

# NFDRS2016 Monitoring the Model

## I. INTRODUCTION

The National Fire Danger Rating System (NFDRS) provides managers with systematic, statistically valid decision-making tools designed to assist with the periodic assessment of potential fire danger. Like all tools, it needs to be maintained in good condition to ensure that it is working properly when it is needed.

The purpose for monitoring the model is to offer examples that highlight the value of the NFDRS2016 model as a fire danger decision support system to aid fire managers and line officers in their decision-making processes. Because this is a new model, a monitoring process can also aid users in discovering flaws or model components that may not be working correctly. Bringing these issues to light will allow the developers to make the appropriate corrections to the model.

Each dispatch zone is unique, and users are encouraged to develop a monitoring and comparison system that makes sense to them and where constructive feedback can be solicited and tracked. The overall goal is to comparatively evaluate the model outputs and fire danger support tools in order to inform users on the new science and improve the use of NFDRS through standardized, interagency applications of the system.

## II. NFDRS2016 Analysis Prototype Development

Monitoring efforts focused on the application and use of the NFDRS2016 model are intended to aid in the successful transition to the model. Efforts should be directed on refining current or developing new fire danger planning tools (i.e. Staffing, Response, Adjective Fire Danger Rating, etc.) and not get preoccupied with the statistical analyses and correlations.

The Southeast Zone Fire (SEZ) Danger Technical Group (FDTG) agreed to develop an analysis prototype using the NFDRS2016 model prior to the 2018 fire season. The FDTG worked to create an evaluation tool that could be used during the 2018 and 2019 fire seasons to test the NFDRS2016 model utilizing the updated staffing and response tools as well as adjective fire danger rating levels, and preparedness levels. The intent of the analysis prototype was to provide an example to draw attention to the NFDRS2016 model and its use as a fire danger decision support system to aid fire managers and line officers in their decision-making processes. Efforts were directed on refining current or developing new fire danger planning tools (i.e. Staffing, Response, Preparedness, Adjective Fire Danger Rating, etc.).

### A. Prototype Components

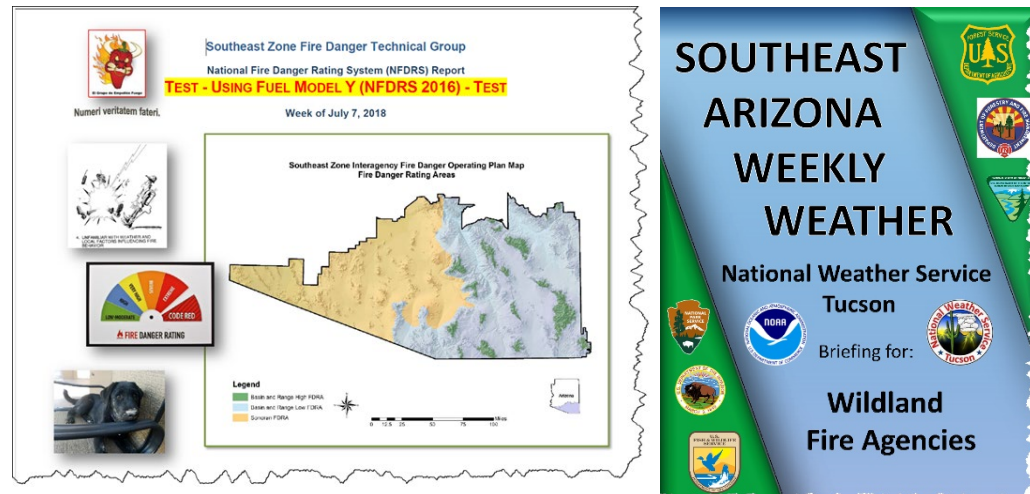
#### 1. NFDRS2016 Fire Danger Operating Plan

The SEZ FDTG produced a draft Fire Danger Operating Plan (FDOP) using the NFDRS2016 FDOP template. This process required updates to the “Fires Analysis” process, performing new analyses using the NFDRS2016 model, and updating the fire danger planning tools. The creation of the draft NFDRS2016 FDOP required updates to the subordinate planning documents and associated planning tools as well.

#### 2. Weekly NFDRS Report

During fire season the SEZ FDTG provides fire managers with a weekly NFDRS report. The report features weekly NFDRS outputs specific to the SEZ that

display current fire danger rating levels as they relate to Preparedness Level, Adjective Fire Danger Rating Level, Staffing Level, and Response Level. The 2018 and 2019 weekly reports featured updated information using a standardized format that displayed relative outputs using both the legacy model (NFDRS78/88) and the NFDRS2016 model. The weekly NFDRS report also provided weekly National Weather Service (NWS) outlooks that were provided by the local NWS office.



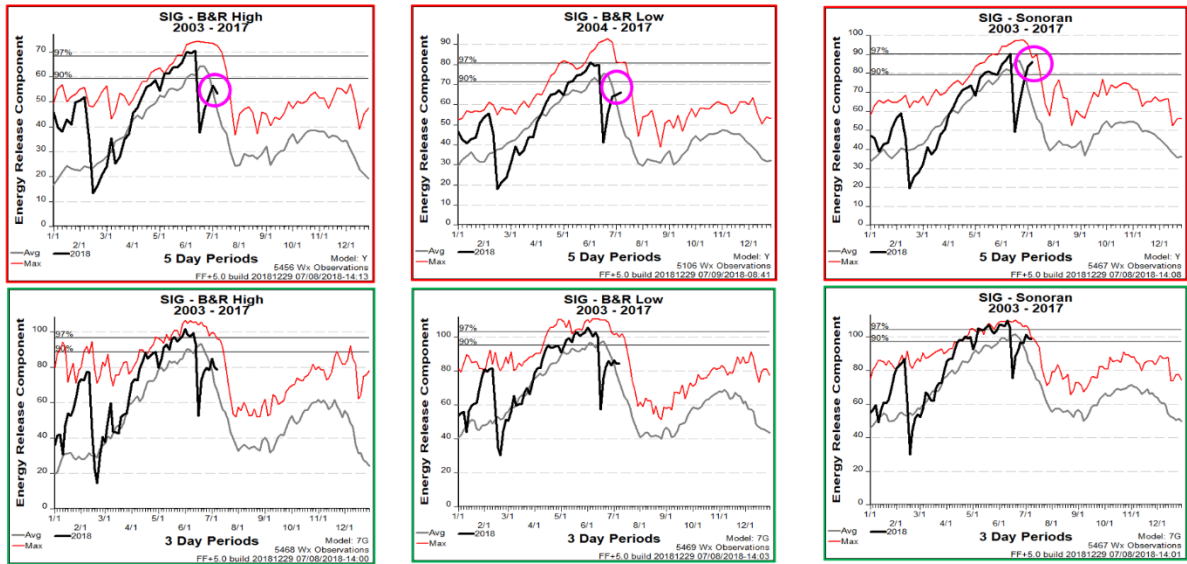
## B. Comparative Products

### 1. FireFamilyPlus Graphs

The 2018 Southeast Zone weekly NFDRS report compared legacy NFDRS (78/88 model) outputs with the new NFDRS2016 outputs. The weekly reports displayed NFDRS2016 and legacy NFDRS outputs using ERC, BI, and IC indices for comparison and tracked the variable outputs as the fire season progressed. Fire managers were able to track the outputs and assess trend patterns during the early- and peak-season periods.

The charts in Figure 1 illustrate the "Average Maximum" (**red** line) and "Average" (**gray** line) ERC values for the time periods of January 1st through December 31<sup>st</sup>. The **black** line shows the daily ERC values for the current year in the evaluation (2018).

The ERC charts using the NFDRS2016 fuel model Y are displayed in the graphs in the upper row with the **red** borders. The 1978 ERC fuel model G charts are displayed in the second row with the **green** borders. Since NFDRS2016 calculates fuel moistures using different models, note that the fuel model Y values are lower than values calculated for fuel model G. It should also be noted that fuel model Y does not include a live fuel component when calculating fuel loading as opposed to fuel model G (Figure 2).



**Figure 1.** NFDRS ERC outputs comparing NFDRS2016 fuel model Y (top row) with legacy NFDRS fuel model G (bottom row). Charts were produced weekly during the course of the 2018 fire season in order to comparatively track the outputs using the two models.

Fuel Model Parameters

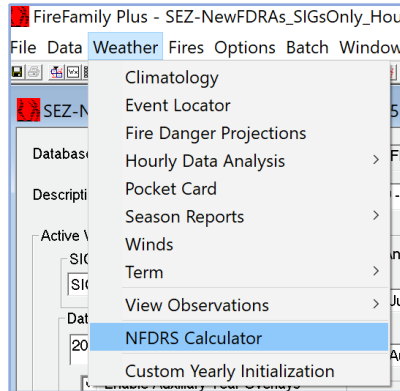
Model Selection: Fuel Model: Y - Timber Use 88 Model:  Add To Table Remove Current Clear Table Close

Fuel Model	88 Model	1 Hour Loading	10 Hour Loading	100 Hour Loading	1000 Hour Loading	Herb Loading	Woody Loading	Drought Loading	1 Hour SA : Vol	10 Hour SA : Vol	100 Hour SA : Vol	1000 Hour SA : Vol	Herb SA : Vol	Woody SA : Vol	Heating #	Moisture Extinction	Depth	Wind Factor	Max SC
G	<input type="checkbox"/>	2.5	2	5	12	0.5	0.5	0	2,000	109	30	8	2,000	1,500	8,000	25	1	0.4	30
Y	<input type="checkbox"/>	2.5	2.2	3.6	10.16	0	0	5	2,000	109	30	8	2,000	1,500	8,000	25	0.6	0.2	5

**Figure 2.** NFDRS2016 fuel model parameters. Fuel model Y does not include herbaceous or woody live fuel components in the fuel loading calculations as compared with fuel model G.

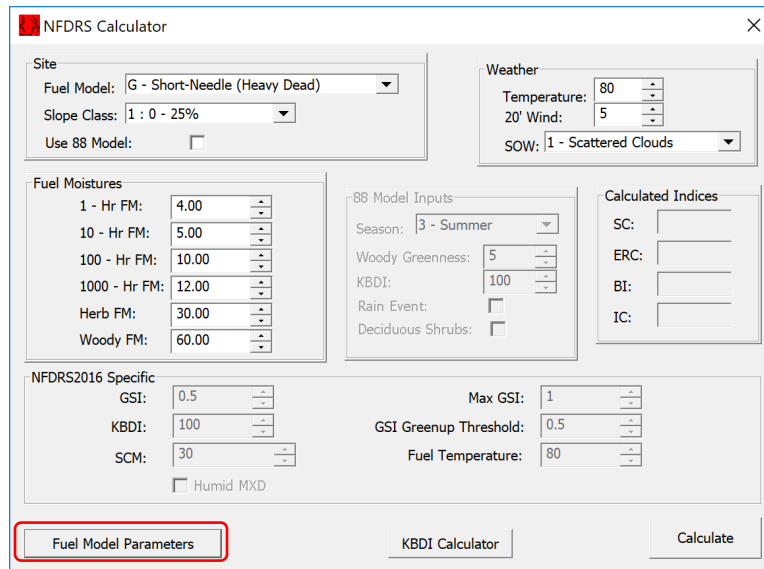
## 2. Fuel Model Parameters

It is important for users to become familiar with and understand the fundamental differences between the legacy versus the NFDRS2016 fuel models. Users can review and compare the fuel model parameters using FireFamily (FFP) by selecting the 'NFDRS Calculator' from the dropdown menu under 'Weather' located in the menu bar at the top of the FFP screen.



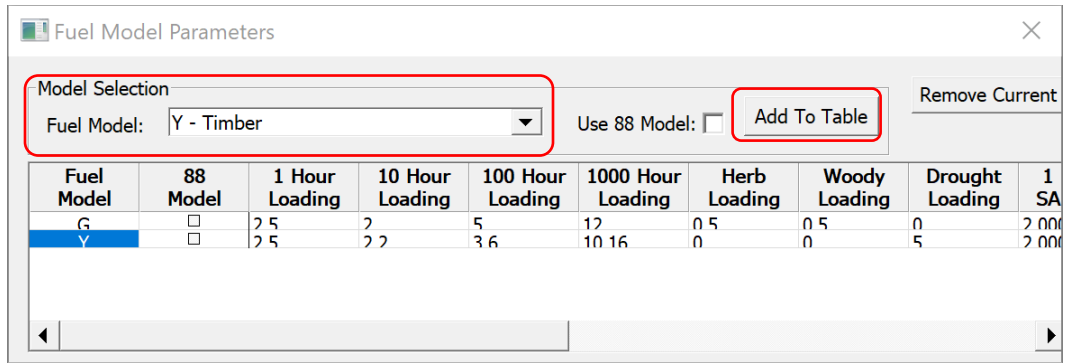
**Figure 3.** Select 'NFDRS Calculator' from the drop-down menu.

The 'NFDRS Calculator' screen will appear, click on the 'Fuel Model Parameters' button at the bottom of the pop-up window.



**Figure 4.** Select 'Fuel Model Parameters' in the lower left-hand corner.

The 'Fuel Model Parameters' window will appear and the user can then select which fuel models to view and compare in the table by selecting the fuel models of interest from the drop-down menu in the 'Model Selection' box and then clicking on the 'Add To Table' button.



**Figure 5.** Users can make fuel model selections in the Fuel Model Parameters window in FFP. Clicking on the down arrow will display a selection window listing all of the fuel models.

Understanding the similarities and differences between the legacy and NFDRS2016 fuel models will help users become more familiar with the new system. Understanding how live and dead fuel moistures are calculated using the new fuel moisture models should also aid users in understanding why the calculated values using the new system are different when compared to the legacy model. Gaining more familiarity and understanding should help users become more comfortable with the new model.

Questions should arise as users compare and contrast outputs. Users should take additional time to study the potential reasons why outputs from the NFDRS2016 model differ from the legacy model. It is recommended that users develop their own system to compare and contrast NFDRS2016 outputs during the course of their respective fire seasons. Whether users develop a weekly report or other form of documentation is up to each zone. The importance of developing, adjusting, and maintaining the tools developed for the various FDOP sub-plans cannot be overstated. These tools are intended to aid decision-makers during the course of each fire season.

### 3. Comparative Evaluations using Microsoft Excel

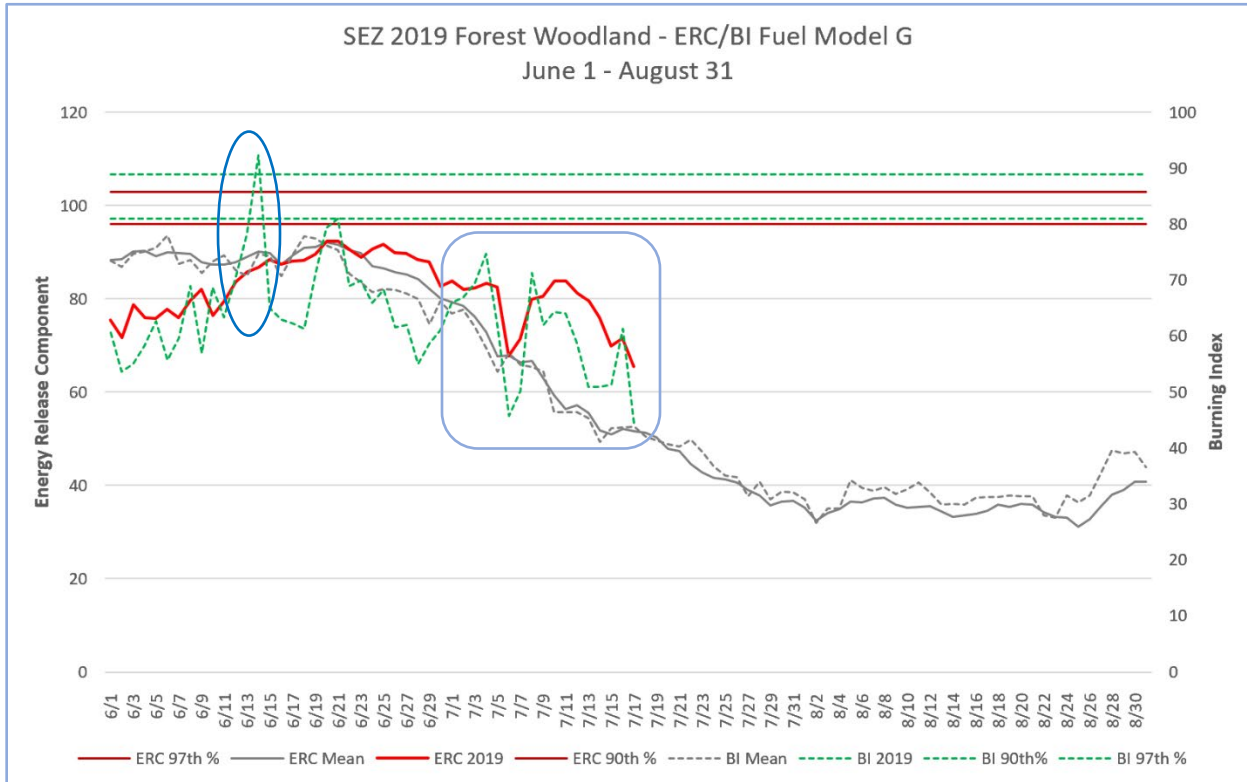
#### a. Seasonal Trends

Microsoft Excel (MS Excel) allows users to import and display FFP data using a variety of graphing options. Users familiar with working in MS Excel may find this useful for comparing and tracking FFP data from the legacy and NFDRS2016 models. Daily listing data for the various indices in FFP can be downloaded and imported into MS Excel. MS Excel allows users the flexibility to decide how they wish to display their data for comparative purposes.

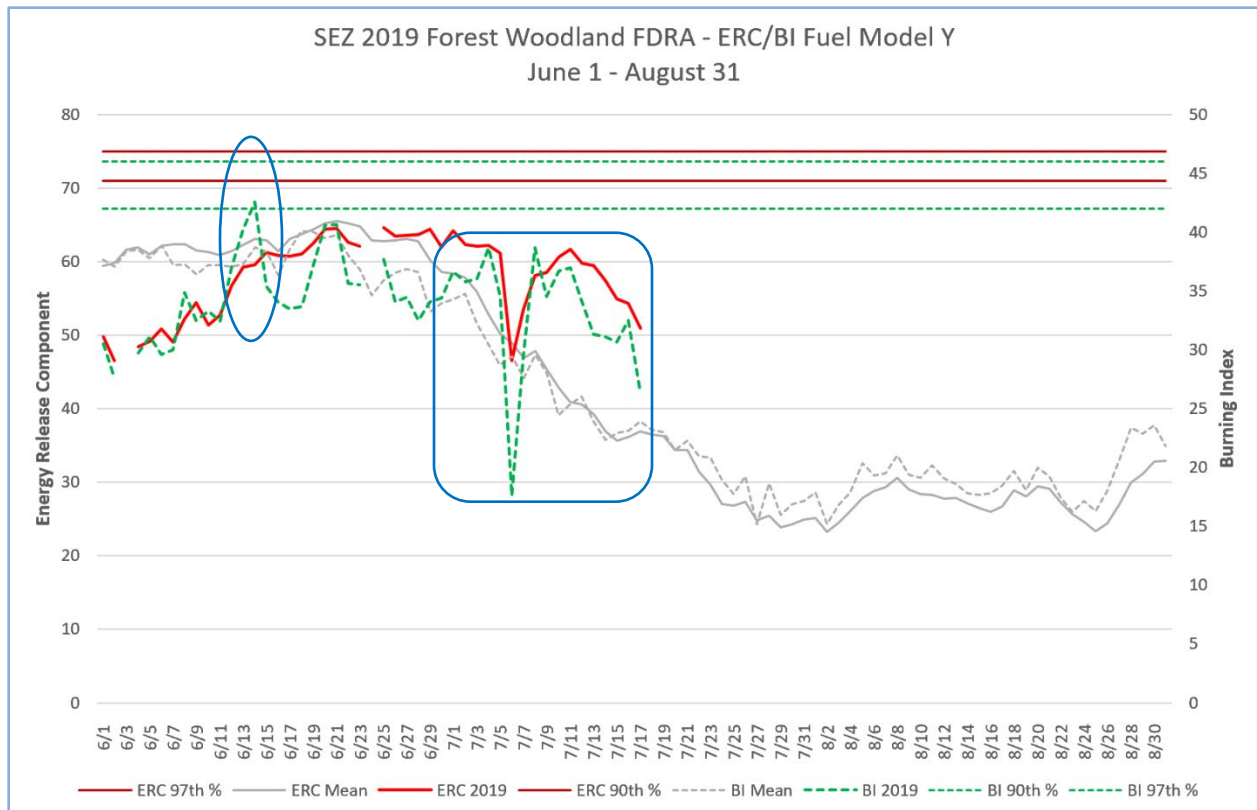
In the past, many NFDRS users tend to look at the NFDRS indices individually when gauging fire danger. Evaluating model outputs may be more meaningful if users compare two or more variables when assessing fire danger. For example, looking at ERC (relatively low daily variability) and BI (high daily variability) for a specific period of time (i.e. fire season), may indicate periods of elevated fire danger (Graphs 1 and 2). Graph 1 displays outputs using fuel model G; graph 2 displays outputs using fuel model Y. Both graphs display an elevated BI value on June 14<sup>th</sup> matching weather forecasts for the day predicting elevated wind speeds. The low ERC and BI values on July 6<sup>th</sup> were due to a precipitation event which can be expected for this FDRA in early July. However, in a “normal” year the ERC and BI values

tend to trend downward as the FDRA transitions into late-fire season with the expected seasonal monsoonal moisture. Both graphs show that the ERC and BI values rebounding to above-average levels indicating a lack of precipitation and fuels quickly drying out.

Both fuel models displayed very similar trends for this timeframe. Note that the output values are different due to the different models used to calculate fuel moisture values. Also remember that fuel model Y does not include live herbaceous and live woody fuel loads in its fuel moisture calculations.



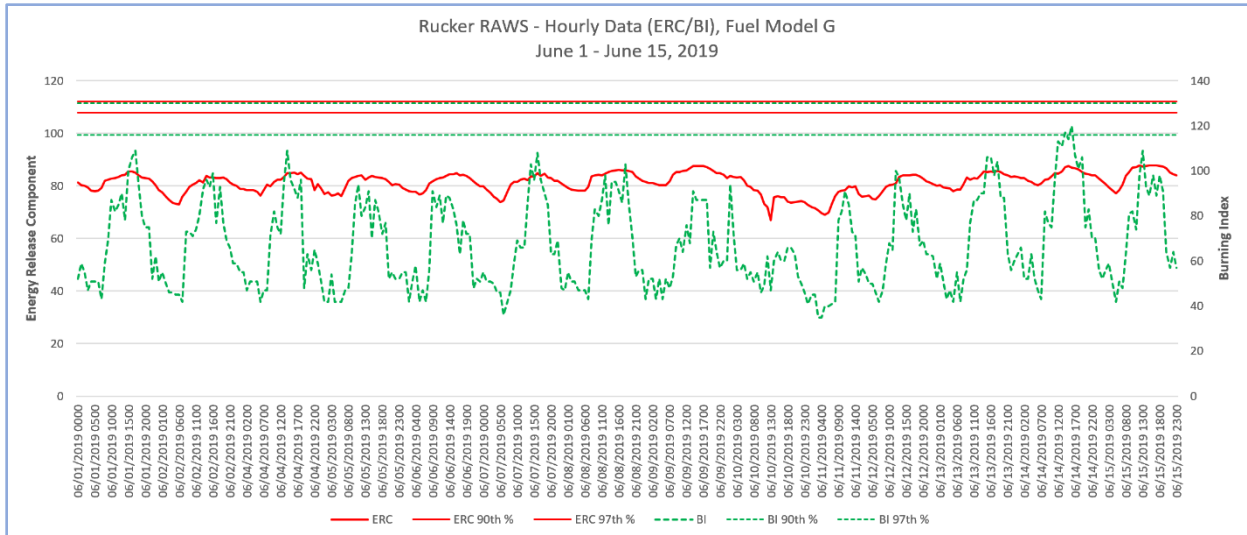
**Graph 1.** ERC and BI values using Fuel Model G looking at a two-month period; peak and late fire season.



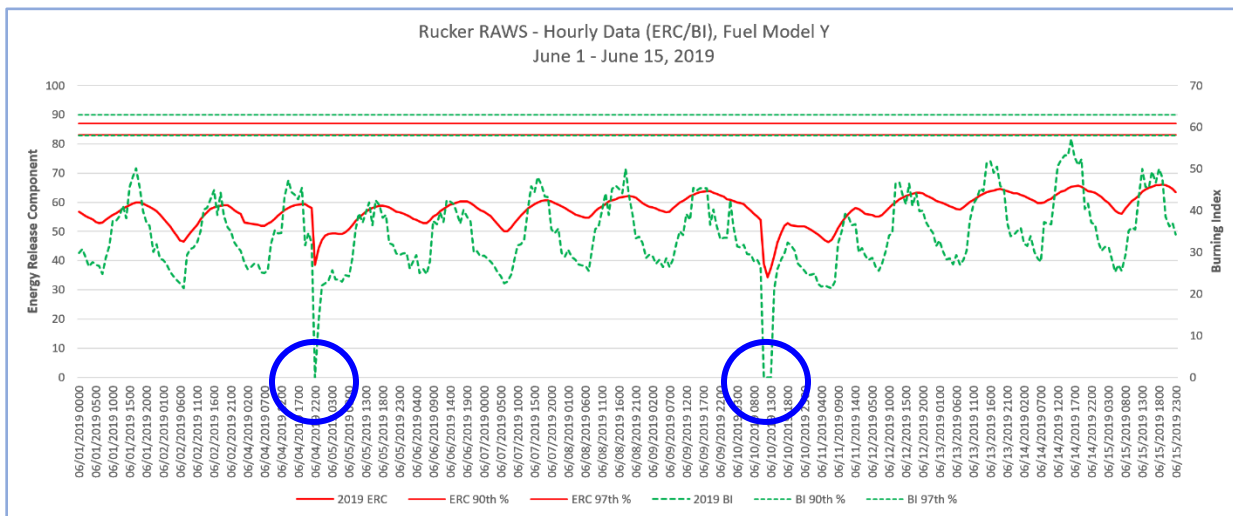
**Graph 2.** ERC and BI values using Fuel Model Y looking at a two-month period; peak and late fire season.

**b. Hourly Data**

The availability of hourly weather data and NFDRS outputs is a new feature with the NFDRS2016 model. Hourly NFDRS outputs can provide insight to users on short-term trends. Hourly information can be used in conjunction with National Weather Service (NWS) weather forecasts to aid fire managers and agency administrators with decision making for fires that are being managed to meet resource objectives, prescribed fire planning, or maybe to aid in extended staffing decisions during peak fire season. Hourly NFDRS outputs can also be used to monitor trends for indices that are more sensitive to changing conditions during the course of a given day (i.e. 1- and 10-hr fuel moistures, Ignition Component, Spread Component, Burning Index) and how these outputs may relate to firefighter safety. Graphs 3 and 4 display hourly ERC and BI outputs for a two-week period. The 90<sup>th</sup> and 97<sup>th</sup> percentiles for these examples are the 15-year percentiles for each index calculated for the identified 3-month fire season for the zone.



**Graph 3.** Hourly ERC and BI values using Fuel Model G over a two-week period during peak fire season in 2019.



**Graph 4.** Hourly ERC and BI values using Fuel Model Y over a two-week period during peak fire season in 2019.

The hourly data using Fuel Model Y shows two periods where BI values are recorded as zero on June 4<sup>th</sup> at 2200 hours and again on June 10<sup>th</sup> at 1300 hours (Graph 4). The hourly data record in FFP shows the BI value of zero on June 4<sup>th</sup> being associated with 0.01 inches of recorded precipitation and a maximum RH value of 46%. The June 10<sup>th</sup> hourly data record shows the BI value of zero being recorded at 1100 hours through 1300 hours and is also associated with recorded precipitation values (0.01 and 0.05) and maximum RH values of 81% and 87% (Table 1).



021414 - Hourly Listing					021414 - Hourly Listing				
06/04/2019	1600	43.8	0.00	46	06/10/2019	0700	29.5	0.00	45
06/04/2019	1700	42.7	0.00	46	06/10/2019	0800	27.8	0.00	52
06/04/2019	1800	45.5	0.00	46	06/10/2019	0900	28.1	0.00	53
06/04/2019	1900	31.6	0.00	46	06/10/2019	1000	26.6	0.00	60
06/04/2019	2000	34.6	0.00	46	06/10/2019	1100	0.0	0.01	81
06/04/2019	2100	32.2	0.00	46	06/10/2019	1200	0.0	0.05	87
06/04/2019	2200	0.0	0.01	46	06/10/2019	1300	0.0	0.00	87
06/04/2019	2300	13.9	0.00	46	06/10/2019	1400	21.0	0.00	87
06/05/2019	0000	22.0	0.00	46	06/10/2019	1500	26.0	0.00	87
06/05/2019	0100	22.5	0.00	50	06/10/2019	1600	28.3	0.00	87
06/05/2019	0200	23.2	0.00	50	06/10/2019	1700	29.7	0.00	87
06/05/2019	0300	25.7	0.00	53	06/10/2019	1800	32.3	0.00	87
06/05/2019	0400	23.5	0.00	53	06/10/2019	1900	31.7	0.00	87
06/05/2019	0500	23.5	0.00	53	06/10/2019	2000	30.3	0.00	87
06/05/2019	0600	23.0	0.00	54	06/10/2019	2100	27.3	0.00	87
06/05/2019	0700	24.5	0.00	54	06/10/2019	2200	26.4	0.00	87
06/05/2019	0800	24.3	0.00	54	06/10/2019	2300	25.6	0.00	87
06/05/2019	0900	28.5	0.00	54					

**Table 1.** Hourly Listing data in FFP for Rucker RAWS. Zero values for BI are associated with recorded precipitation amounts and elevated RH values.

Differences in model output values can be attributed, in part, to how the dead and live fuel moisture values are calculated. The Nelson Dead Fuel Model more accurately models diurnal and seasonal dead fuel moisture using hourly fire weather observations. NFDRS2016 provides hourly inputs to the Nelson model that include temperature, relative humidity, hourly precipitation and solar radiation. There are no user inputs to run the model and the model can be configured to estimate the moisture content of any size of fuel particle, from the smallest one-hour fuels to the largest 1000-hour fuels.

The Growing Season Index (GSI) is used for calculating live fuel moisture. The GSI model operates on daily surface weather observations of minimum temperature, vapor pressure deficient and photoperiod, all of which can be directly calculated from sensible weather parameters already being measured at each RAWS station.

The main benefit of GSI is that it predicts green-up and dormancy from surface weather data. GSI requires no constant human intervention yet accurately reflects within season and between season live fuel conditions from daily weather observations. This removes the need to ‘manage’ the live fuel conditions such as green-up date, freeze date, cure date and dormant date that are inputs to the current model.

### C. WIMS Evaluation

The following information represent guidance on the operational testing of NFDRS2016 in WIMS.

At the May 2018 workshop in Tucson, AZ, the Geographic Area Leadership groups were instructed to begin testing WIMS “WIMS PROD”. There are three main goals for this test:

1. Familiarize Subject Matter Experts (SME’s) with the new WIMS functions and screens in preparation to help others within their geographic areas as they transition to the new model.
2. Familiarize SME’s with the real time differences between the legacy and NFDRS2016 fuel model(s).

3. Test the new WIMS functionality and report problems/bugs back to the developers/programmers.

The following information includes instructions to be completed first in FireFamilyPlus and then in WIMS.

### 1. Fire Family Plus 5.0

- a. Open your most current hourly NFDRS2016 compliant database in FireFamilyPlus 5.0.
- b. Determine climatological breakpoints for NFDRS2016
  - (1) Identify the SIG(s) or station(s) that will be used for the test.
  - (2) Determine which fuel model(s) will be used for the test. At the minimum Fuel model 'Y' needs to be included.
  - (3) Use FireFamilyPlus to determine the two top tier breakpoint values for ERC to be entered into WIMS for the new Fuel model(s) (e.g. 90<sup>th</sup>/97<sup>th</sup>, 80<sup>th</sup>/95<sup>th</sup>). These values will be used to calculate the Staffing Index which will be used to compare legacy models with the new models.
  - (4) Verify climatological breakpoints for the legacy fuel models that are currently be used in WIMS.

### 2. WIMS PROD

- a. Edit the Station Catalog (ESTA)
- b. Activate the new NFDRS16 Fuel Model(s). The new fuel models will automatically appear on the ID list but they need to be activated.
- c. Once the new fuels models are activated the output values will begin to be calculated. WIMS automatically does a recalc when the new models are activated so no manual recalculation is needed.

Adopt 2016 Models

D e t	Active Fuel Models	P r i	ID	** 78 NFDRS Only **			88 s b	S i p	G r s	C l i	MXD
				H S	Herb Date	Greenup Date					
<input type="checkbox"/>	<input checked="" type="checkbox"/>	1	7G	F	30-May-17	01-May-17		1=0-25%	A	1	L
<input type="checkbox"/>	<input checked="" type="checkbox"/>	5	16V					1=0-25%	A		L
<input type="checkbox"/>	<input checked="" type="checkbox"/>	6	16W					1=0-25%	A		L
<input type="checkbox"/>	<input checked="" type="checkbox"/>	7	16X					1=0-25%	A		L
<input type="checkbox"/>	<input checked="" type="checkbox"/>	8	16Y					1=0-25%	A		L
<input type="checkbox"/>	<input checked="" type="checkbox"/>	9	16Z					1=0-25%	A		L
<input type="checkbox"/>	<input checked="" type="checkbox"/>										
<input type="checkbox"/>	<input checked="" type="checkbox"/>										
<input type="checkbox"/>	<input checked="" type="checkbox"/>										

- d. Add the two Staffing Index Breakpoints for the new model(s) that were determined using FFP.
- e. ERC will be used for this evaluation

MXD	SCM	Herb FM	Woody FM	X-1000	Staffing Idx Breakpoints					
					EC	DC	Low		High	
							SI%	Val	SI%	Val
L	30	2.5	50	6	EC	5	90	96	97	107
L	108	30	25	0			90		97	
L	62	30	25	0			90		97	
L	104	30	25	0			90		97	
L	5	30	25	0			90		97	
L	19	30	25	0			90		97	

- f. Navigate to the Default NFDRS Parameters Screen (ENFDR)
  - (1) There is a new role in WIMS called the 'Model Manager'. Right now, the owner of the station has been given this role and is the only one that make certain edits to the ENFDR screen.
  - (2) The Model Manager can make changes to the live and dead fuel moisture calculations by adjusting the standard inputs, but if you unsure about adjustments the default values can be used for now.
- g. Navigate to the Compare Screen (COMP)
  - (1) Enter the desired weather station or SIG and date range
  - (2) Select 'fetch station data'

### COMPARE FUEL MODELS

Station

Start Date

End Date

(3) A number of data types and viewing options are available to use for your analysis

12 FUEL MODELS RETURNED 27-JUN-18 TO 11-JUL-18 STATION 420916

Fuel Model

Obs Type

Fuel Model

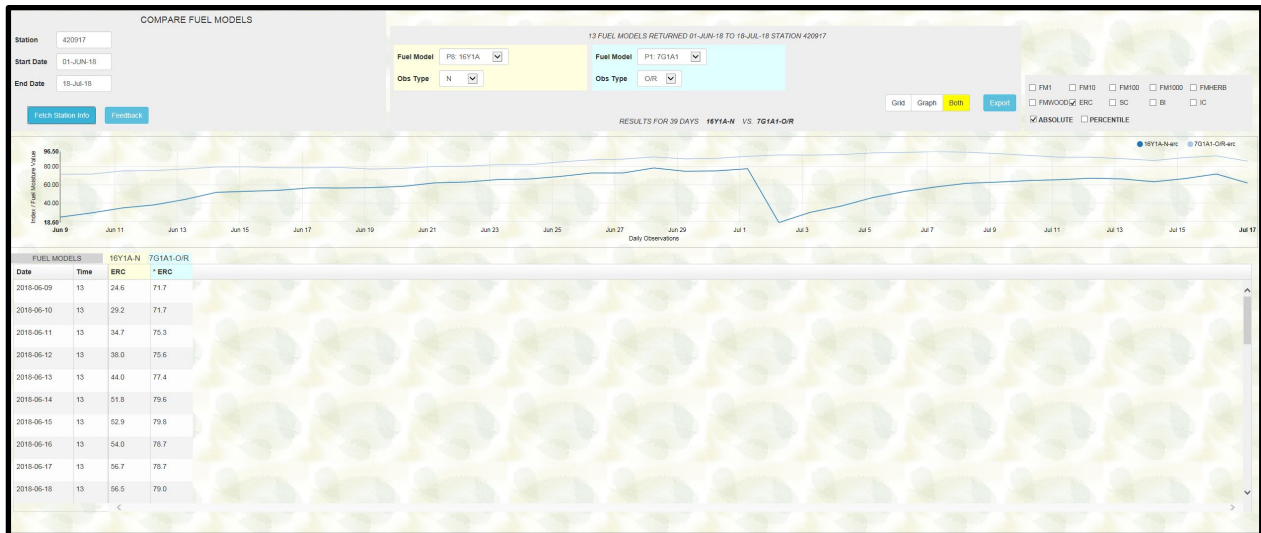
Obs Type

FM1    FM10    FM100    FM1000  
 FMHERB    FMWOOD    ERC    SC  
 BI    IC    ABSOLUTE  
 PERCENTILE

RESULTS FOR 15 DAYS 16Z1A-N VS. 7G1A1-O/R

- h. Select different settings to view comparisons of output values between the legacy fuel models and the NFDRS16 fuel model(s).
- i. The data can be viewed as a grid or a time series graph.

- j. Absolute values can be compared as well as percentile values although a standard procedure has not been developed or published to create and import the percentiles. Just compare absolute values for now.



- k. Take notes of the differences and trends
  - l. For the purpose of evaluation check the comp screen once a week and make notes on how the different fuel models have performed with respect to the actual fire danger/fire activity of the week.
- m. Navigate to the Display Index Format screen (DIDX)
  - (1) Select the test SIG or station and select the 'O/R+N' observation type and set the date range.
  - (2) Compare the calculated Staffing Level(SL) between the legacy model(s) and the NFDRS16 models
  - (3) Take note of the differences and trends.

#### D. Response and Staffing Levels

Response levels (e.g. “Low”, “Moderate”, “High”) were established to assist fire managers with decisions regarding the most appropriate response to an initial fire report until a qualified Incident Commander arrives at the incident. Response levels are derived from the most appropriate NFDRS index and/or component that have a high level of correlation to historical fire occurrence. Ignition Component (IC) with NFDRS fuel models G (legacy model) and Y (NFDRS2016) was determined to be the NFDRS index that statistically correlated strongly to the potential for fires to occur.

The staffing level forms the basis for decisions regarding the “degree of readiness” of initial attack (IA) resources and support resources. The Staffing Level matrix for this comparative evaluation was based on an analysis of cumulative frequency of occurrence using the Ignition Component (IC) index as related to a given Dispatch/Response Level. The Staffing Levels are expressed as numeric values where “1” represents the low end of the fire danger scale and “5” represents the high

end. Staffing Level is intended to provide fire managers with day-to-day decision support regarding staffing of suppression resources.

Example 1 illustrates the use of IC and fuel model Y and fire business thresholds for each FDRA developed with FFP v5. Example 2 illustrates the use of IC and fuel model G without fire business thresholds.

**Dispatch Level/Response Level Worksheet  
Tucson Interagency Dispatch Center**

Fire Danger Rating Area (FDRA)	Ignition Component (Fuel Model Y)		
Sonoran FDRA	0-30	31-60	61-100
Basin & Range Low Elevation FDRA	0-22	23-50	51-100
Basin & Range High Elevation FDRA	0-15	16-40	41-100
Dispatch Level:	Low	Moderate	High

**Example 1.** SEZ Response Level Worksheet - Fuel Model Y using the Ignition Component Index and fire business thresholds for each FDRA.

**Dispatch Level/Response Level Worksheet  
Tucson Interagency Dispatch Center**

Fire Danger Rating Area (FDRA)	Ignition Component (Fuel Model G)		
Sonoran FDRA	0-33	34-66	67-100
Basin & Range Low Elevation FDRA	0-33	34-66	67-100
Basin & Range High Elevation FDRA	0-33	34-66	67-100
Dispatch Level:	Low	Moderate	High

**Example 2.** SEZ Response Level Worksheet - Fuel Model G using the Ignition Component Index without fire business thresholds for each FDRA.

Example 3 illustrates the staffing level worksheet based on the NFDRS 78/88 model. This matrix uses the outputs from the dispatch/response level worksheet using the IC outputs from each of the three FDRAs based on fuel model G. Values for fuel model G were derived from WIMS data. This staffing level worksheet also incorporates additional inputs (fire activity, significant fire potential).

**Staffing Level Worksheet  
Tucson Interagency Dispatch Center**

Dispatch Level	Fire Activity? Y/N	LOW		MODERATE		HIGH	
		N	Y	N	Y	N	Y
N	N	1	2	2	3	3	4
Y	Y	2	3	3	4	4	5
		N	Y	N	Y	N	Y

Significant Fire Potential?  
Forecasted High Risk Day/Event (Y/N)

**Example 3.** SEZ Staffing Level Worksheet

Monitoring the model during the 2018 fire season revealed the need to update and improve the Staffing Plan for the SEZ. Following discussions and solicitation for feedback the FDTG developed a new matrix for determining Staffing Levels for the Zone. The new matrix utilizes fuel model Y and BI for the period of May 1<sup>st</sup> through August 31<sup>st</sup> as well as the determination of Significant Fire Potential (forecasted “high risk day/event”) to help determine the staffing level for the zone (Example 4).

BI Decision Thresholds	0-19		20-28		29-39		40-46		47+	
Significant Fire Potential Forecasted High Risk Day/Event (Y/N)	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Staffing Level	SL 1		SL 2		SL 3		SL 4		SL 5	

**Example 4.** SEZ Staffing Level Matrix – Fuel Model Y, Burning Index, Fire Season (May 1st – August 31st).

### E. Peak-Season and Late-Season Comparisons

Determining response and staffing levels utilizes daily NFDRS outputs. This comparison evaluated two peak-fire season dates (Examples 4 and 5) and one late-season date (Example 6) to illustrate the daily variability as well as seasonal variability with the two NFDRS models. Differences in the daily IC outputs between the legacy and NFDRS2016 models is related to how NFDRS2016 now calculates the live and dead fuel moisture values.

Fuel Model Y	June 4, 2018			Staffing Level	Fuel Model G	June 4, 2018		
FDRA	IC	Response Level	FDRA		IC	Response Level	Staffing Level	
B&R High	80	High	4	B&R High	63	Moderate	3	
B&R Low	92	High	4	B&R Low	74	High	4	
Sonoran	95	High	4	Sonoran	71	High	4	

**Example 4.** SEZ response and staffing level outputs for June 4, 2018, historically the driest month of the fire season in the zone.

Fuel Model Y	June 5, 2018			Staffing Level	Fuel Model G	June 5, 2018		
FDRA	IC	Response Level	FDRA		IC	Response Level	Staffing Level	
B&R High	37	Moderate	3	B&R High	37	Moderate	3	
B&R Low	57	High	4	B&R Low	58	Moderate	3	
Sonoran	58	Moderate	3	Sonoran	68	High	4	

**Example 5.** SEZ response and staffing level outputs for June 5, 2018, historically the driest month during fire season in the zone.

Fuel Model Y	July 14, 2018	Staffing	Fuel Model G	July 14, 2018	Staffing
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FDRA	IC	Response Level	Level	FDRA	IC	Response Level	Level
B&R High	0	Low	1	B&R High	1	Low	1
B&R Low	1	Low	1	B&R Low	2	Low	1
Sonoran	16	Low	1	Sonoran	15	Low	1

**Example 6.** SEZ response and staffing level outputs for July 14, 2018, summer monsoonal period beginning in the zone.

Model output differences have been evaluated and discussed with fire managers and dispatch center personnel. The SEZ FDTG continues to comparatively evaluate NFDRS outputs during pre-, peak-, and late-fire season to determine whether the fire business thresholds for each FDRA need to be adjusted or if another NFDRS index may work better. Fire managers have provided mixed feedback; some managers indicated that the NFDRS2016 model may be over-predicting while others agreed with the outputs during peak-fire season. The new model appears to work well during the shoulder seasons when compared with the legacy NFDRS model. Fire managers and the SEZ FDTG will work during the off-season to more closely evaluate these tools and make adjustments which will be evaluated during the 2019 fire season.

## F. Historical Fire Comparisons

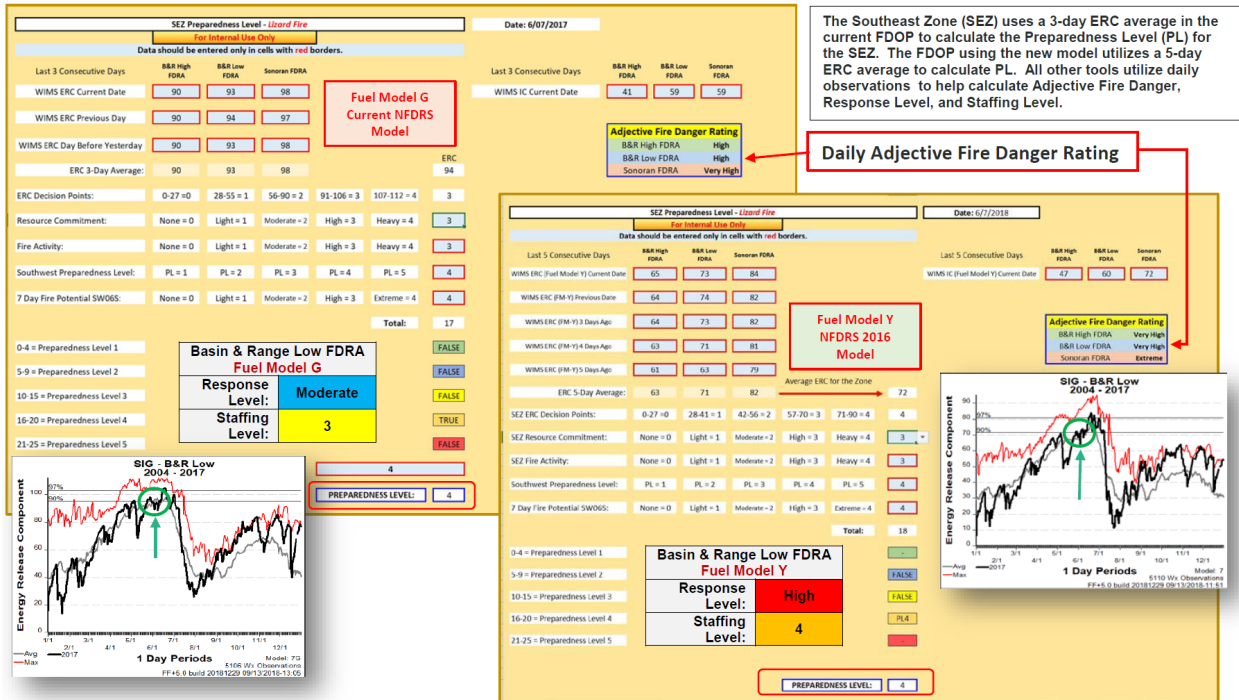
Evaluating historical fire occurrences and comparing the legacy model outputs with the new NFDRS2016 outputs can provide users with a frame of reference as they begin to implement the new model.

### a. Lizard Fire

The Lizard Fire was discovered on the afternoon of June 7, 2017 following the passage of a fast-moving storm front which produced multiple lightning strikes. The fire was located in the Basin and Range FDRA and the final acreage was calculated at 15,230 acres.

The NFDRS2016 model ranked the Adjective Fire Danger Rating at “Very High” for that day. The legacy model ranked the Adjective Rating at “High”. The NFDRS2016 model calculated the response level to be “High” versus “Moderate” using the legacy model. The staffing level was calculated to be “4” using NFDRS2016 versus a “3” rating using the legacy model (Example 7).

ERC graphs using both models showed daily values trending upward as the zone was nearing peak-fire season. Both graphs (ERC-G and ERC-Y) tracked very comparably and values were near the 90<sup>th</sup> percentile on June 7<sup>th</sup>.



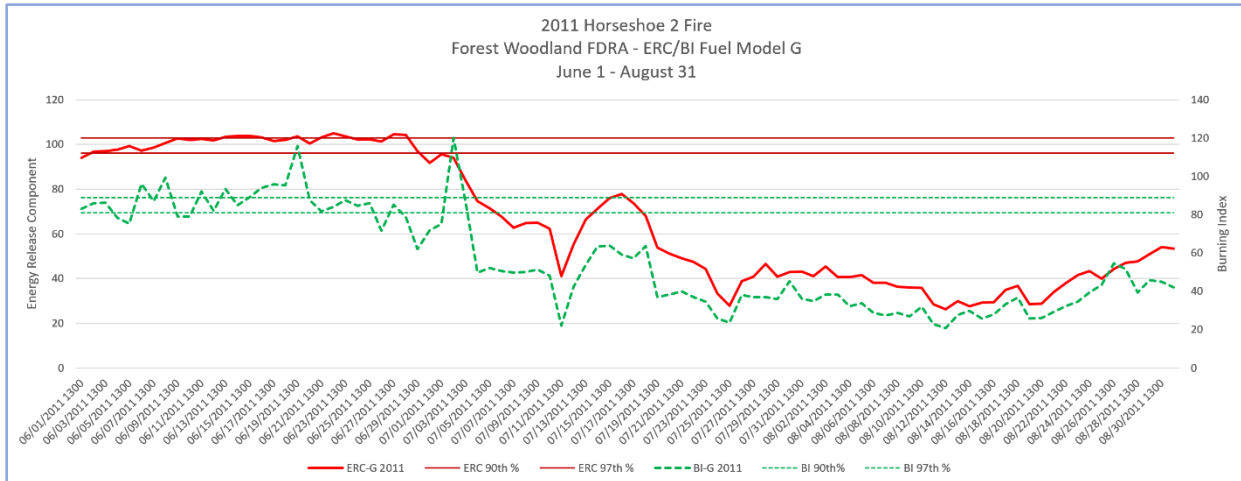
**Example 7.** Lizard Fire, June 7, 2017. NFDRS and FDOP tool outputs comparing NFDRS2016 with the legacy NFDRS model.

b. Horseshoe 2 Fire

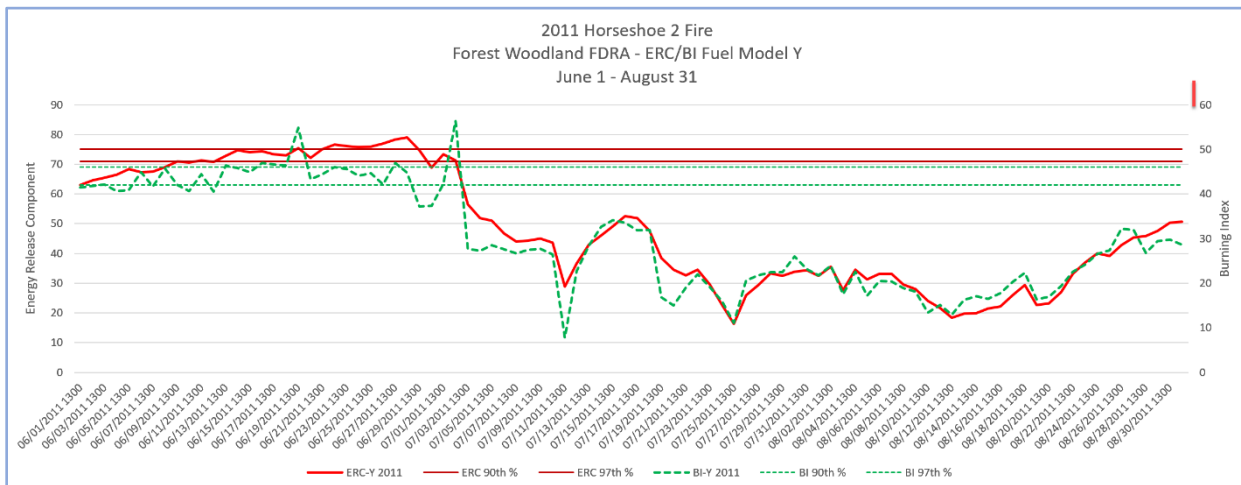
The 2011 fire season recorded a number of large fires in the southwestern U.S. The Horseshoe 2 fire was discovered on May 8, 2011. The fire was located in the Forest-Woodlands FDRA and the final acreage was recorded to be 222,990 acres. This fire was called out on August 14, 2011.

Graphs 5 and 6 display daily ERC and BI values for the identified fire season (June – August 2011). June typically represents the peak of fire season in the desert southwest. Both graphs show ERC values trending at or above the 97<sup>th</sup> percentile. BI values are also shown trending at or above the 90<sup>th</sup> and 97<sup>th</sup> percentiles through June. The first three weeks of June experienced very high to extreme fire behavior on this fire.



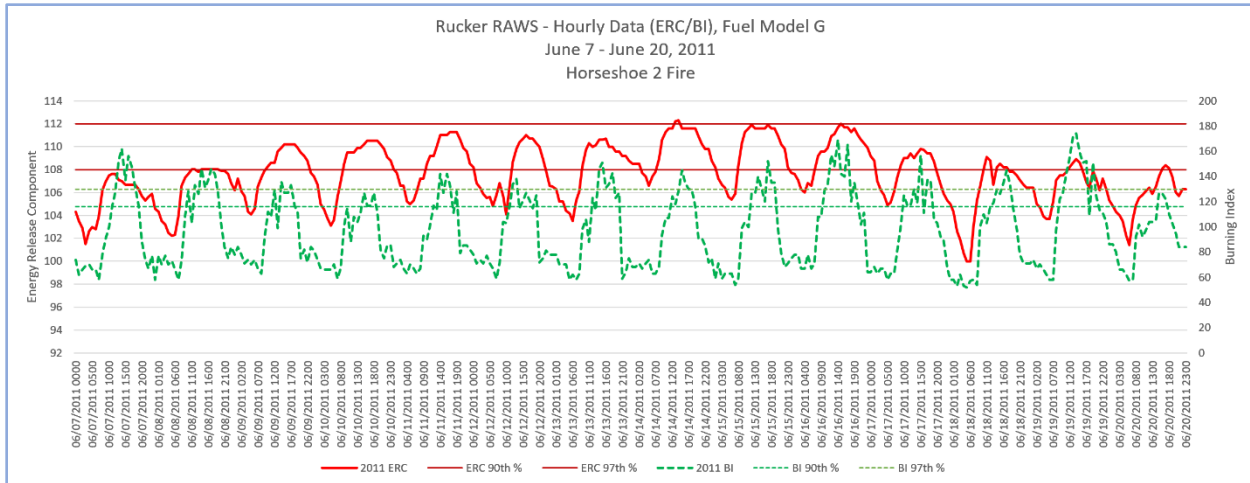


**Graph 5.** Daily ERC and BI values using Fuel Model G for the 2011 fire season during the Horseshoe 2.



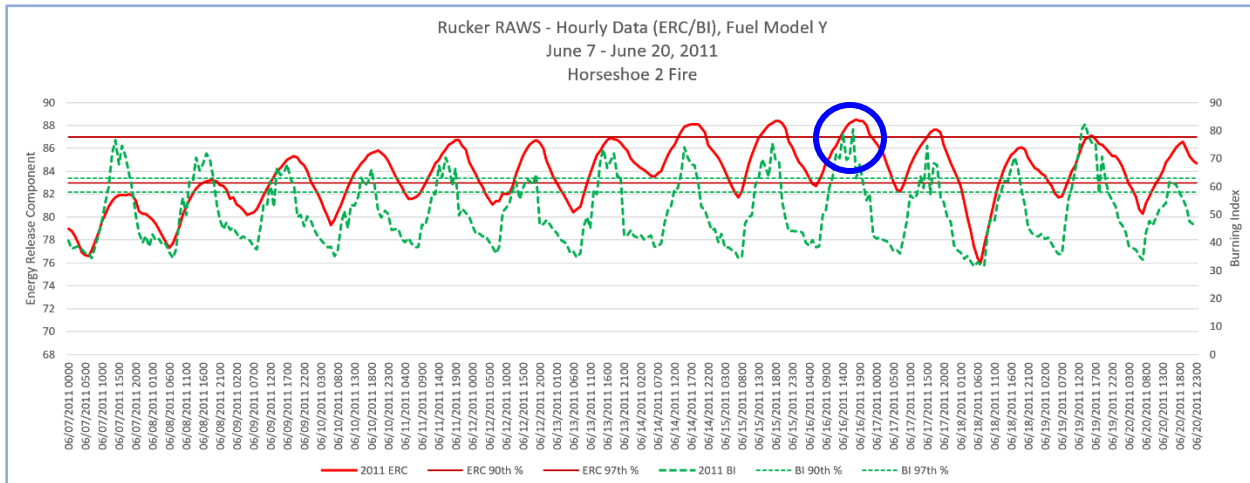
**Graph 6.** Daily ERC and BI values using Fuel Model Y for the 2011 fire season during the Horseshoe 2.

Graph 7 displays hourly ERC and BI values for the period of June 7<sup>th</sup> – 20<sup>th</sup> in 2011. Fuel model G shows peak ERC values trending above the 90<sup>th</sup> percentile through June 13<sup>th</sup> and peaking above the 97<sup>th</sup> percentile beginning on June 14<sup>th</sup> at around 1500 hours. BI values peaked above the 97<sup>th</sup> percentile for most of this time period.



**Graph 7.** Hourly ERC and BI values using Fuel Model G over a two-week period (June 7-20, 2011) during the Horseshoe 2 fire in 2011.

Graph 8 also displays hourly ERC and BI values for the period of June 7<sup>th</sup> – 20<sup>th</sup> in 2011. Values calculated using fuel model Y indicates peak ERC values trending above the 90<sup>th</sup> percentile from June 8<sup>th</sup> through June 12<sup>th</sup> and peaking above the 97<sup>th</sup> percentile on June 14<sup>th</sup> beginning at around 1500 hours. BI values peaked above the 97<sup>th</sup> percentile for most of this time period.



**Graph 8.** Hourly ERC and BI values using Fuel Model Y over a two-week period (June 7-20, 2011) during the Horseshoe 2 fire in 2011.

Graph 8 shows ERC and BI values on June 16<sup>th</sup> both peaking above their respective 97<sup>th</sup> percentile thresholds at 1700 hours. The hourly data in FFP for this time period shows 1-, 10-, and 100-hour fuel moisture values being critically low (1.9%, 4.5%, and 5.1%) as well as a minimum RH value of 4% (Table 2). These values indicate the potential for extreme fire behavior.

021414 - Hourly Listing

FireFamily Plus Hourly Listing Report  
Hourly Listing of Selected Values

FF+5.0 build 20191211 08/24/2019-11:01  
printed on: 08/24/2019 at 11:01:14 AM  
using database: C:\Users\Mark\Documents\Work\NFDRS 1

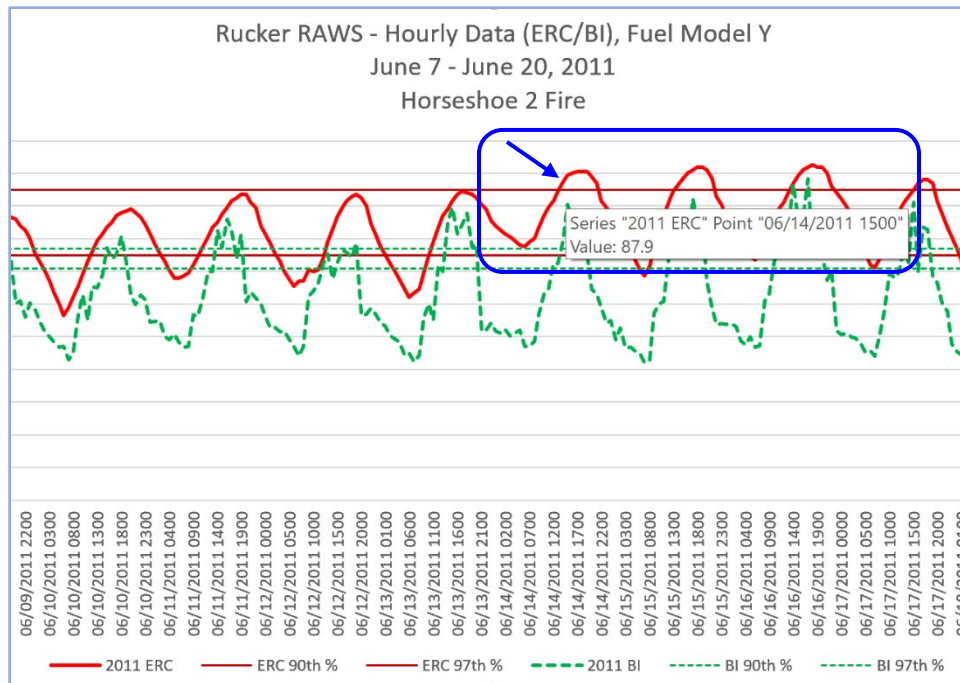
-----  
Active Working Set:  
Station: 021414 - RUCKER  
Data years: 2011 - 2011  
Analysis Period Length: 1 days  
Annual filter dates: June 16 thru June 16  
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Station Details:  
021414 RUCKER Fuel model: Y (Use 0  
Slope class: 2 Climate class: 1 Greenup: 04/07  
Start KBDI: 83 Start FM1000:15 Avg. Precip: 19.0  
FM1 = FM10? N Herb Annual? N Deciduous? N  
Aspect: 0 Slope posit.: U Elevation: 5700  
Latitude: 31.76 Longitude: -109.35  
Weighed Stick Moistures Used: No  
SOW: Use SR\_SOW if SOW is Missing  
WetFlag: Use SR\_WetFlag if WetFlag is Missing  
-----

DATE	Time	ERC	BI	FM1	FM10	F100	MnRH
06/16/2011	0000	85.4	44.0	4.2	4.1	5.1	4
06/16/2011	0100	84.8	44.2	4.8	4.1	5.1	4
06/16/2011	0200	84.4	43.4	5.2	4.1	5.1	4
06/16/2011	0300	84.0	39.9	5.6	4.1	5.1	4
06/16/2011	0400	83.4	38.9	6.1	4.2	5.1	4
06/16/2011	0500	82.9	40.9	6.5	4.3	5.1	4
06/16/2011	0600	82.7	38.3	6.5	4.5	5.1	4
06/16/2011	0700	83.2	38.6	6.3	4.8	5.1	4
06/16/2011	0800	83.9	49.8	5.8	4.7	5.1	4
06/16/2011	0900	84.8	51.5	5.0	4.6	5.1	4
06/16/2011	1000	85.2	59.8	4.4	4.8	5.1	4
06/16/2011	1100	85.8	63.1	3.9	4.8	5.1	4
06/16/2011	1200	86.2	71.7	3.4	4.9	5.1	4
06/16/2011	1300	86.9	70.2	2.9	5.0	5.1	4
06/16/2011	1400	87.4	79.2	2.5	4.8	5.1	4
06/16/2011	1500	87.9	69.5	2.2	4.7	5.1	4
06/16/2011	1600	88.2	70.5	2.0	4.6	5.1	4
06/16/2011	1700	88.4	80.5	1.9	4.5	5.1	4
06/16/2011	1800	88.5	63.0	2.0	4.4	5.1	4
06/16/2011	1900	88.4	68.0	2.2	4.3	5.1	4
06/16/2011	2000	88.4	61.7	2.4	4.2	5.1	4
06/16/2011	2100	88.0	55.0	2.7	4.2	5.1	4
06/16/2011	2200	87.2	57.4	3.0	4.3	5.1	4
06/16/2011	2300	86.8	42.3	3.3	4.2	5.1	4

**Table 2.** Hourly Listing data in FFP for Rucker RAWS. Both ERC and BI values are well above the 97<sup>th</sup> percentile for the FDRA. The low values for the 1-, 10-, and 100-hour fuel moisture values as well as the low minimum RH value indicate the potential for extreme fire behavior.

Note that when displaying graph data in MS Excel, if the cursor is held over any point on the graph a pop-up window will appear, and display information associated with that point. Graph 9 shows an ERC value of 87.9 at 1500 hours on June 14, 2011.



**Graph 9.** Data series information displayed in MS Excel.

## 2. Comparative Evaluation Summary

There are a wide variety of methods available to evaluate and compare legacy and NFDRS2016 model outputs. Each zone is unique, and users are encouraged to develop a monitoring and comparison system that makes sense to them and where constructive feedback can be solicited and tracked. Feedback information is where constructive changes or adjustments to the various FDOP tools can be effectively applied.

Weekly reports that highlight side-by-side comparisons of the NFDRS2016 and legacy models help fire mangers and dispatch center personnel become more familiar with the new science. Differences in model outputs should be expected and new users to the system have the opportunity to learn why outputs may vary. The biggest difference in the new model outputs is in how the live and dead fuel moistures are calculated.

The Nelson Dead Fuel Model more accurately models diurnal and seasonal dead fuel moisture using hourly fire weather observations. NFDRS2016 provides *hourly* inputs to the Nelson model that include temperature, relative humidity, hourly precipitation and solar radiation. There are no user inputs to run the model and the model can be configured to estimate the moisture content of any size of fuel particle, from the smallest one-hour fuels to the largest 1000-hour fuels.

The Growing Season Index (GSI) is used for calculating live fuel moisture. The GSI model operates on daily surface weather observations of minimum temperature, vapor pressure deficient and photoperiod, all of which can be directly calculated from sensible weather parameters already being measured at each RAWs station.

The main benefit of GSI is that it predicts green-up and dormancy from surface weather data. GSI requires no constant human intervention yet accurately reflects within season and between season live fuel conditions from daily weather observations. This removes the need to 'manage' the live fuel conditions such as

green-up date, freeze date, cure date and dormant date that are inputs to the current model.

Comparative evaluations provide NFDRS users with a better understanding in how the new model operates. Improving user knowledge with the NFDRS2016 model provides the opportunity to refine current or develop new fire danger planning tools (i.e. Staffing, Response, Preparedness, Adjective Fire Danger Rating, etc.).