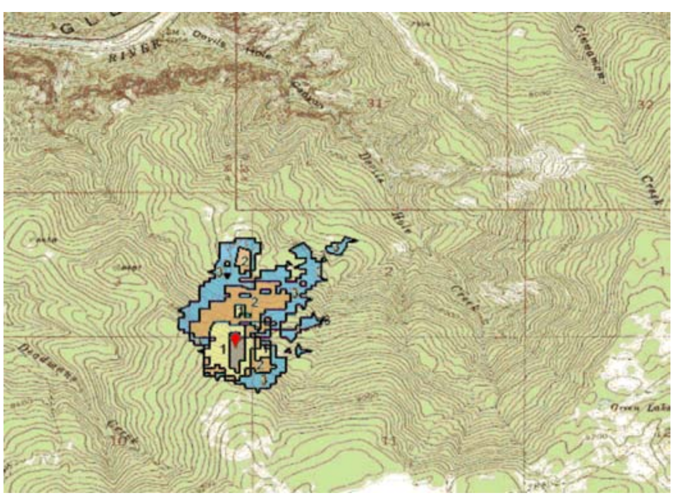
Near-term fire behavior inputs are very similar to those of STFB but more finely tuned. The NTFB model produces outputs that represent simulated growth in the form of a 'fire progression' (similar to the FARSITE desktop model). Unlike STFB, NTFB can utilize wind and weather data that change over the duration of the simulation.

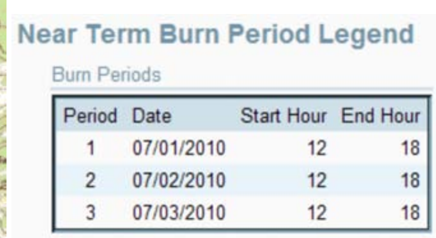
The model retrieves forecasted weather and winds for the selected time using NDFD for current simulations. For historic fires, the model can use historic weather archived for the analyst selected RAWS. The analyst can also opt to utilize wind and weather inputs from any other type of reliable forecast information.

Scenario Inputs

Because this simulation was performed on a previous date, the wind and weather data was derived from archived hourly observations collected at the Gypsum RAWS. The model was initialized with the data described in the Scenario Parameters.

NTFB Results





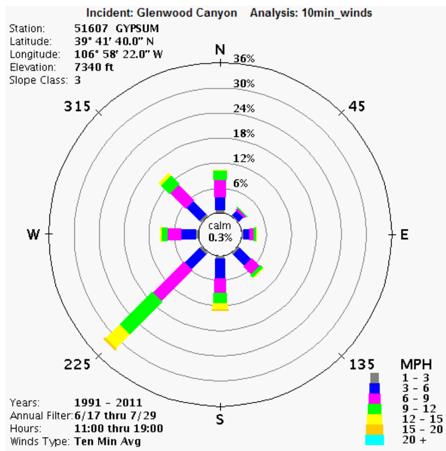
Near Term Burn Period Legend

Burn Periods

Period	Date	Start Hour	End Hour
1	07/01/2010	12	18
2	07/02/2010	12	18
3	07/03/2010	12	18

In the example above it appears that hourly parameters will tend to move the fire in a more northeasterly down slope direction with a final size of 140 acres. Acreage information is found in the Values Inventory which can be accessed from the Results Tab. An examination of the hourly winds used in the simulation reveals winds during the second and third burn period were in fact different than the static 10 mph W wind used in the STFB runs. In the NTFB simulation and the wind direction is more from the SW as in indicated in the wind rose below.

Gypsum RAWS Wind Rose



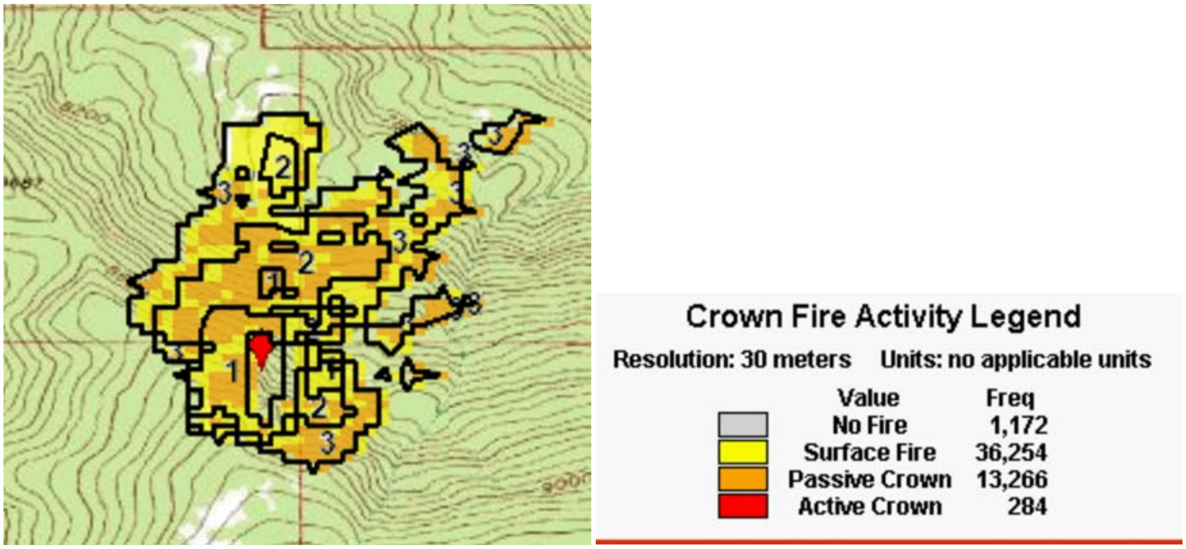
The multiple spots that are depicted in the NTFB run likely result from the SW winds moving the fire into more timbered fuels (see landscape map on page two).

BE AWARE – Although NTFB can model fire growth for up to seven days, it is generally most appropriate for one to three day time frames due to forecast uncertainty past three days.

Near-Term Fire Behavior Characteristics

A fire behavior characteristics grid is also automatically generated with a Near-Term analysis. In the Near-Term option, fire characteristics are only generated within the projected fire perimeter. In this example the grid depicts the fire behavior characteristics derived from the fire environment at the time each pixel was burned. The Near-Term characteristics grid may be useful for contemplating appropriate suppression tactics along a potential fire perimeter.

Near-Term Fire Behavior Characteristics



Long-Term Analysis with the Fire Spread Probability Model (FSPro)

FSPro calculates the probability of fire spread from a current fire perimeter or ignition point for a specified time period. The strength of the FSPro model is the ability to model probable long-term fire spread without a high confidence weather forecast through the use of historical climatology. In the FSPro model hundreds of fires are simulated over a wide variety of weather and wind combinations. The probability of any individual landscape pixel burning is computed as follows: Assume 100 fires are simulated – the pixels that burn in 80-100 of those fires make up the 80-100% probability contour, the pixels the burned in 60-80 of the simulations make up the 60-80% probability contour and so on. In each burn period fire spread is simulated in a manner similar to a STFB run in that a single combination of wind and weather are used for the entire burn period. However, the analyst does have several options available to customize the input parameters to best reflect the fire environment and observed fire behavior.

Scenario Inputs

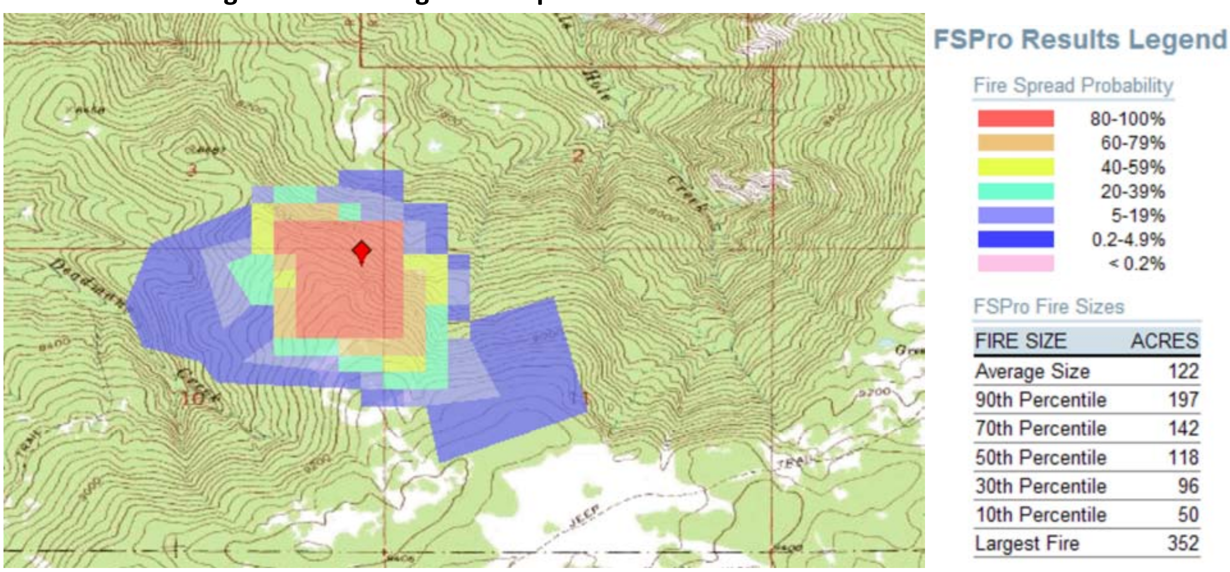
In the following FSPro examples 256 fires were simulated over a three day period using historic climatology from the Gypsum RAWS.   Winds in the first simulation were constrained to the 10-minute average data set.   Otherwise all inputs are consistent with the Scenario Parameters listed on page one.

10-min Average Wind Matrix

Speed	45	90	135	180	225	270	315	360
3	0.35	0.47	0.73	0.67	0.81	0.67	0.77	0.64
6	1.54	1.59	3.98	4.83	4.98	3.62	4.53	3.31
9	0.84	1.24	2.86	3.69	10.68	3.33	5.45	4.18
12	0.33	0.76	1.12	2.50	11.20	1.62	3.11	2.35
15	0.15	0.27	0.40	1.46	4.82	0.48	1.14	0.37
20	0.03	0.11	0.11	0.44	0.71	0.09	0.21	0.05
25	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00

The probability of simulating one or more fires with a rare event wind is greatly diminished or even eliminated if using only the 10-min. average winds. In the wind matrix above the highest wind speed that could have been selected for an individual fire event is 25 mph and the most common direction for a 25 mph wind is from the NW or SW. The highest percentage of 10-min average winds, approximately 22%, are 6-12 mph from the SW. Remember – the wind matrix provides the starting point for the gridded wind profile so the random wind selected to model each of the 256 fires would have been adjusted to account for terrain and vegetation drag. Use of the 10-minute average winds is appropriate in shorter term situations (out to 7 days), in sites that are very sheltered, or when a 7-10 day weather forecast is available and confidence in the forecast is high.

FSPro Results Using 10-min. Average Wind Speeds



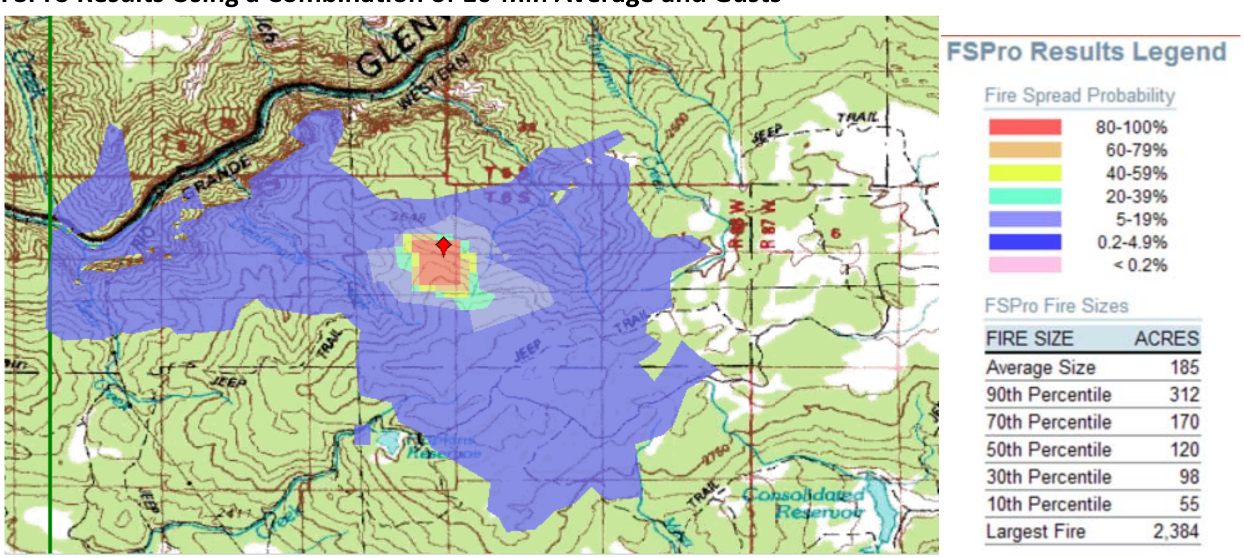
Similar to the Analyst Assisted STFB results, using 10-min average winds indicate fire spread upslope in a southeast direction. The average fire size in this simulation was 122 acres with 80-100% probability that the fire will reach at least 74 acres. Expected acreage by probability information is found in the Values at Risk Report which is access from the Results Tab. The blocky results are due to a 90 meter landscape resolution (the default in FSPro simulations) in combination with the scale of the screen capture.

Combination of 10-min Average and Gusts Matrix

Speed	45	90	135	180	225	270	315	360
5	0.70	0.74	1.62	1.95	1.83	1.45	1.82	1.35
10	0.88	1.34	3.55	4.22	9.12	3.05	4.83	3.82
15	0.51	0.88	2.69	3.64	7.85	1.80	3.67	2.24
20	0.47	0.55	0.99	1.96	4.21	1.93	2.58	1.78
25	0.31	0.27	0.50	1.66	3.89	1.54	1.37	1.03
30	0.11	0.15	0.35	1.28	2.39	0.86	0.64	0.39
35	0.07	0.09	0.11	0.37	0.82	0.34	0.27	0.12
40	0.01	0.03	0.03	0.14	0.17	0.10	0.12	0.01
45	0.01	0.01	0.03	0.05	0.06	0.03	0.02	0.01
50	0.00	0.00	0.01	0.03	0.01	0.00	0.01	0.01

Creating a wind file with a combination of 10-minute average and wind gusts allows for a larger range of wind speeds. In the combination matrix there is a 0.07% chance of having any of the 256 fires be simulated with a wind speed of 50mph. There is 0.03% chance that a 50 mph wind will be from the south. Winds are still primarily from the SW but most likely to be in the 5-15 mph range. Use the combined wind file when modeling long-term scenarios (7 or more days), the long-range forecast calls for higher than normal winds, or frontal passages are expected.

FSPro Results Using a Combination of 10-min Average and Gusts



The blockiness has diminished due to the increased map scale used in the screen capture. It appears that some of the simulated fires were modeled with the rare event SE, SW and NW winds resulting in the large spread events in the 0.2-4.9% probability contour. During the SE wind event the fire jumped I-

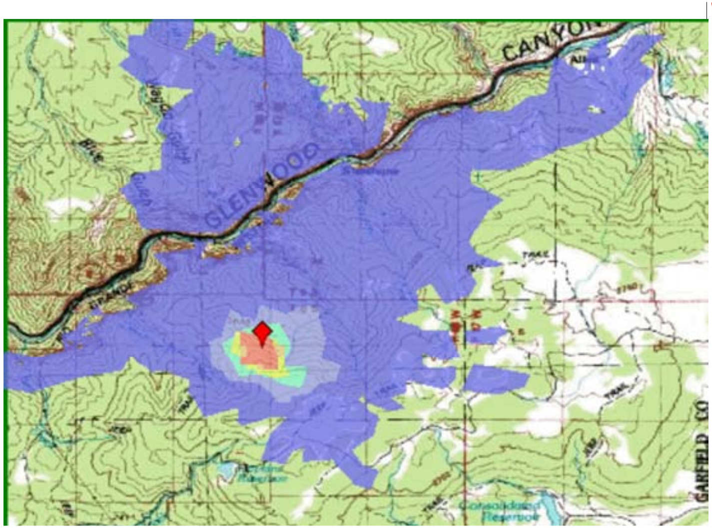
70 even though it has been added as a barrier – in all of the WFDSS models barriers will stop surface fire spread but can still be breached with spotting. Hence, the results indicate some type of crown fire activity and spotting was modeled during the simulation. The 80-100% probability remains at 74 acres but average fire size has increased to 185 acres.

Gusts Only Matrix

Speed	45	90	135	180	225	270	315	360
5	0.00	0.01	0.05	0.12	0.01	0.03	0.00	0.03
10	0.23	0.55	2.22	2.01	1.02	0.55	1.38	1.23
15	0.74	1.03	4.34	4.32	4.03	2.30	4.26	2.70
20	0.91	1.00	1.87	3.48	7.71	3.78	4.95	3.51
25	0.62	0.54	1.00	3.33	7.76	3.09	2.70	2.06
30	0.23	0.31	0.70	2.56	4.78	1.71	1.29	0.78
35	0.15	0.19	0.21	0.74	1.65	0.68	0.54	0.24
40	0.01	0.07	0.05	0.28	0.33	0.20	0.24	0.01
45	0.01	0.01	0.07	0.09	0.12	0.07	0.04	0.03
50	0.00	0.00	0.01	0.04	0.01	0.00	0.00	0.01
55	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00

Use of the gusts only wind matrix should be used judiciously for very select situations. In the gusts only matrix the highest wind speeds top out at 55 mph. Gusts of this nature have equal chances of coming from the S, the SW or the NW. The prominent direction is still SW with the highest probability of a wind from this direction being in the 15-25 mph range which is about 10 mph higher than the wind file generated with the combination of 10-minute average and wind gusts.

FSPro Results Using Gusts Only



FIRE SIZE	ACRES
Average Size	314
90th Percentile	678
70th Percentile	236
50th Percentile	157
30th Percentile	108
10th Percentile	68
Largest Fire	7,045

Estimated Fire Size After Three 6-hour Burn Periods	
Model	**Acres**
STFB – Auto	96
STFB – Assisted	176
NTFB	140
FSPro – 10 min ave wind	74-122- 352
FSPro – 10 min ave and gusts	74-185- 2,384
FSPro-Gusts	95 – 314 – 7,045

*FSPro estimates include; fire size in the 80-100% probability area, average fire size, and largest fire size respectively.

BE AWARE - Due to the small database used in the FSPro example, 3 days and 256 fires, the probability of capturing a fire burning under 'rare event' conditions is greatly diminished. In addition, the ERC's recorded at the Gypsum RAWS on the initiation date were in the 80th percentile bin so dead and live fuel moistures started at slightly different moisture contents than was used in the analyst assisted STFB and NTFB analysis (80^{th} percentile = 1hr=3, 1-hr=4, 100hr=7, lhfm=60, lwfm=80. In addition, the burn period associated with the 80^{th} percentile is 4 hours rather than 6 as was used in the STFB and NTFB.)

Summary of Common FSPro Analytical Issues – A review completed by the National Decision Support Center RD&A

1. Number of Fires – too few fires were used for the simulation
2. Live Herbaceous Fuel Moistures –calculated values were accepted but were inappropriate or too low
3. High Forecast to Analysis Length Ratio – too many forecast days were selected given the length of the analysis
4. Landscape Change Rules – use of landscapes with no adjustments to canopy characteristics or fuel models
5. Entering Notes – lack of documentation, especially where non-standard inputs were used
6. Burn Period – defaults were often used without considering the observed fire behavior

Factors that may Contribute to Poor Results

1. Start and End Periods for ERC- season length is often too short
2. Wind Start and End Hours and Wind Type – defaults commonly accepted
3. Marking and Analysis a "Complete" – analyses are accepted that appear to be calibration runs**