



# Overview of NFDRS2016

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NATIONAL NFDRS 2016 ROLLOUT WORKSHOP

28 APR 2018

# Outline

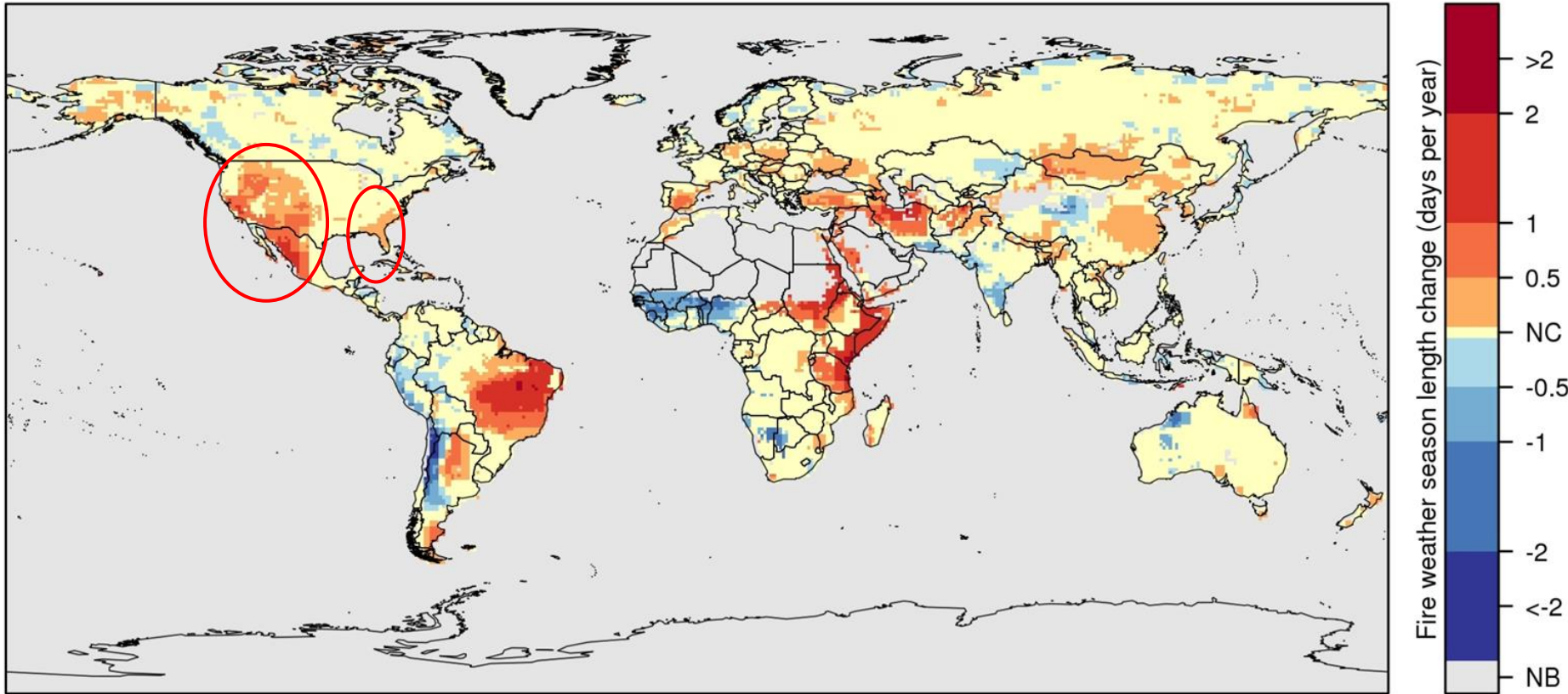
- ▶ Introduce the NFDRS changes
- ▶ Talk about some elements relating to model comparison and evaluation
- ▶ Look at the future
- ▶ Why we should care.....

## **A horse walks into a bar...**

- ▶ The bartender says, "Hey."
- ▶ The horse replies, "Sure."

# Fire weather conditions are changing

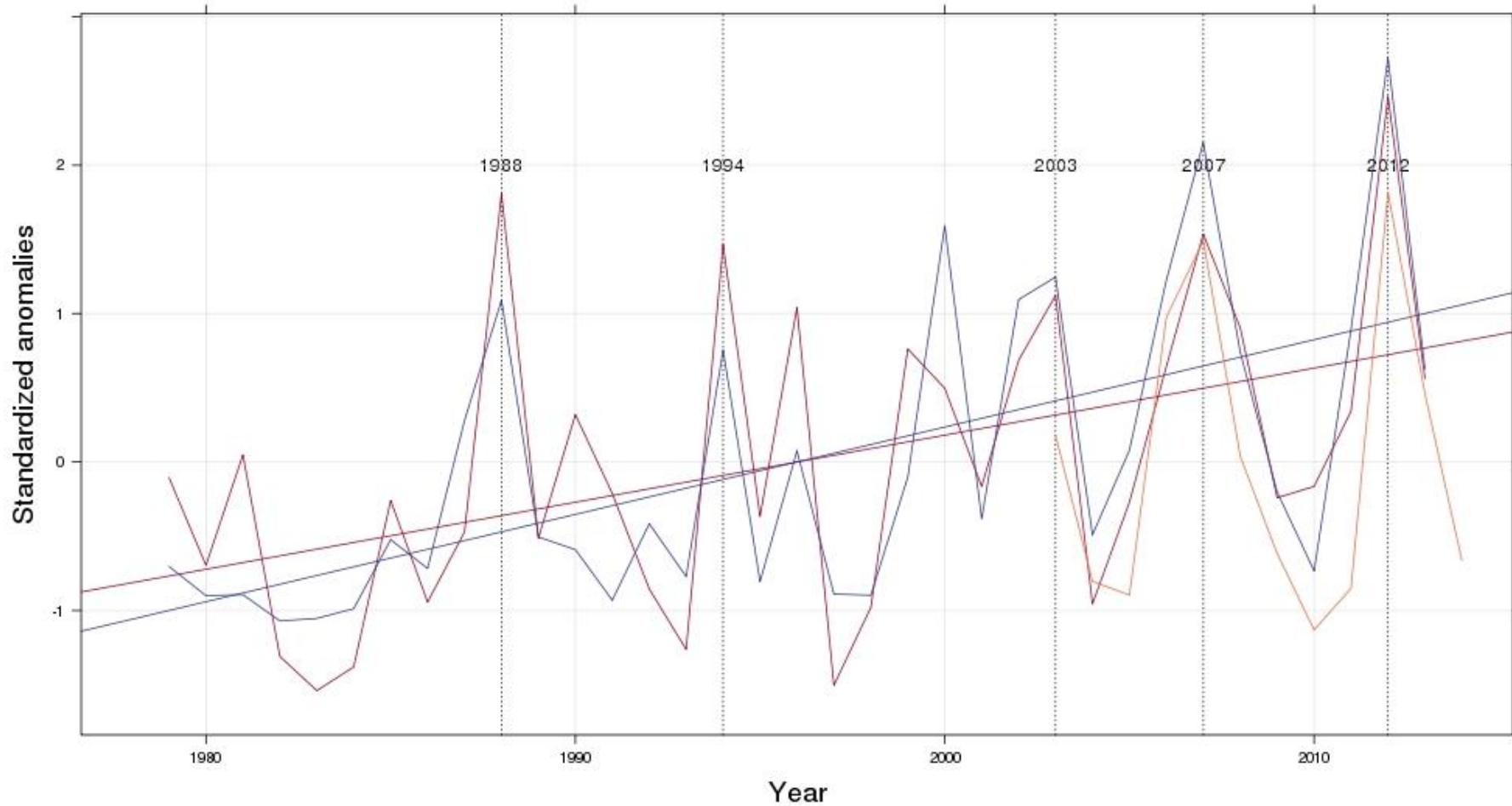
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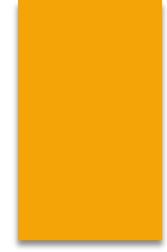
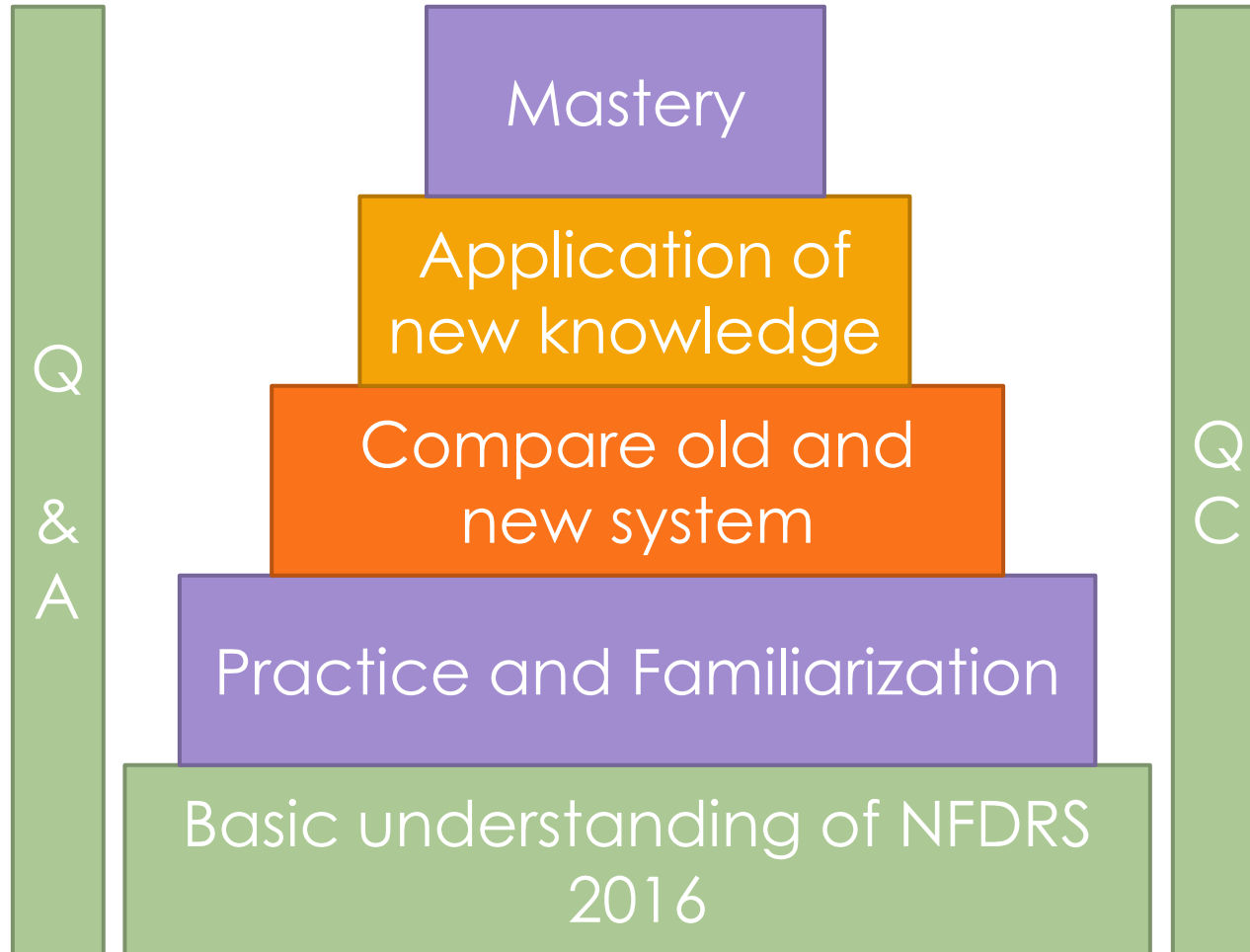


Fire weather seasons have lengthened across 29.6M km<sup>2</sup> (25.3%) of the Earth's vegetated surface. (Jolly et al 2015, Nature Communications)

Climatic changes account for 85% of the burned area variations across Western National Forests (Jolly et al, unpublished)

**Western US National Forests**  
Mean Fire Weather Season Length  
Western National Forests Burned Area  
MODIS FRP-derived season length



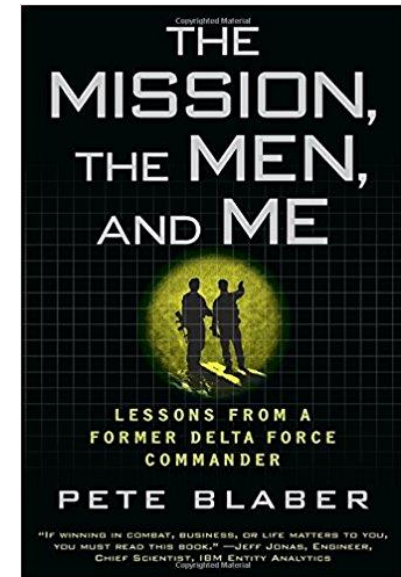


# Philosophy

- ▶ Two desires for today:
  - ▶ **Learn:** About the new model and how to use the tools to explore it
  - ▶ **Commit:** To be a part of a learning community

## A learning model:

1. Saturate
2. Incubate
3. Illuminate



# Fire Danger Rating: The Next 20 Years, 1987

## John E. Deeming

Abstract: For the next 10 years, few changes will be made to the fire-danger rating system. During that time, the focus will be on the automation of weather observing systems and the streamlining of the computation and display of ratings. The time horizon for projecting fire danger will be pushed to 30 days by the late 1990's. A close alignment of the fire-danger rating system with the fire-behavior and fire-planning systems will occur with the release of the second-generation fire model in the late 1990's. Improved utilization of all of these systems will be delayed until more structured approaches to decision making are adopted by management. By 2007, expert systems utilizing real-time direct and remotely sensed weather and fuel moisture data will be on line.

<https://www.fs.usda.gov/treearch/pubs/28099>



# Four guidelines of a fire danger rating system

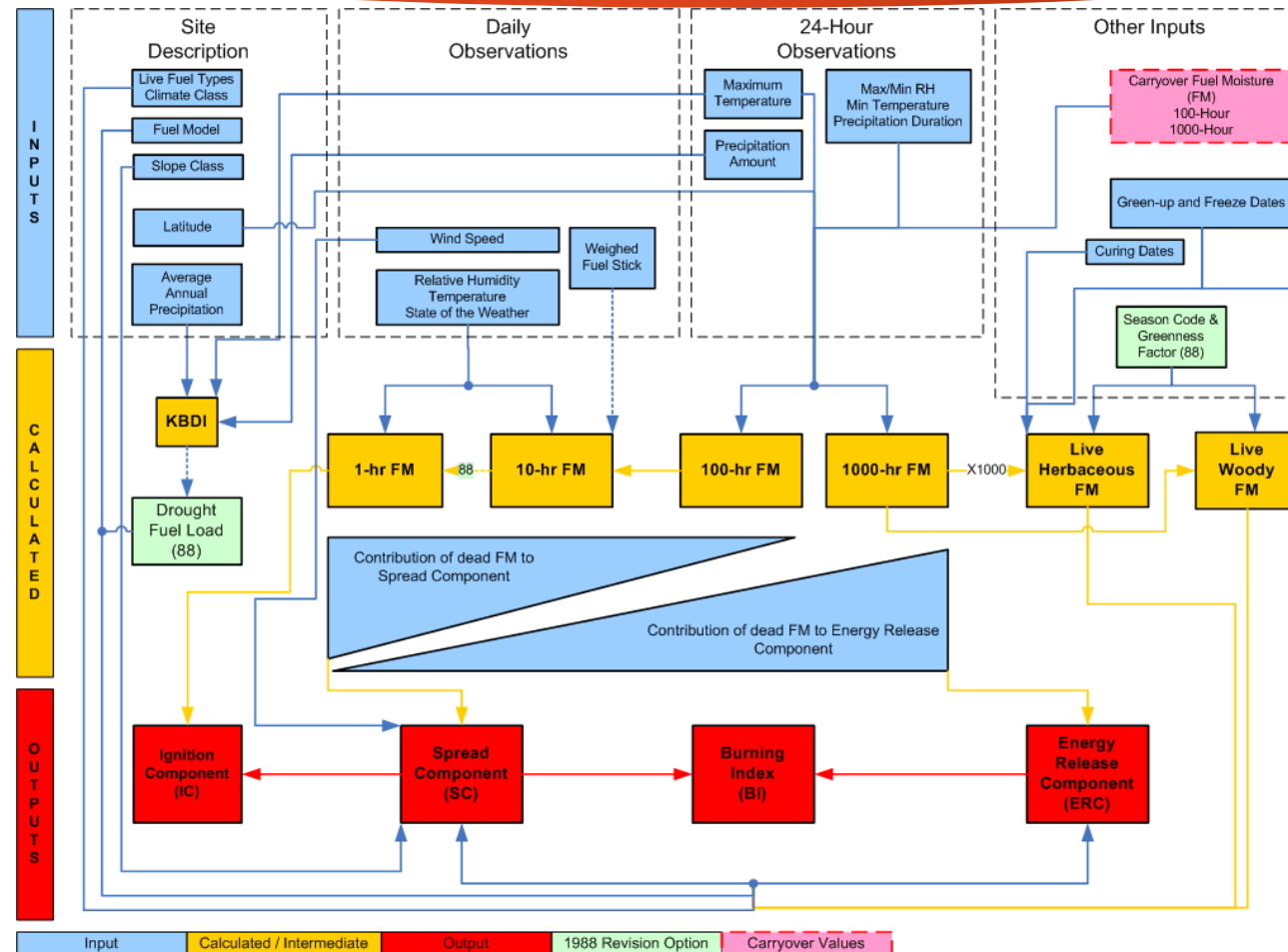
- ▶ To develop consistency among protection agencies, the National Fire Danger Rating System (NFDRS) was developed in the early 70's. It was designed around four basic guidelines. The research charter said the National Fire Danger Rating System would be:
  - A. Scientifically based.**
  - B. Adaptable to the needs of local managers.**
  - C. Applicable anywhere in the country.**
  - D. Reasonably inexpensive to operate.**

# Components of a fire danger rating system

- ▶ **Modular:** New science can easily be added
- ▶ **Integrative:** Fire danger indices integrated over both space (FDRA) and multiple time horizons (today -> season -> inter-annual)
- ▶ **Generalized:** Same system performs across a range of climates. It should work everywhere.
- ▶ **Applicable:** Normalize index scales and apply indices across a spectrum of fire management decisions. Maintain a 'common language' across all agencies.

<https://kahoot.it>

# Structure of the 1978/88 National Fire Danger Rating System



## Check-in Question

- ▶ What are the required user inputs to NFDRS?
- ▶ Daily?
- ▶ Seasonal?

# Case for Change

- ▶ Prepares NFDRS to integrate into future uses of weather data
  - Described in the FENC/CEFA RAWs Network Analysis of 2011, including increasing use of gridded data in analysis products like NFDRS
- ▶ Preparing to do this for over a decade:
  - Installing solar radiation sensors on RAWs
  - Evaluating new model performance
  - Lessons learned in extensive analysis in Fire Danger Operating Plans correlating NFDRS Indices, fuel models and fire activity.

# Outline

- ▶ Major Changes
  - ▶ Fuel moisture models and fuel models
- ▶ Minor Changes
  - ▶ Drought fuel loading and Herbaceous curing
  - ▶ Other fuel model and site description changes
- ▶ Simplifications and parameter elimination summary

# New live fuel moisture model



Check-in  
Question

- ▶ What are the current inputs / drivers of live fuel moisture models in NFDRS 78/88?

# New Live Fuel Moisture Model

- ▶ Live fuel moisture model in the 1978 / 1988 NFDRS is acknowledged as the weakest sub-model in NFDRS. The original NFDRS developers intended to replace it at the earliest possible convenience.
- ▶ The new herbaceous and woody fuel moisture calculations will use the Growing Season Index and it will transform that index into live fuel moisture values

# Growing Season Index (GSI)

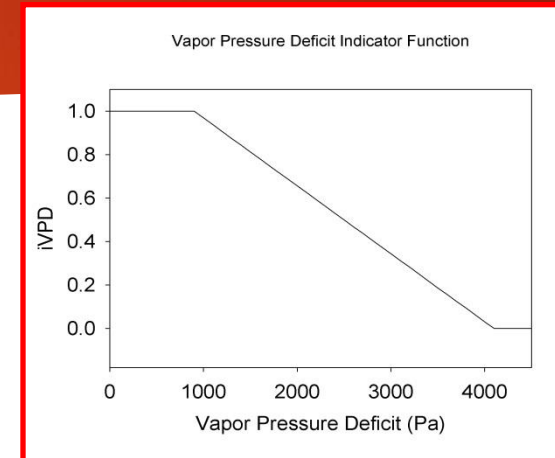
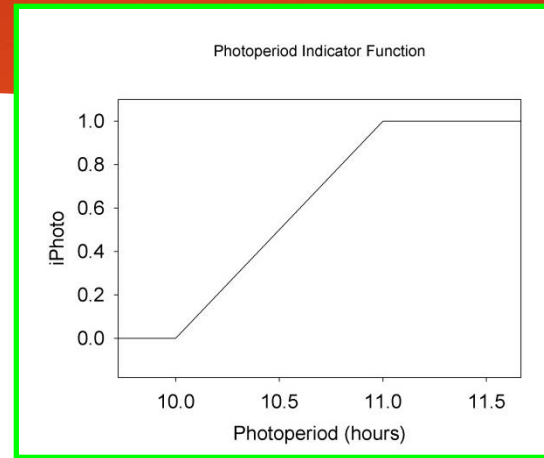
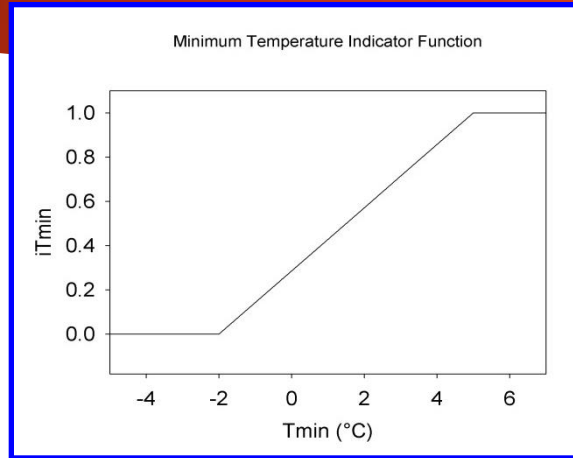
- ▶ **Growing Season Index – GSI** – is a meteorologically-based, generalized phenology model
- ▶ It requires no constant human intervention yet accurately reflects within season and between season live fuel conditions from daily weather observations.
  - ▶ Predicts green-up date and shows herbaceous curing
  - ▶ Automatically integrates freezing and dormancy
  - ▶ Eliminates the need for Climate Class, Green-up date, freeze date, season codes and greenness factors (88 system)

**Jolly, W.M., Nemani, R., Running, S.W., 2005. A generalized, bioclimatic index to predict foliar phenology in response to climate. *Global Change Biology* 11, 619-632.**

# Growing Season Index (GSI) ...

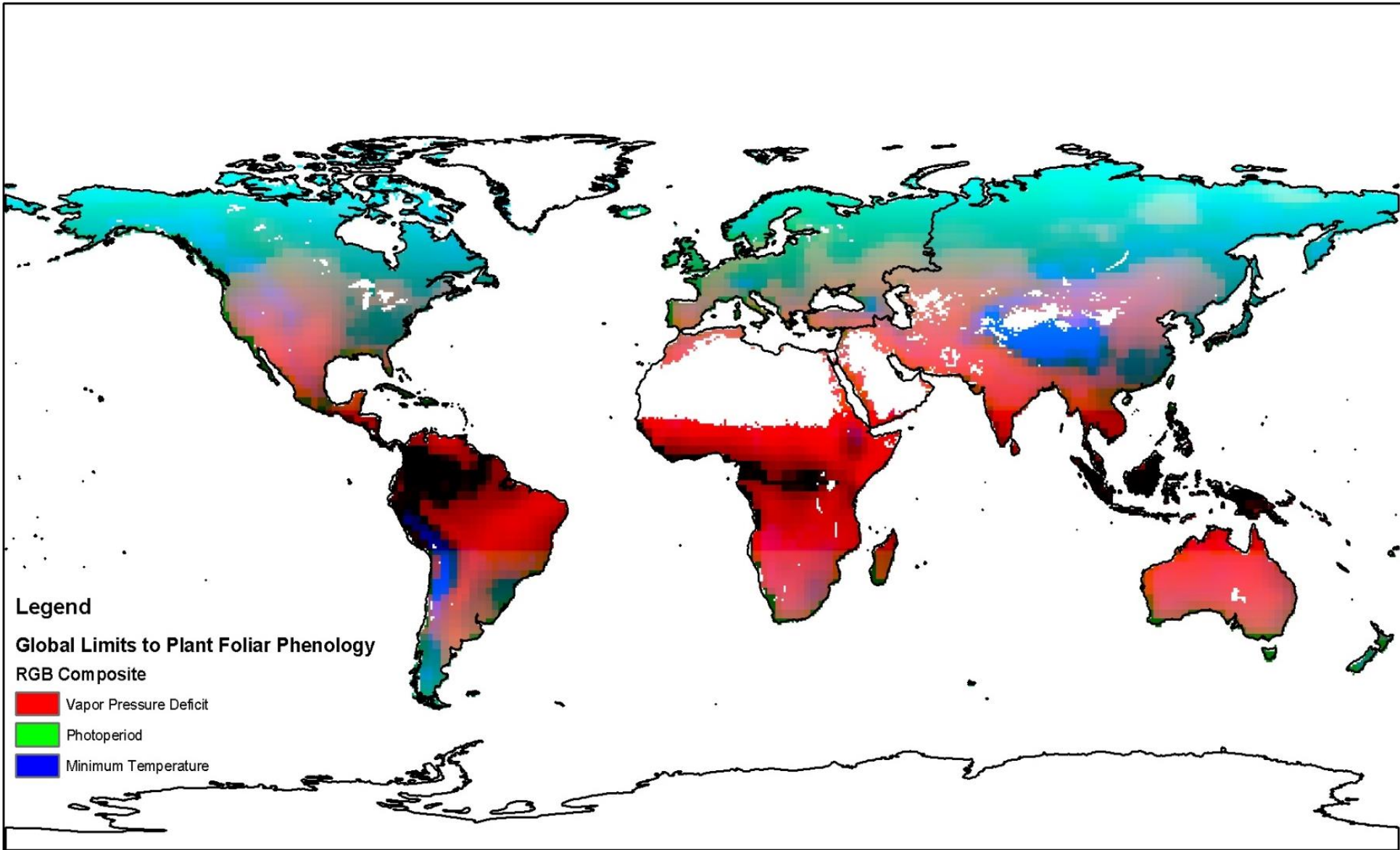
- ▶ Calculated DAILY
- ▶ GSI has 3 inputs:
  - ▶ 24 hour minimum temperature (TMIN)
  - ▶ Vapor pressure deficit (VPD)
    - ▶ Calculated from relative humidity and air temperatures
      - ▶  $RH = (VP_{act} / VP_{sat}) * 100$
      - ▶  $VPD = VP_{sat} - VP_{act}$
    - ▶ Can be calculated from either 24 hour maximum or 24 hour average temperature (VPD<sub>max</sub> and VPD<sub>avg</sub>, respectively)
  - ▶ Photoperiod or Daylength
    - ▶ Calculated from station latitude and yearday

# The Growing Season Index



$$\text{Growing Season Index (iGSI)} = i_{Tmin} * i_{Photo} * i_{VPD}$$

The final index varies continuously from zero (limiting) to one (unconstrained)

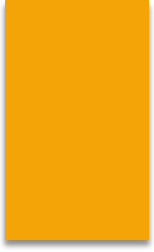


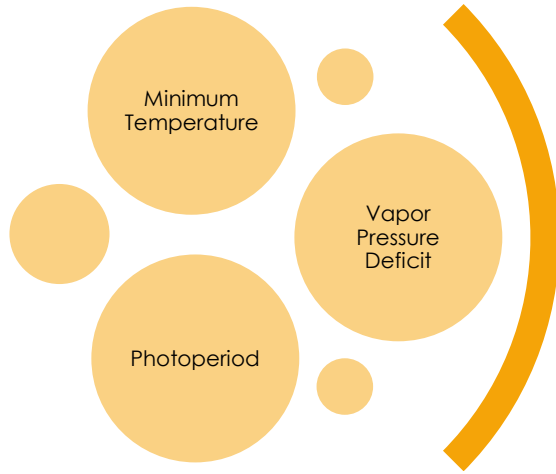
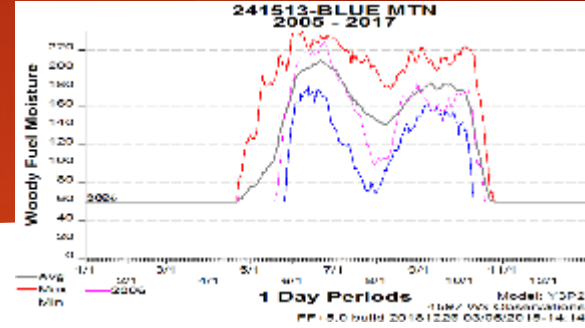
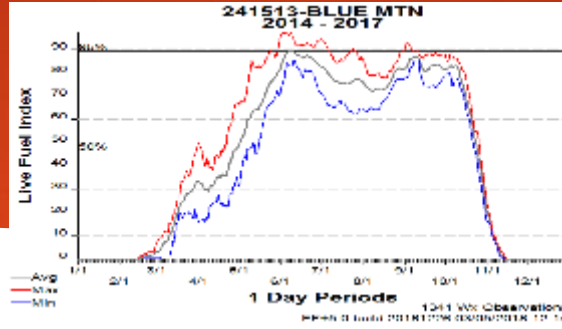
**Legend**

**Global Limits to Plant Foliar Phenology**

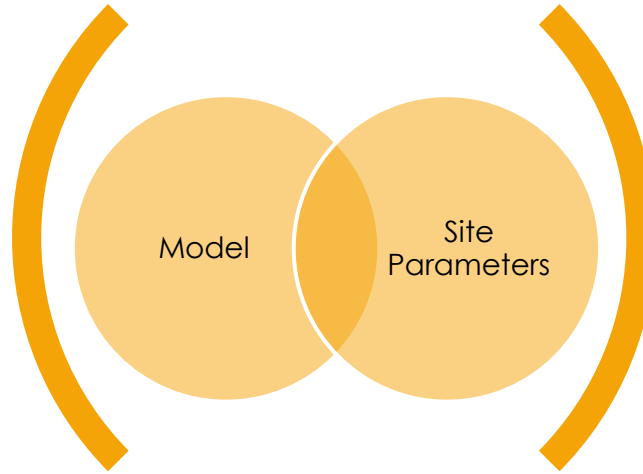
**RGB Composite**

- Vapor Pressure Deficit
- Photoperiod
- Minimum Temperature

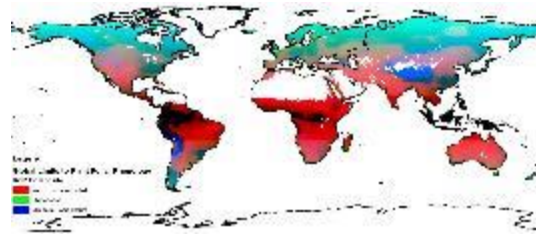
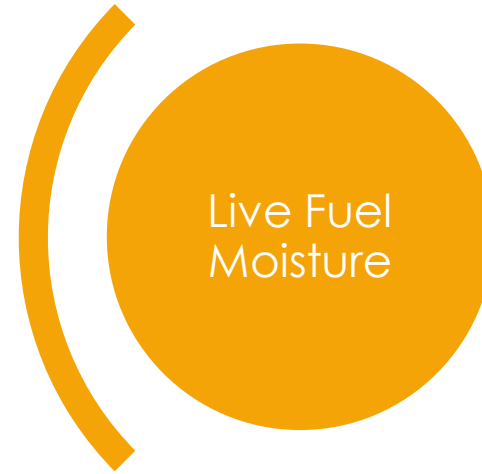




Daily Weather Inputs

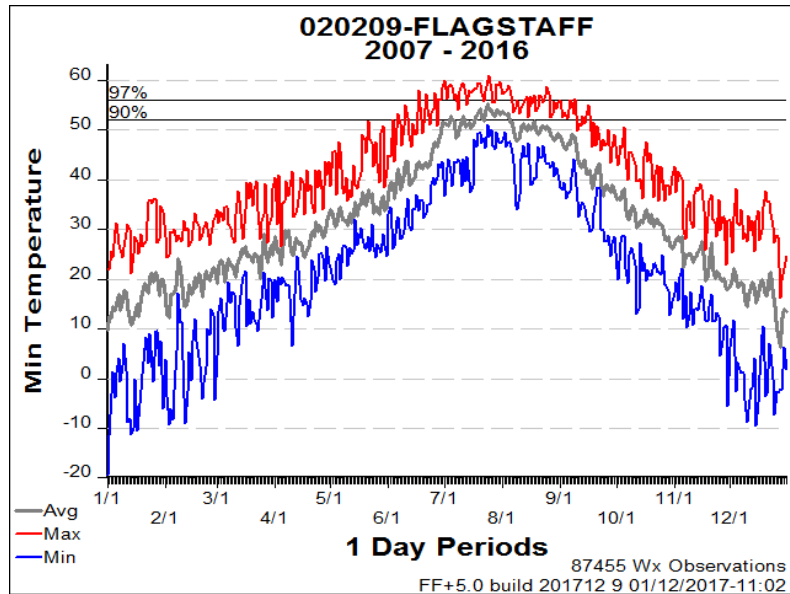


Growing Season Index

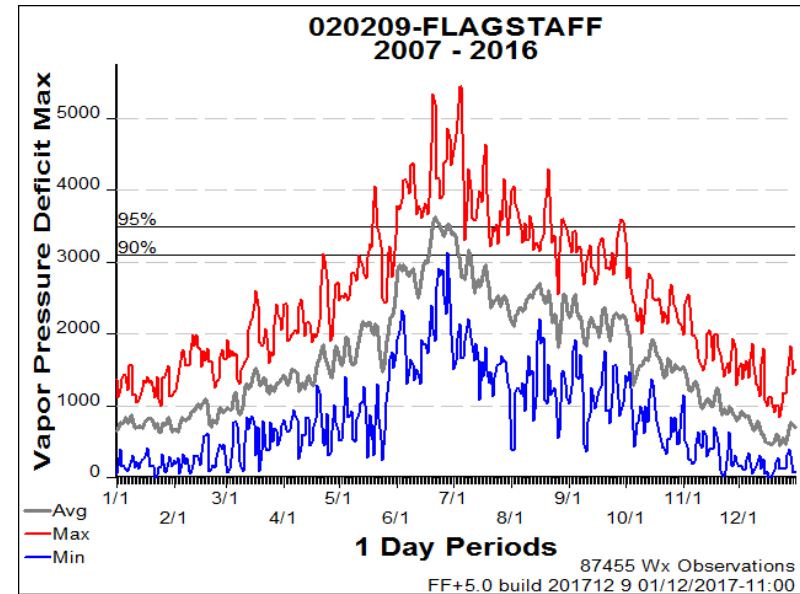


# Example weather inputs to GSI

## Minimum temperature

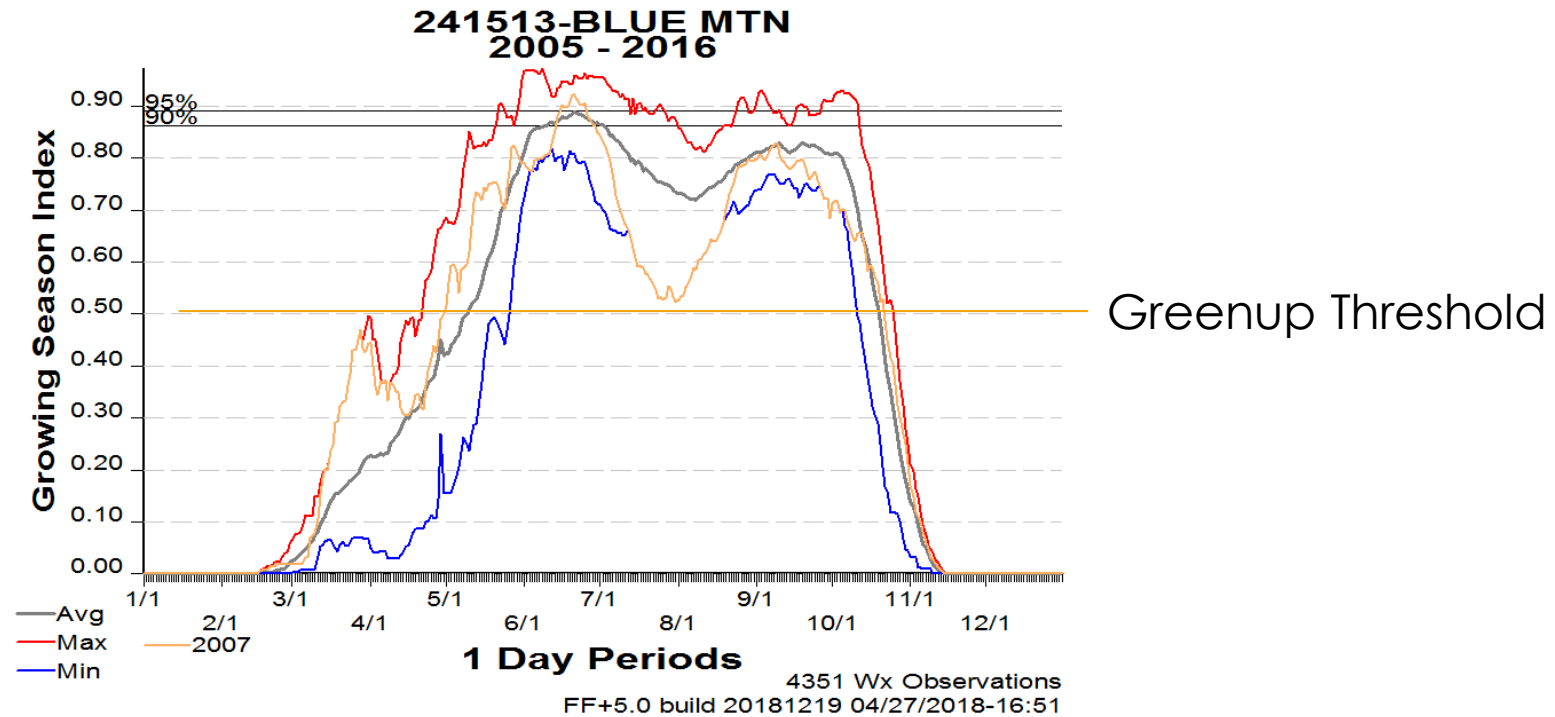


## Vapor pressure deficit





# Example GSI plot



Note: NO MORE LFI..... From now on, it will ONLY be called GSI

# Growing Season Index

Rules-of-thumb for interpreting  
GSI values

GSI Value	Classification / Interpretation
<b>GSI Increasing</b>	
0 to .5	Pre-greenup; dormancy
> .5	Green-up
.75 to 1.0	Full plant canopy development
<b>GSI decreasing</b>	
1.0 to .5	Curing herbaceous vegetation
< 0.5	Leaf senescence
Below 0.5	Entering complete curing or dormancy



Calculate  
GSI

Rescale GSI

Calculated  
LFM from GSI

# LFM model parameters

▶ LFM model parameters:

- ▶ GSI indicator thresholds
- ▶ Maximum GSI value

- ▶ Default is 1.0 but can be used for model calibration

- ▶ Green-up threshold

- ▶ Default is 0.5

- ▶ Minimum and maximum live herbaceous and woody fuel moistures

- ▶ Minimum herbaceous FM is 30% and Maximum herbaceous FM is 250%
  - ▶ Minimum woody FM is 60% and maximum herbaceous FM is 200%
  - ▶ These are the same maximum values used in NFDRS 1978 / 1988

	Lower Limit	Upper Limit
<b>Minimum Temperature</b>	28.4° F (-2°C) ( $T_{MMin}$ )	41° F (5°C) ( $T_{MMax}$ )
<b>Vapor Pressure Deficit</b>	900Pa ( $VPD_{Min}$ )	4100Pa ( $VPD_{Max}$ )
<b>Photoperiod</b>	36000 sec ( $Photo_{Min}$ )	39600 sec ( $Photo_{Max}$ )

$$iVPD = \begin{cases} 0, & \text{If } VPD \geq VPD_{Max} \\ 1 - \frac{VPD - VPD_{Min}}{VPD_{Max} - VPD_{Min}}, & \text{If } VPD_{Max} > VPD > VPD_{Min} \\ 1, & \text{If } VPD \leq VPD_{Min} \end{cases}$$

Vapor Pressure Deficit

$$iPhoto = \begin{cases} 0, & \text{If } Photo \leq Photo_{Min} \\ \frac{Photo - Photo_{Min}}{Photo_{Max} - Photo_{Min}}, & \text{If } Photo_{Max} > Photo > Photo_{Min} \\ 1, & \text{If } Photo \geq Photo_{Max} \end{cases}$$

Photoperiod

$$iT_{min} = \begin{cases} 0, & \text{If } T_{min} \leq T_{MMin} \\ \frac{T_{min} - T_{MMin}}{T_{MMax} - T_{MMin}}, & \text{If } T_{MMax} > T_{min} > T_{MMin} \\ 1, & \text{If } T_{min} \geq T_{MMax} \end{cases}$$

Minimum Temperature

	Lower Limit	Upper Limit
<b>Minimum Temperature</b>	28.4° F (-2°C) ( $T_{MMin}$ )	41° F (5°C) ( $T_{MMax}$ )
<b>Vapor Pressure Deficit</b>	900Pa ( $VPD_{Min}$ )	4100Pa ( $VPD_{Max}$ )
<b>Photoperiod</b>	36000 sec ( $Photo_{Min}$ )	39600 sec ( $Photo_{Max}$ )

# GSI Example

	Lower Limit	Upper Limit	Default GSI Greenup Threshold
Live Herbaceous Fuel Moisture	30% ( $Min_H$ )	250% ( $Max_H$ )	0.5 ( $GU_H$ )
Live Woody Fuel Moisture	60% ( $Min_W$ )	200% ( $Max_W$ )	0.5 ( $GU_W$ )

# Calculating LFM from GSI

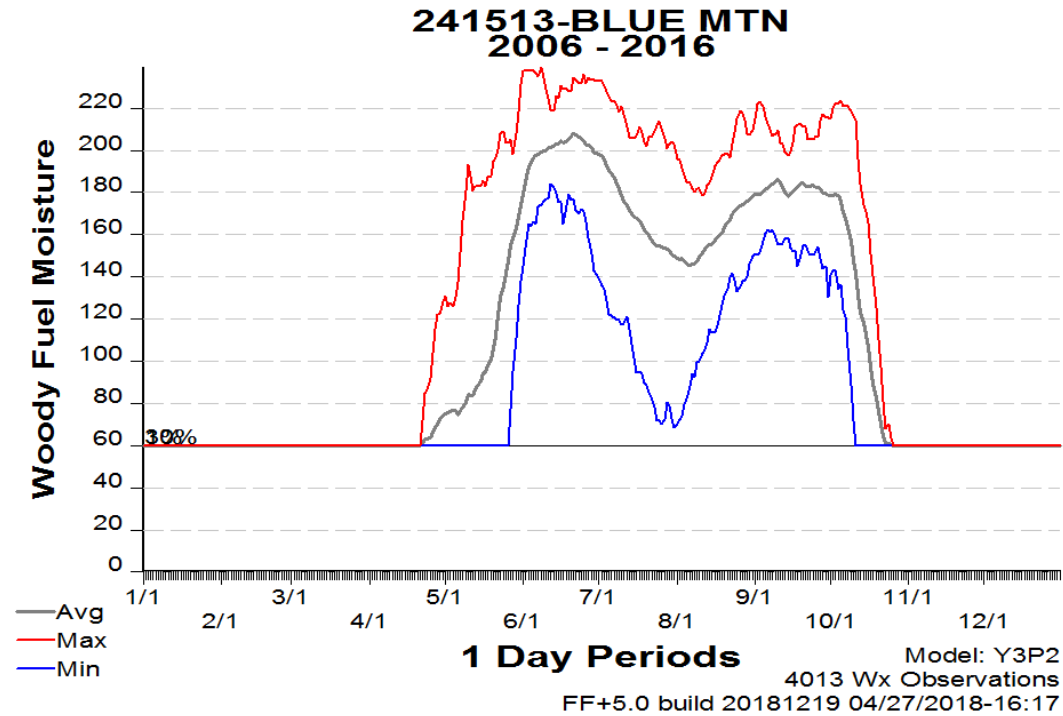
$$\blacktriangleright LFM_{W|H} = \left( \begin{array}{l} GSI'_{W|H} < GU_{W|H} \\ GSI'_{W|H} \geq GU_{W|H} \end{array} \middle| \begin{array}{l} Min_{W|H} \\ m * GSI'_{W|H} + b \end{array} \right)$$

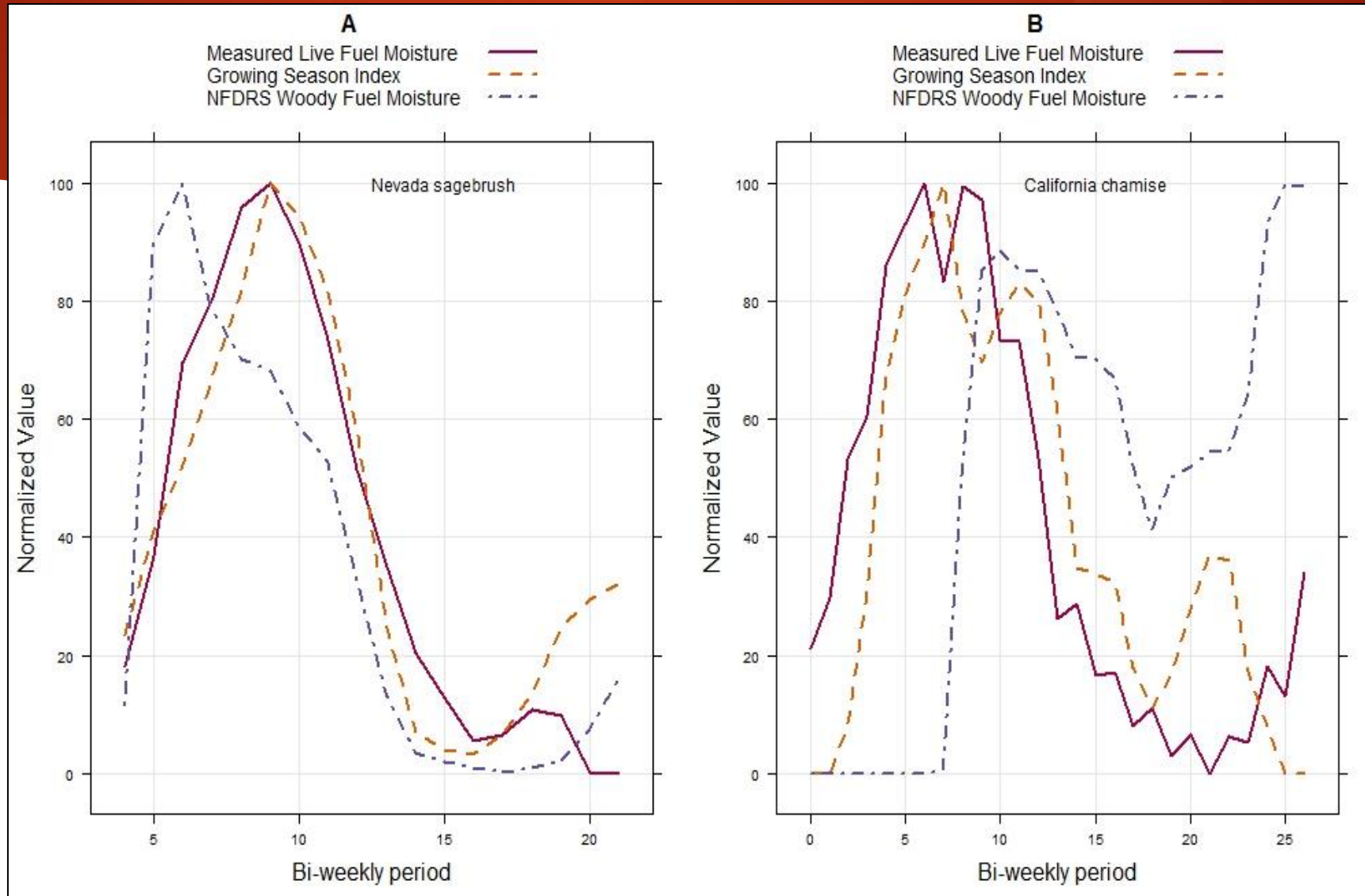
$$m = \frac{Max_H - Min_H}{1.0 - GU_H}$$

$$b = Max_H - m$$



# Example GSI-derived herbaceous fuel moisture





## Display/Edit Default NFDRS Parameters

[Back to Menu](#)

Station ID:

Effective Date:

Info: Standard Defaults for GSI Herb and Woody FM Options have been loaded.

NFDR Parameters

**GSI Herb FM Options**

GSI Woody FM Options

Nelson Dead Fuel Moisture Options

Load Fuel Model Percentiles

Temp Min Index Min (C):

Temp Min Index Max (C):

VPD Index Min:

VPD Index Max:

Day Length Index Min (sec):

Day Length Index Max (sec):

VPD Usage

VPD Max

VPD Avg

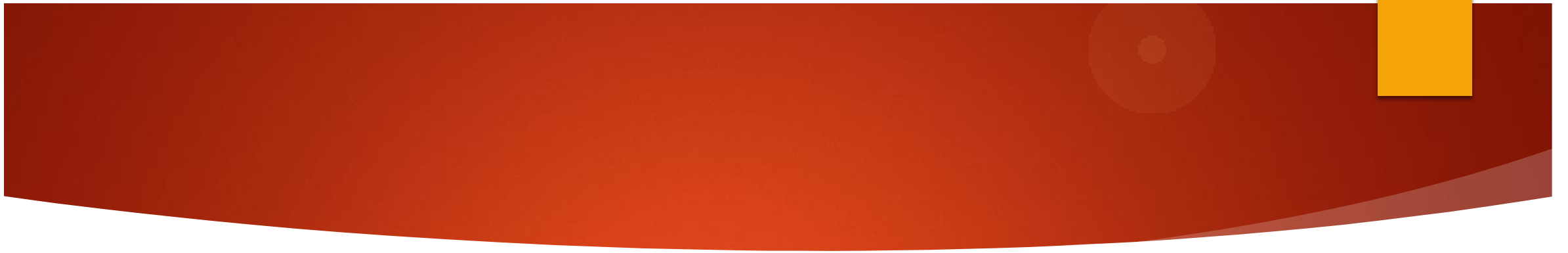
GSI Average Running Length (days):

Max GSI (for scaling):

Greenup Threshold:

Max Herb FM:

Min Herb FM:



# New dead fuel moisture model

# New Dead Fuel Moisture Model

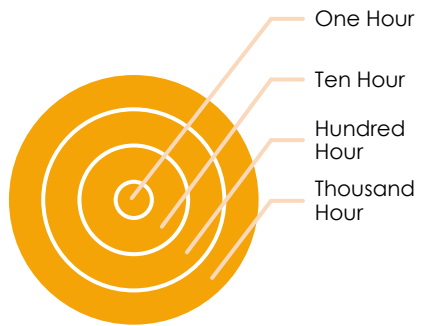
- ▶ The previous version of NFDRS required direct user input of State-of-the-Weather (SOW) and changing R to O in WIMS to calculate fine dead fuel moisture before any indices are produced.
- ▶ It also required a separate model for calculating 1/10 hr and 100/1000hr dead fuel moistures.
- ▶ The old 1hr – 1000hr fuel moistures models will be replaced by the scalable Nelson Dead Fuel Moisture Model

# New Fine Dead Fuel Moisture Model

## Nelson

- ▶ Nelson Model:
  - ▶ More accurately models diurnal and seasonal dead fuel moisture using hourly fire weather observations
  - ▶ Requires no daily human intervention (I.E. No state-of-the-weather)
  - ▶ Has been running in a prototype mode in operational WIMS since December, 2011 and has been part of fire behavior prediction tools (FARSITE, FlamMap) for over a decade

# Nelson Dead Fuel Moisture Model



- ▶ Calculated HOURLY
- ▶ Nelson has 4 weather inputs:
  - ▶ Temperature
  - ▶ Relative Humidity
  - ▶ Solar Radiation
  - ▶ Precipitation

- ▶ We define an instance of the Nelson model of the four timelag dead fuel classes used in NFDRS:

Time Lag	Stick Diameter (inches/cm)
1 hour	0.16 in / 0.4 cm
10 hour	0.5 in / 1.28 cm
100 hour	1.6 in / 4.0 cm
1000 hour	3 in / 7.62 cm



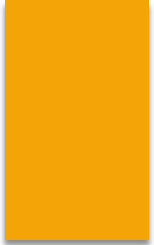
# Nelson Model Specifics

- ▶ Accounts for diffusive and capillary water transport between the fuel and the atmosphere
- ▶ Derives surface temperature from an energy balance
  - ▶ Net input of heat gains and losses
- ▶ Accounts for dew formation on fuel surface
- ▶ Scalable to any size dead fuel

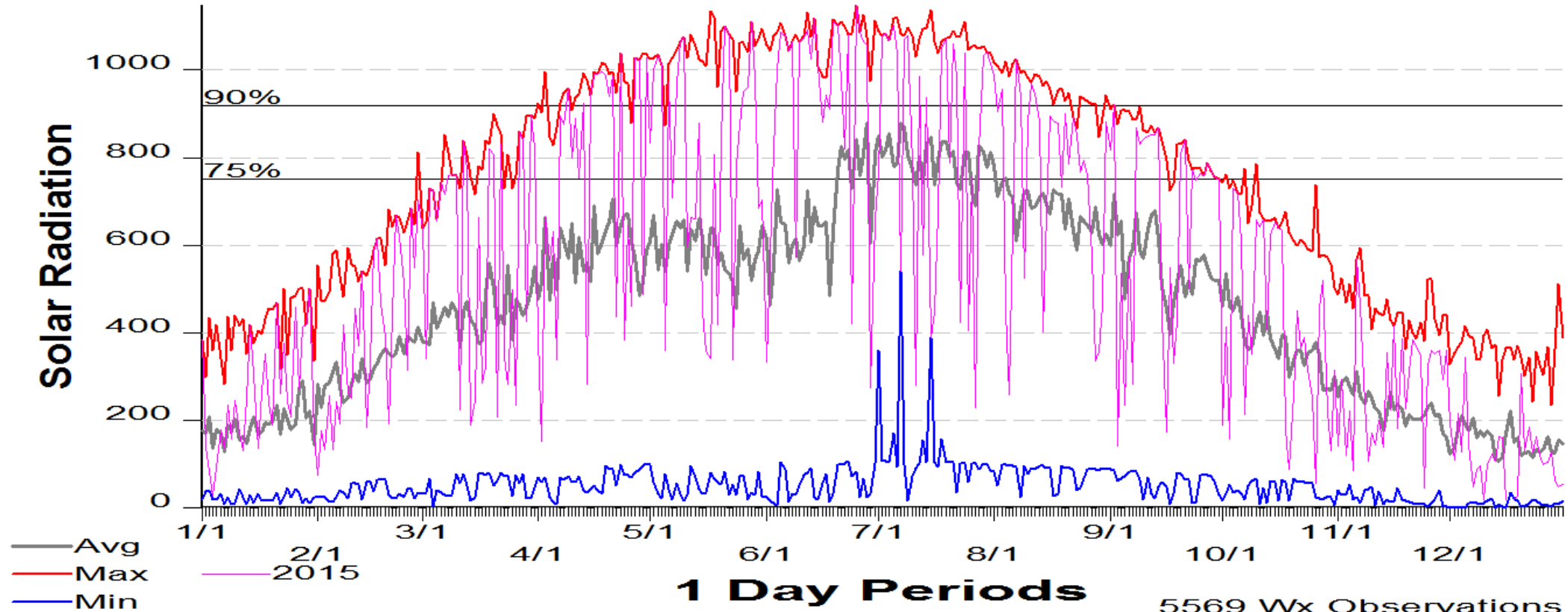
# Fuel Energy Balance

**Heat Loss = Heat Gain**

- ▶ **Conduction + Longwave Radiation + Evaporation  
= Solar Heating + Convective Heating**



# 241513-BLUE MTN 2001 - 2016

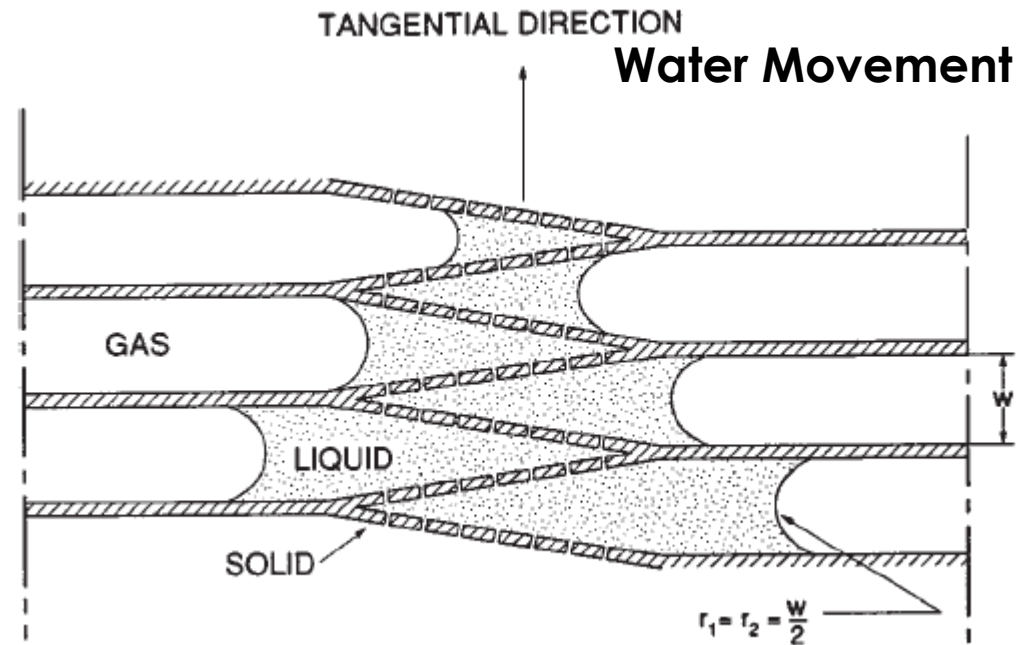


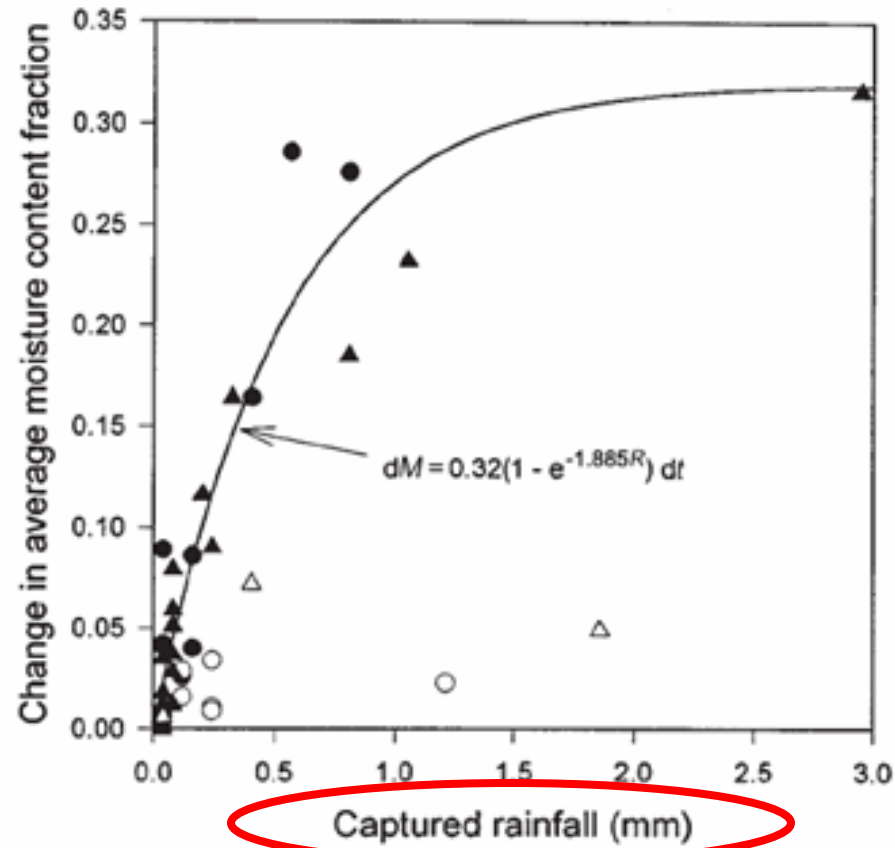
**1 Day Periods**

5569 Wx Observations

FF+5.0 build 20181219 04/29/2018-18:29

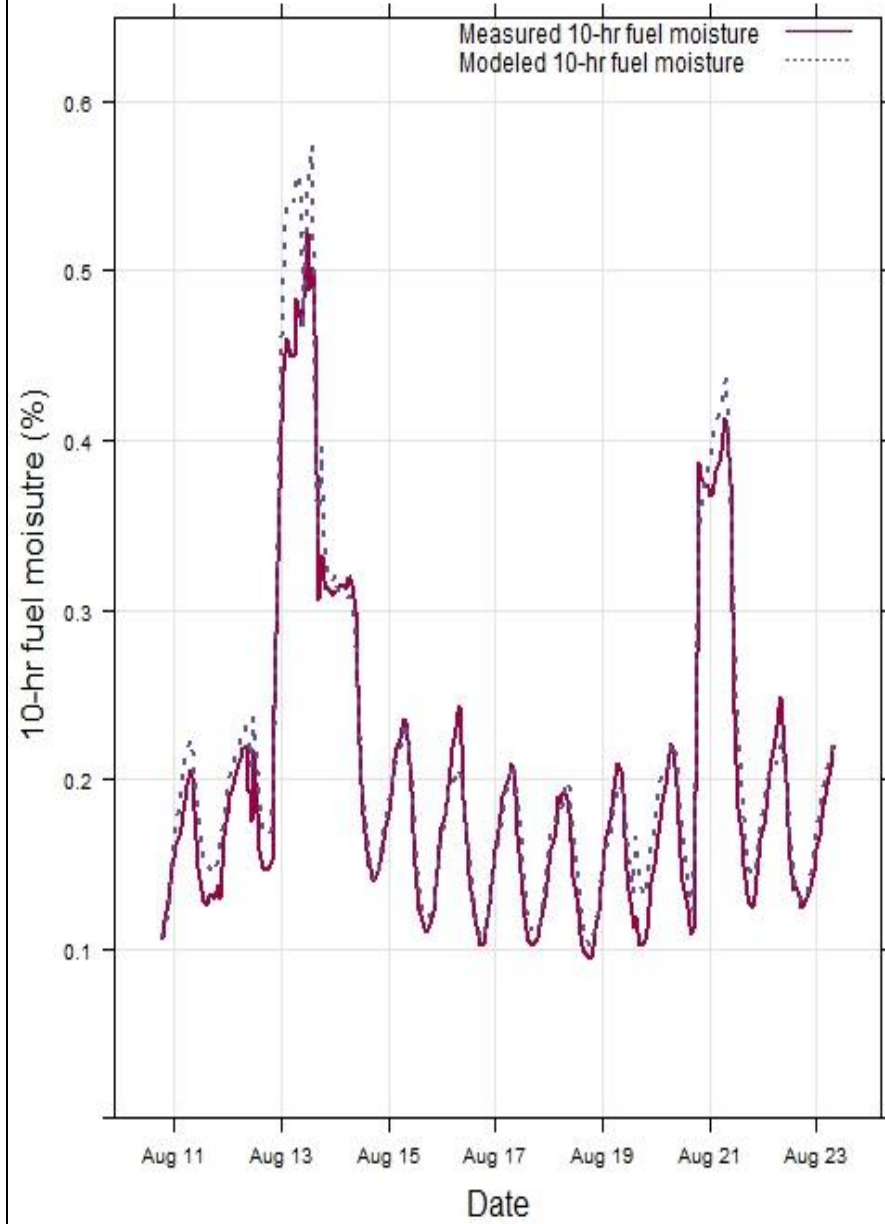
# Capillary water transport in Nelson



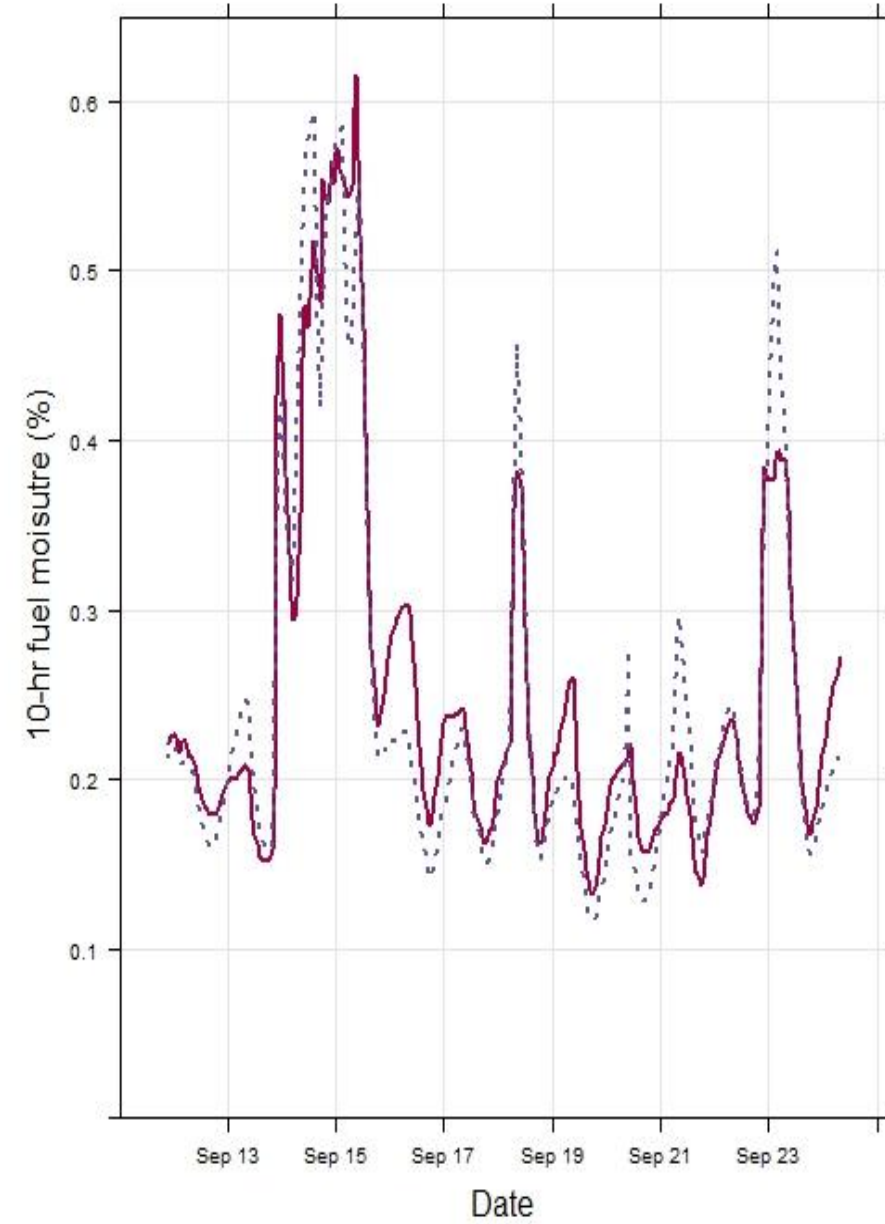


Changes in stick average moisture content fraction versus hourly captured rainfall ( $dt = 1$  h) during field experiments in Burnsville, N.C. (circles), and Mio, Mich. (triangles). Solid symbols initial moisture fraction smaller than 0.4; open symbols, initial fraction greater than 0.4 (from Nelson, 2000).

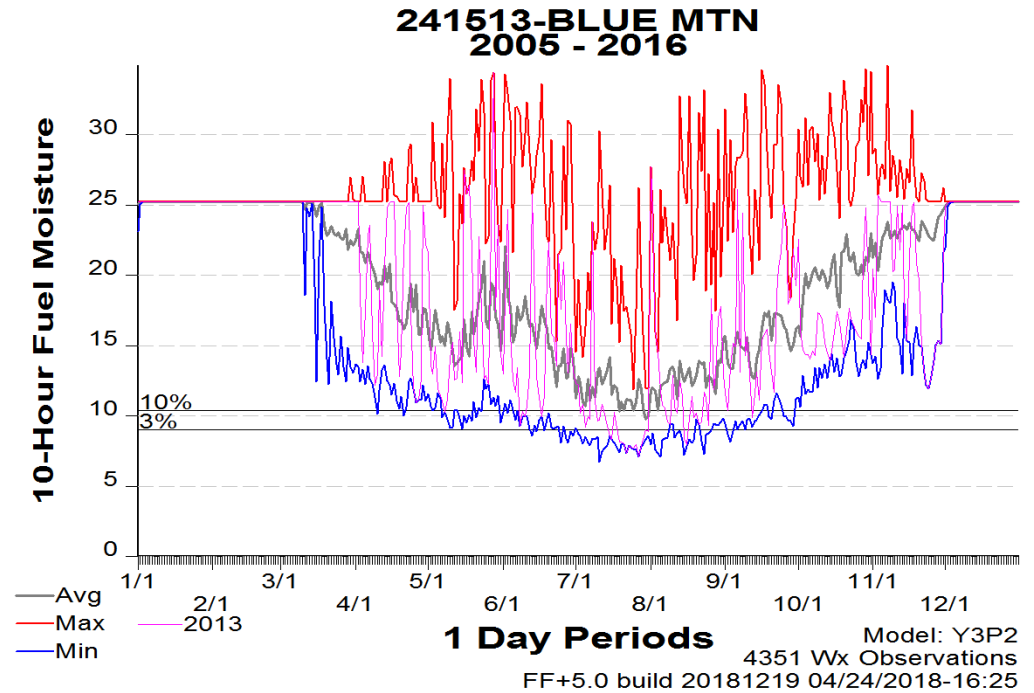
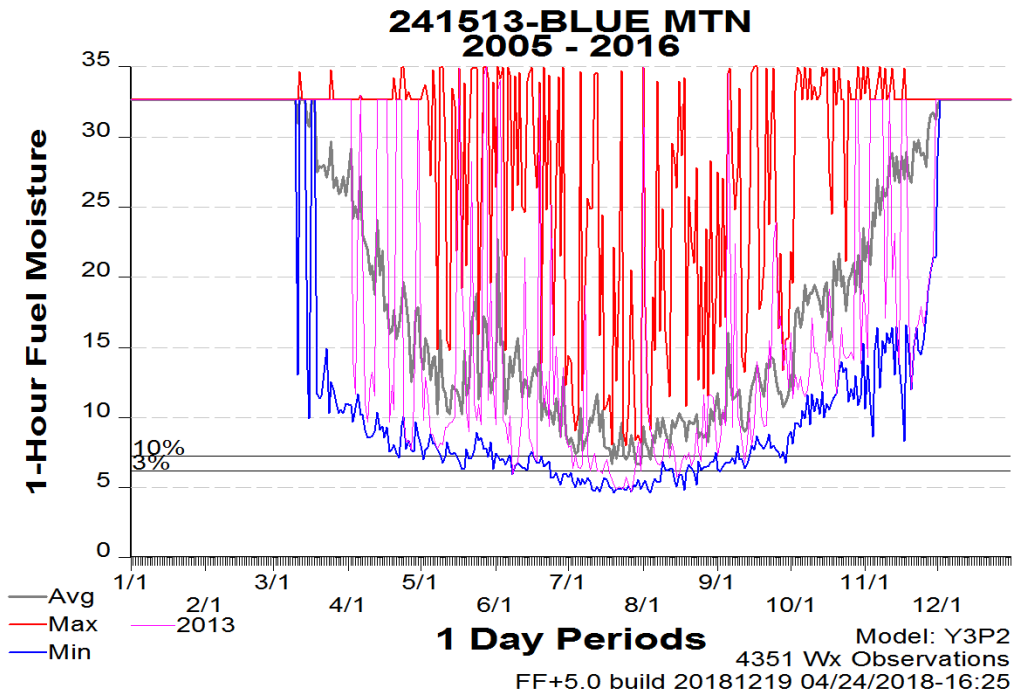
Burnsville, NC



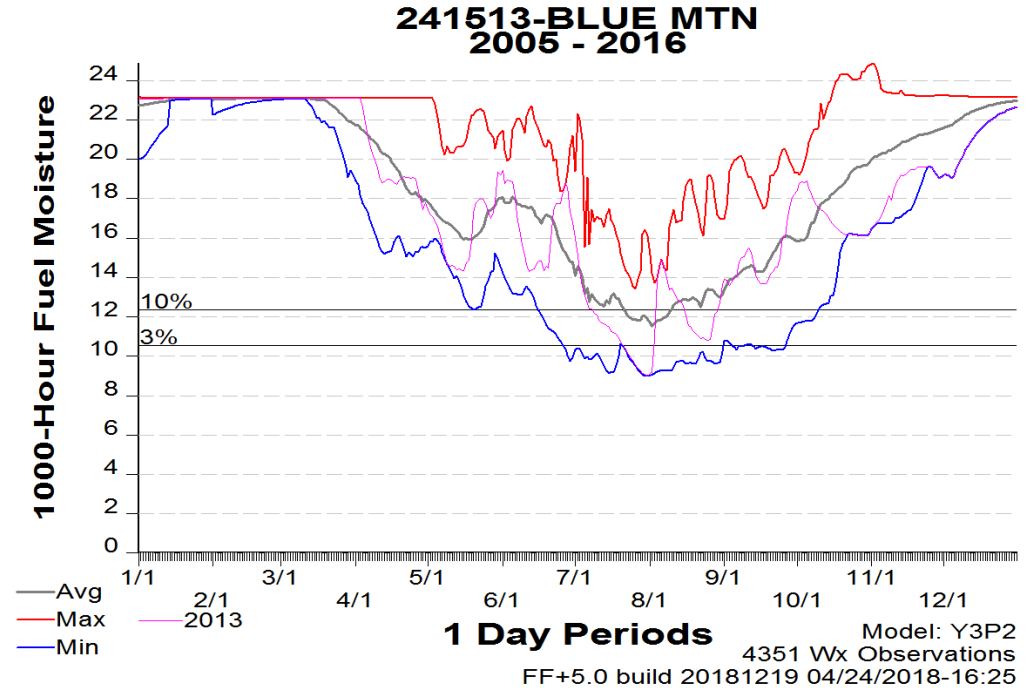
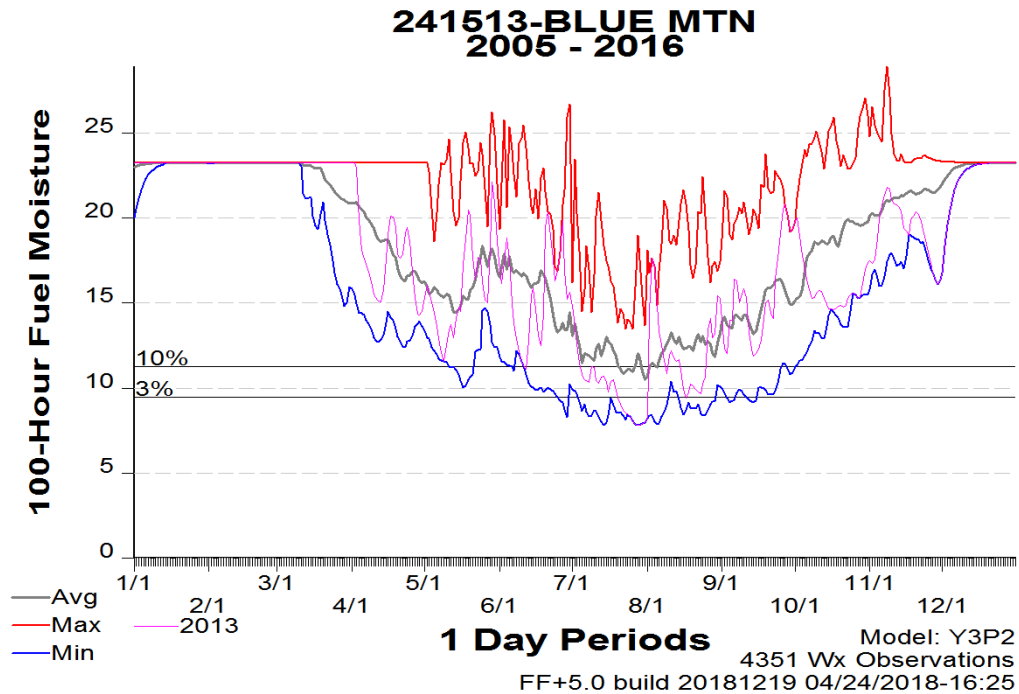
Mio, MI



# Example Nelson 1 hr and 10 hr fuel moistures



# Example Nelson 100hr and 1000hr fuel moistures

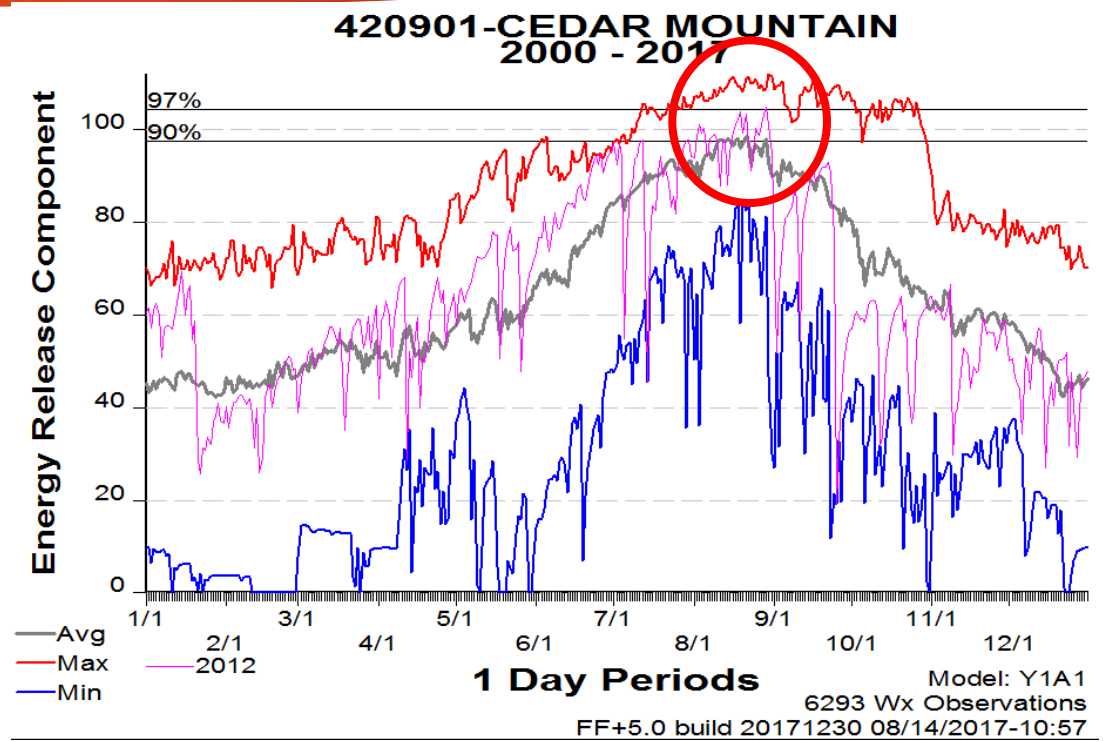
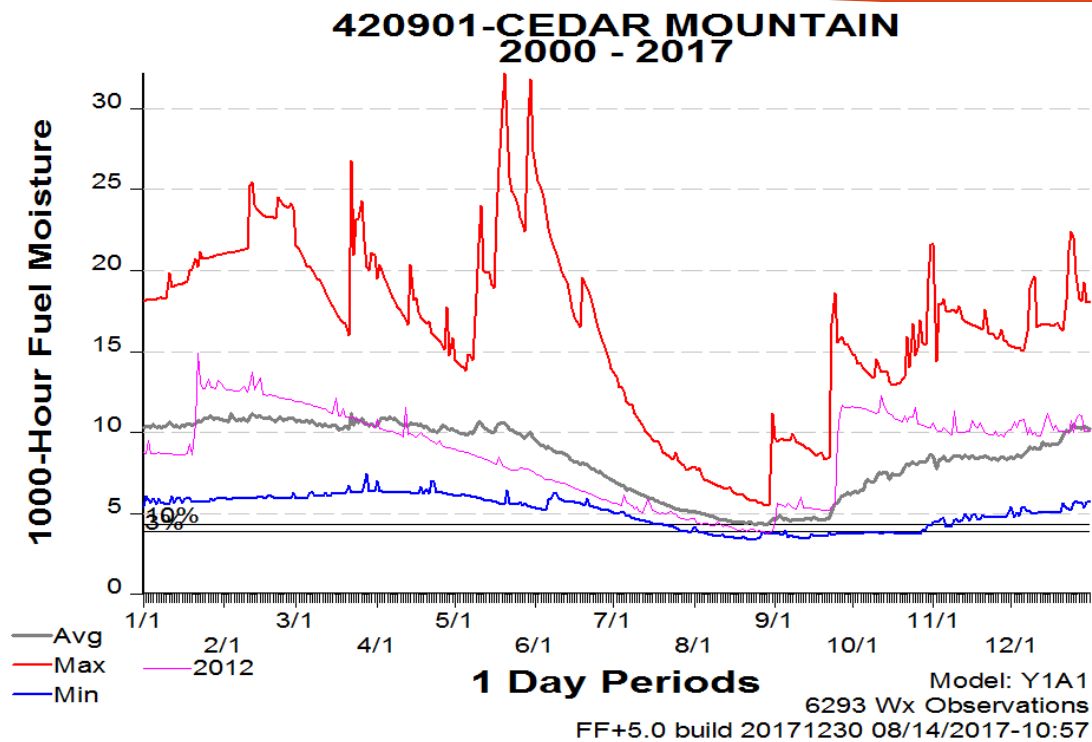




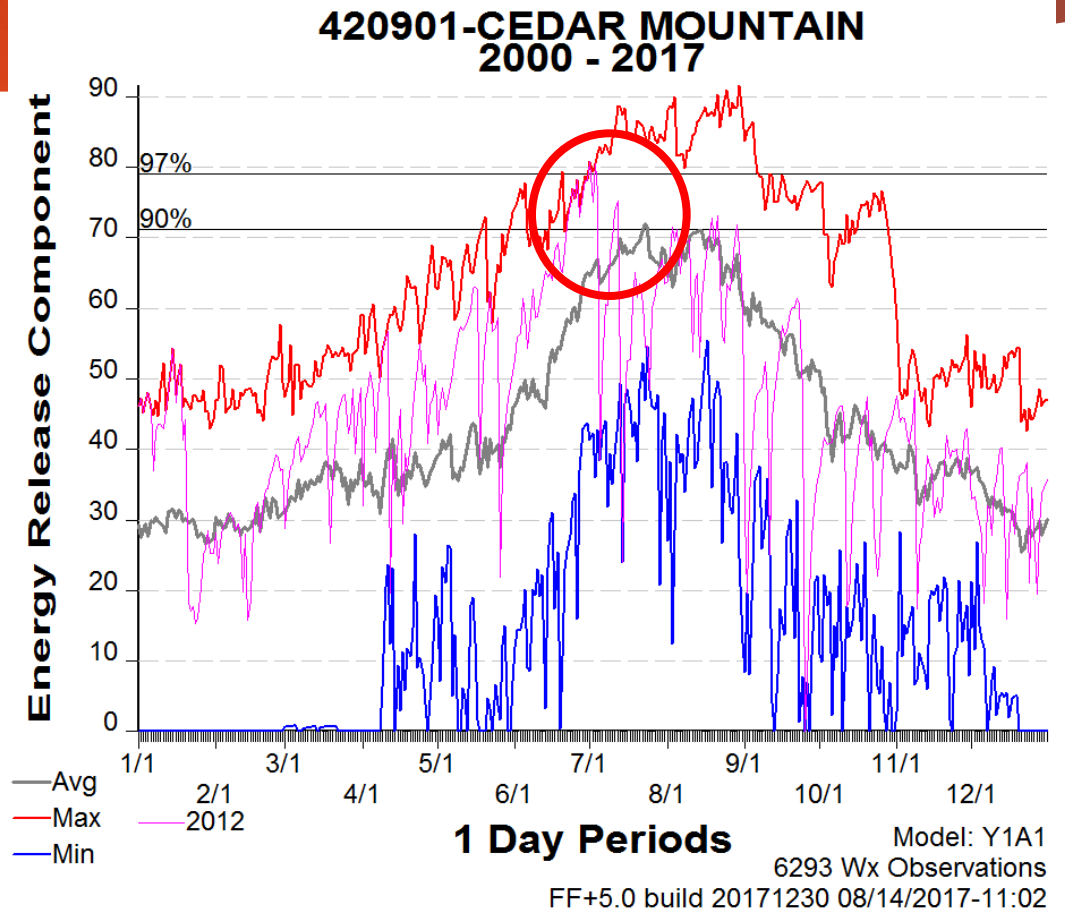
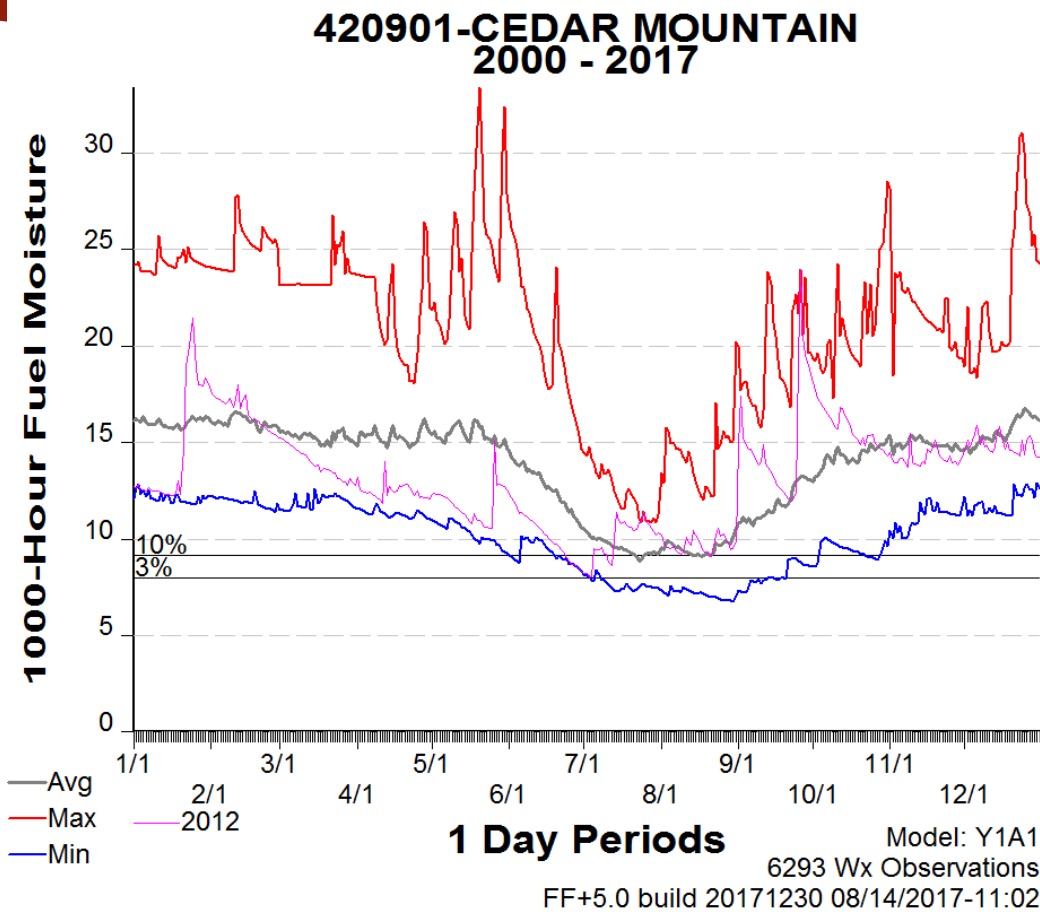


# Recent Nelson 1000-hr Model Modifications

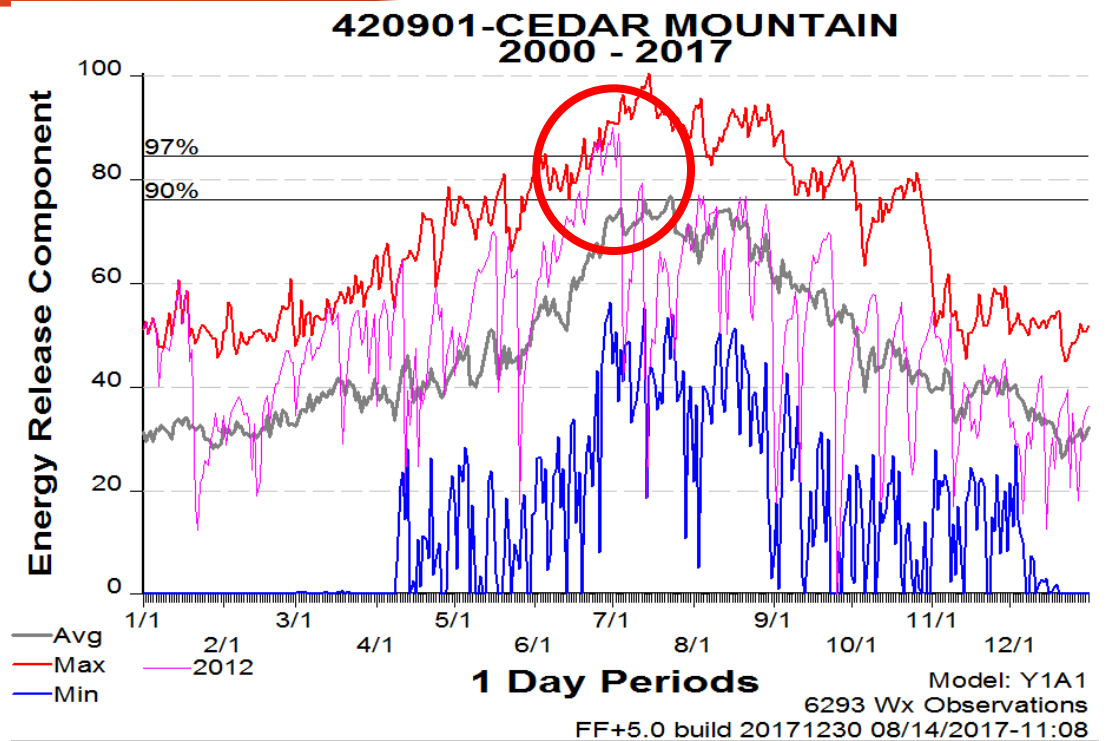
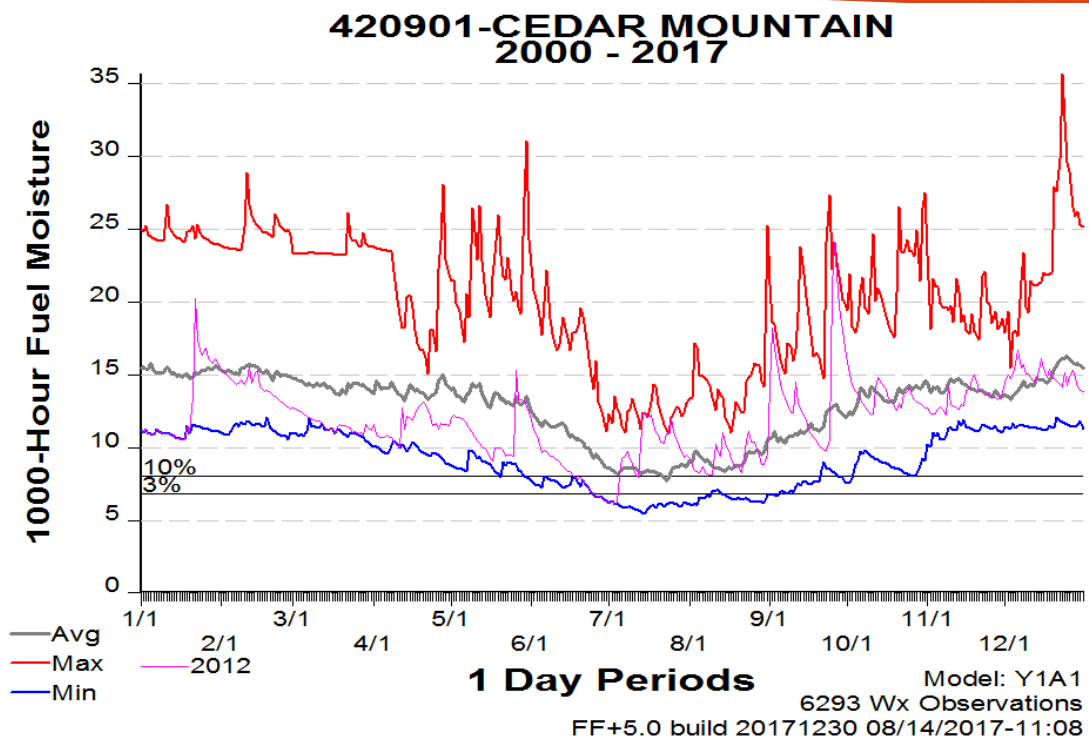
# Uncorrected Nelson 1000hr and subsequent ERC



# New Minimum Adsorption Rate

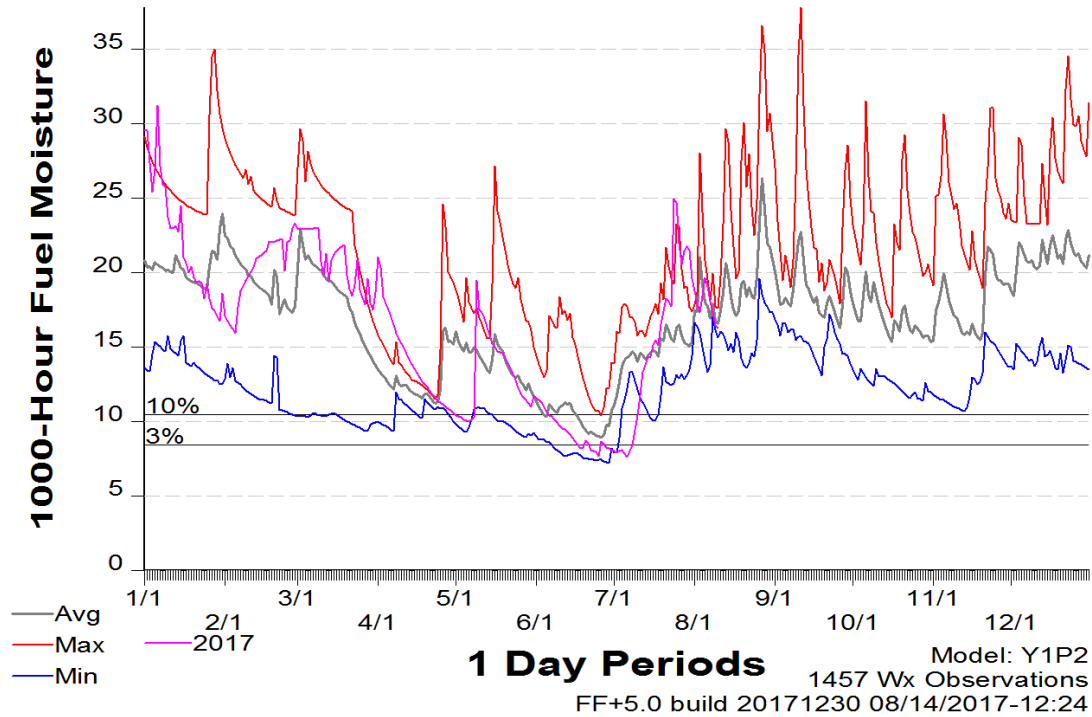


# New minimum Adsorption Rate and Realigned fuel stick diameters

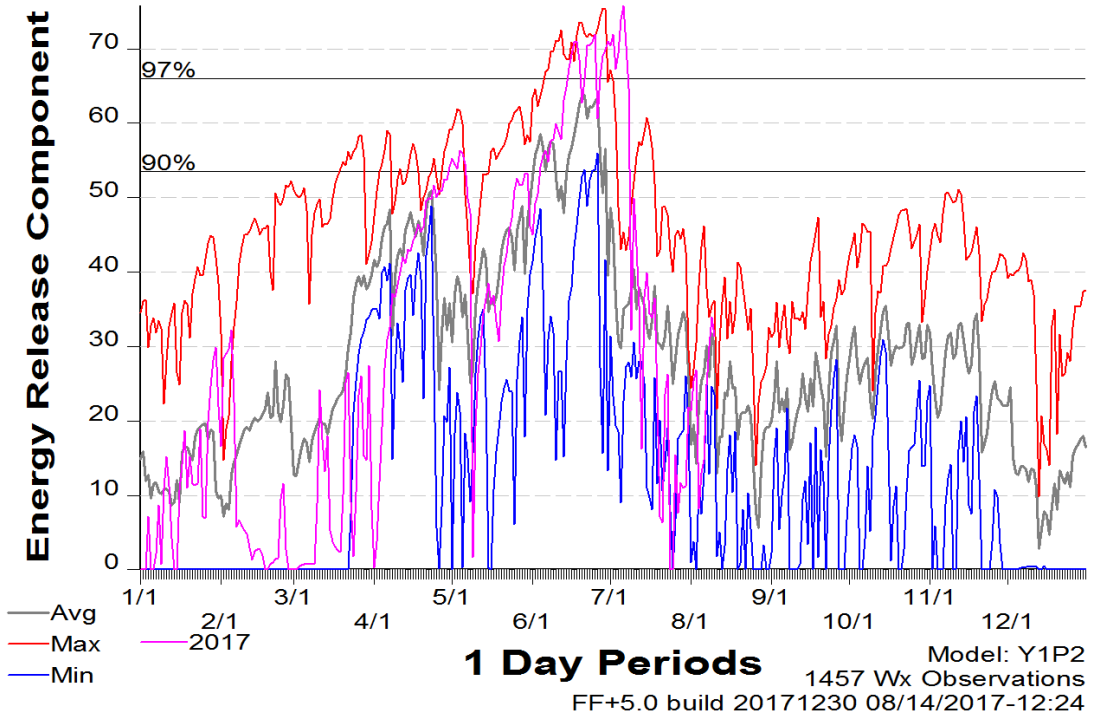


# Flagstaff example: New Model with 2017

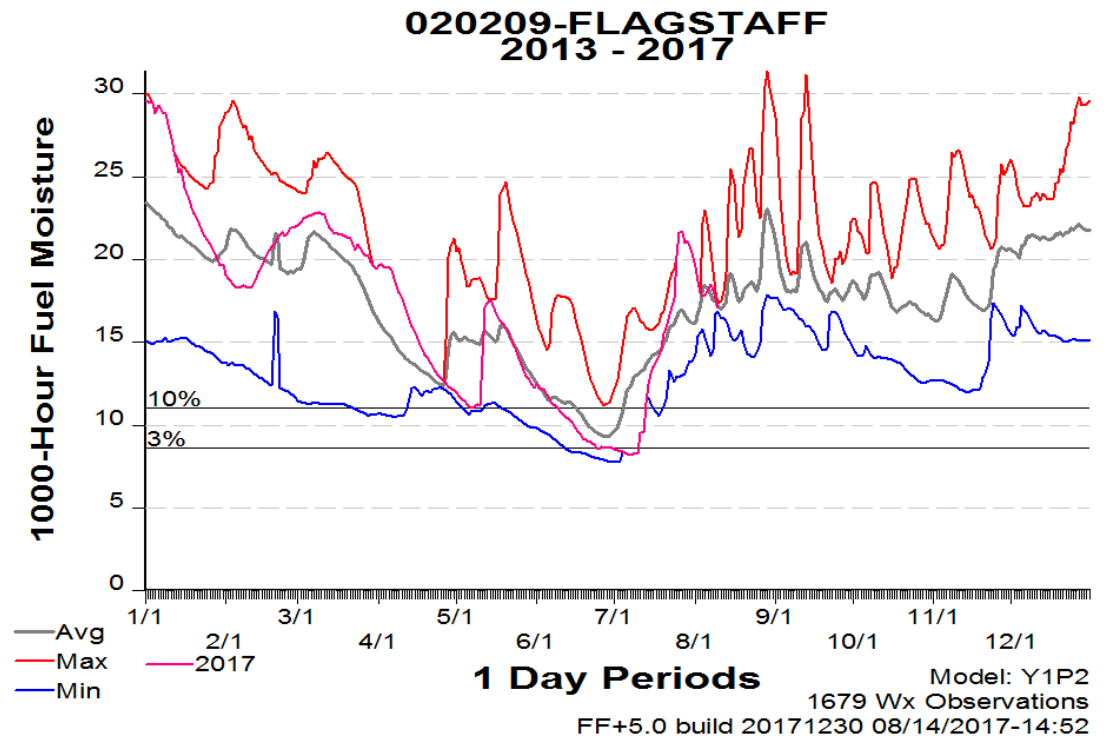
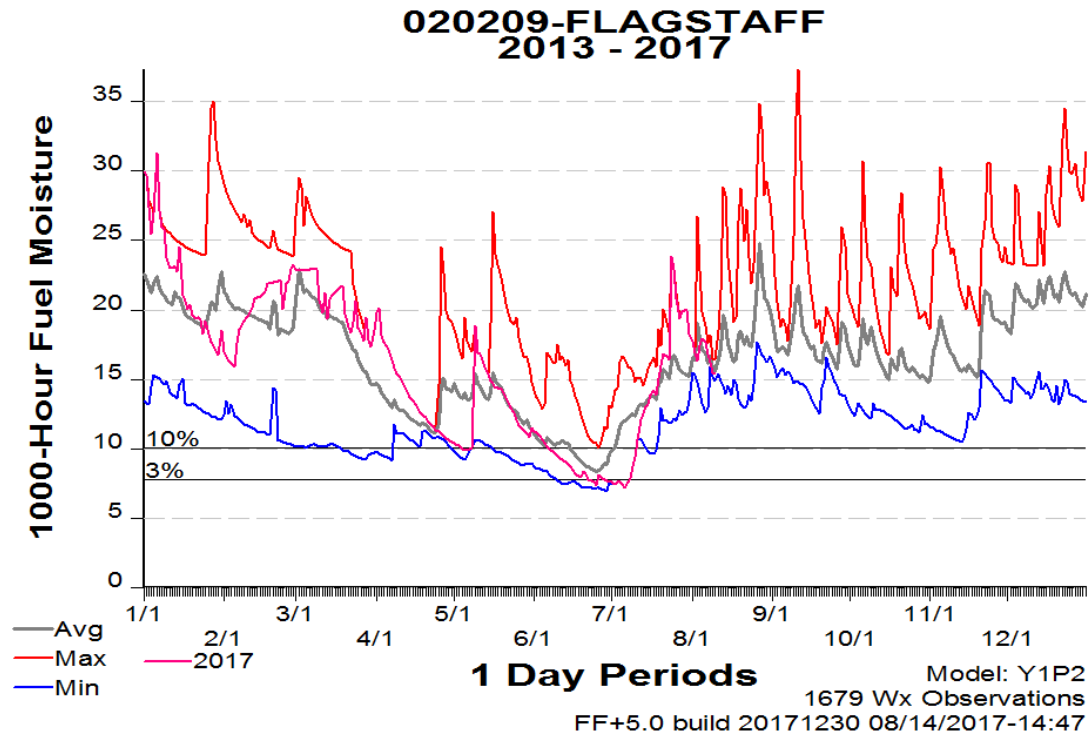
020209-FLAGSTAFF  
2013 - 2016

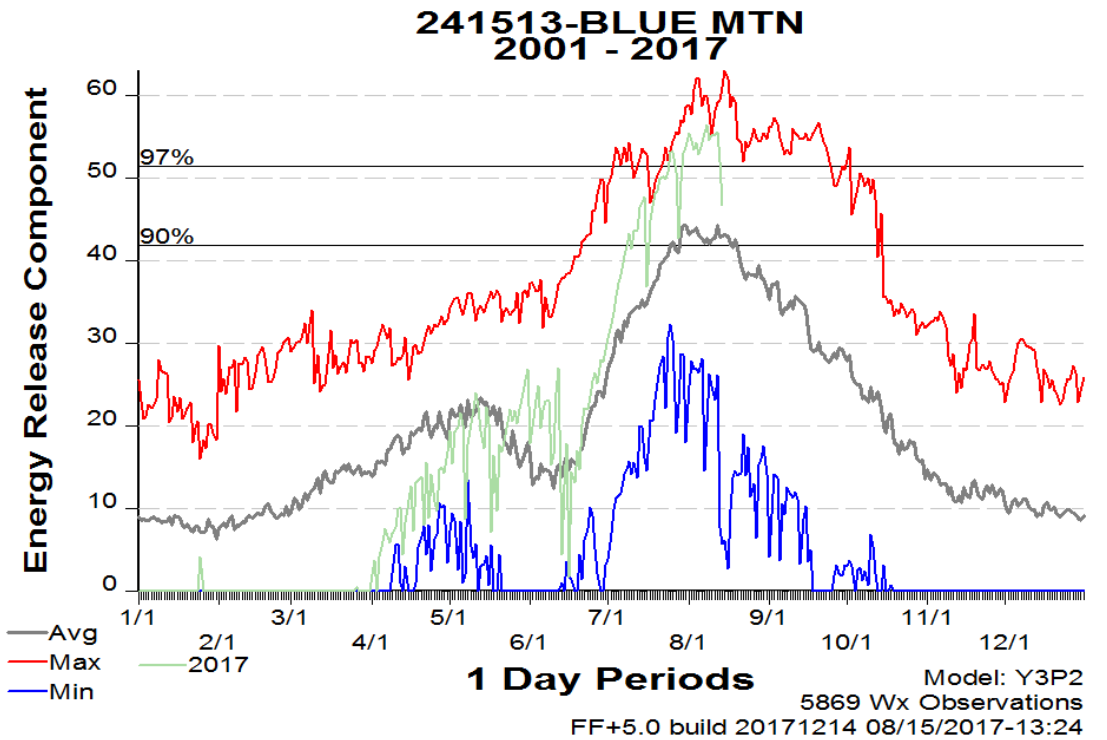
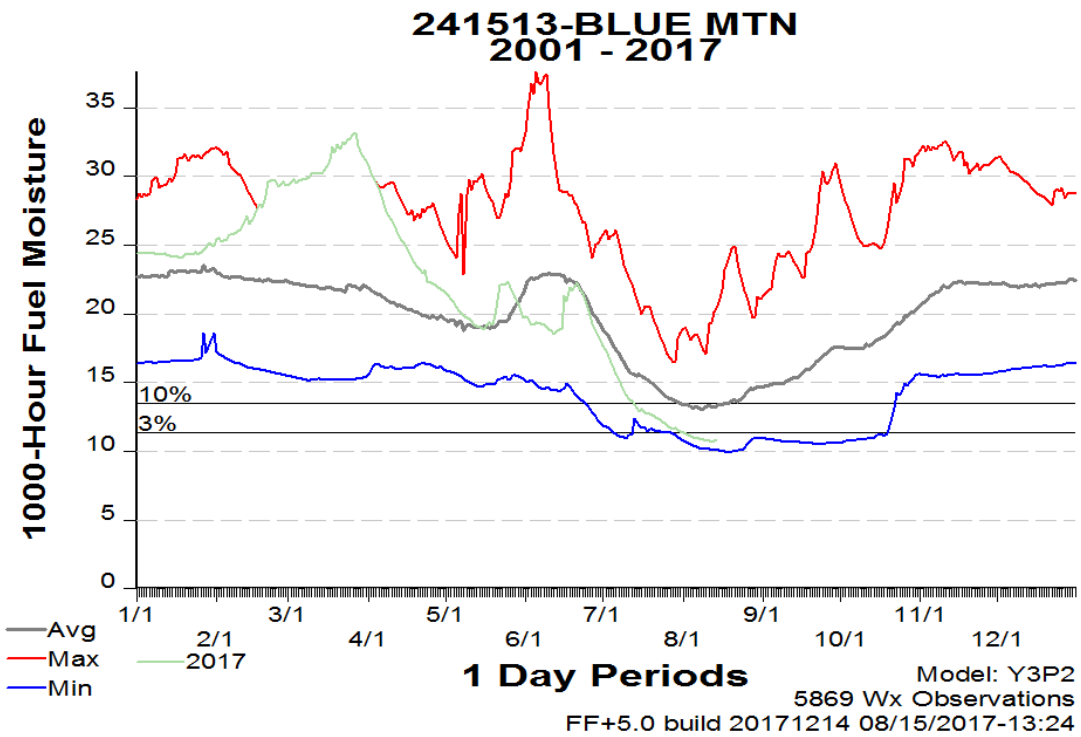


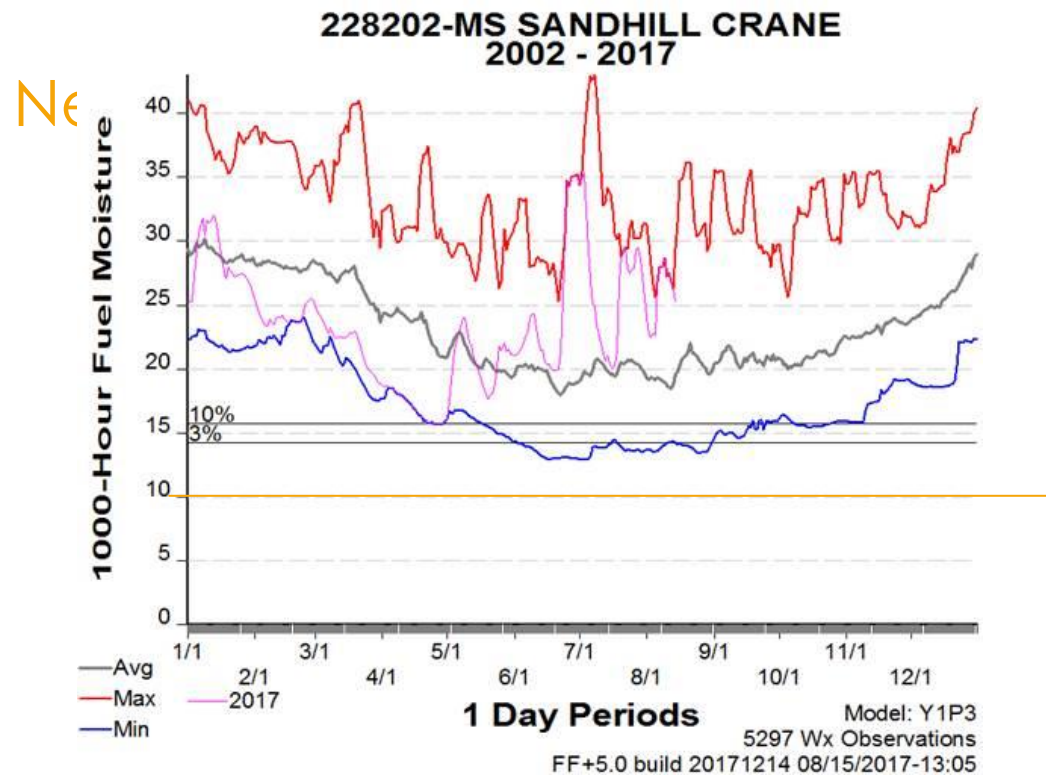
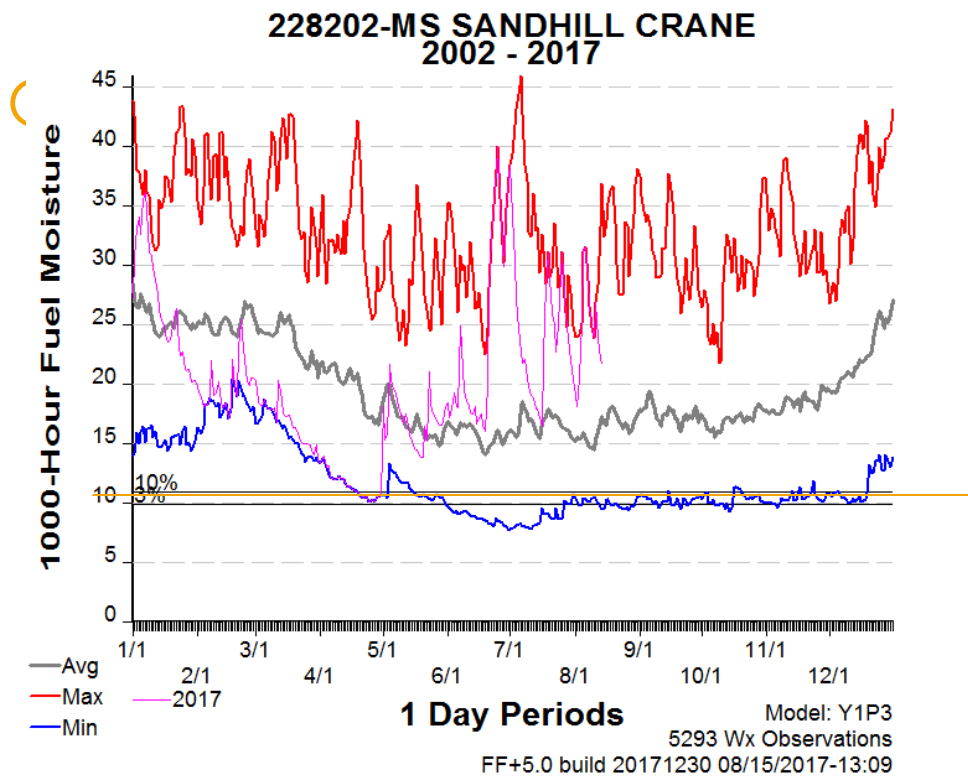
020209-FLAGSTAFF  
2013 - 2016



# Determining stick moisture from nodes

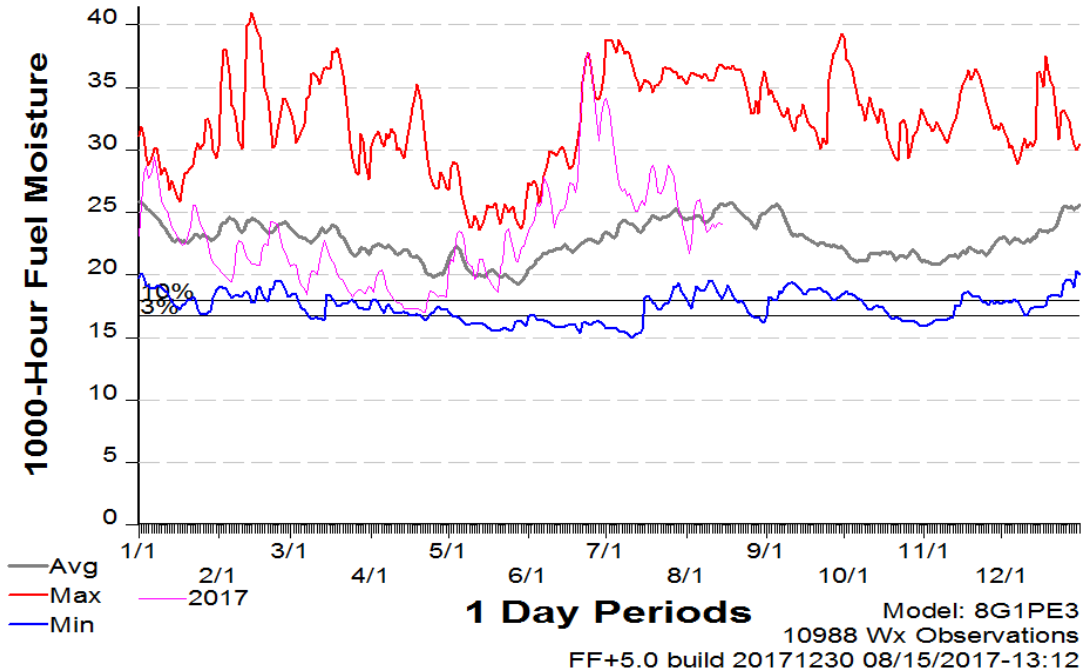




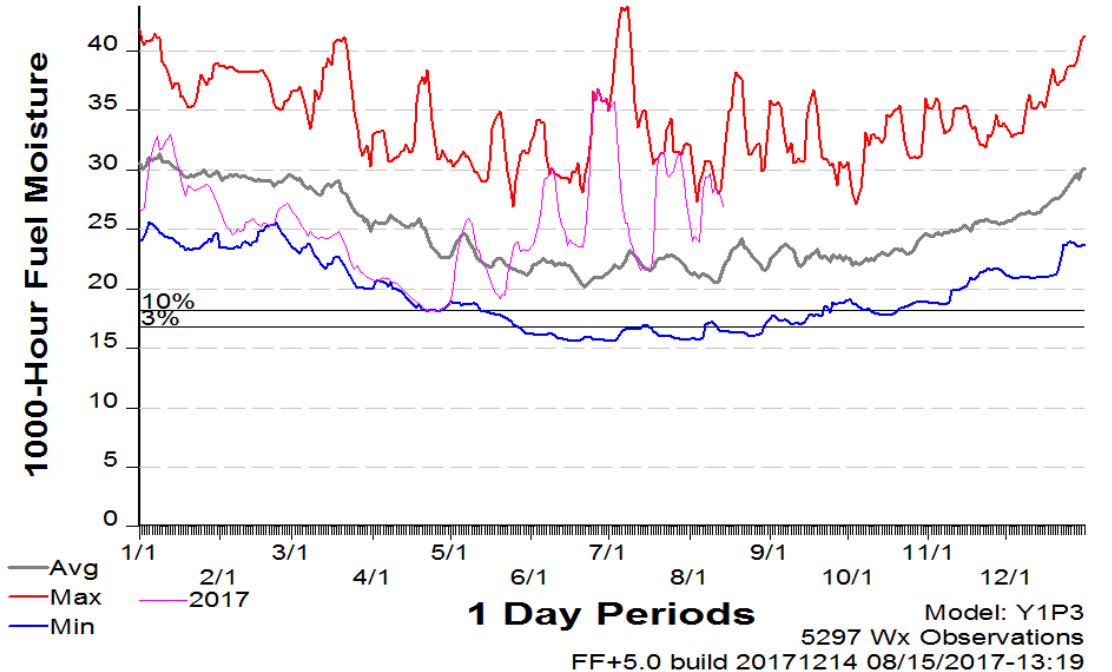




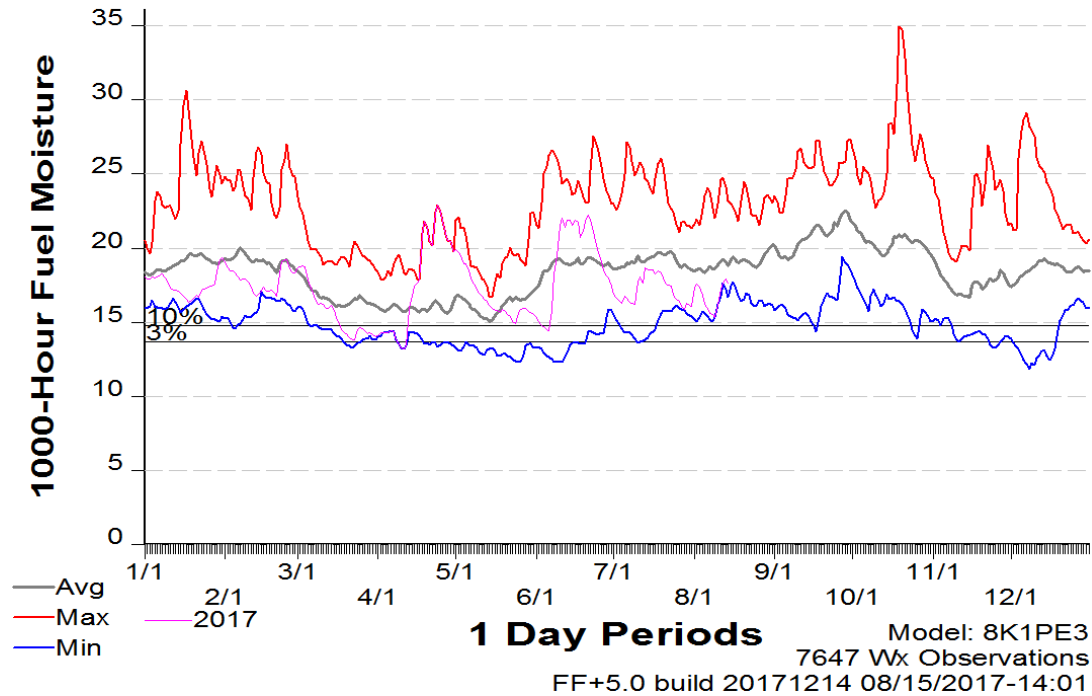
### 228202-MS SANDHILL CRANE 2002 - 2017



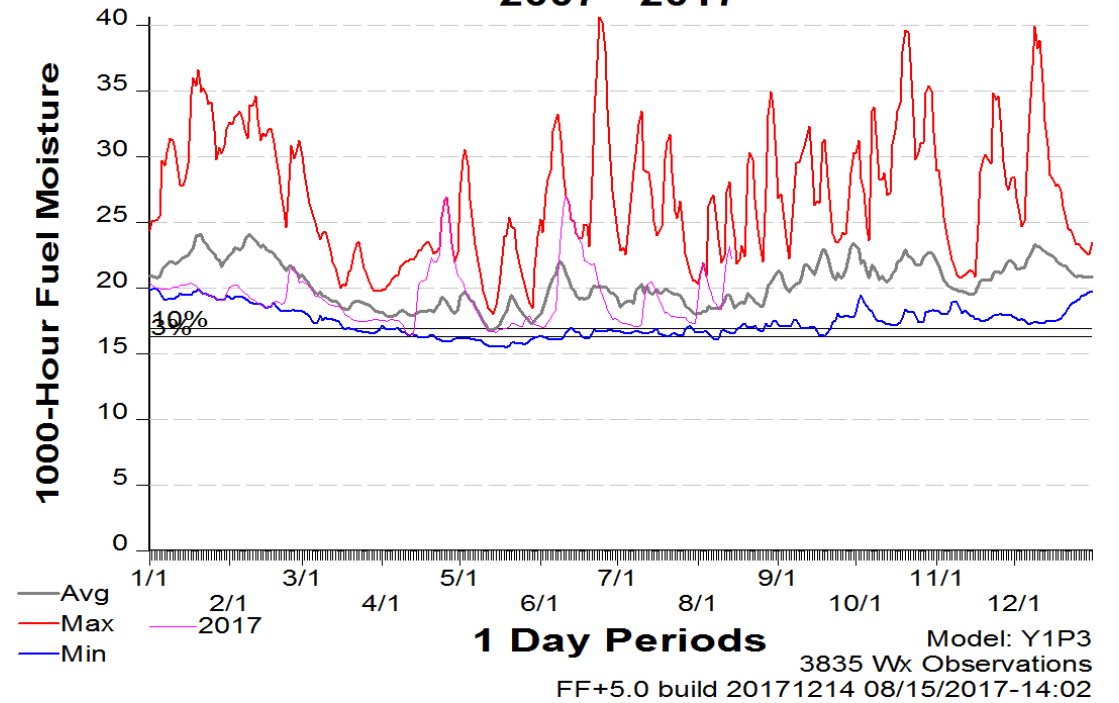
### 228202-MS SANDHILL CRANE 2002 - 2017

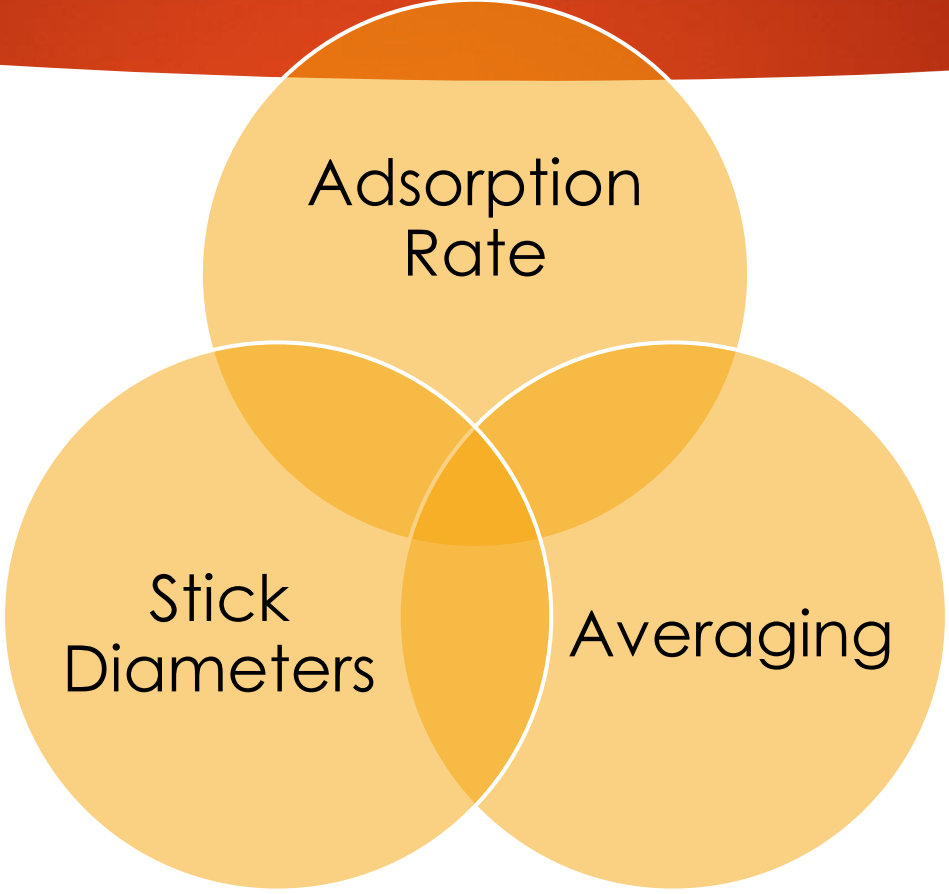


**086501-NATIONAL KEY DEER  
2007 - 2017**



**086501-NATIONAL KEY DEER  
2007 - 2017**



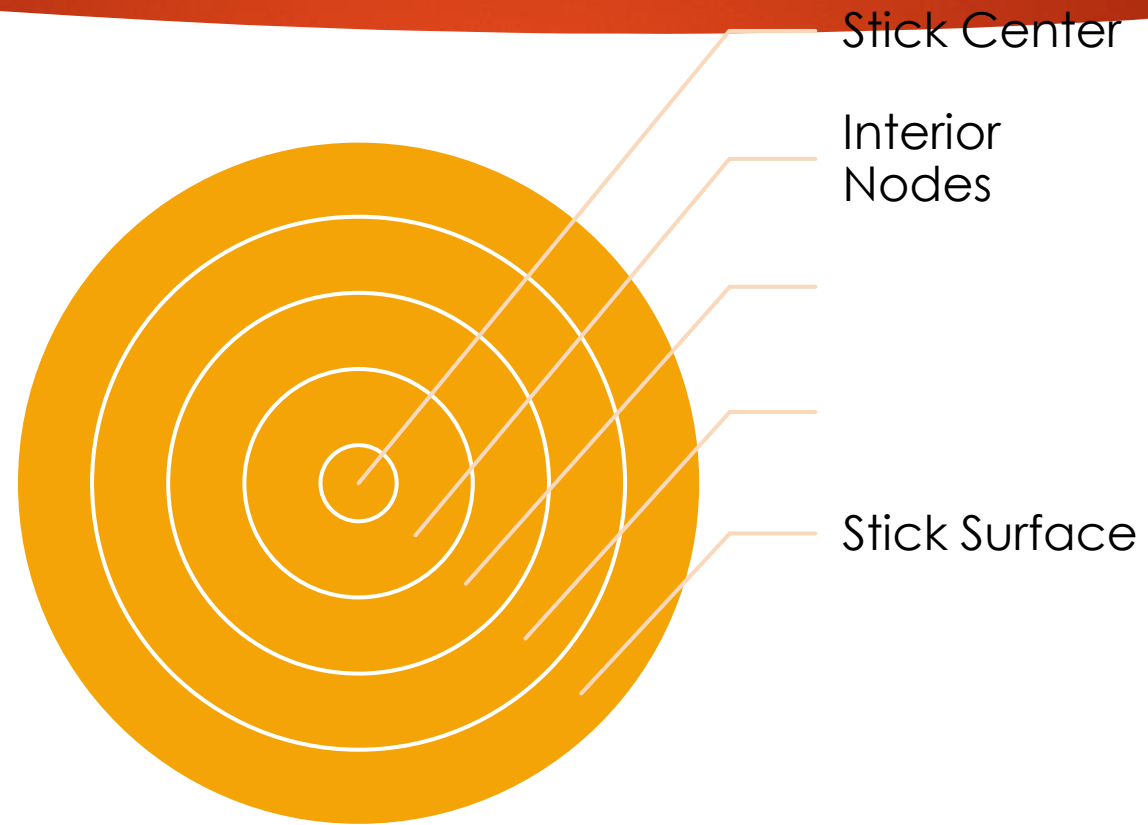


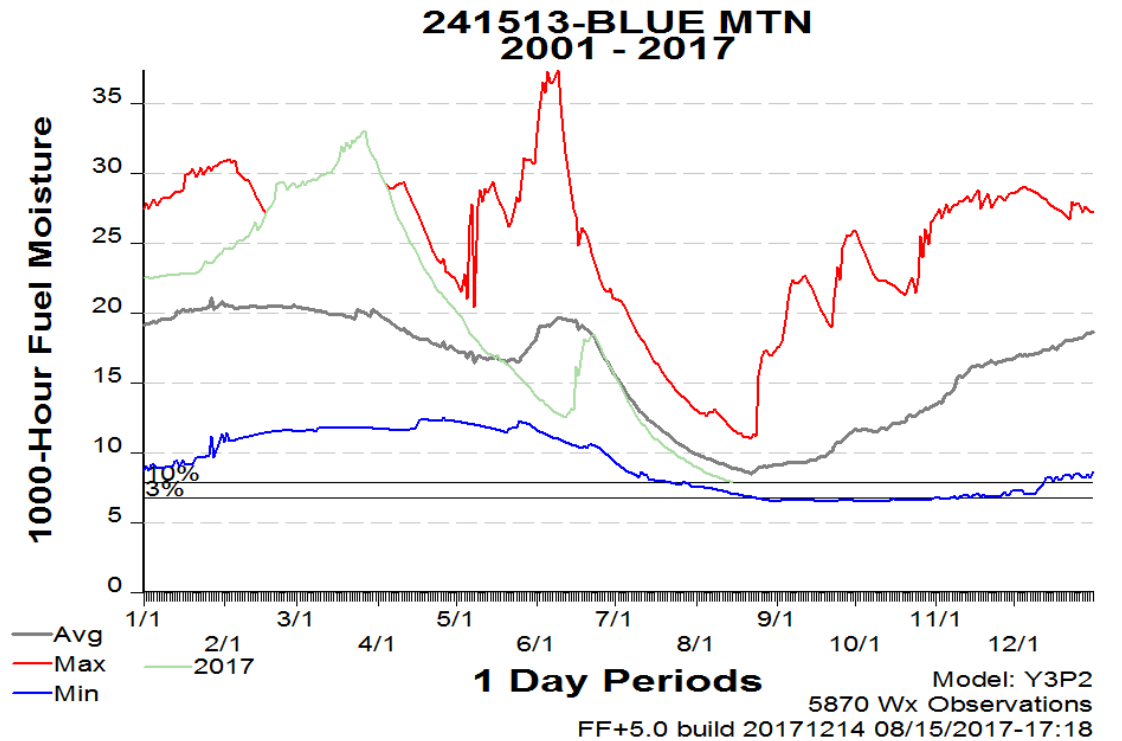
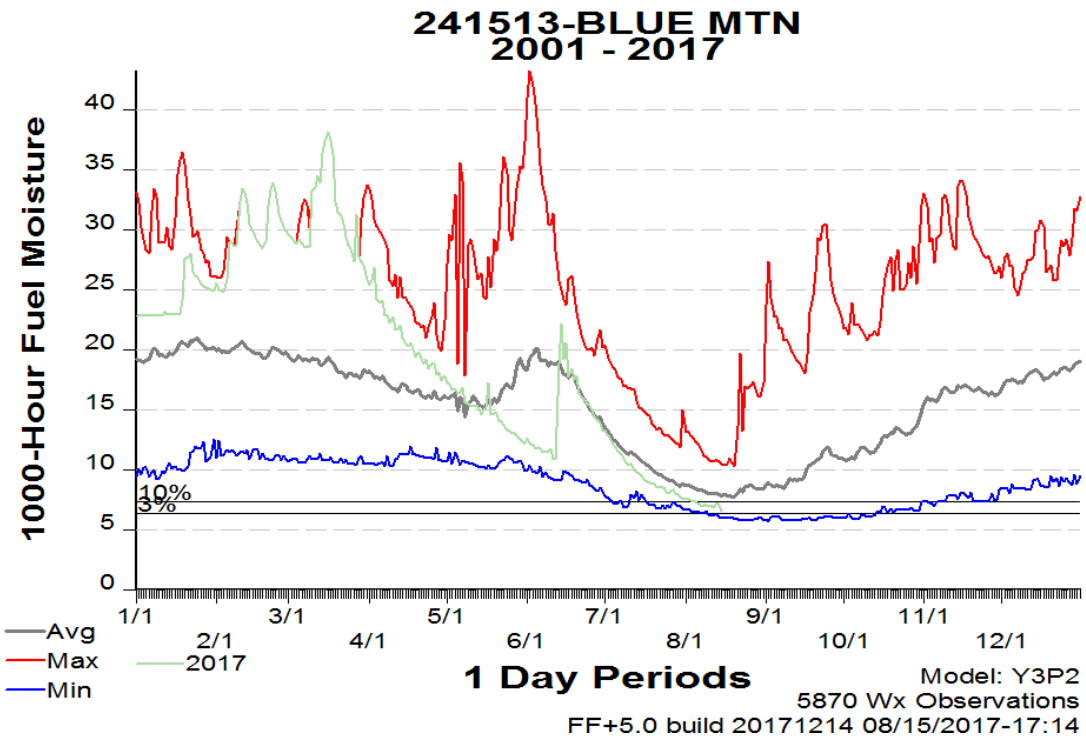
Adsorption  
Rate

Stick  
Diameters

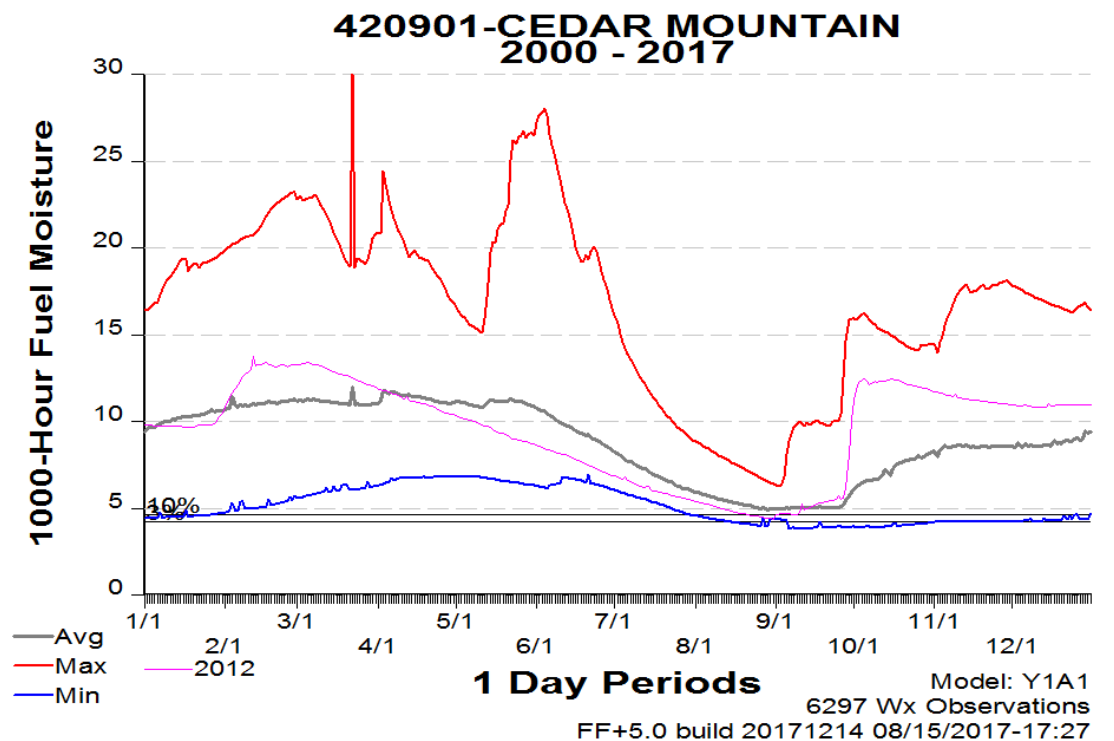
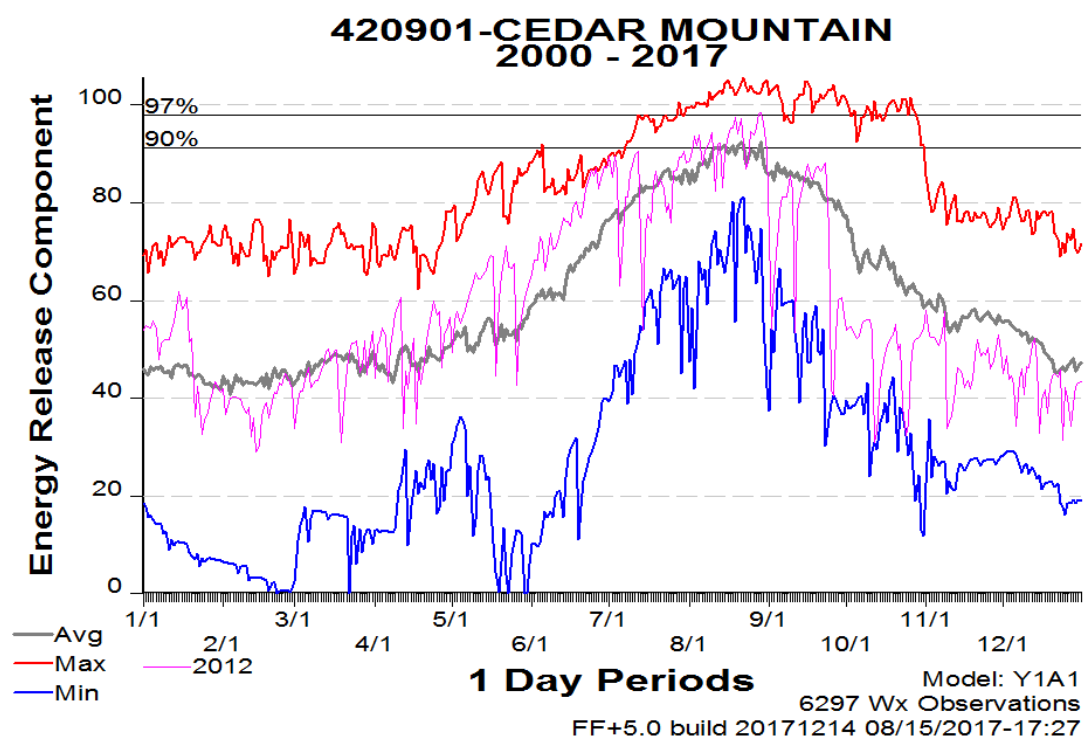
Averaging

# Nelson Model

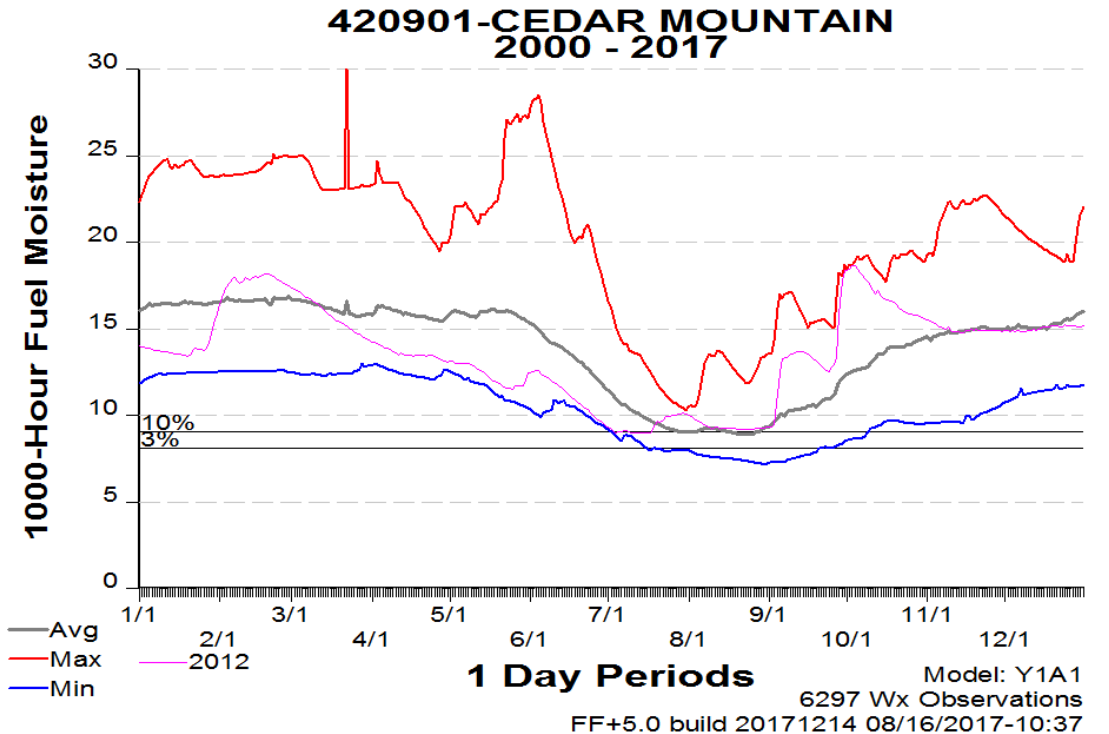
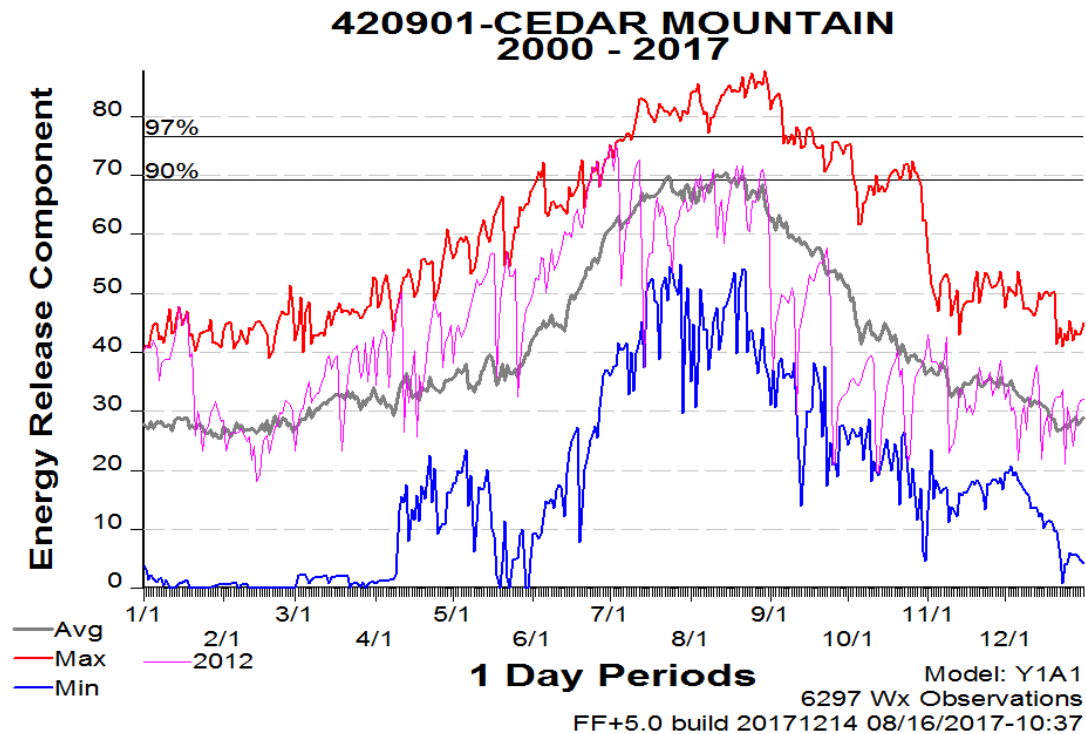




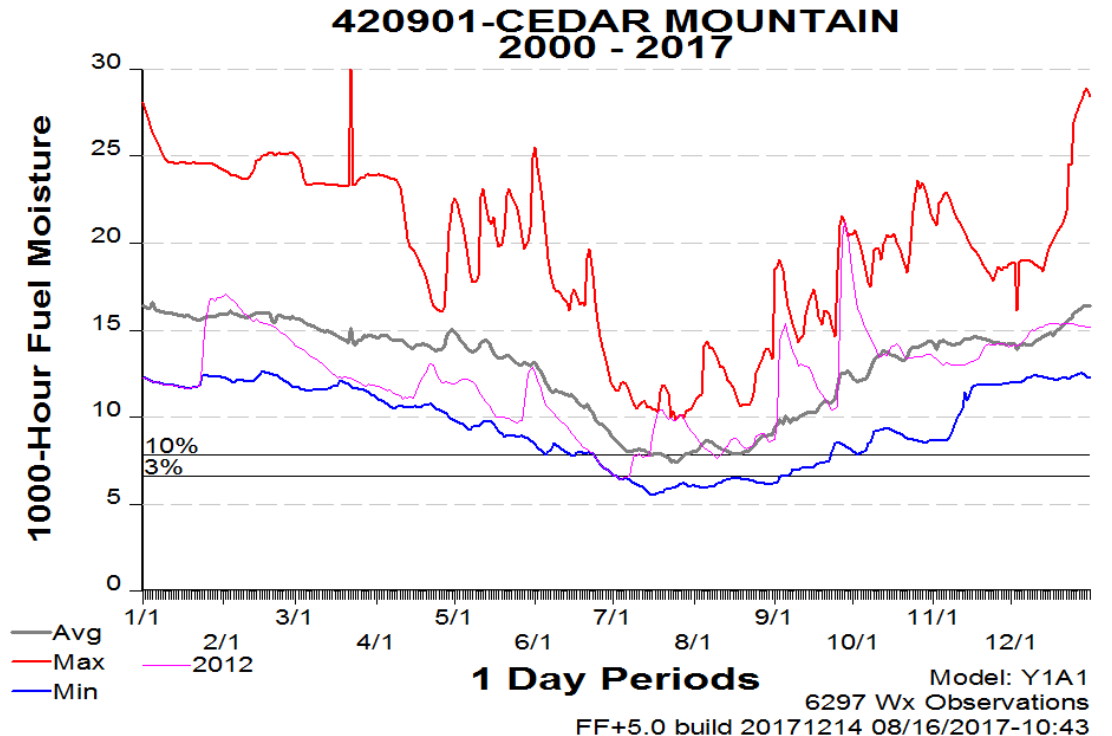
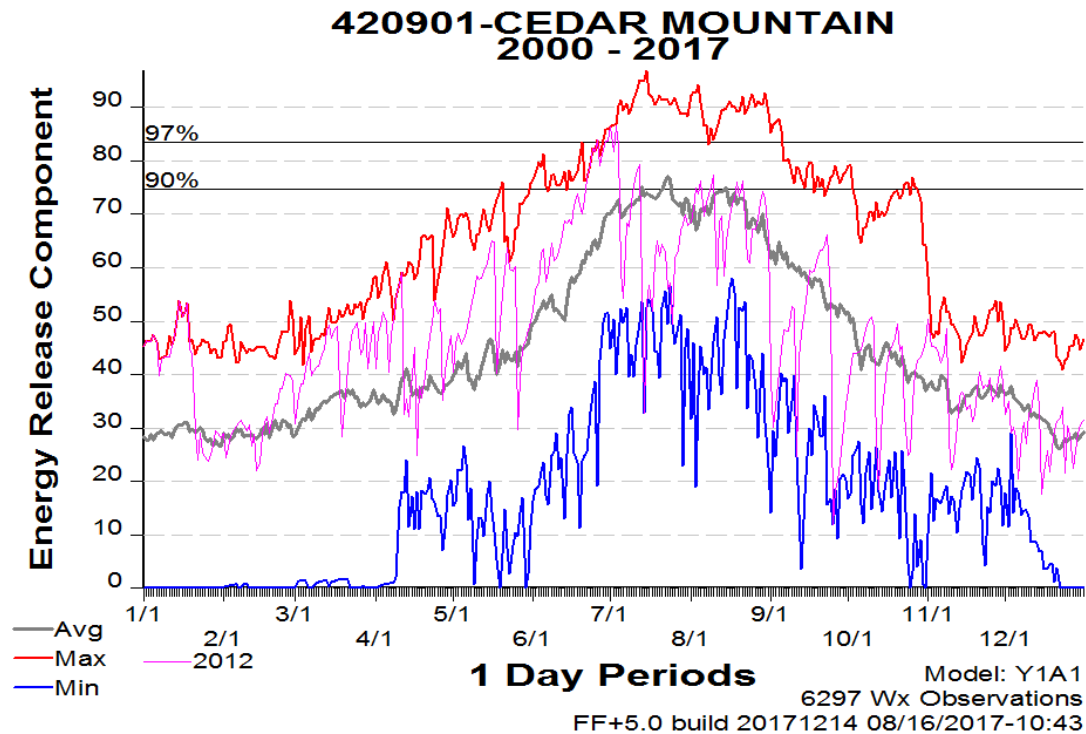
# New model with Radial Median



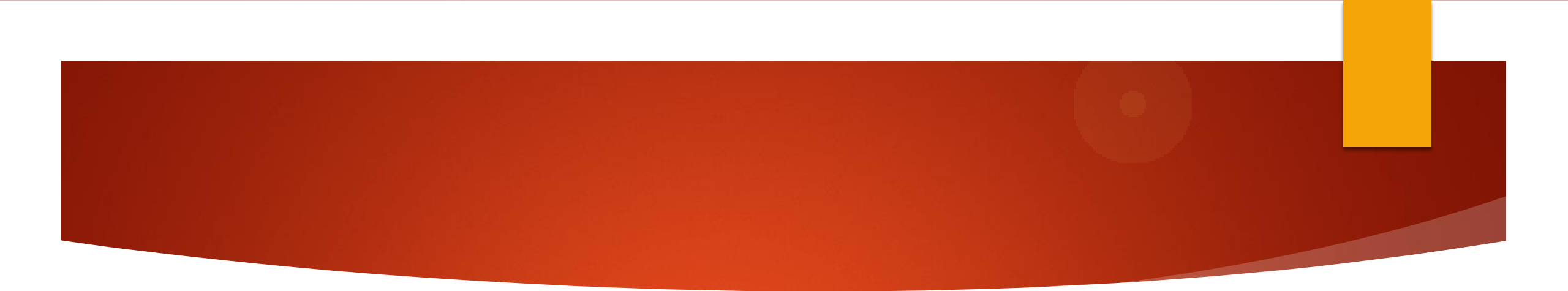
# New model with Radial Median and Adsorption Correction



# New model with Radial Median, Adsorption Correction and modified stick radii





- 
- ▶ Change the Minimum Adsorption Rate
  - ▶ Change the stick diameters
  - ▶ Change the radial averaging method

### Display/Edit Default NFDRS Parameters

[Back to Menu](#)

Station ID:

Effective Date:

Info: Standard Defaults for GSI Herb and Woody FM Options have been loaded.

NFDR Parameters

GSI Herb FM Options

GSI Woody FM Options

Nelson Dead Fuel Moisture Options

Load Fuel Model Percentiles

Use Nelson 100 hour fuel moisture computation:

Use Nelson 1000 hour fuel moisture computation:

1 hour fuel moisture stick radius:

10 hour fuel moisture stick radius:

100 hour fuel moisture stick radius:

1000 hour fuel moisture stick radius:

NFDRS Index Frequency:

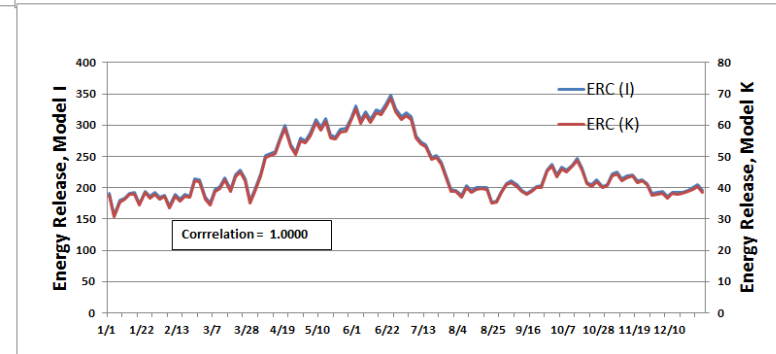
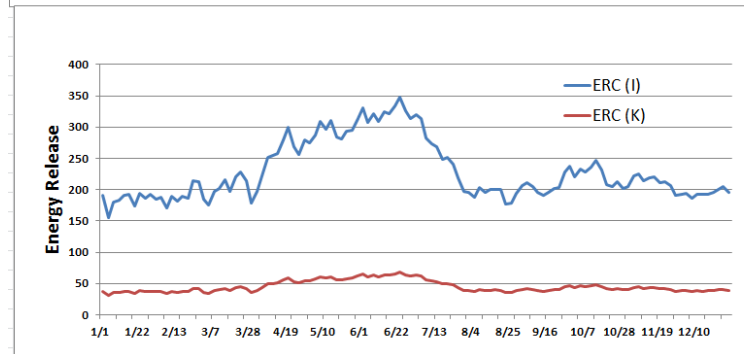
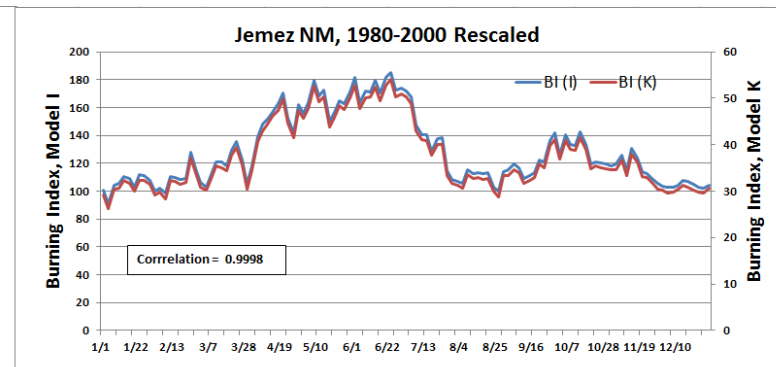
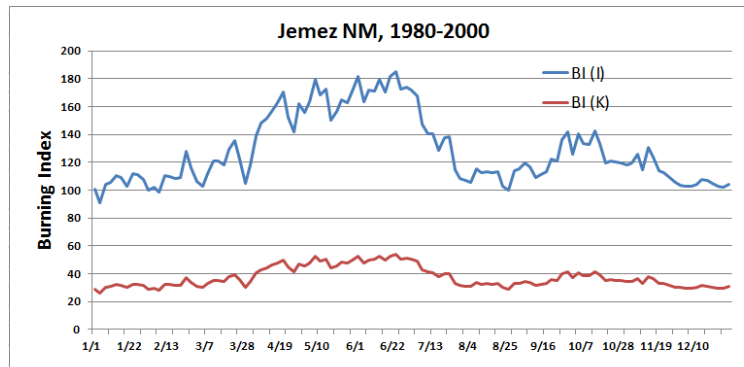
- ▶ // Initialize the dead fuel moisture models
- ▶ OneHourFM.initializeParameters(0.2, "One Hour"); // 1hr Dead FM  
model init
- ▶ TenHourFM.initializeParameters(0.64, "Ten Hour"); // 10hr Dead FM  
model init
- ▶ HundredHourFM.initializeParameters(2.0, "Hundred Hour"); // 100hr Dead  
FM model init
- ▶ ThousandHourFM.initializeParameters(3.81, "Thousand Hour");

# NFDRS Fuel Models

# Consolidate Fuel Models

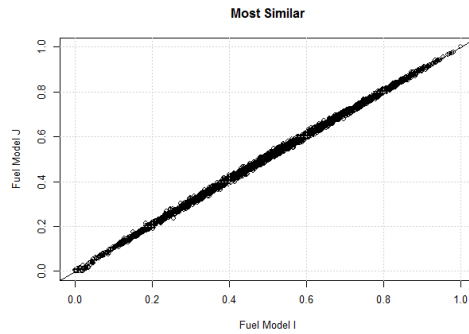
- ▶ John Deeming, the lead developer of the NFDRS in use today, proposed reducing the 9 fuel models in the 1972 system to 4 in the 1978 update
  - ▶ He negotiated to 20 with his steering committee
  - ▶ In the 1988 update, essentially 20 more were added
- ▶ Outputs from most NFDRS fuel models are not unique
  - Similarity analysis of output distributions revealed just four really unique fuel model types.

# Indexes from different fuel models are correlated though their ranges may differ significantly

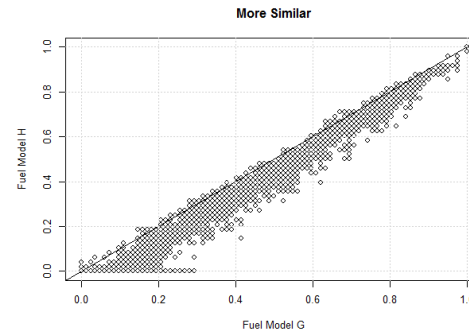


# ERC correlation analysis between four model pairs

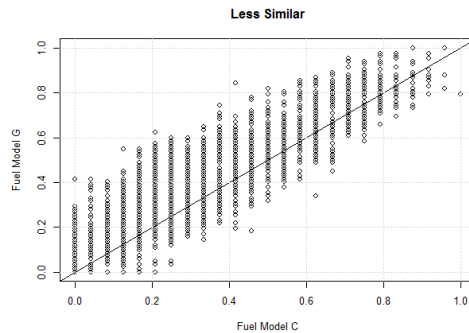
I versus K  
Correlation = 1.0



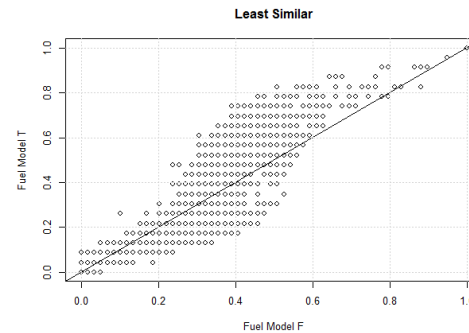
G versus H  
Correlation = 0.9885



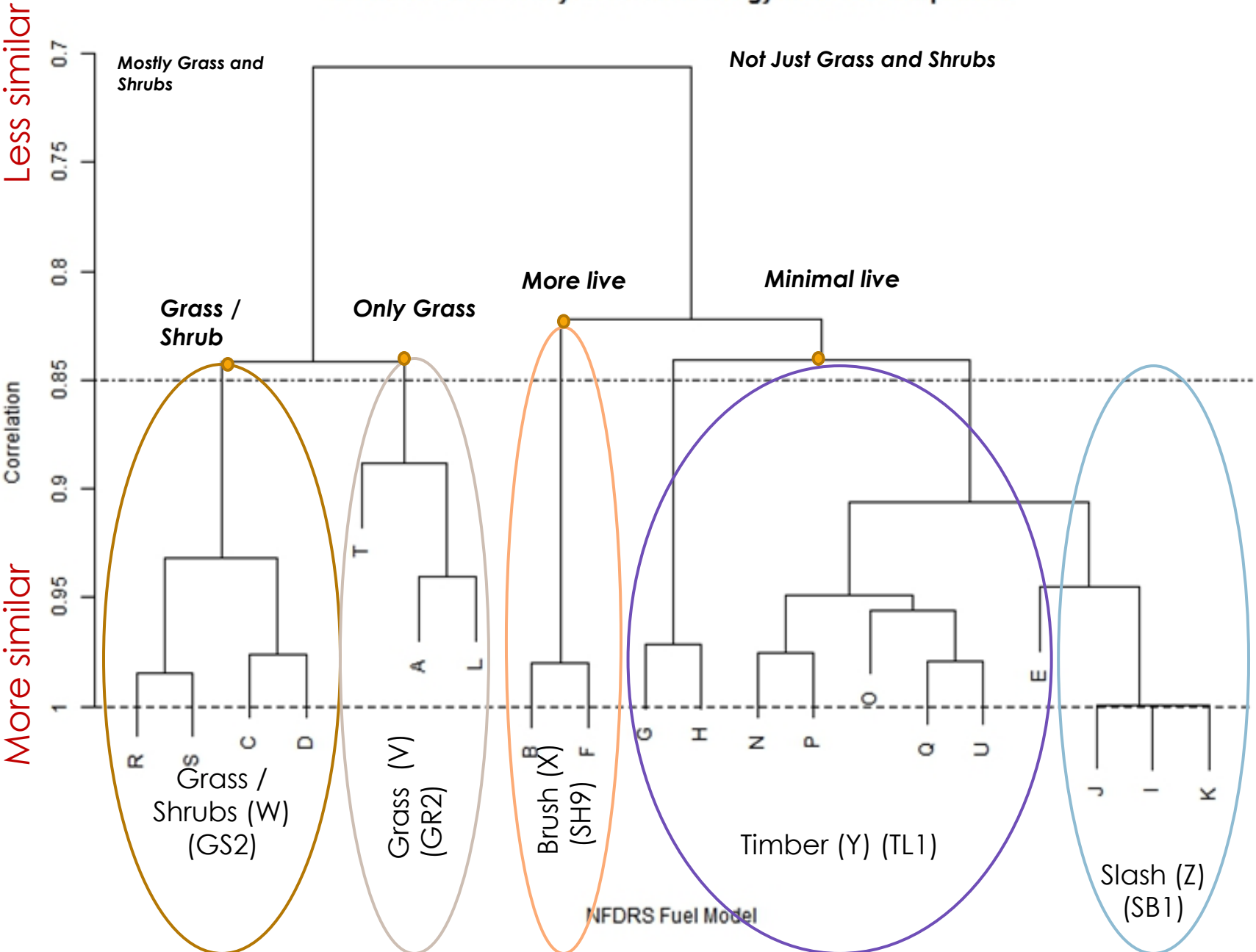
G versus C  
Correlation = 0.6825



F versus T  
Correlation = 0.6784



### Fuel Model Similarity Matrix for Energy Release Component





# Deeming, 1987

- ▶ The standard fire-danger rating fuel models will be a subset of the fuel models used for fire-behavior predictions and fire planning.
- ▶ Live-fuel moisture models will certainly be improved as will dead-fuel moisture models (Rothermel and others 1986). More importantly for some areas of the country, will be a better understanding and modeling of the effects of living plants on fire danger.

# New Five Fuel Models

- ▶ Fuel models are derived from existing 40 FBPS fuel models with addition of a 1000 hour and drought fuel loading
  - ▶ No new fuel models to learn
    - ▶ V – GR2 (Grass)
    - ▶ W – GS2 (Grass/Shrub)
    - ▶ X – SH9 (Brush)
    - ▶ Y – TL1 (Timber)
    - ▶ Z – SB1 (Slash)

NFDRS 2016 Fuel Type	NFDRS 2016 Fuel Model	Equivalent NFDRS 1978 Fuel Model
Grass	V	A,L,T
Grass / Shrub	W	R,S,C,D
Brush	X	B, F
Timber	Y	G,H,N,P,O,Q,U,E
Slash	Z	I,J,K

Fuel Model Parameters

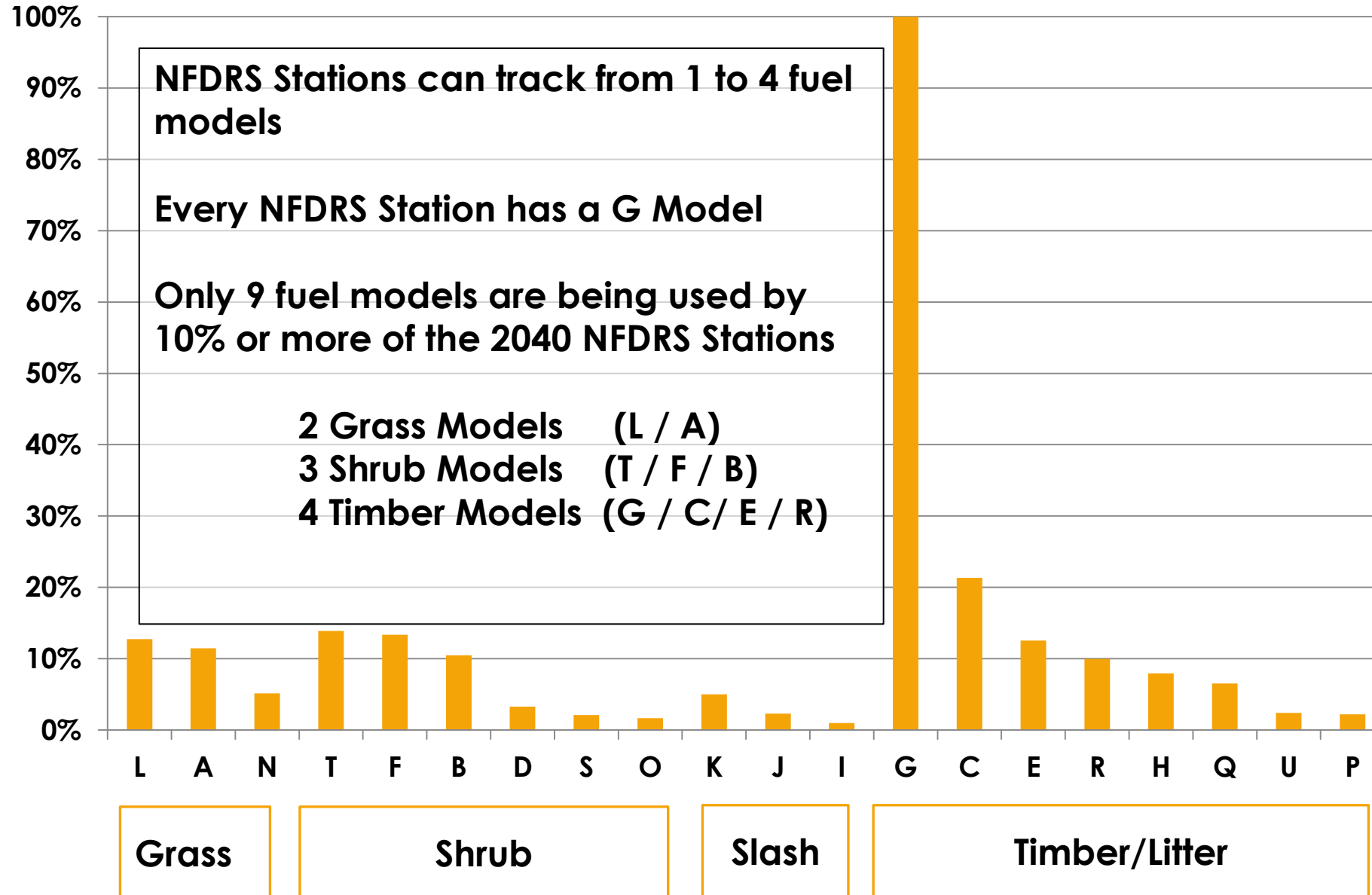
Model Selection

Fuel Model:  Use 88 Model:

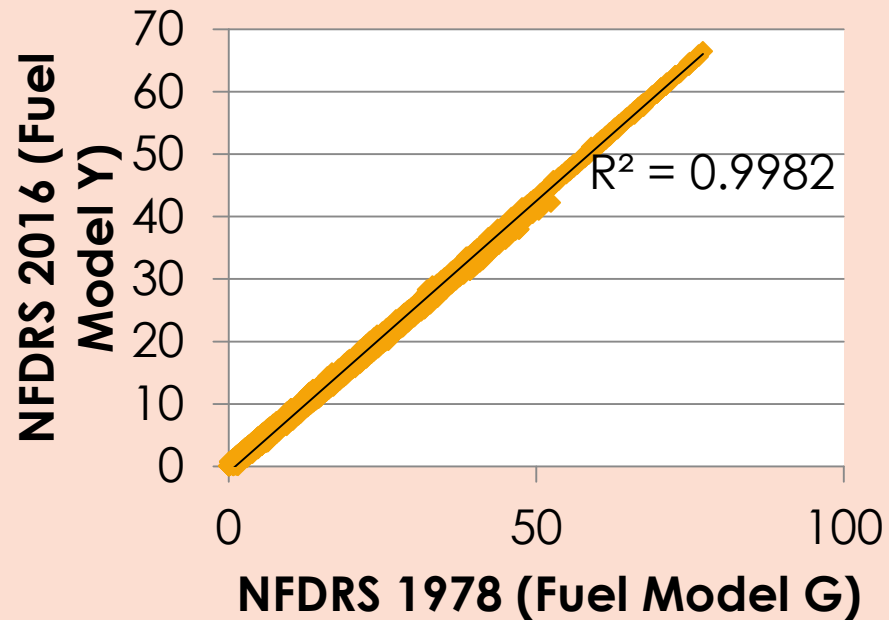
Fuel Model	88 Model	1 Hour Loading	10 Hour Loading	100 Hour Loading	1000 Hour Loading	Herb Loading	Woody Loading	Drought Loading	1 Hour SA : Vol	10 Hour SA : Vol	100 Hour SA : Vol	1000 Hour SA : Vol	Herb SA : Vol	Woody SA : Vol	Heating #	Moisture Extinction	Depth	Wind Factor	Max SC
G	<input type="checkbox"/>	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

NFDRS Fuel Model	Scott and Burgan Equivalent	Fuel Loading (tons ac <sup>-1</sup> )							Surface Area to Volume Ratio (ft <sup>-1</sup> )						Fuel Heat Content (btu lb <sup>-1</sup> )	Moisture Extinct (%)	Depth (ft)	Wind Adjustment Factor (DIM)	Max SC
		1 Hr	10 Hr	100 Hr	1000 Hour	Herb	Woody	Drought	1 Hr	10 Hr	100 Hr	1000 Hour	Herb	Woody					
Code	Code	L1	L10	L100	L1000	LHERB	LWOOD	LDROUGHT	SG1	SG10	SG100	SG1000	SGHERB	SGWOOD	HD	MXD	DEPTH	WNDFC	SCM
V	GR2	0.1	0	0	0	1.0	0	1.1	2000	109	30	8	2000	1500	8000	15(40)	1.0	0.6	108
W	GS2	0.5	0.5	0	0	0.6	1	1.6	2000	109	30	8	2000	1500	8000	15(40)	1.5	0.4	62
X	SH9	4.5	2.45	0	0	1.55	7	8.5	2000	109	30	8	2000	1500	8000	25(40)	4.4	0.4	104
Y	TL1	2.5	2.2	3.6	8.64	0	0.2	15.44	2000	109	30	8	2000	1500	8000	25(40)	1	0.2	5
Z	SB2	4.5	4.25	4	4	0	0	16.75	2000	109	30	8	2000	1500	8000	25(40)	1	0.4	19

## Percent of Active NFDRS Stations in WIMS (n=2040) with Each Fuel Model, Grouped by Type



# Fuel Model Comparison Exercise



**NFDRSCalculator**

**Site**  
 Fuel Model: **Y - Timber**  
 Slope Class: **1 : 0 - 25%**  
 Use 88 Model:

**Weather**  
 Temperature: **80**  
 20' Wind: **5**  
 SOW: **1 - Scattered Clouds**

**Fuel Moistures**  
 1 - Hr FM: **4**  
 10 - Hr FM: **5**  
 100 - Hr FM: **10**  
 1000 - Hr FM: **12**  
 Herb FM: **30**  
 Woody FM: **60**

**88 Model Inputs**  
 Season: **3 - Summer**  
 Woody Greenness: **5**  
 KBDI: **100**  
 Rain Event:   
 Deciduous Shrubs:

**Calculated Indices**  
 SC: **0**  
 ERC: **0**  
 BI: **0**  
 IC: **0**

**NFDRS2016 Specific**  
 GSI: **0.5**      Max GSI: **1**  
 KBDI: **100**      GSI Greenup Threshold: **0.5**  
 SCM: **30**       Humid MXD

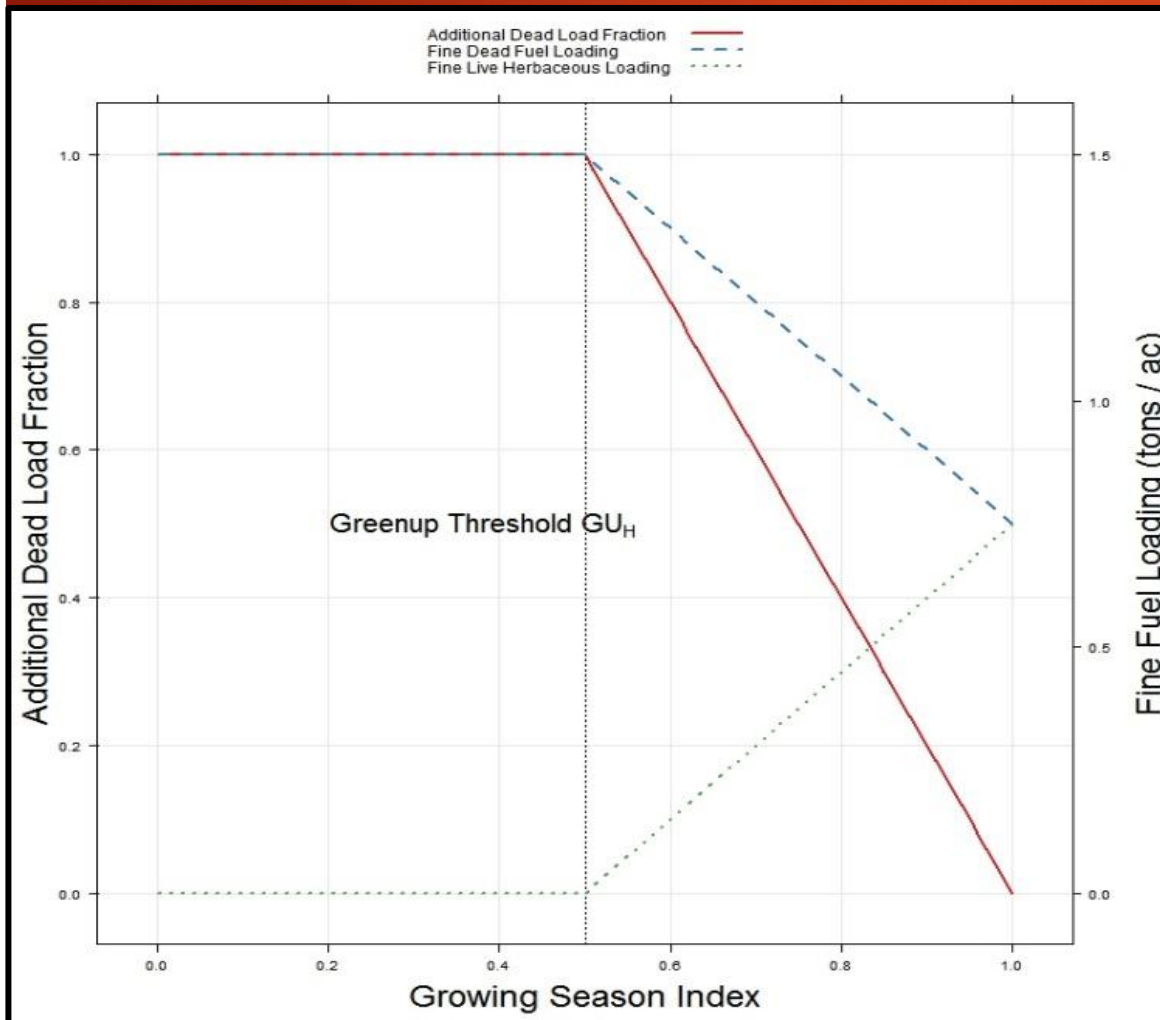
Fuel Model Parameters      KBDI Calculator      Calculate

# Minor Changes

- ▶ GSI-driven curing function
  - ▶ Replaces load transfer logic
- ▶ Maintain the drought fuel loading
- ▶ Moisture of extinction
- ▶ Site-specific maximum spread component and variable slope input



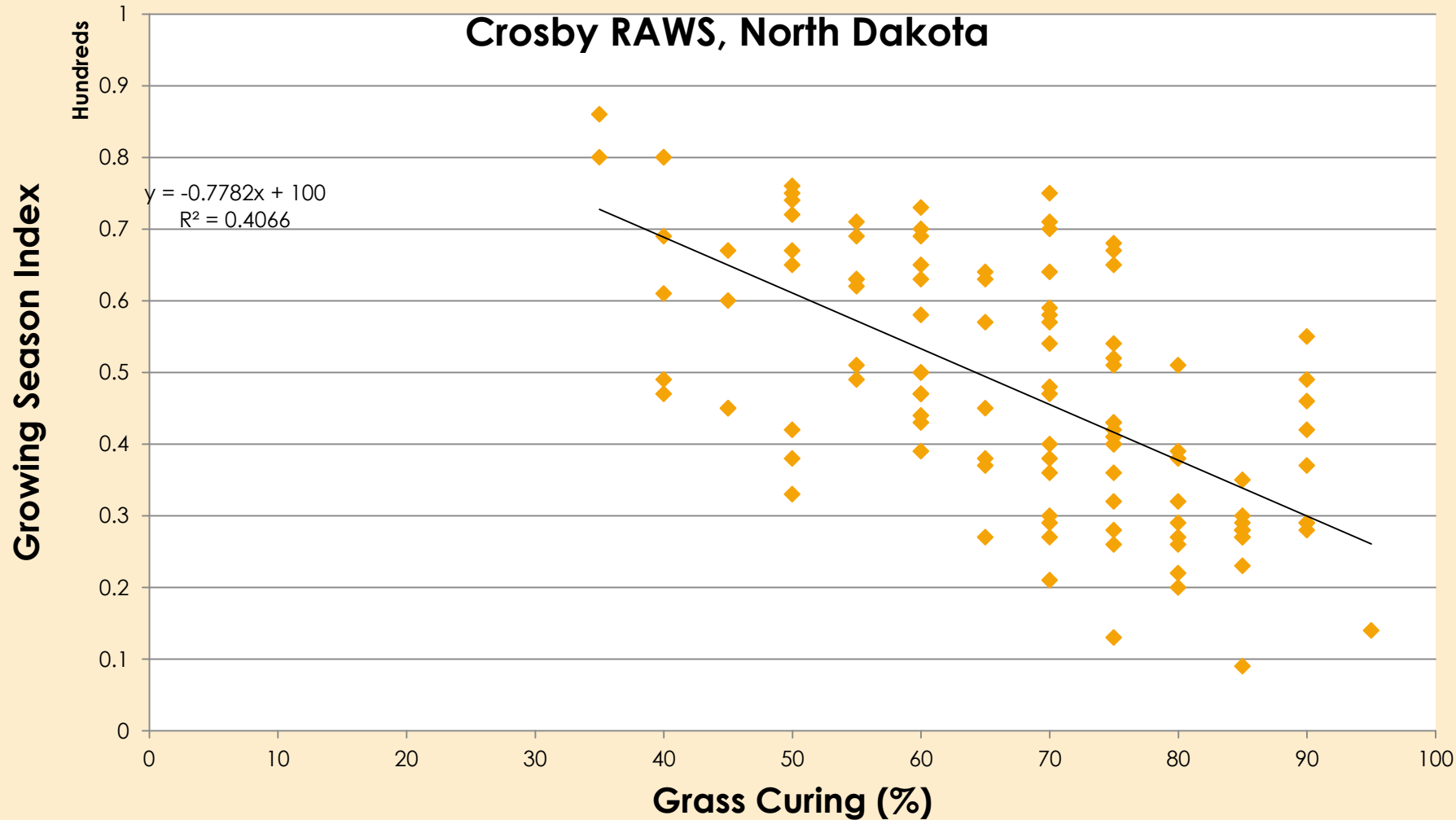
# Curing



- ▶ Remove the 'Load Transfer' for dynamic fuel models and replace with 'Curing'
- ▶ Calculated as a function of GSI
- ▶ Only applies to fuel models with live herbaceous loading

Back to the calculator.....

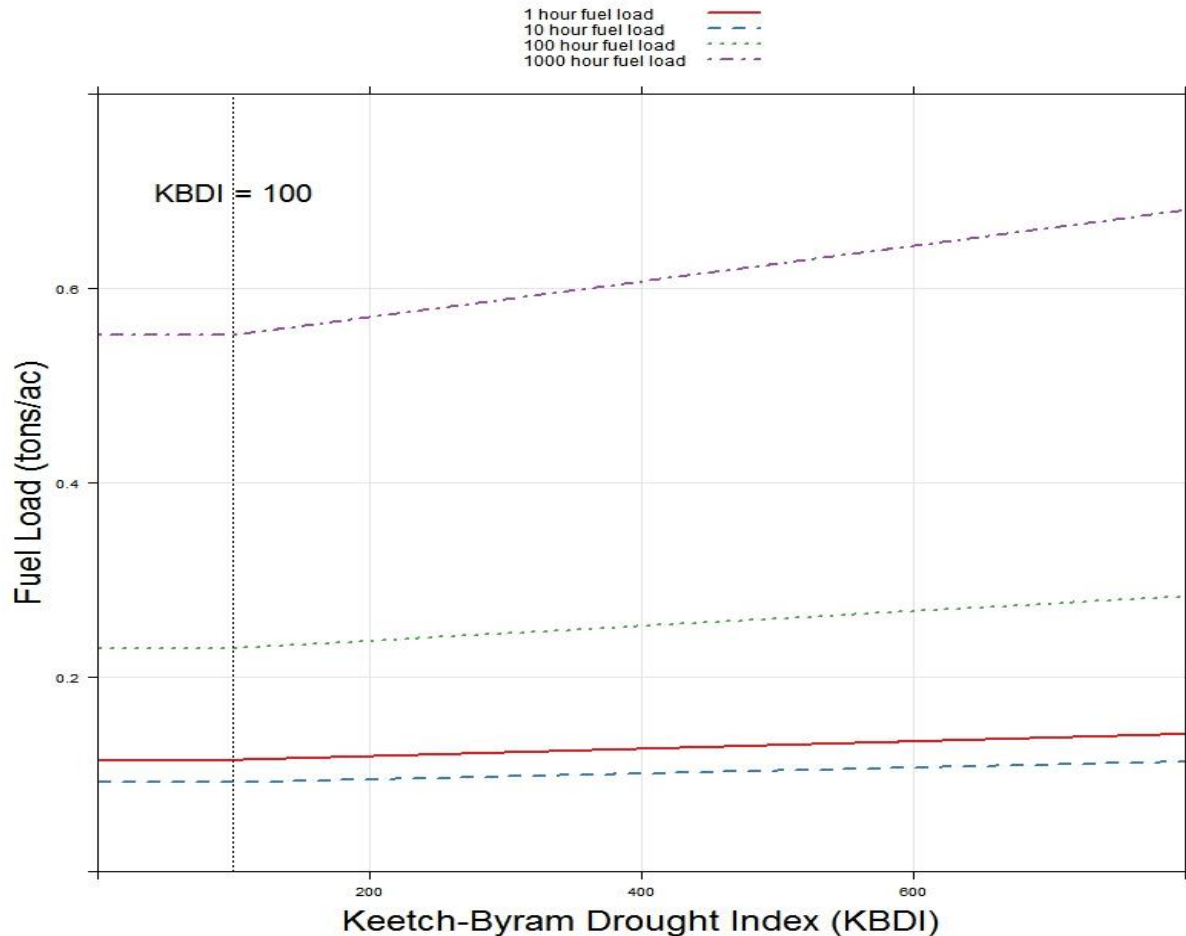
# We can predict curing with GSI



# GSI-driven curing function

- ▶ Curing is expressed as the ratio of fine dead fuel to total loading
- ▶  $C = \frac{w_{dead}}{w_{total}}$
- ▶ Additional loading is calculated based on the running average of the herbaceous GSI value
- ▶ 
$$\left( \begin{array}{l} GSI < HerbGreenup \\ GSI \geq HerbGreenup \end{array} \right) C = - \left( \left( \frac{1.0}{(1.0 - GU_H)^*} \right) * GSI' \right) + \left( \frac{1.0}{1.0 - GU_H} \right)$$
  
$$C = 1$$
- ▶ Once C is calculated the 1hr and herbaceous loadings are calculated as follows:
- ▶  $W1P = W1 + WHERB * C$
- ▶  $WHERBP = WHERB * (1 - C)$


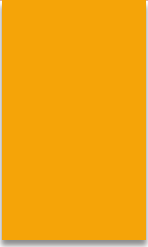
# Drought fuel loading



Example increase in fuel load for fuel model Y

- Additional fuel loading added to fuel moisture in response to drought
- We expect to improve drought representation in future versions
  - KBDI is currently being utilized as a place-holder for improved drought metrics

```
if (tmpKBDI > 100 )
{
    WTOTD = W1 + W10 + W100;
    WTOTL = WHERB + WWOOD;
    WTOT = WTOTD + WTOTL;
    PackingRatio = WTOT / fDEPTH;
    WTOTD = WTOTD + W1000;
    DroughtUnit = WDROUGHT / 700.;
    W1 = W1 + (W1 / WTOTD) * (tmpKBDI - 100) * DroughtUnit;
    W10 = W10 + (W10 / WTOTD) * (tmpKBDI - 100) * DroughtUnit;
    W100 = W100 + (W100 / WTOTD) * (tmpKBDI - 100) * DroughtUnit;
    W1000 = W1000 + (W1000 / WTOTD) * (tmpKBDI - 100) * DroughtUnit;
    WTOT = W1 + W10 + W100 + W1000 + WTOTL;
    fDEPTH = (WTOT - W1000) / PackingRatio;
}
```

- 
- 
- ▶ How much drought fuel loadings is added to the 1000 hour loading when the KBDI is 650?

# Other modifications

- ▶ Adjective Rating calculations often work poorly in humid regions here the Spread Component does not approve the SCMax value of the fuel model
  - ▶ We have added the ability to allow SCMax to vary by location
- ▶ Also, moisture of extinction values for all fuel models are too low to allow proper system operation in more humid areas
  - ▶ We have added a 'humid' switch in WIMS to allow the user to set MXD to 40%
- ▶ Finally, we have added an option to allow the direct input of slope into NFDRS. This paves the way for gridded fire danger applications in the future.



Why change SCMax?

Computed class level	Upper value for class												
0	SI = 0												
1	SI-low/8												
2	SI-low/4												
3	(SI-low)(3/8)												
4	SI-low/2	Desired Number of Staffing Classes	Displayed Staffing Class										
5	(SI-low)(3/4)												
6	SI-low												
7	(SI-low + SI-high)/2		3	0	1	1	1	1	1	1	4	4	5
8	SI-high		4	0	1	1	1	1	3	3	4	4	5
9	> SI-high	5	0	1	1	2	2	3	3	4	4	5	
		6	0	1	1	2	2	3-	3+	4	4	5	
		7	0	1	1	2	2	3-	3+	4-	4+	5	
		8	0	1	1	2-	2+	3-	3+	4-	4+	5	
		9	0	1-	1+	2-	2+	3-	3+	4-	4+	5	
		Computed 9-Class Level	0	1	2	3	4	5	6	7	8	9	

# Adjective Rating in WIMS / WFAS

Staffing Levels (SL)	Adjective Fire Danger Rating (R)				
<b>1-, 1, 1+</b>	<b>L</b>	<b>L</b>	<b>L</b>	<b>M</b>	<b>M</b>
<b>2-, 2, 2+</b>	<b>L</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>H</b>
<b>3-, 3, 3+</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>VH</b>
<b>4-, 4, 4+</b>	<b>M</b>	<b>H</b>	<b>VH</b>	<b>VH</b>	<b>E</b>
<b>5</b>	<b>H</b>	<b>VH</b>	<b>VH</b>	<b>E</b>	<b>E</b>
<b>Ignition Component</b>	<b>0-20</b>	<b>21-45</b>	<b>46-65</b>	<b>66-80</b>	<b>81-100</b>

# ESTA

Adopt 2016 Models

D e l	Active Fuel Models	P r i	ID	** 78 NFD RS Only **											Staffing Idx Breakpoints						
				H S	Herb Date	Greenup Date	88 s b	S l p	G r s	C l i	MXD	SCM	Herb FM	Woody FM	X- 1000	SI	DC	Low		High	
															SI%			Val	SI%	Val	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	1	7G ▾	P ▾	01-Apr-15	30-Mar-15	▾	3=41-55% ▾	P ▾	2 ▾	L ▾	30	7.2	60	18	EC ▾	5	90	55	97	62
<input type="checkbox"/>	<input checked="" type="checkbox"/>	2	7C ▾	P ▾	01-Apr-15	30-Mar-15	▾	2=26-40% ▾	A ▾	2 ▾	L ▾	32	7.2	60	18	EC ▾	5	90	16	97	18
	<input checked="" type="checkbox"/>		▾	▾			▾	▾	▾	▾	▾					▾					
	<input checked="" type="checkbox"/>		▾	▾			▾	▾	▾	▾	▾					▾					
	<input checked="" type="checkbox"/>		▾	▾			▾	▾	▾	▾	▾					▾					
	<input checked="" type="checkbox"/>		▾	▾			▾	▾	▾	▾	▾					▾					
	<input checked="" type="checkbox"/>		▾	▾			▾	▾	▾	▾	▾					▾					
	<input checked="" type="checkbox"/>		▾	▾			▾	▾	▾	▾	▾					▾					

# Snow Flags

- ▶ Carried over from NFDRS 78/88
- ▶ Sets air temperature to 0 C / 32 F
- ▶ Sets RH to 99.99%
- ▶ Sets Solar Radiation to 0
- ▶ PPT = 0

	StationID	ObsDate	Type	OMC 10	Season	GreenHerb	GreenShrub	SR_SOW	SR_WetFlag	SnowFlag
861	241513	02/10/17 13:00	O					2	1	1
862	241513	02/11/17 13:00	O					3	0	1
863	241513	02/12/17 13:00	O					2	0	1
864	241513	02/13/17 13:00	O					2	0	1
865	241513	02/14/17 13:00	O					2	0	1
866	241513	02/15/17 13:00	O					2	0	1
867	241513	02/16/17 13:00	O					3	0	1
868	241513	02/17/17 13:00	O					0	0	1
869	241513	02/18/17 13:00	O					3	0	1
870	241513	02/19/17 13:00	O					3	0	1
871	241513	02/20/17 13:00	O					3	0	1
872	241513	02/21/17 13:00	O					4	1	1
873	241513	02/22/17 13:00	O					3	0	1
874	241513	02/23/17 13:00	O					3	0	1
875	241513	02/24/17 13:00	O					3	0	1
876	241513	02/25/17 13:00	O					2	0	1
877	241513	02/26/17 13:00	O					3	0	1
878	241513	02/27/17 13:00	O					3	0	1
879	241513	02/28/17 13:00	O					2	0	1
880	241513	03/01/17 13:00	O					3	0	1
881	241513	03/02/17 13:00	O					2	0	1
882	241513	03/03/17 13:00	O					2	0	1
883	241513	03/04/17 13:00	O					3	0	1
884	241513	03/05/17 13:00	O					3	0	1
885	241513	03/06/17 13:00	O					2	0	1
886	241513	03/07/17 13:00	O					3	0	1
887	241513	03/08/17 13:00	O					3	0	1
888	241513	03/09/17 13:00	O					3	0	1
889	241513	03/10/17 13:00	O					3	1	1
890	241513	03/11/17 13:00	O					3	0	1
891	241513	03/12/17 13:00	O					2	0	1
892	241513	03/13/17 13:00	O					3	0	1
893	241513	03/14/17 13:00	O					2	1	1
894	241513	03/15/17 13:00	O					3	0	1
895	241513	03/16/17 13:00	O					2	0	1
896	241513	03/17/17 13:00	O					2	0	0
897	241513	03/18/17 13:00	O					3	0	0
898	241513	03/19/17 13:00	O					2	0	0
899	241513	03/20/17 13:00	O					2	0	0
900	241513	03/21/17 13:00	O					3	0	0
901	241513	03/22/17 13:00	O					3	0	0
902	241513	03/23/17 13:00	O					3	0	0

- ▶ Already export from WIMS
- ▶ Will work on automated input value
- ▶ Pre-loaded in the WRCC DRI RAWs points from 2001-2016 for the Continental United States

# What doesn't change?

- ▶ Most of the same weather inputs
- ▶ All the same output components and indices: still have ERC, BI, SC and IC
- ▶ The look, feel and use of both FireFamily+ and WIMS

# Summary of simplifications

- ▶ No need for:
  - ▶ Climate class
  - ▶ No required manual entries:
    - ▶ Green-up, freeze and dormant dates
    - ▶ State-of-the-weather
  - ▶ All of the revisions in the 1988 system
    - ▶ Deciduous WAF, season codes, greenness factors, 1hr=10hr
- ▶ Weighed sticks
- ▶ Fosberg 1 and 10 hour fuel moisture model
- ▶ Burgan live fuel moisture model
- ▶ Dynamic Load Transfer
- ▶ Total of 35 fuel models eliminated



# End result of changes:

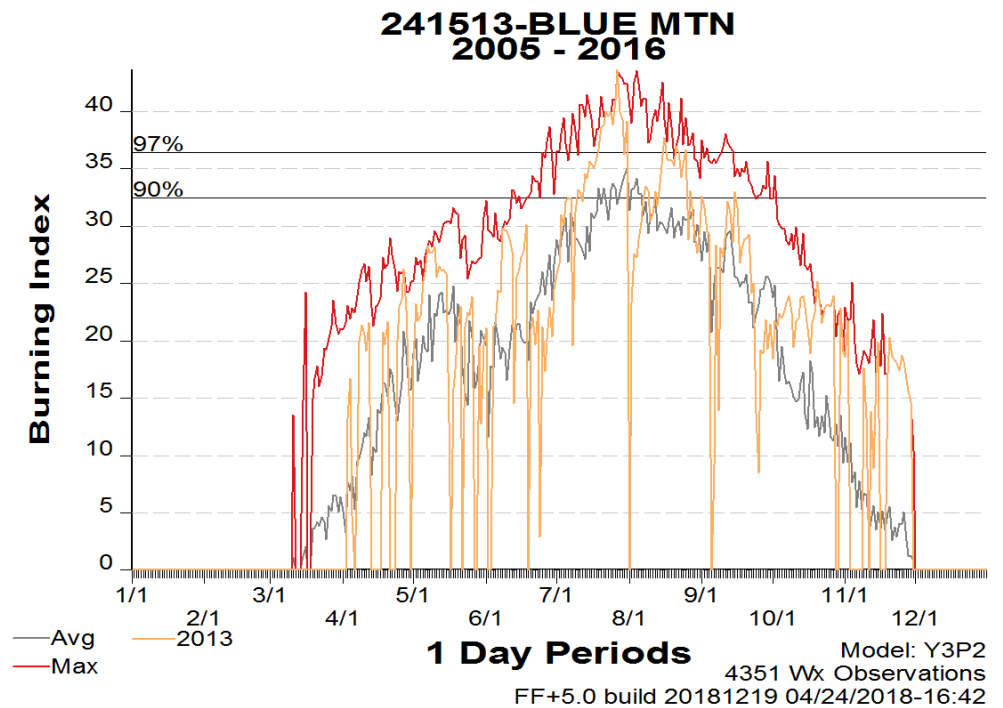
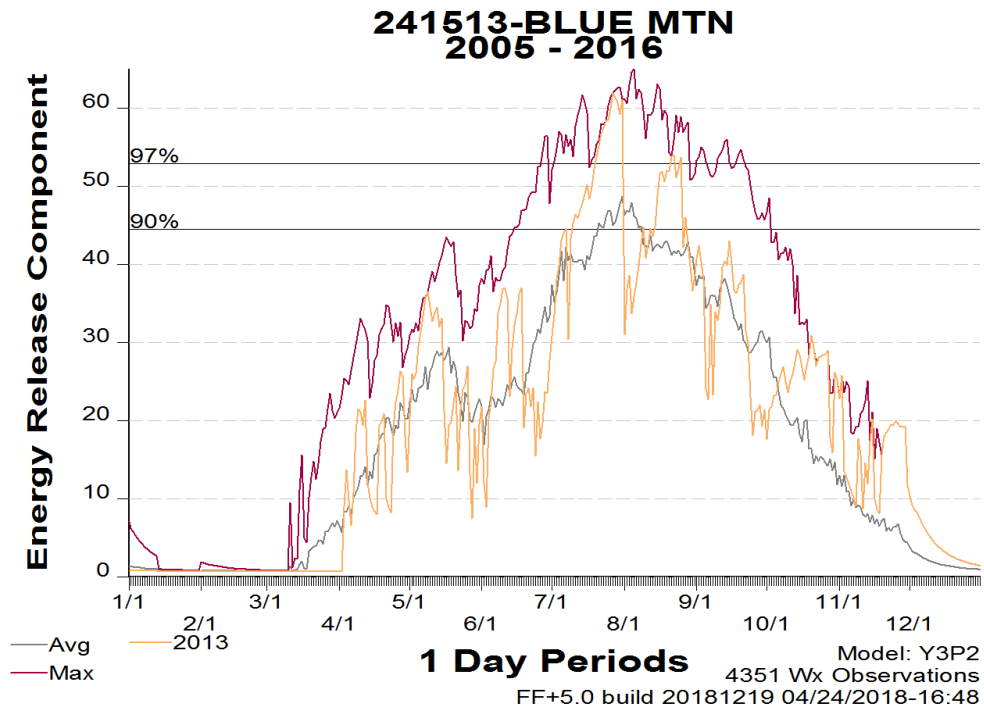
- ▶ **What doesn't change?**

- ▶ Most of the same weather inputs
- ▶ All the same output components and indices: still have ERC, BI, SC and IC
- ▶ The look, feel and use of both FireFamily+ and WIMS

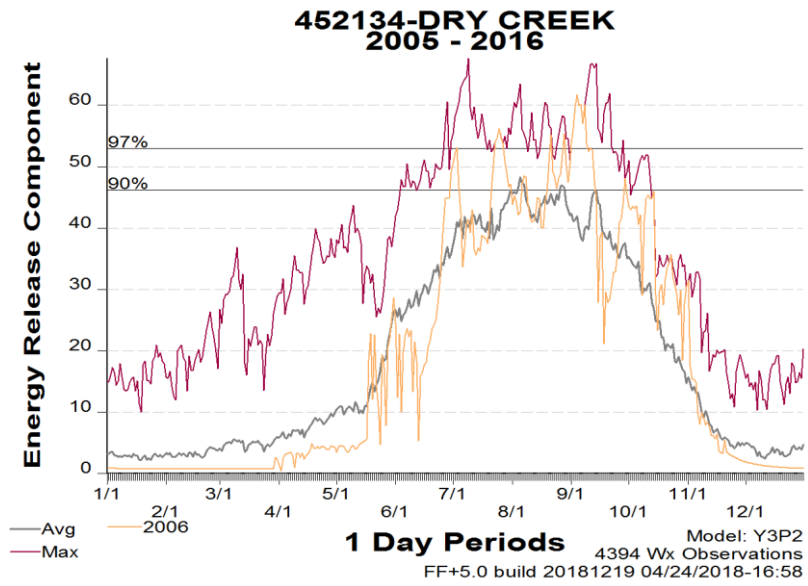
- ▶ **How it's better?**

- ▶ Fully automated NFDRS and more consistent
- ▶ Improved response to drought
- ▶ More easily applied to gridded weather
- ▶ Ready for future work
- ▶ Reduced workload (No R/O, SOW daily entries or seasonal entries)

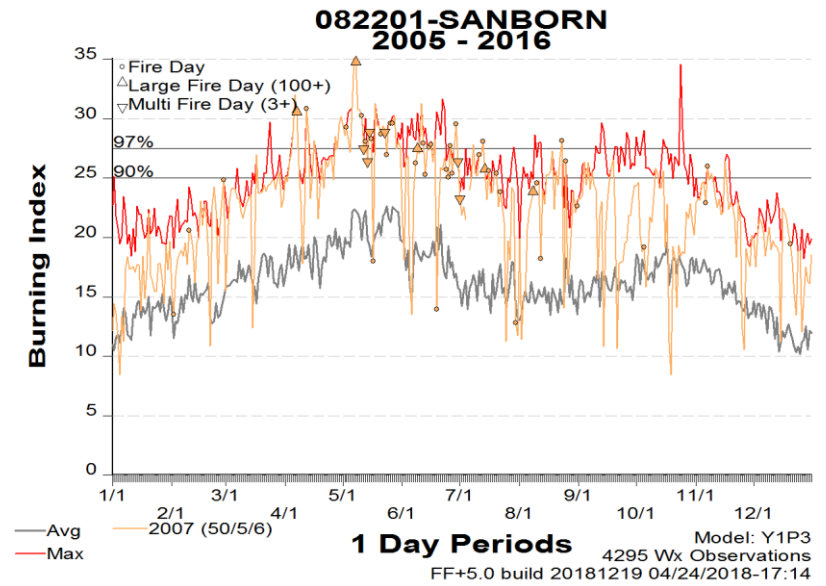
# Example ERC and BI from NFDRS2016



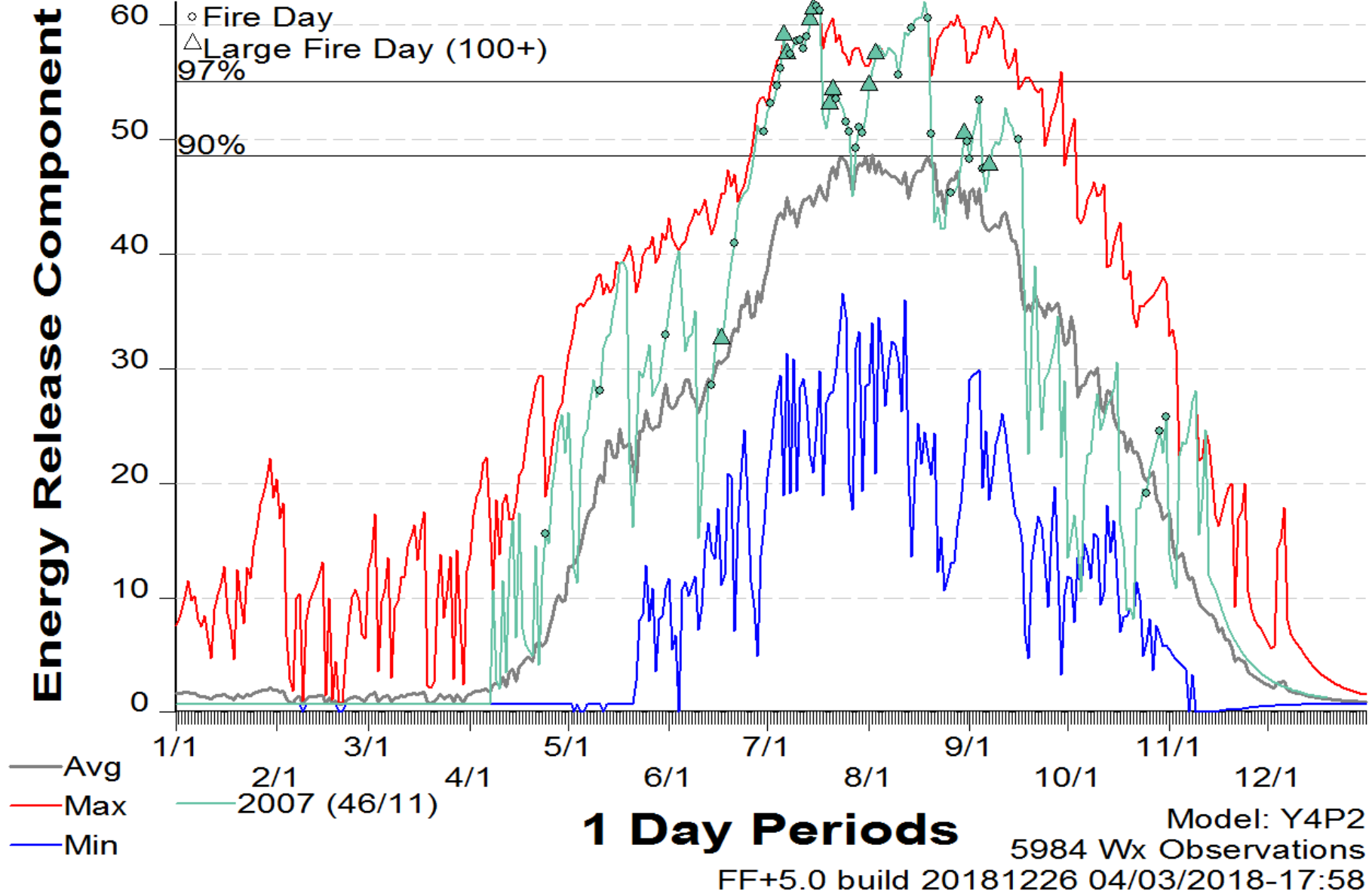
# Central Washington



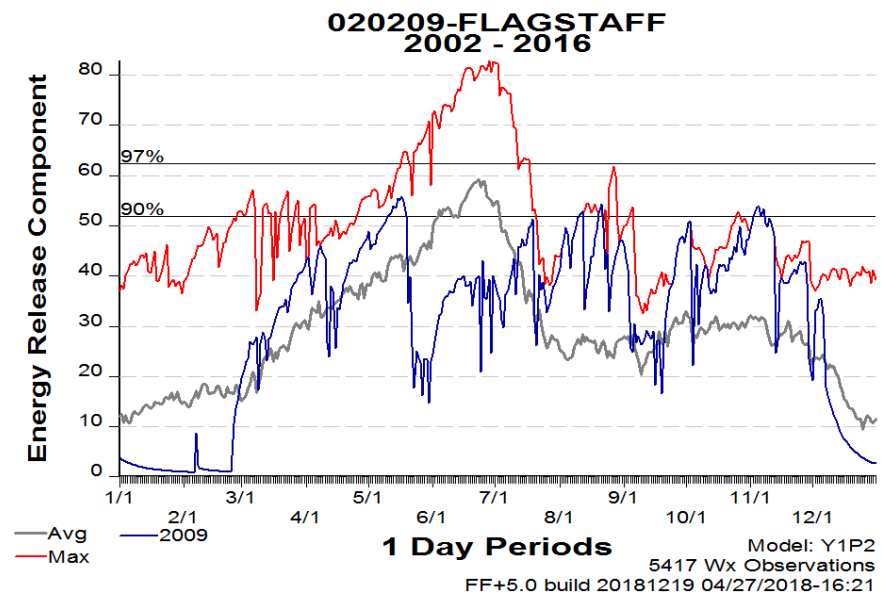
# Florida



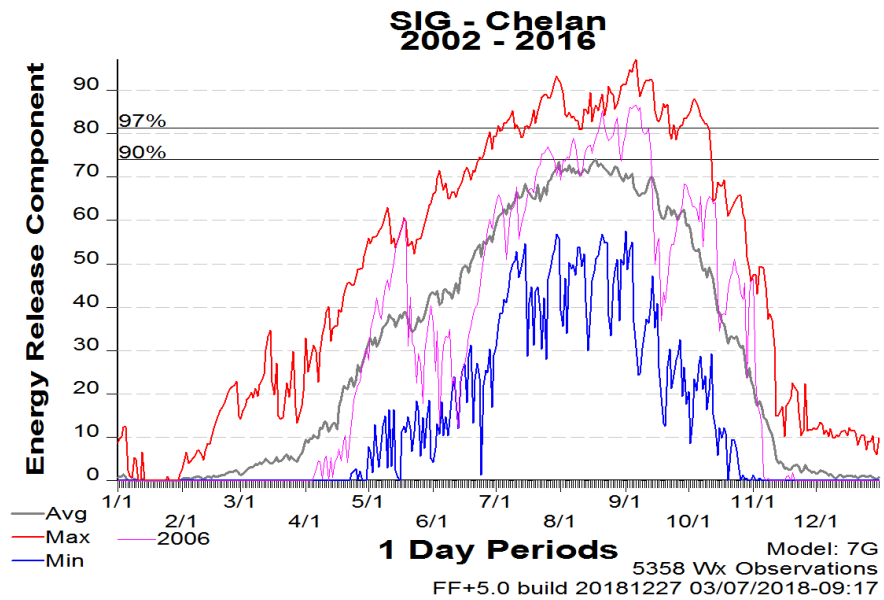
# 101220-TEAPOT 2001 - 2017



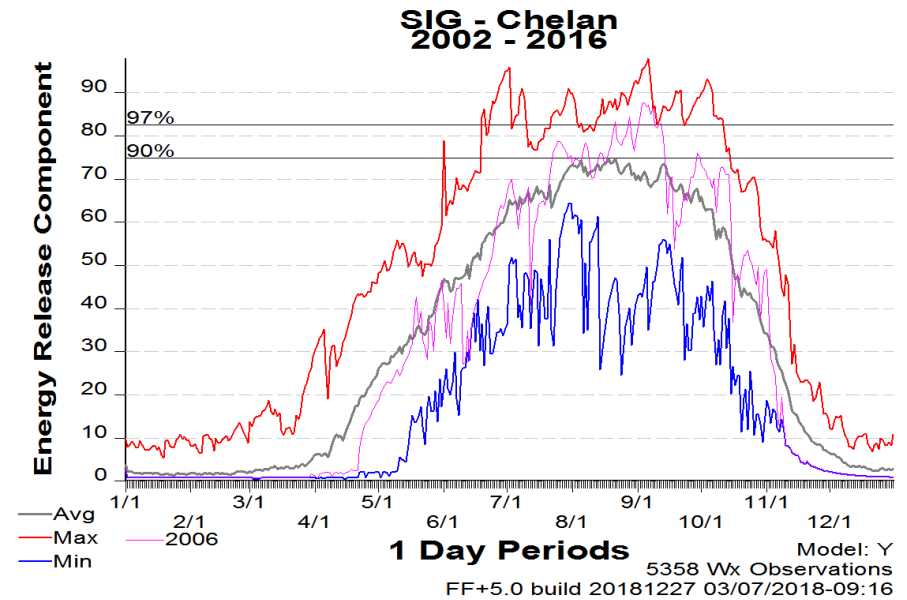
# Flagstaff, AZ



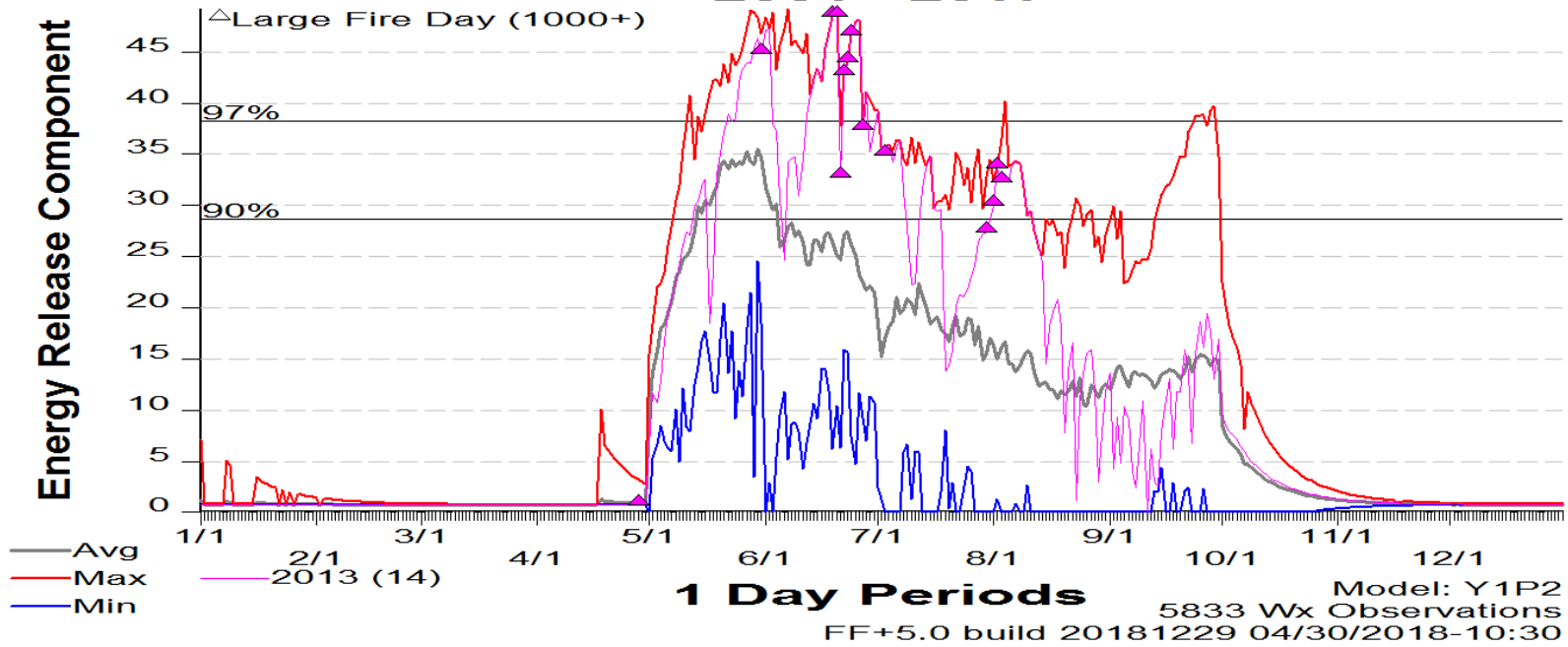
## ERC Fuel Model G

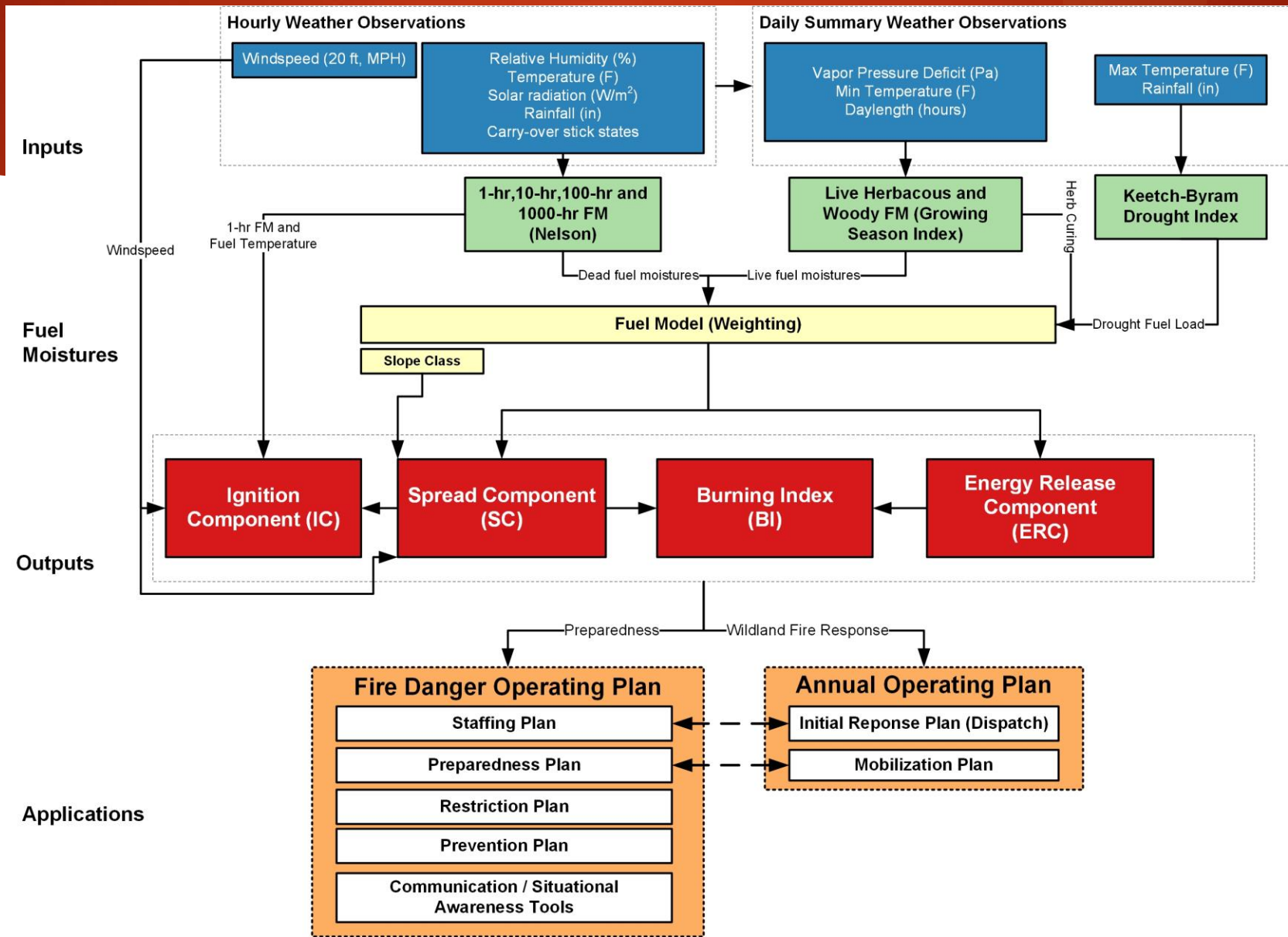


## ERC Fuel Model Y



### 500741-FAIRBANKS 2001 - 2017







# Things to know

- ▶ The absolute numbers will change!
- ▶ The absolute numbers will change!
- ▶ The absolute numbers will change!
- ▶ The percentiles should be comparable
- ▶ Consider comparing frequency in each staffing class
- ▶ Decimals matter and they are a good thing
- ▶ Fire Danger doesn't tell me anything about potential fire behavior
  - ▶ Not true.... That's next
- ▶ Fire Danger can be used to quantify actual energy release, spread rates or flame length? NO!

# Contingency Plans

- ▶ Make the KBDI drought fuel loading optional
- ▶ Swap back in the old FM100 and FM1000 models
- ▶ Revert back to representative fuel models from the 1978 system

# All future applications should consider.....

- ▶ NEVER discussing absolute index values but rather use percentiles for all communications
- ▶ Consider selecting and calibrating TWO indices for a given area: one for preparedness decisions and the other for response decisions
- ▶ Objective criteria for Decision Points
  - ▶ Logistics regressions are meant to predict a yes or no response
- ▶ Bivariate evaluations or more (All we want is the best predictor)



This is ONLY THE BEGINNING, GET USED  
TO CHANGE!

- ▶ But with less impact to you as a user /  
manager of NFDRS

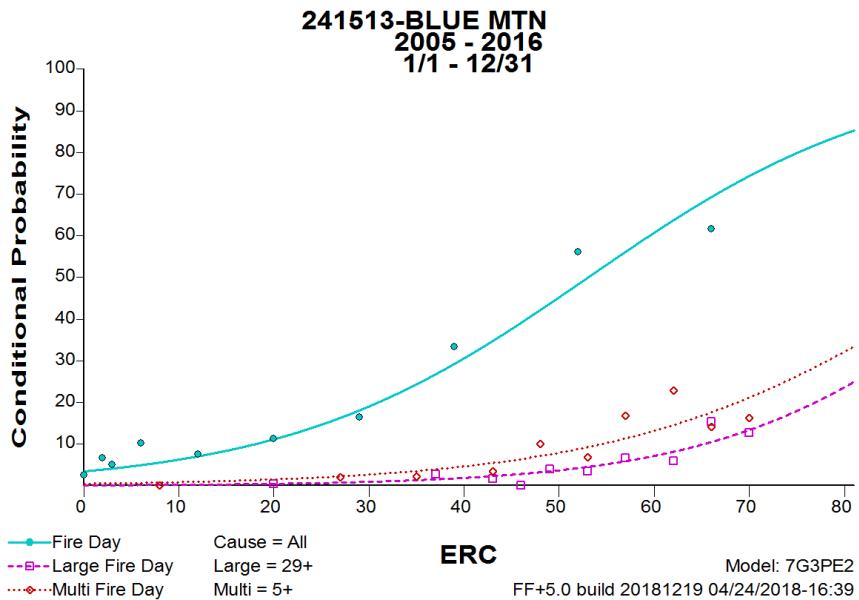
# Model Evaluation

# Energy Release Component

## Fuel Model G

Chi Square DF P-Value R(L)-Sq.

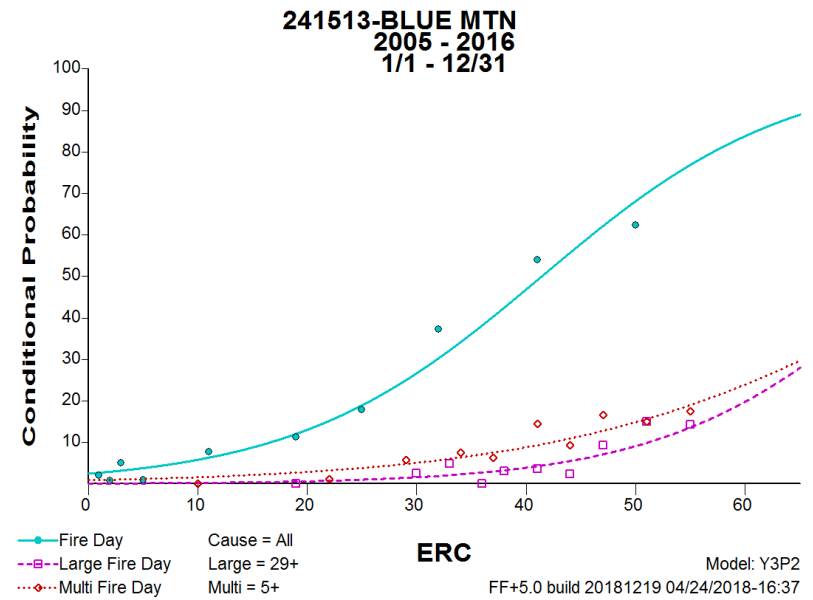
33.3 8 0.0001 0.97



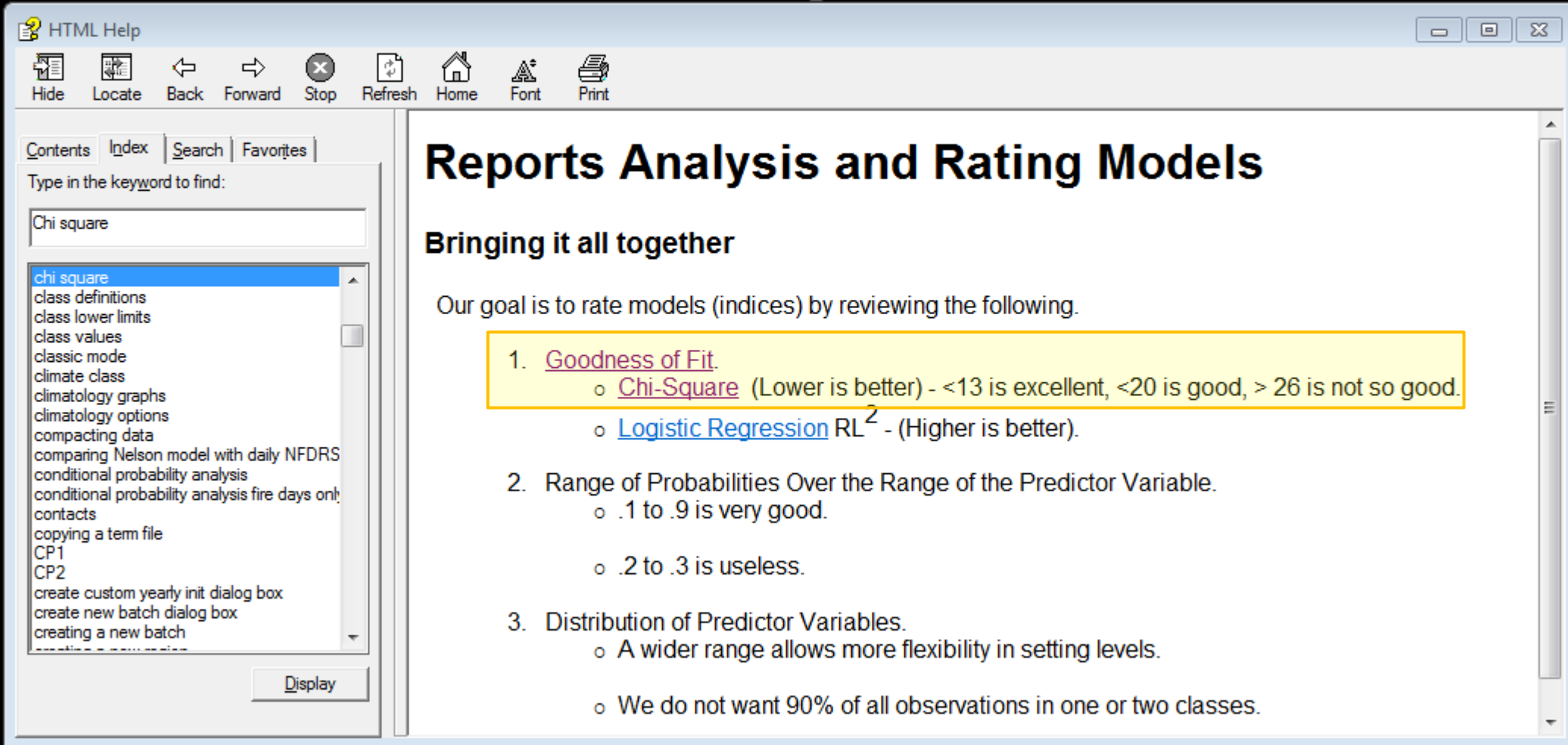
## Fuel Model Y

Chi Square DF P-Value R(L)-Sq.

33.3 8 0.0001 0.97



# FireFamilyPlus 4.1



The screenshot shows a web browser window titled "HTML Help" with a toolbar containing icons for Hide, Locate, Back, Forward, Stop, Refresh, Home, Font, and Print. The main content area displays a search interface with tabs for Contents, Index, Search, and Favorites. A search box contains the text "Chi square". Below the search box is a list of search results, with "chi square" selected. The list includes items such as "class definitions", "class lower limits", "class values", "classic mode", "climate class", "climatology graphs", "climatology options", "compacting data", "comparing Nelson model with daily NFDRS", "conditional probability analysis", "conditional probability analysis fire days onl", "contacts", "copying a term file", "CP1", "CP2", "create custom yearly init dialog box", "create new batch dialog box", and "creating a new batch". A "Display" button is located at the bottom of the search results list.

## Reports Analysis and Rating Models

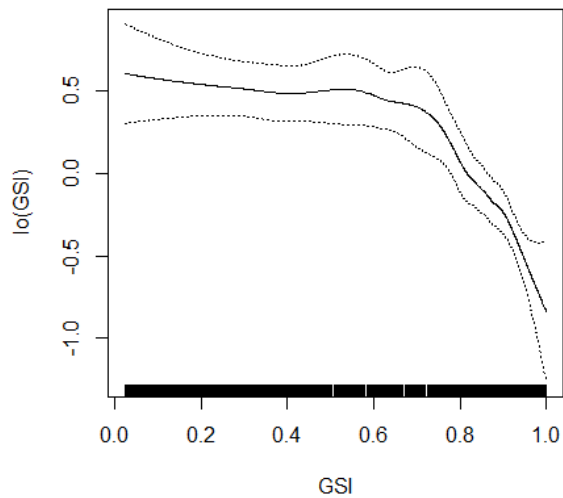
### Bringing it all together

Our goal is to rate models (indices) by reviewing the following.

1. [Goodness of Fit](#).
  - o [Chi-Square](#) (Lower is better) - <13 is excellent, <20 is good, > 26 is not so good.
  - o [Logistic Regression](#)  $RL^2$  - (Higher is better).
2. Range of Probabilities Over the Range of the Predictor Variable.
  - o .1 to .9 is very good.
  - o .2 to .3 is useless.
3. Distribution of Predictor Variables.
  - o A wider range allows more flexibility in setting levels.
  - o We do not want 90% of all observations in one or two classes.

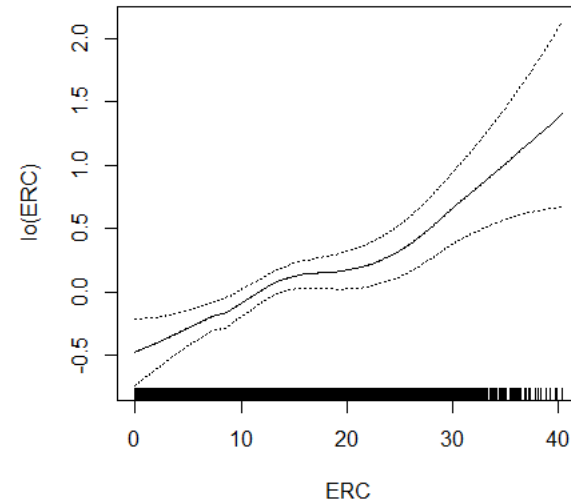
# Predicting fire dangers as combinations of variables

GSI



Not Linear

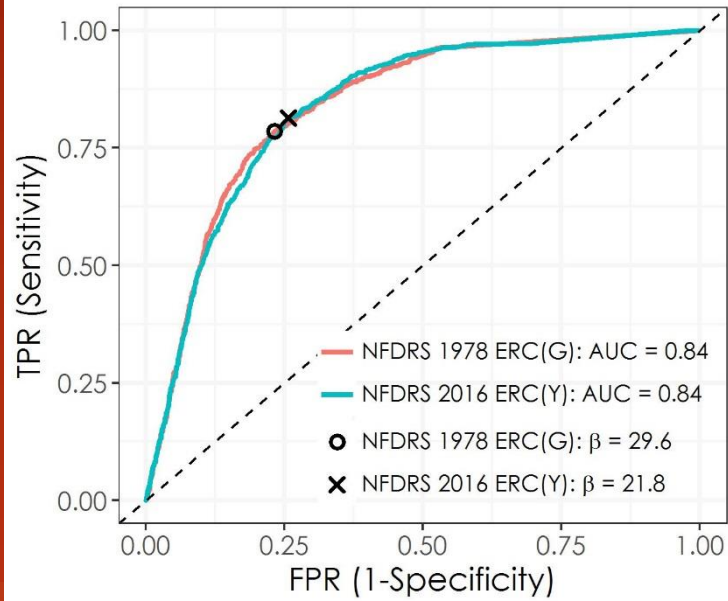
ERC



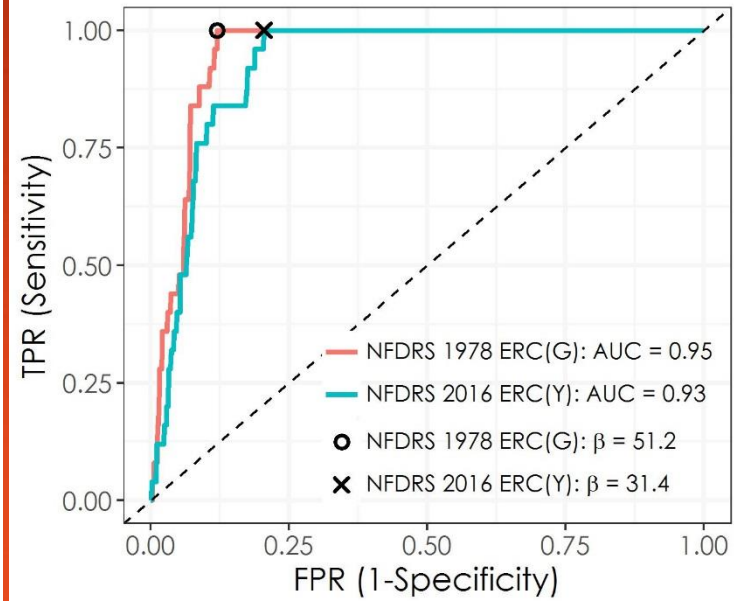
Linear



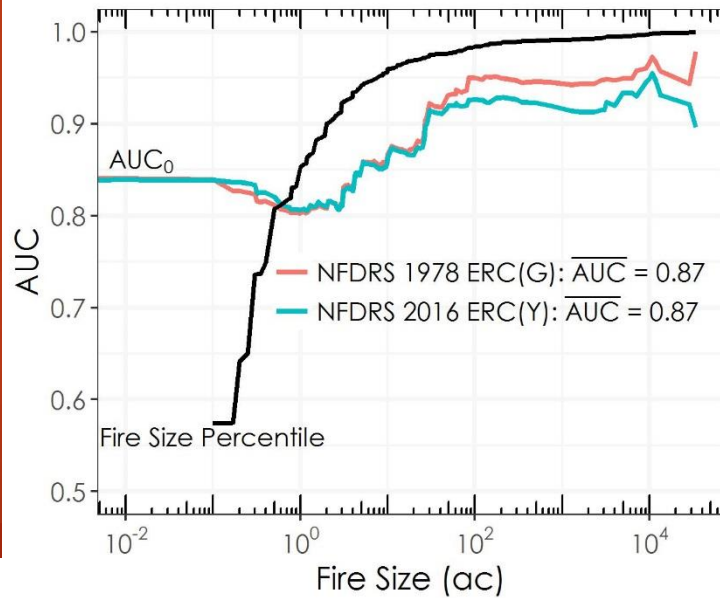
SIG-LDW, 2003-2016, New Fire Days > 0 ac



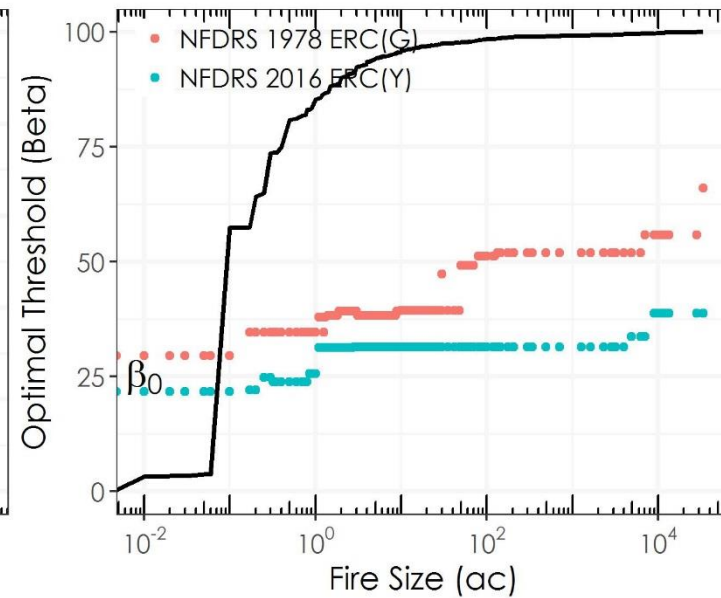
SIG-LDW, 2003-2016, New Fire Days > 100 ac



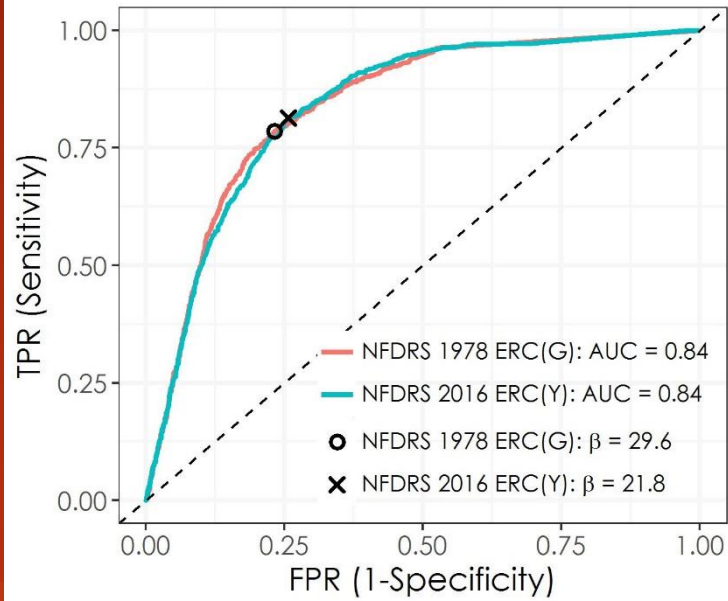
SIG-LDW, 2003-2016



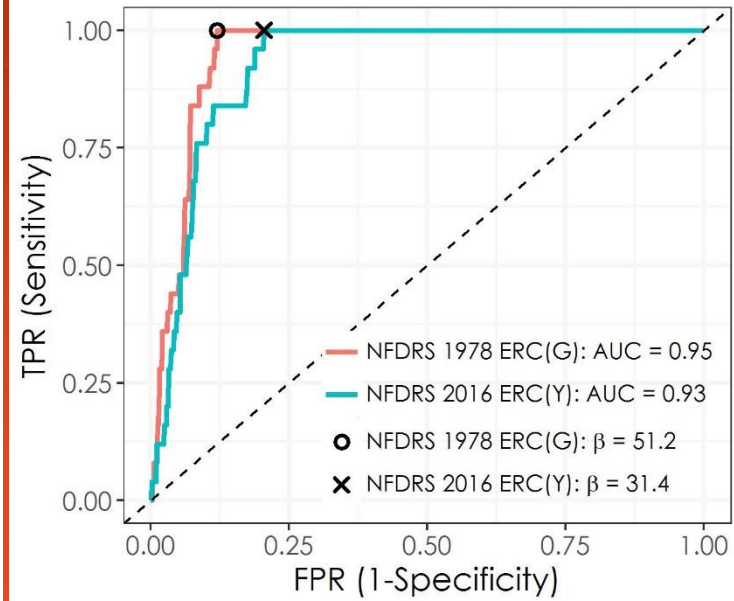
SIG-LDW, 2003-2016



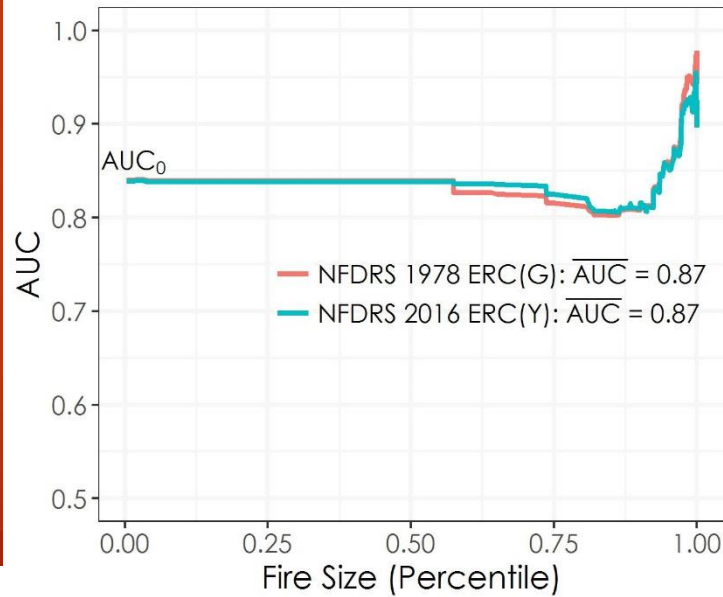
SIG-LDW, 2003-2016, New Fire Days > 0 ac



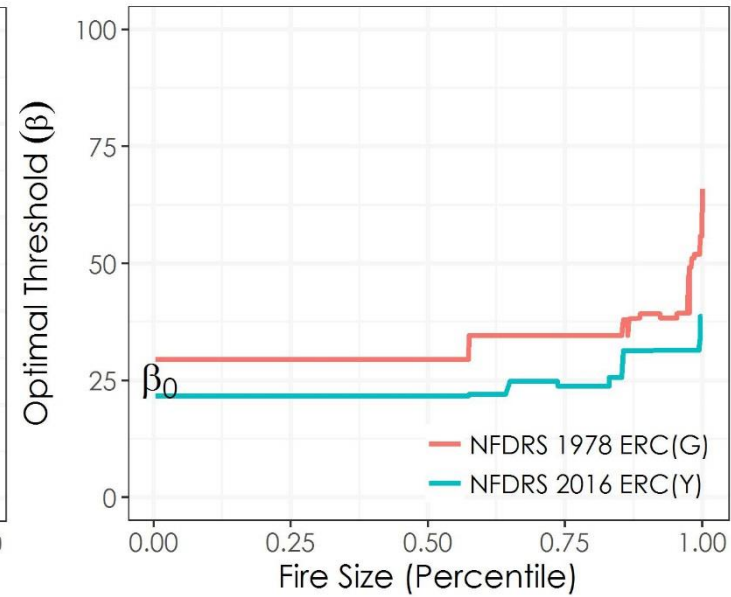
SIG-LDW, 2003-2016, New Fire Days > 100 ac

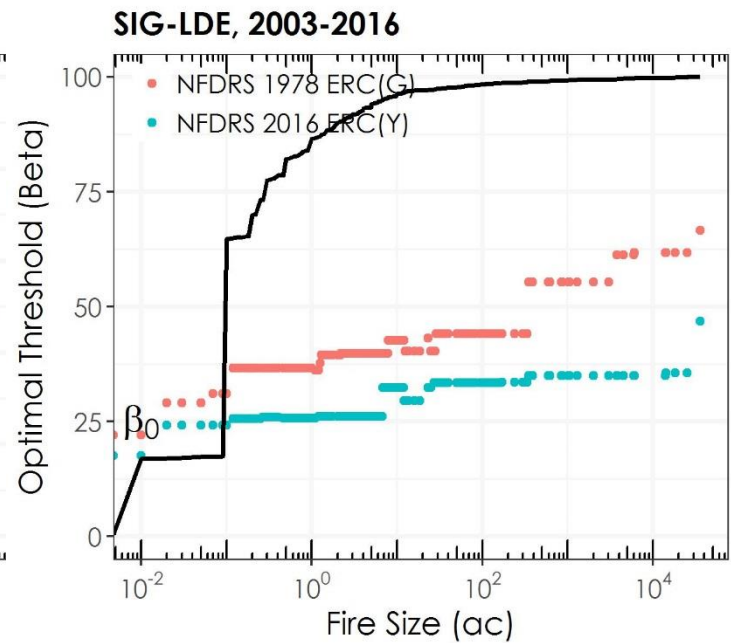
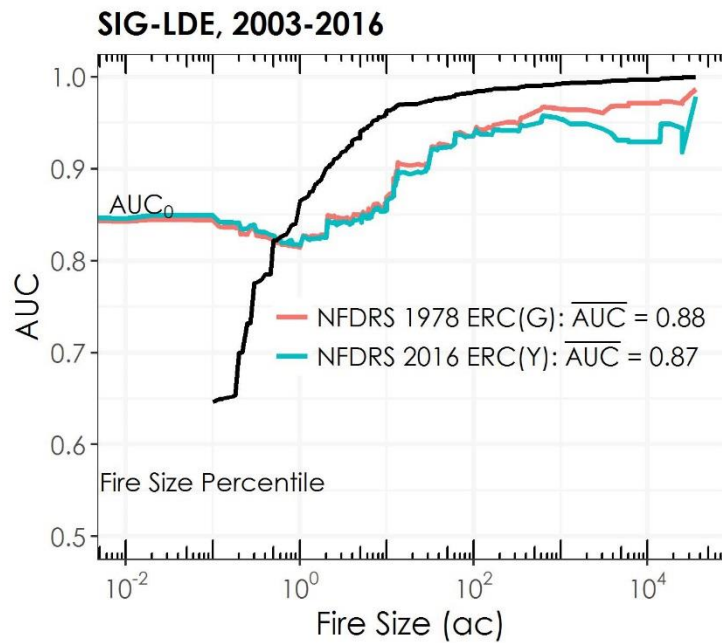
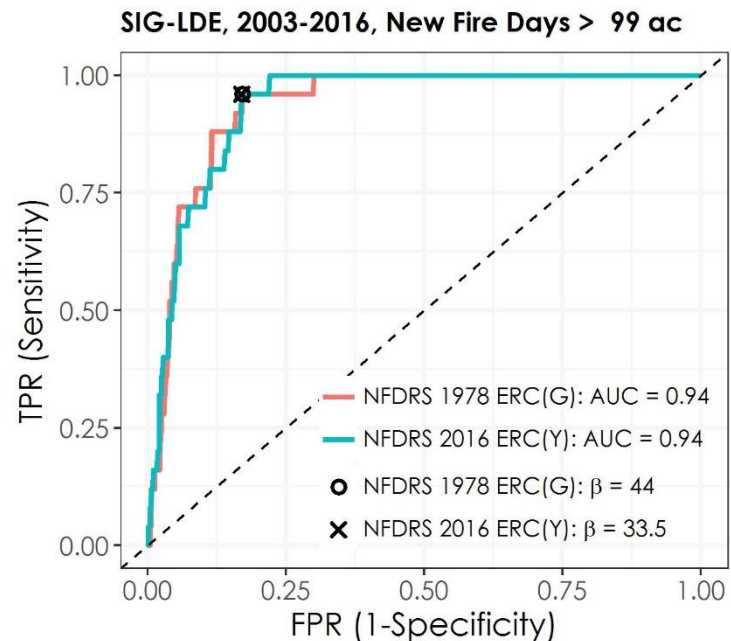
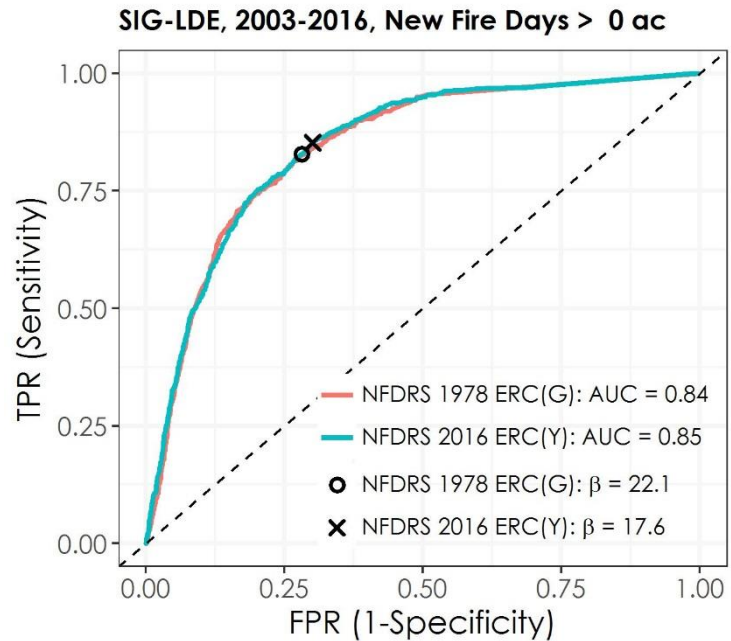


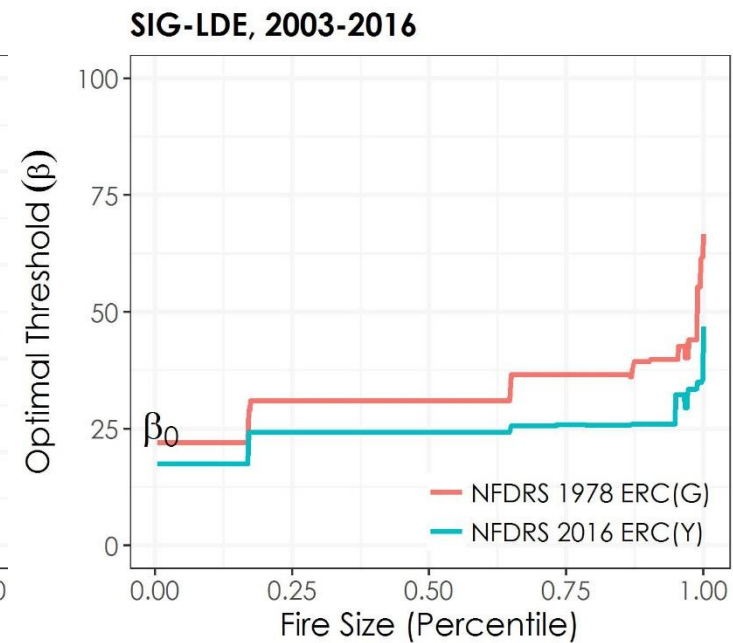
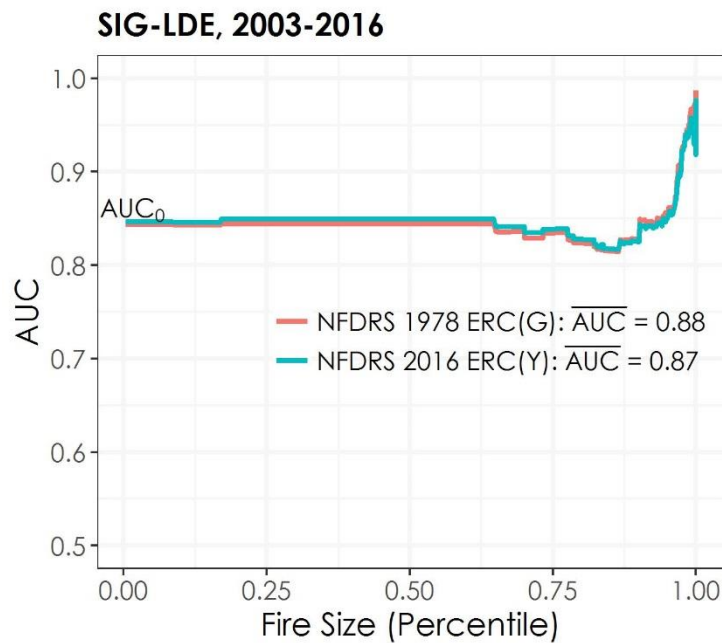
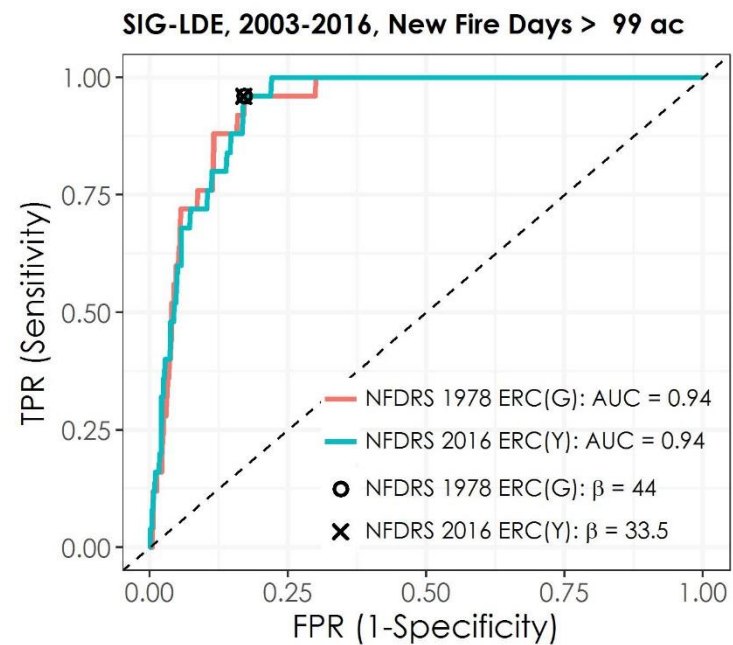
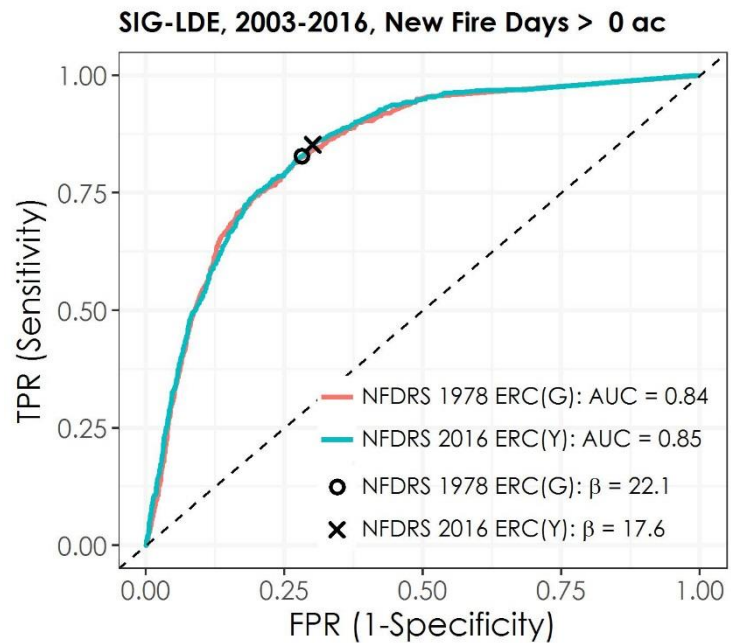
SIG-LDW, 2003-2016



SIG-LDW, 2003-2016



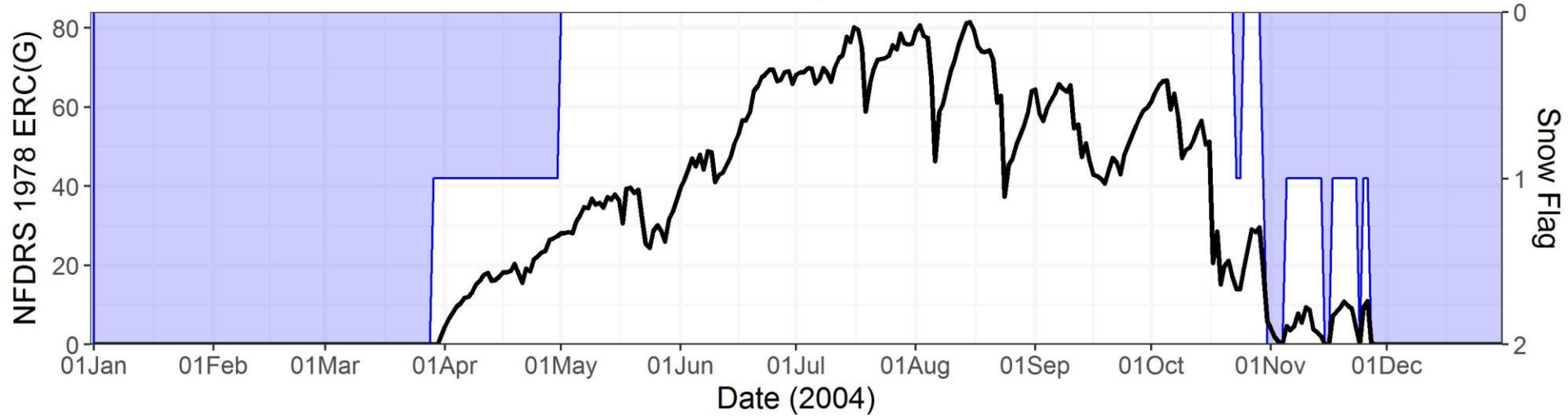




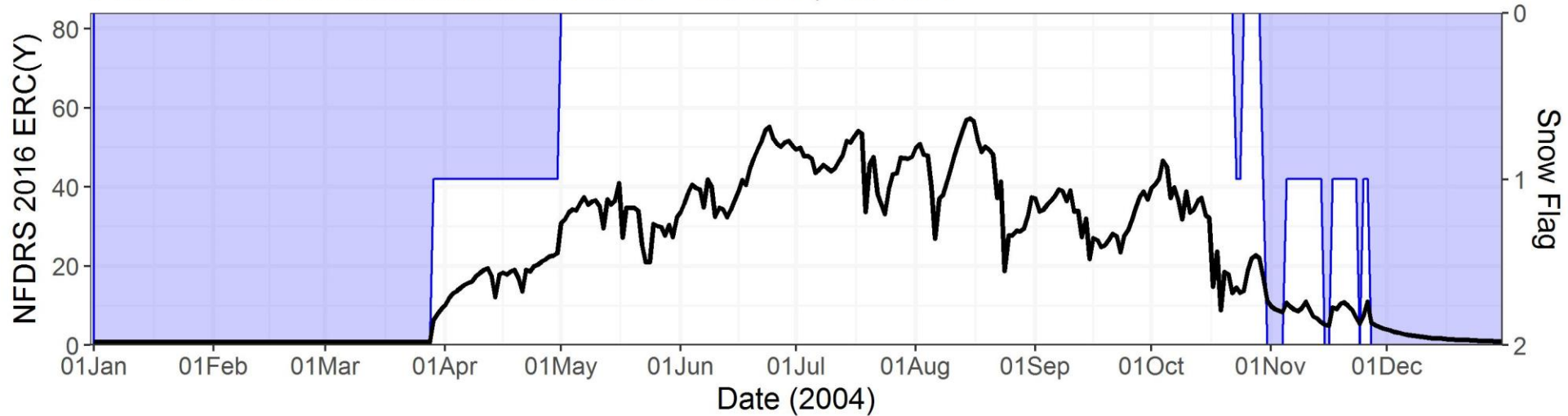
<https://gacc.nifc.gov/nwcc/districts/CWICC/FDRA.html>



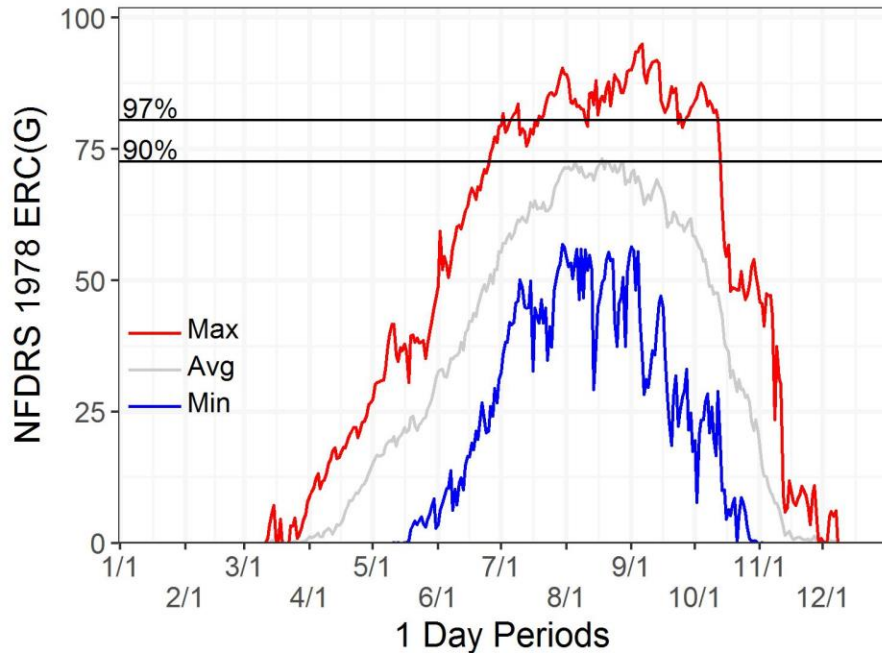
FDRA - Chelan Mountains : RAWs - 452132, 452134



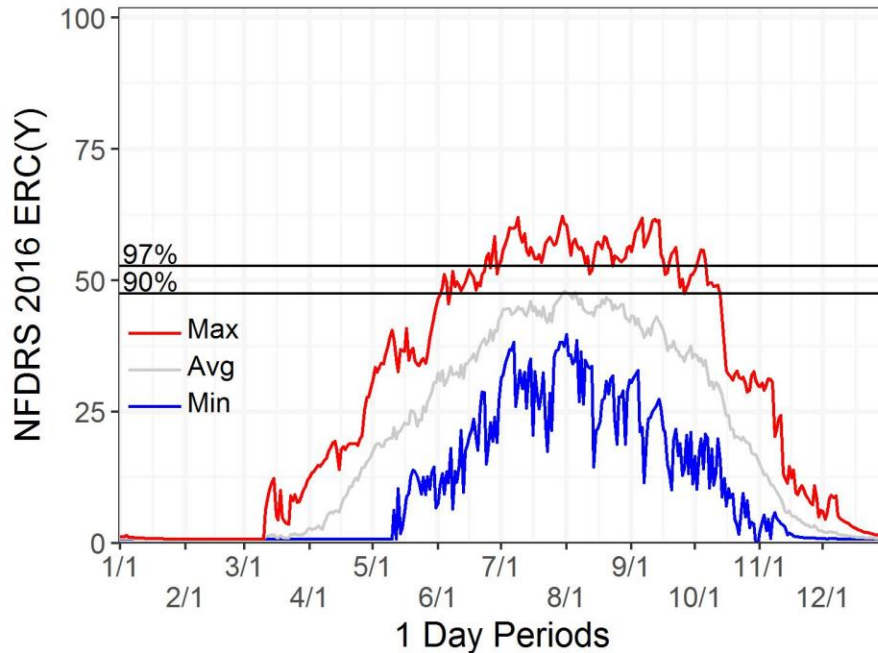
FDRA - Chelan Mountains : RAWs - 452132, 452134



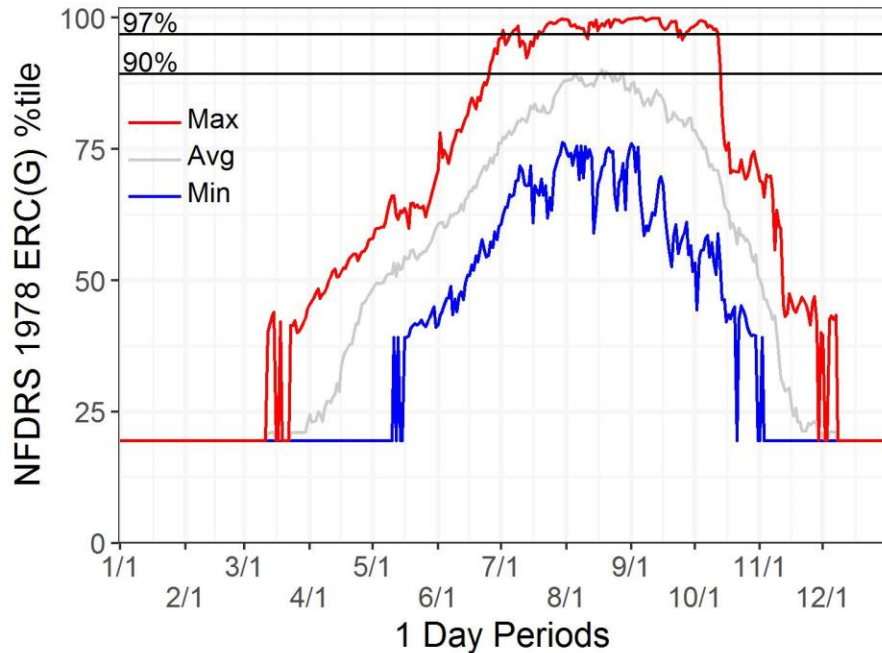
FDRA - Chelan : 2003-2016



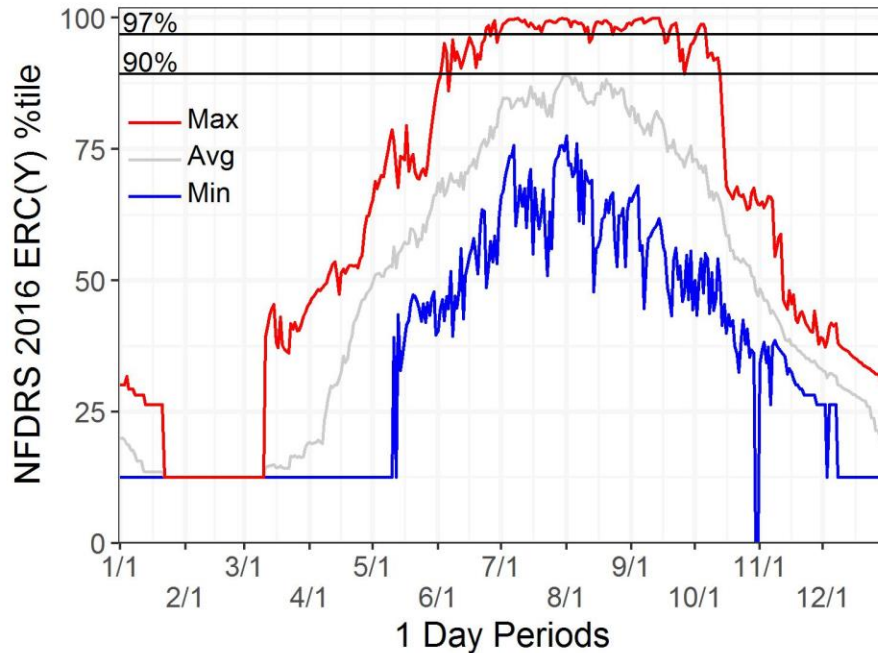
FDRA - Chelan : 2003-2016



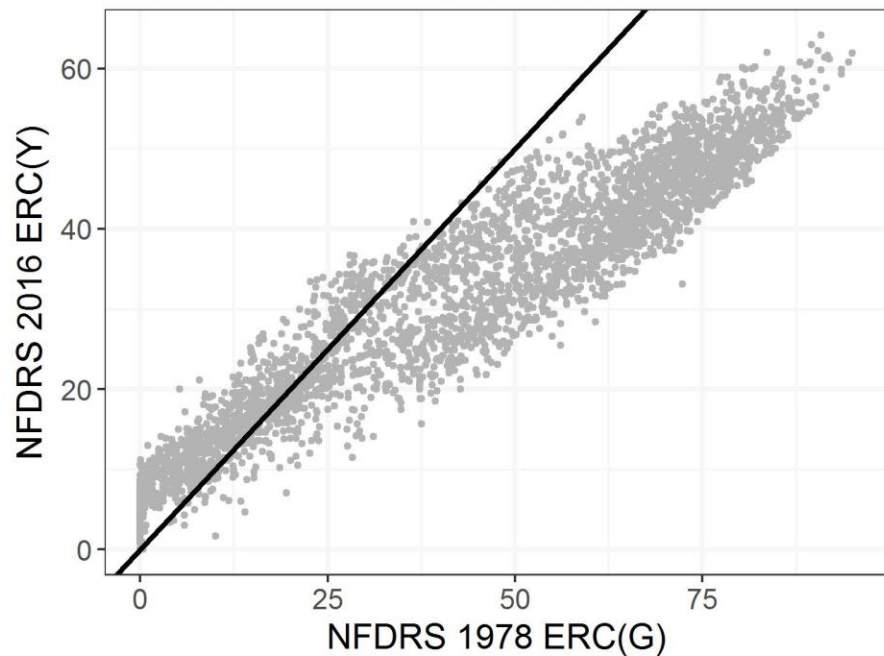
FDRA - Chelan : 2003-2016



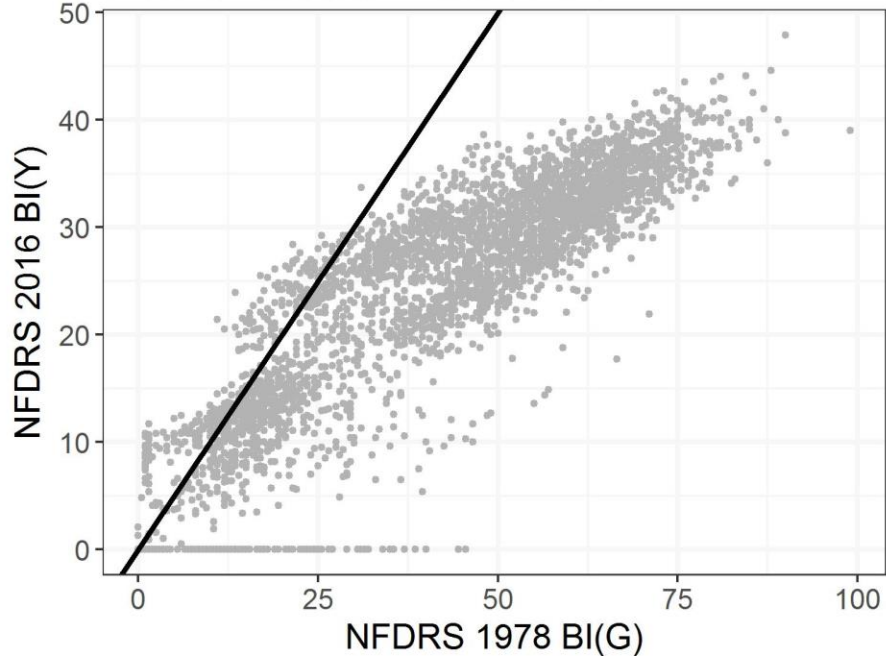
FDRA - Chelan : 2003-2016



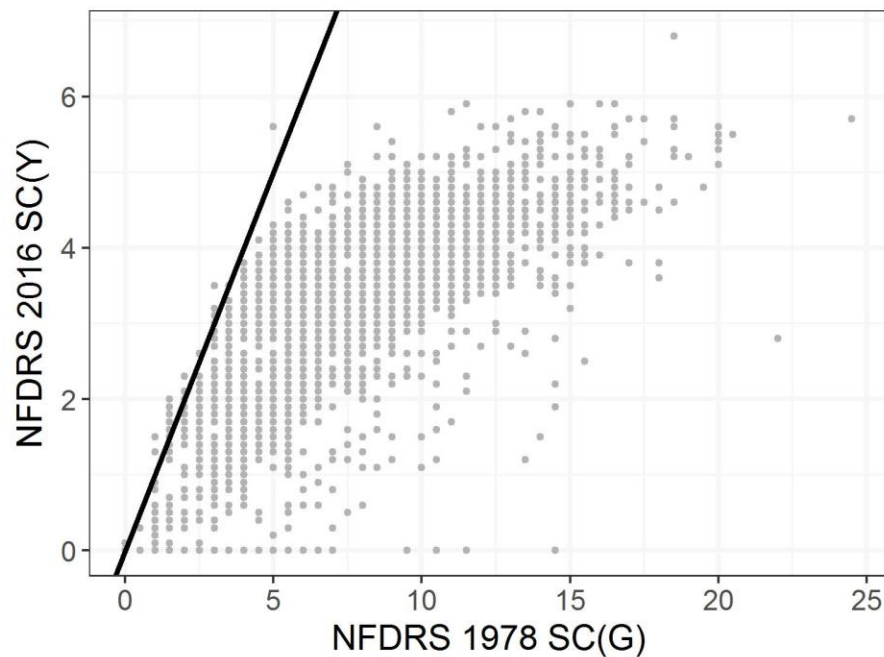
FDRA - Chelan : 2003-2016



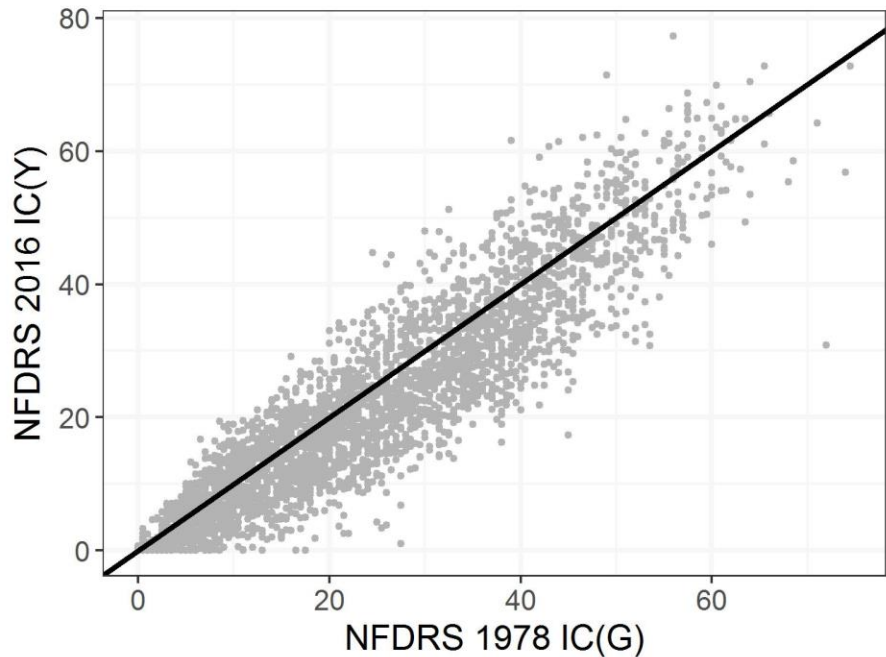
FDRA - Chelan : 2003-2016



FDRA - Chelan : 2003-2016

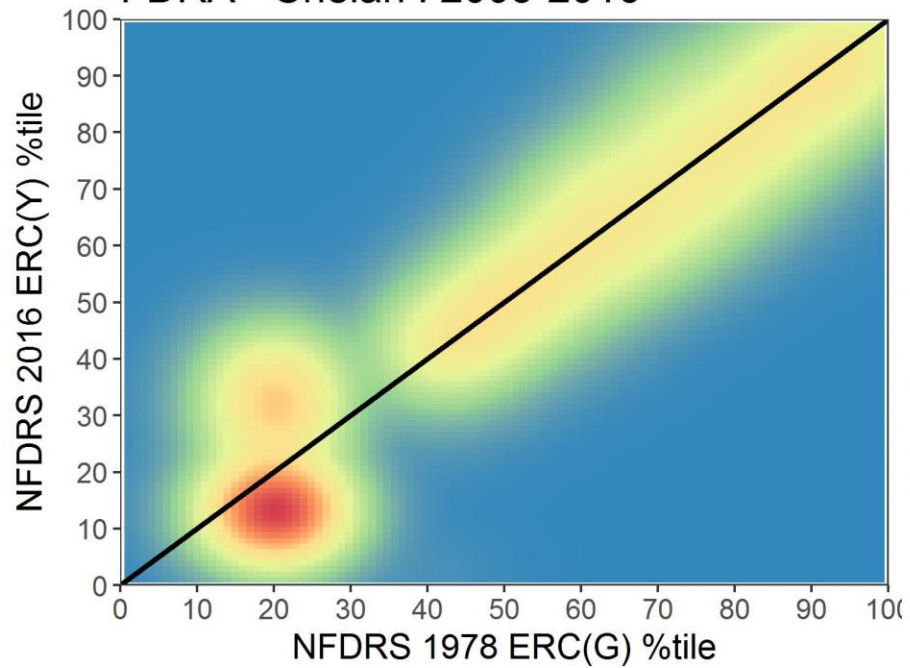


FDRA - Chelan : 2003-2016

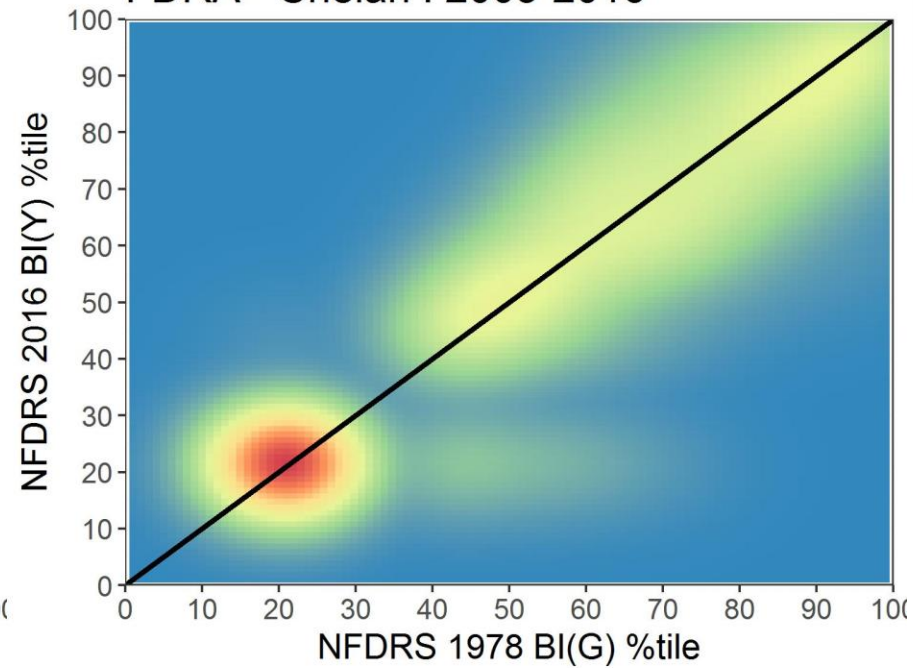




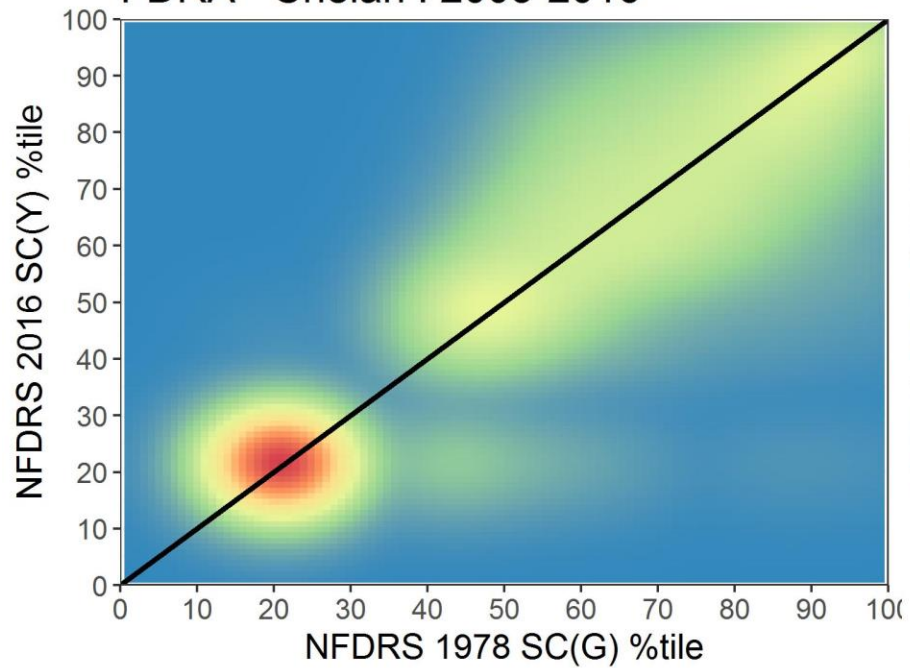
FDRA - Chelan : 2003-2016



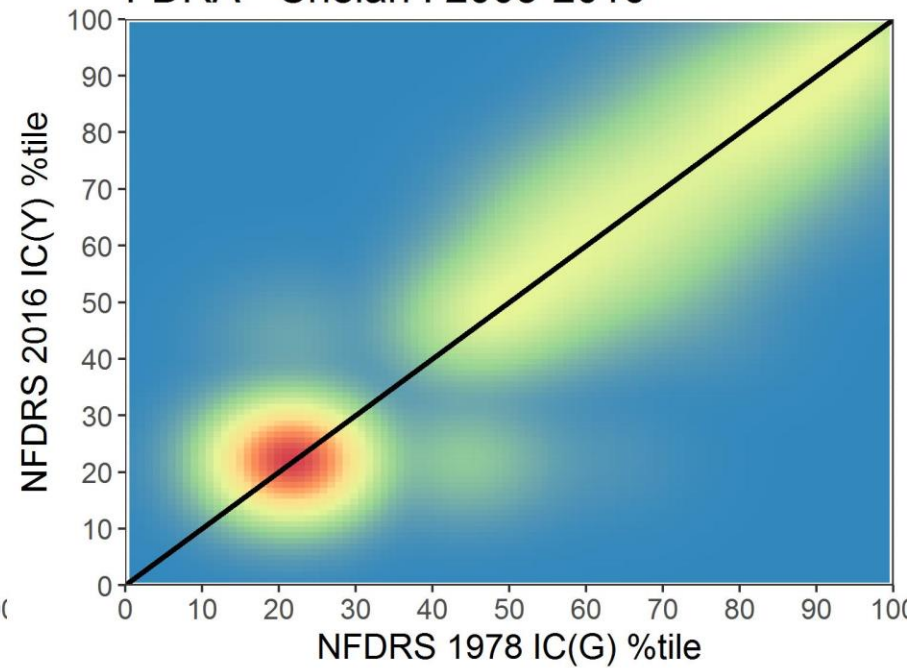
FDRA - Chelan : 2003-2016



FDRA - Chelan : 2003-2016



FDRA - Chelan : 2003-2016



FDRA – Chelan : 2003 – 2016 : 5607 days

		NFDRS 2016 ERC(Y)						
		(0,22.5]	(22.5,45]	(45,90]	(90,97]	(97,100]		
NFDRS 1978 ERC(G)		SL 1	SL 2	SL 3	SL 4	SL 5		
	(0,22.5]	SL 1	1406	777	0	0	0	2183
	(22.5,45]	SL 2	1	266	72	0	0	339
	(45,90]	SL 3	0	72	2292	141	17	2522
	(90,97]	SL 4	0	0	153	190	52	395
	(97,100]	SL 5	0	0	4	64	100	168
		1407	1115	2521	395	169	5607	

From WIMS User's Guide  
Appendix E. NFDRS  
Technical Reference

<http://pnwnfdr.pythonanywhere.com/wacwc/chelan/>

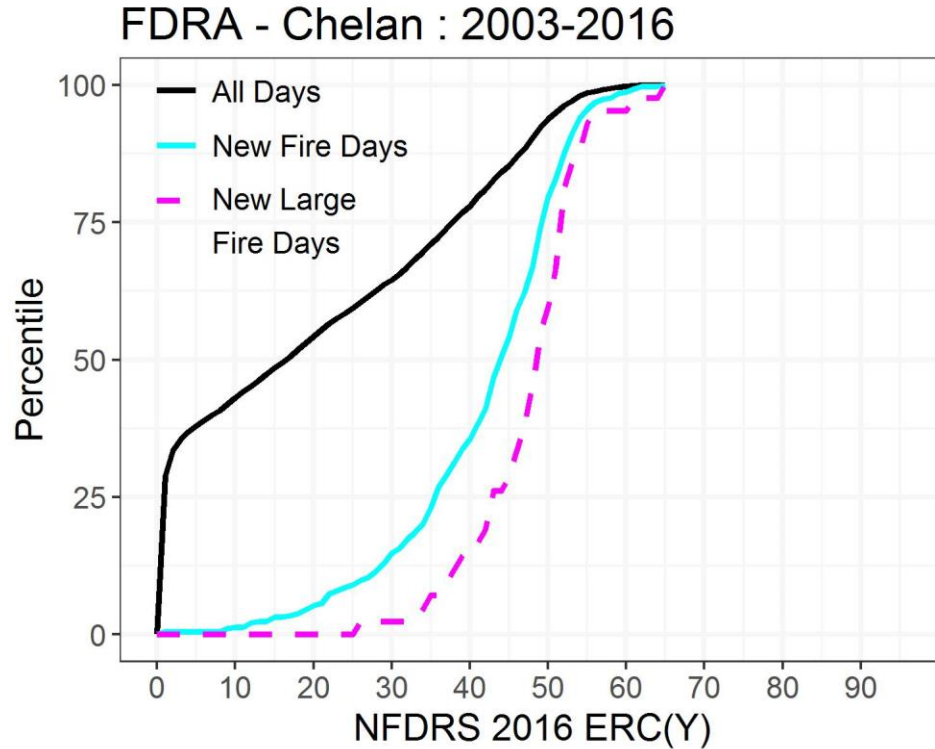
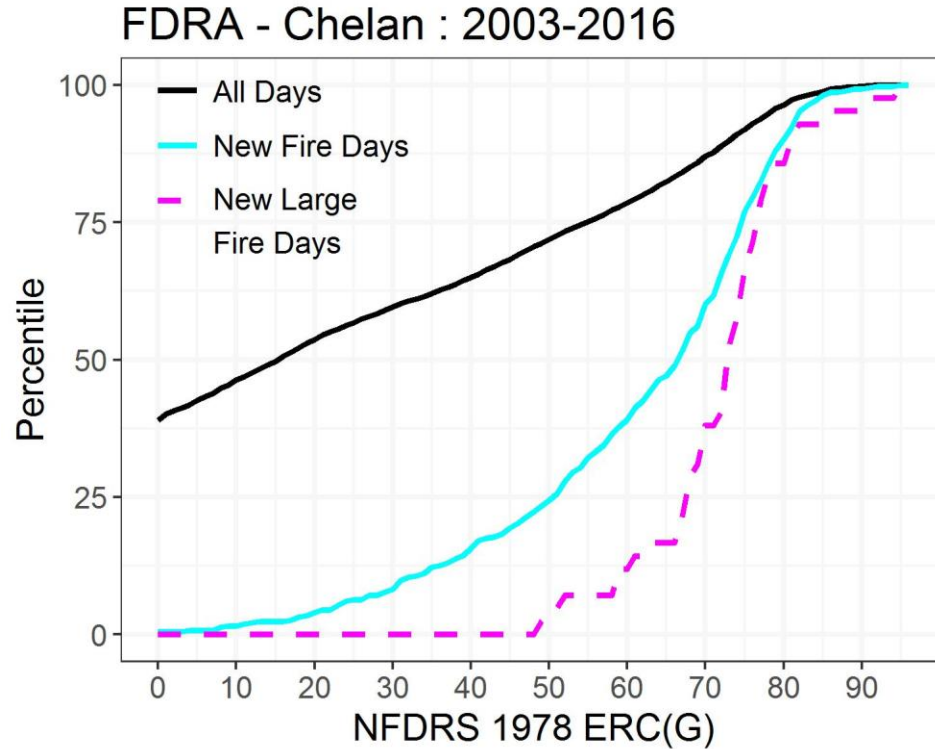
**Staffing Levels (1-5)** - Divisions of Energy Release Component Fuel Model-G (37|52|69|76) based on historic Problem Fire occurrence:

- 60% of Problem Fires were discovered at Staffing Level 5
- 30% of Problem Fires were discovered at Staffing Level 4
- 10% of Problem Fires were discovered at Staffing Level 3
- No Problem Fires have been discovered at Staffing Level 1 or 2

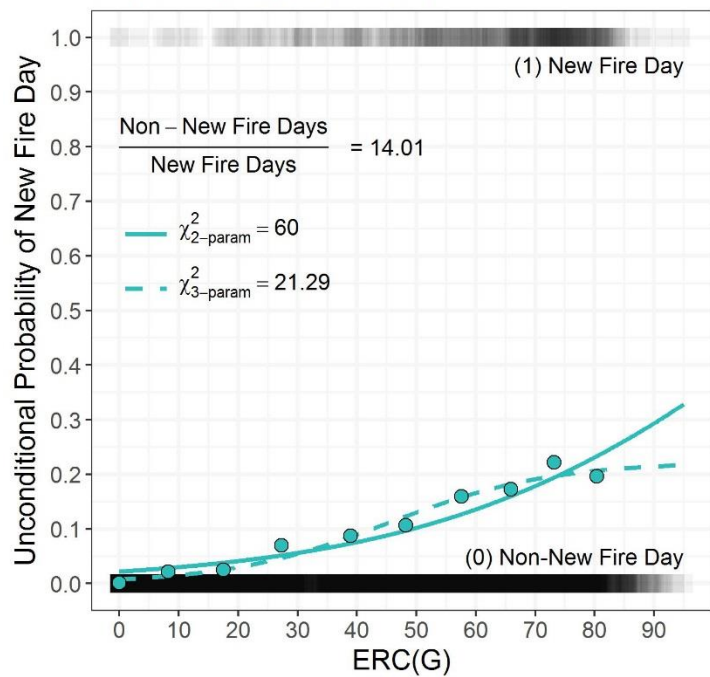
*\*Note that Staffing Level is date limited such that Levels 3, 4, and 5 will not be reached until 3, 2, and 1 week prior to the earliest historic occurrence of a Problem Fire (6/26).*

<http://pnwnfdr.pythonanywhere.com/wacwc/chelan/>

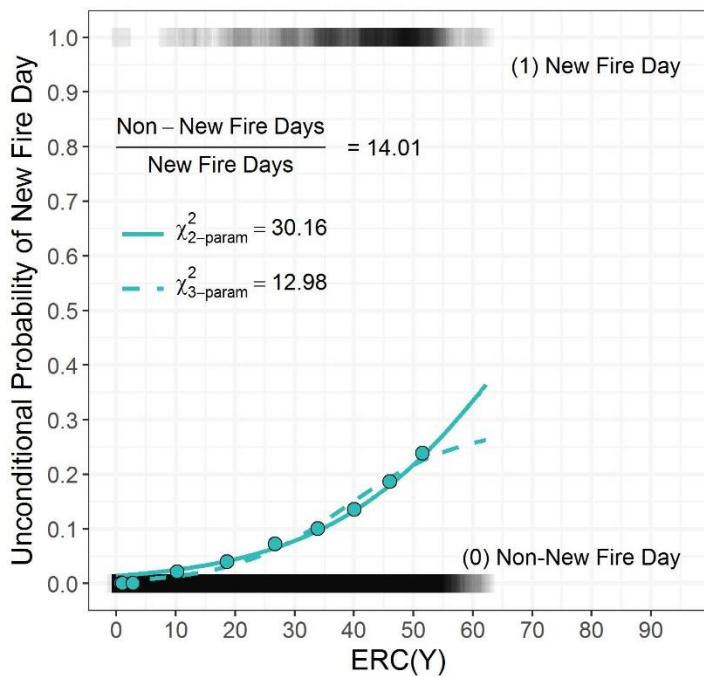
**Problem Fire** - A fire with a final size of 100+ acres, fires of this size are considered a problem for typical resource staffing.



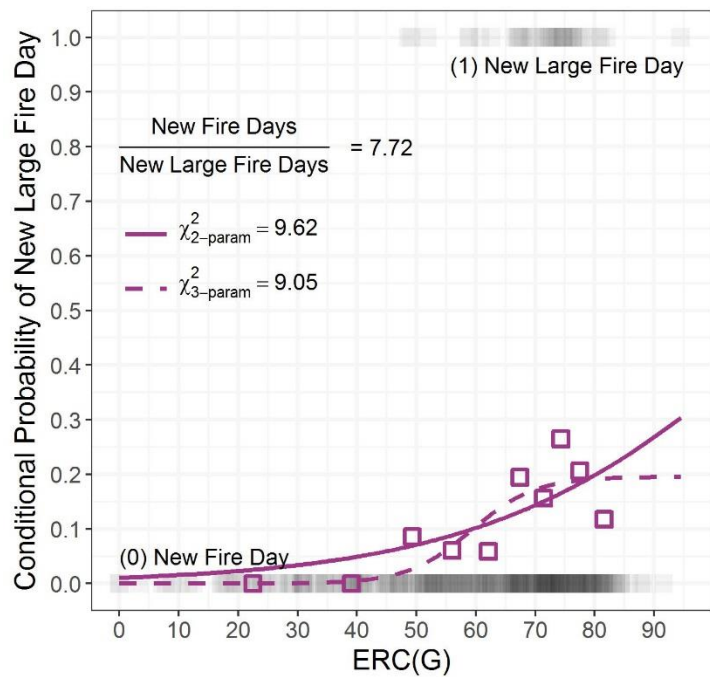
FDRA - Chelan : 2003-2016



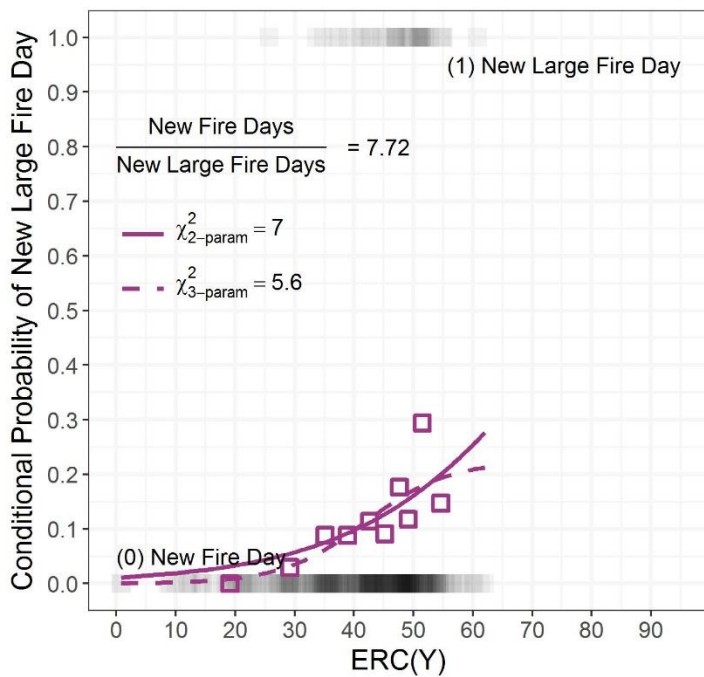
FDRA - Chelan : 2003-2016

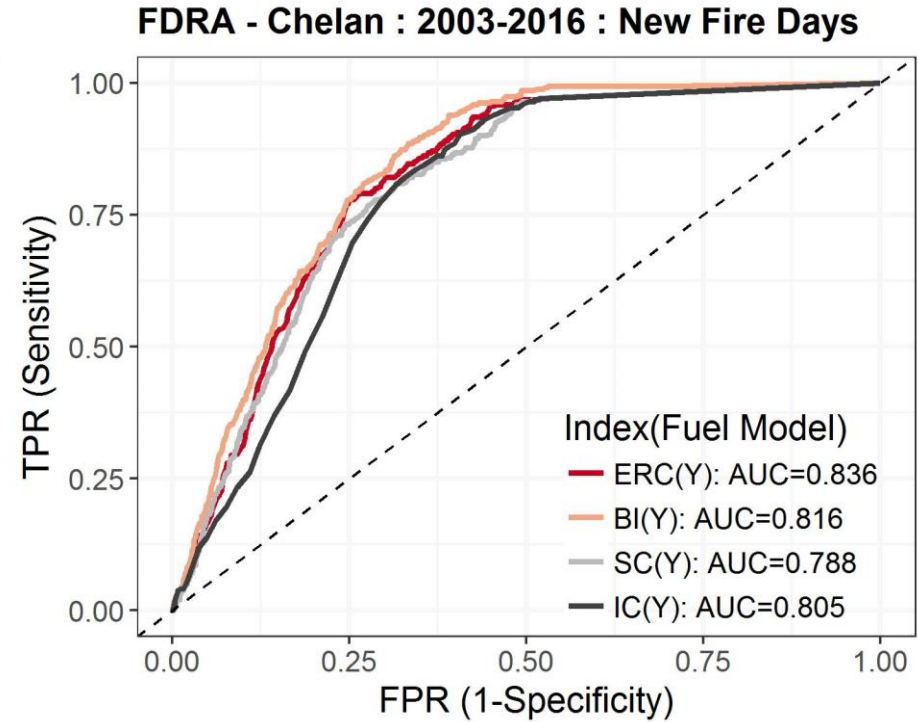
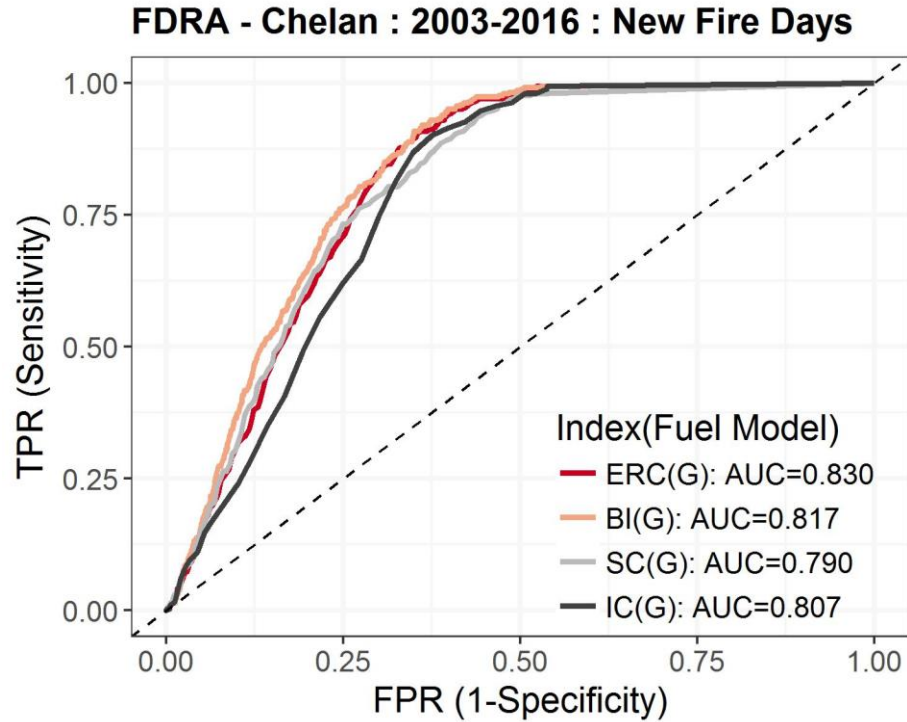


FDRA - Chelan : 2003-2016



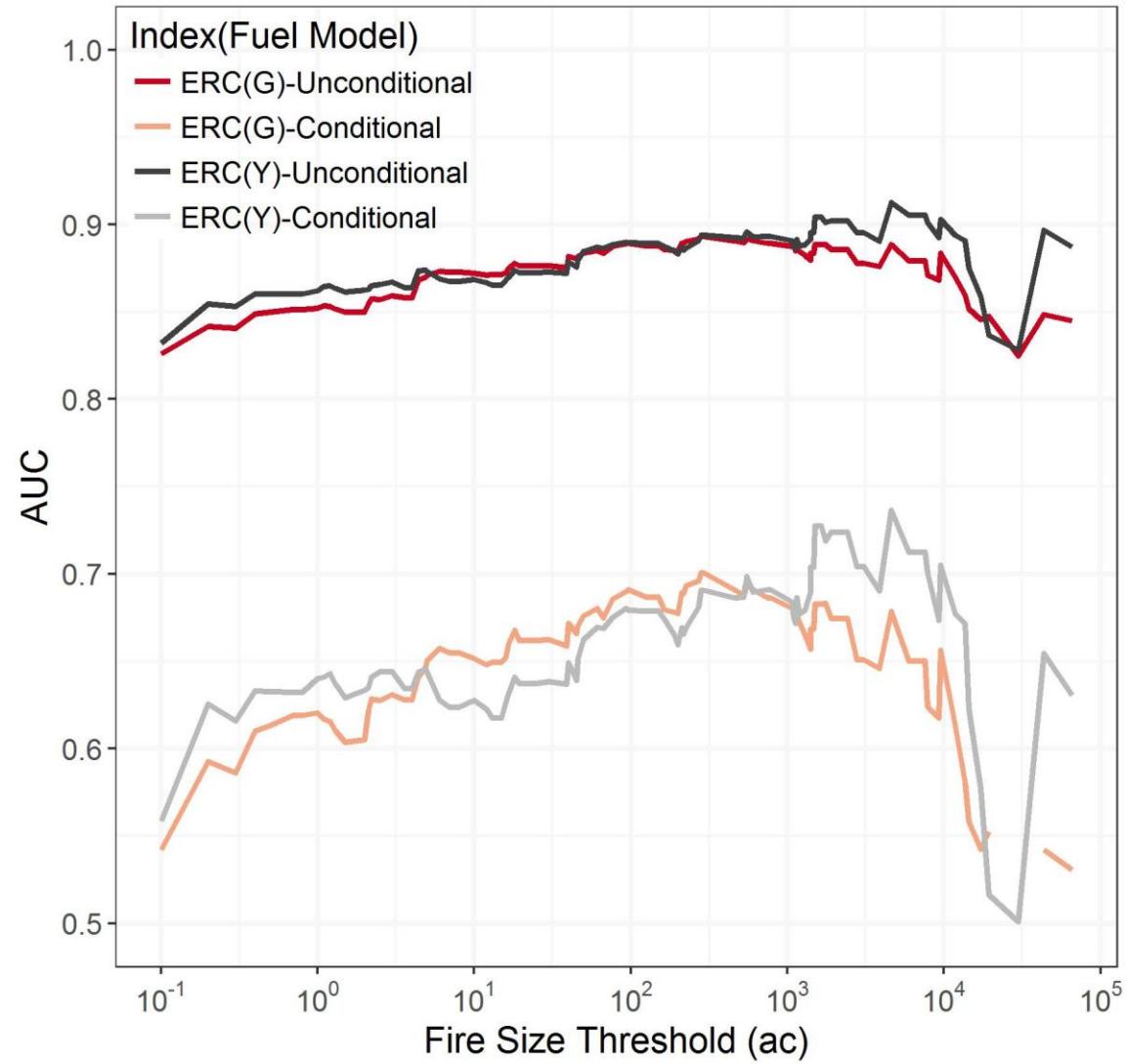
FDRA - Chelan : 2003-2016





SIG	Index	Fuel_Model	Years	Number_Yrs	FD_AUROCC	Num_All_Days	Num_Fire_Days
Chelan	ERC	G	2003_2016	14	0.830	5104	340
Chelan	BI	G	2003_2016	14	0.817	5104	340
Chelan	SC	G	2003_2016	14	0.790	5104	340
Chelan	IC	G	2003_2016	14	0.807	5104	340
Chelan	ERC	Y	2003_2016	14	0.836	5104	340
Chelan	BI	Y	2003_2016	14	0.816	5104	340
Chelan	SC	Y	2003_2016	14	0.788	5104	340
Chelan	IC	Y	2003_2016	14	0.805	5104	340

### FDRA - Chelan : 2003-2016





# The Future of Fire Danger in the United States

# The future of NFDRS

- ▶ Integrate overstory into Fire Danger Calculation
- ▶ Spatial WIMS
  - ▶ With password-free data access
- ▶ Seven day forecasts from the NWS NDFD
- ▶ Two week forecasts from GFS
- ▶ Better evaluation data (growth days versus report days)



# Fire Environment Indicator - Energy Release Component (NRO3) (04/30/2018)

7

Low  
0 - 7

Moderate  
7 - 20

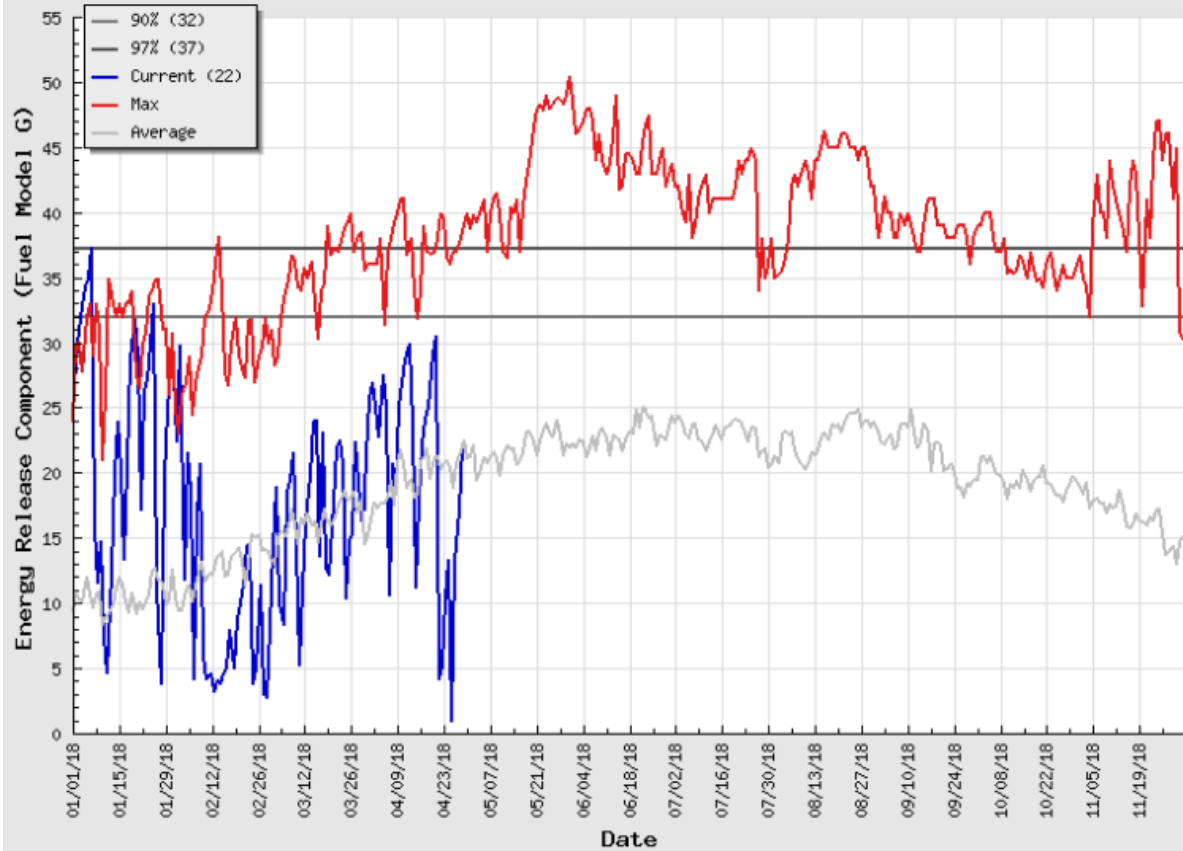
High  
20 - 41

V High  
41 - 54

Extreme  
54 - 60

SA38 - AL North

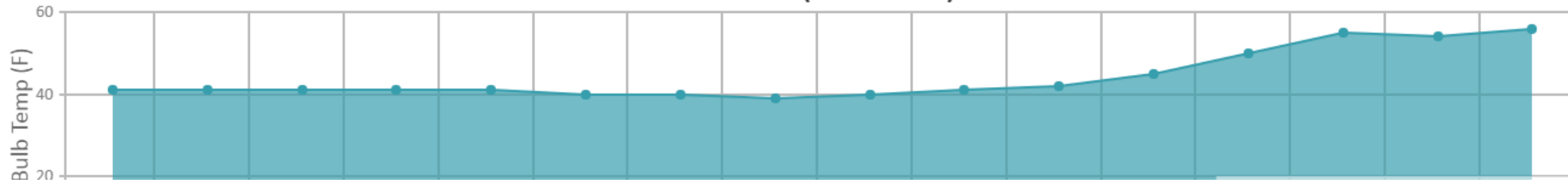
Valid Date: 29-Apr-2018



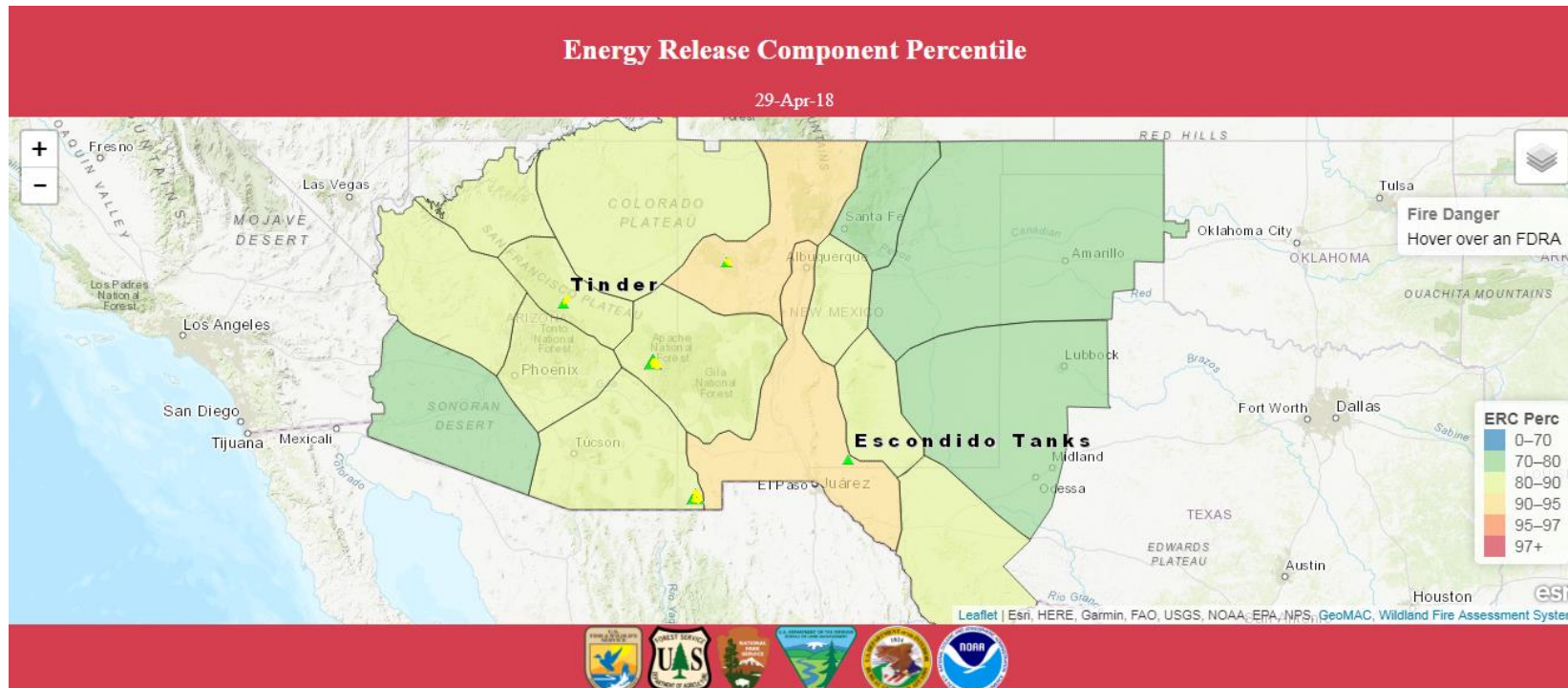
## BLUE MTN (MISSOULA) (241513)

Date	Hour	Dry Bulb (F)	RH (%)	Windspeed (mph)	Wet Flag	Snow Flag
04/30/2018	0	41	100	0	N	N
04/30/2018	1	41	100	0	N	N
04/30/2018	2	41	100	0	N	N
04/30/2018	3	41	100	0	N	N
04/30/2018	4	41	100	0	N	N
04/30/2018	5	40	99	0	N	N
04/30/2018	6	40	100	0	N	N
04/30/2018	7	39	98	1	N	N
04/30/2018	8	40	98	0	N	N
04/30/2018	9	41	95	0	N	N
04/30/2018	10	42	97	1	N	N
04/30/2018	11	45	88	1	N	N
04/30/2018	12	50	77	2	N	N
04/30/2018	13	55	62	2	N	N
04/30/2018	14	54	53	3	N	N
04/30/2018	15	56	49	1	N	N

BLUE MTN (MISSOULA)



<https://www.wfas.net/prototypes/swcc/>

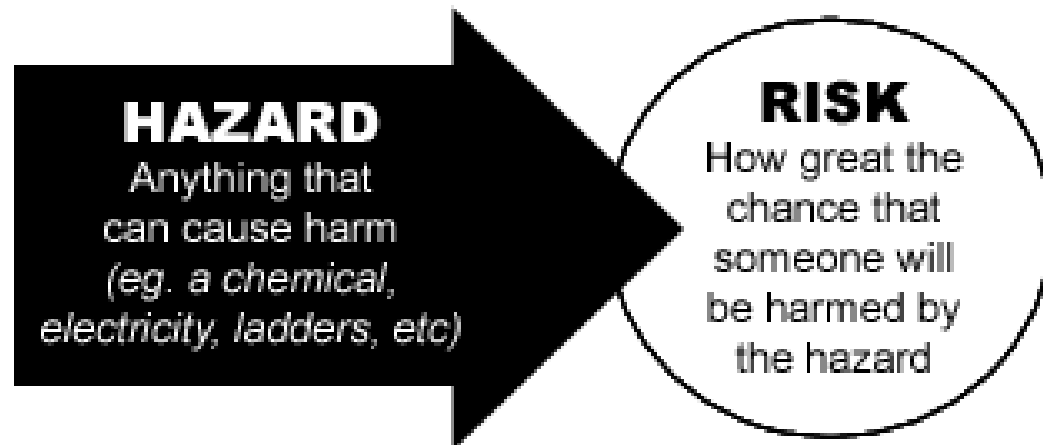


# Risk = Hazard X Exposure

Hazard: Anything that can cause harm

Exposure: Dose, duration, frequency

We will focus on Operational Risk



United States  
Department of  
Agriculture

Forest Service

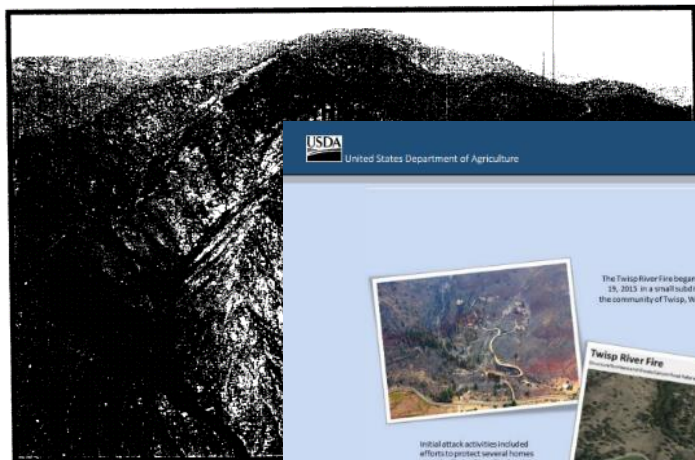
5100 Fire  
December 2003  
0351-2M48-MTDC



# Accident Investigation Factual Report

*Cramer Fire Fatalities  
North Fork Ranger District  
Salmon-Challis National Forest  
Region 4*

Salmon, ID, July 22, 2003



USDA United States Department of Agriculture



The Frog Fire began on July 30, 2015 in a remote region of the Modoc National Forest.




"If the accident didn't happen, I wouldn't have any sense of the danger we were in." —Firefighter

## Yarnell Hill Fire


June 30, 2013



USDA United States Department of Agriculture



The Twisp River Fire began on August 15, 2013 in a small subdivision near the community of Twisp, Washington.





Initial attack activities included efforts to protect several homes near the Twisp River Fire's origin.

### Twisp River Fire Fatalities and Entrapments

Learning Review Narrative

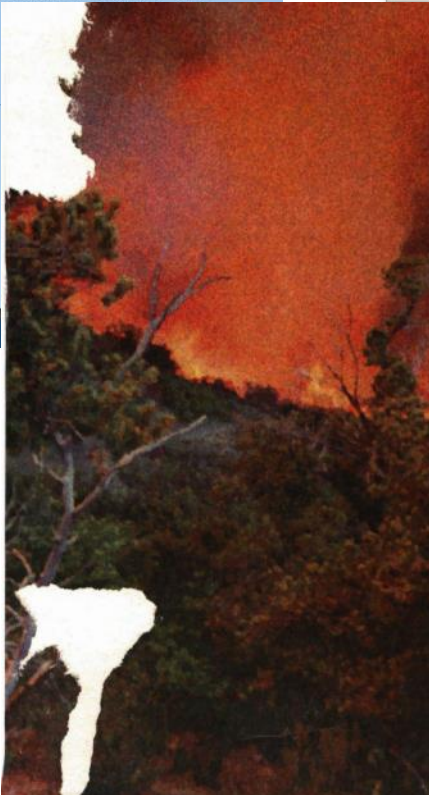
Fall 2016

## Frog Fire Fatality


Learning Review Report

July 6, 2016



## South Canyon Fire Investigation

of the 14 fatalities that occurred on July 6, 1994 near Glenwood Springs, Colorado



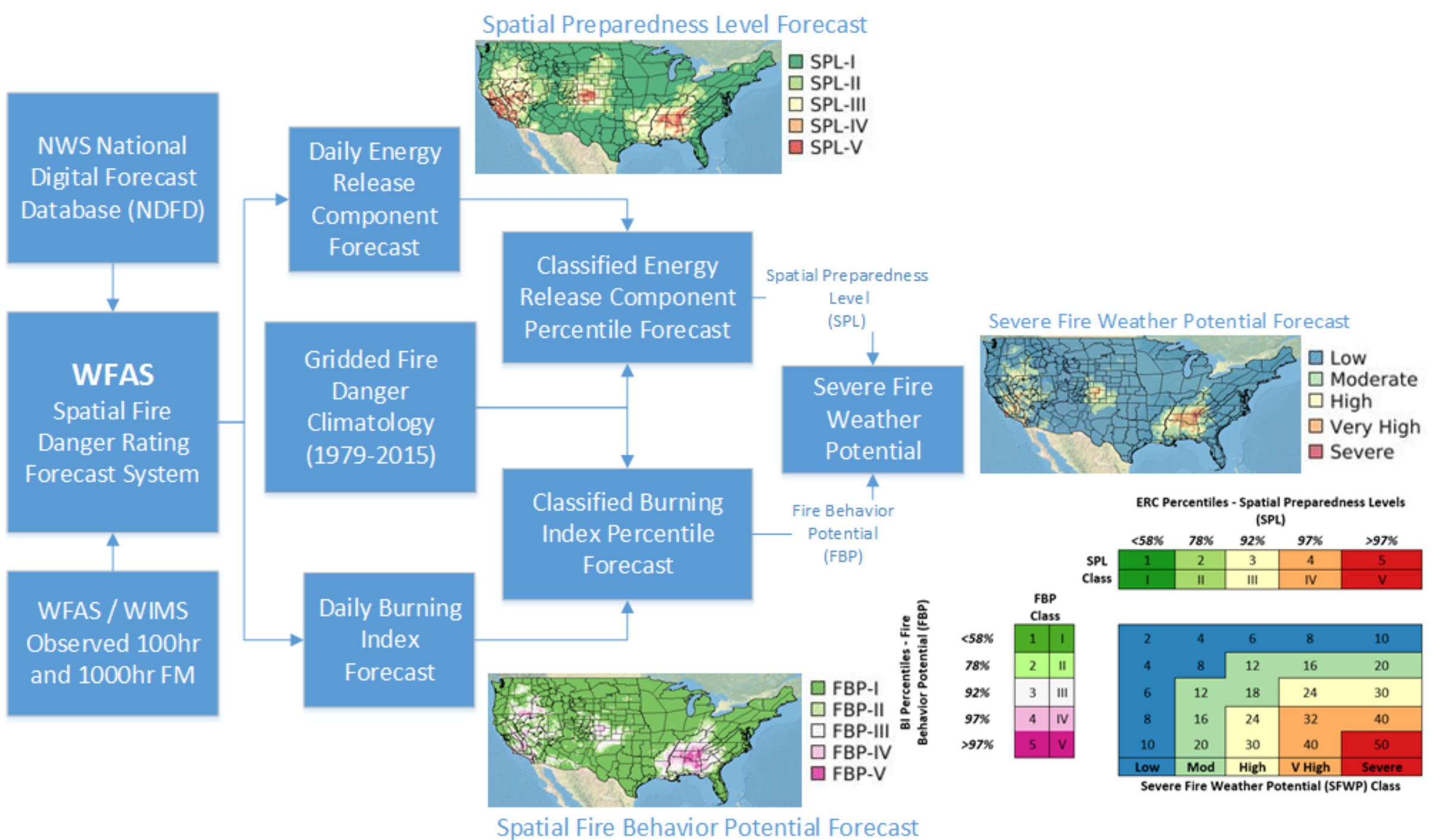
Investigation  
November 2016

# Thirtymile Fire Investigation Report

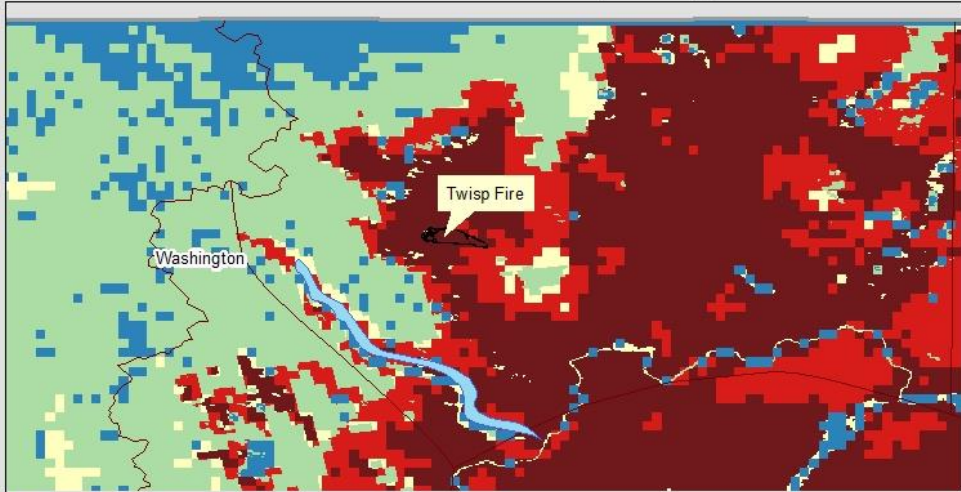
United States  
Department of  
Agriculture

Forest  
Service





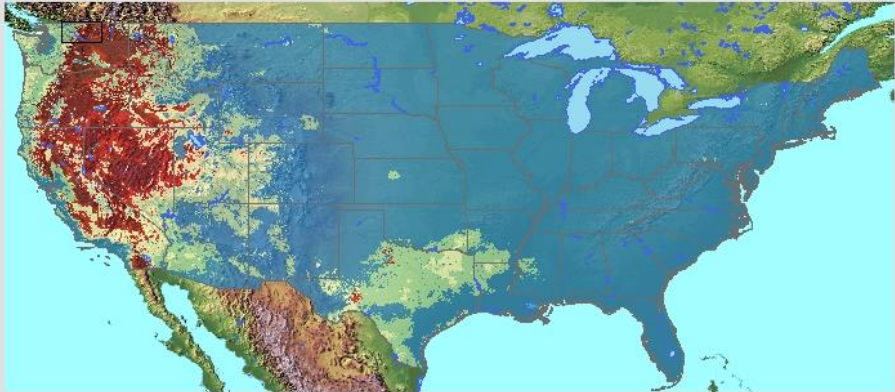
### Severe Fire Weather Potential, 19 Aug 2015



#### Legend

Spatial Severe Fire Weather Potential: Low (Blue), Moderate (Light Green), High (Yellow), Very High (Red), Severe (Dark Red)

#### National Severe Fire Weather Potential Map (Combination of SPL and SFBP)



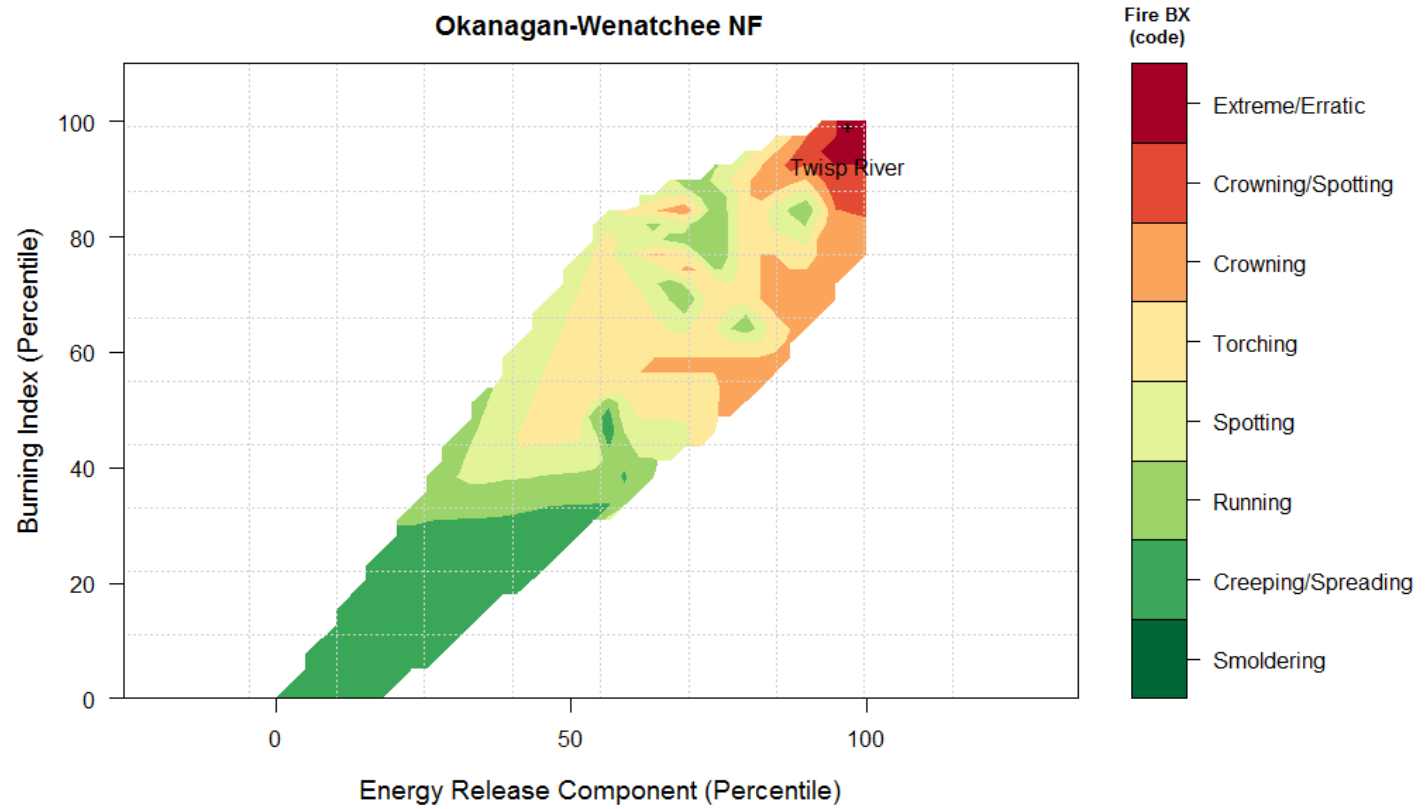
#### Spatial Preparedness Level (SPL) (Based on Energy Release Component)



#### Spatial Fire Behavior Potential (SFBP) (Based on Burning Index)



### Okanagan-Wenatchee NF

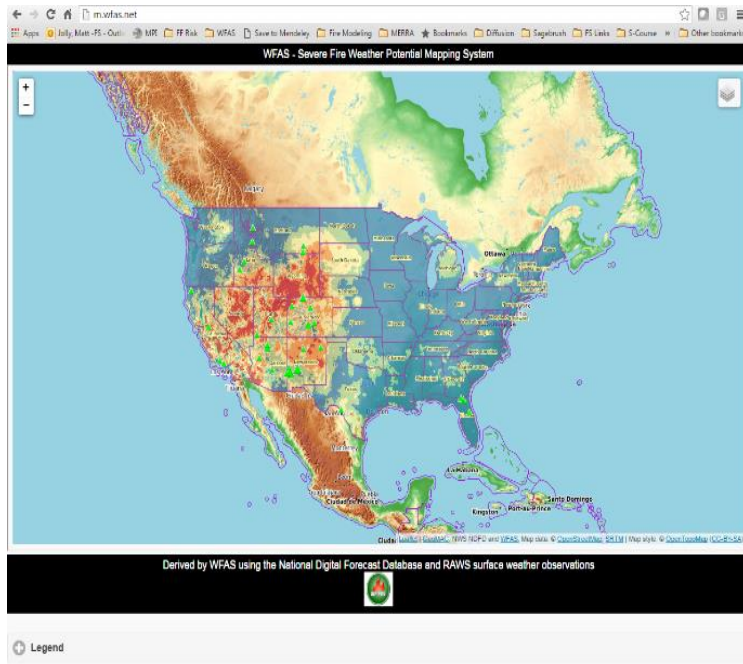




# From Fire Danger to Fire Behavior



# Severe Fire Weather Potential Mapping

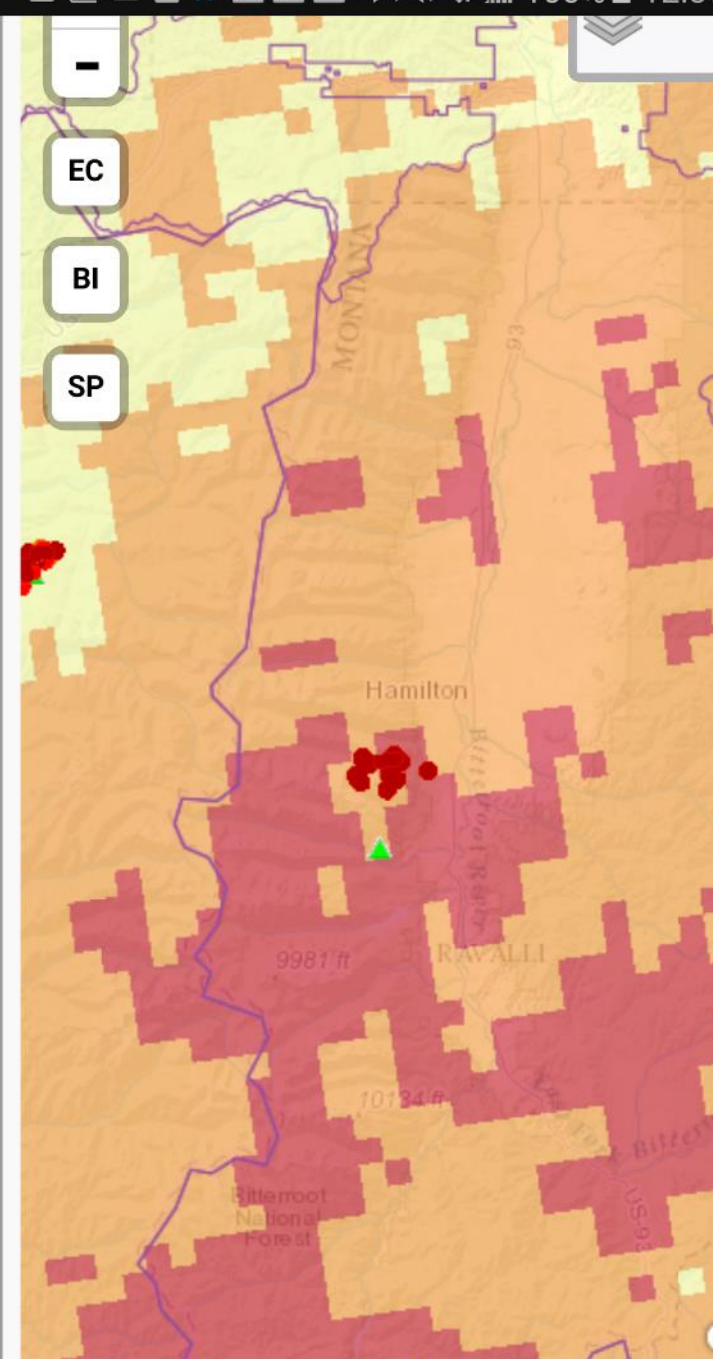
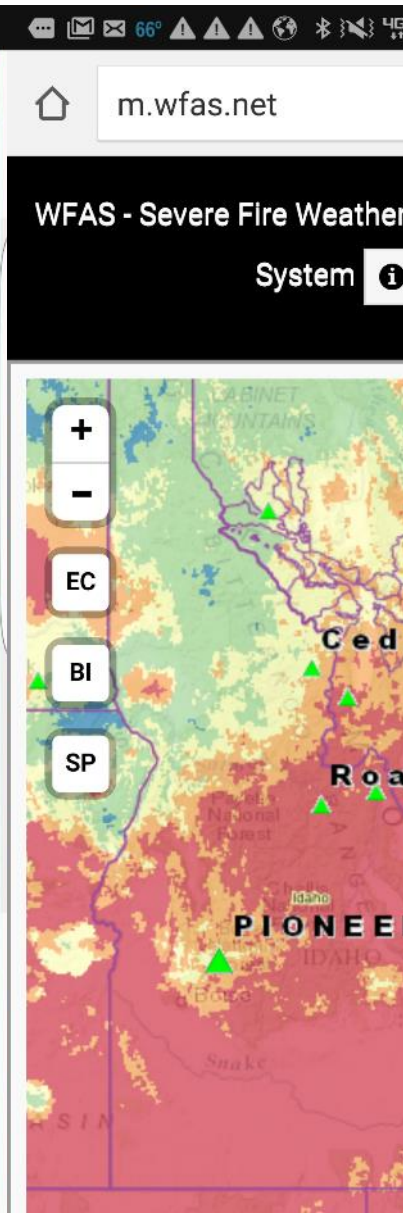
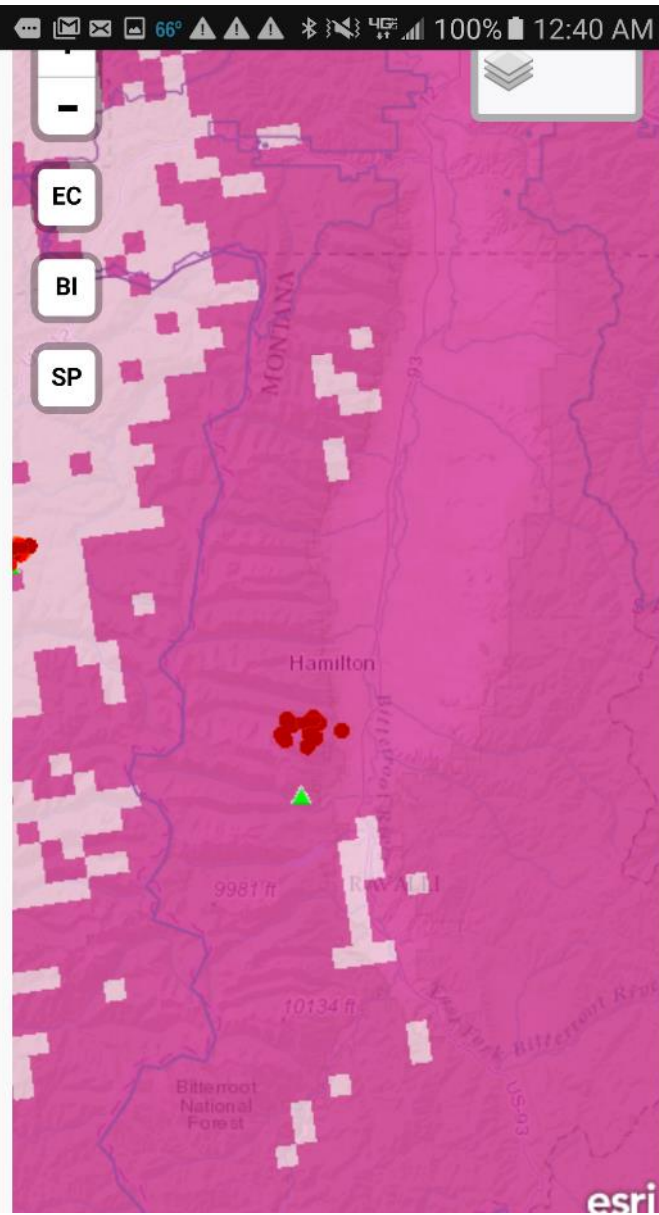
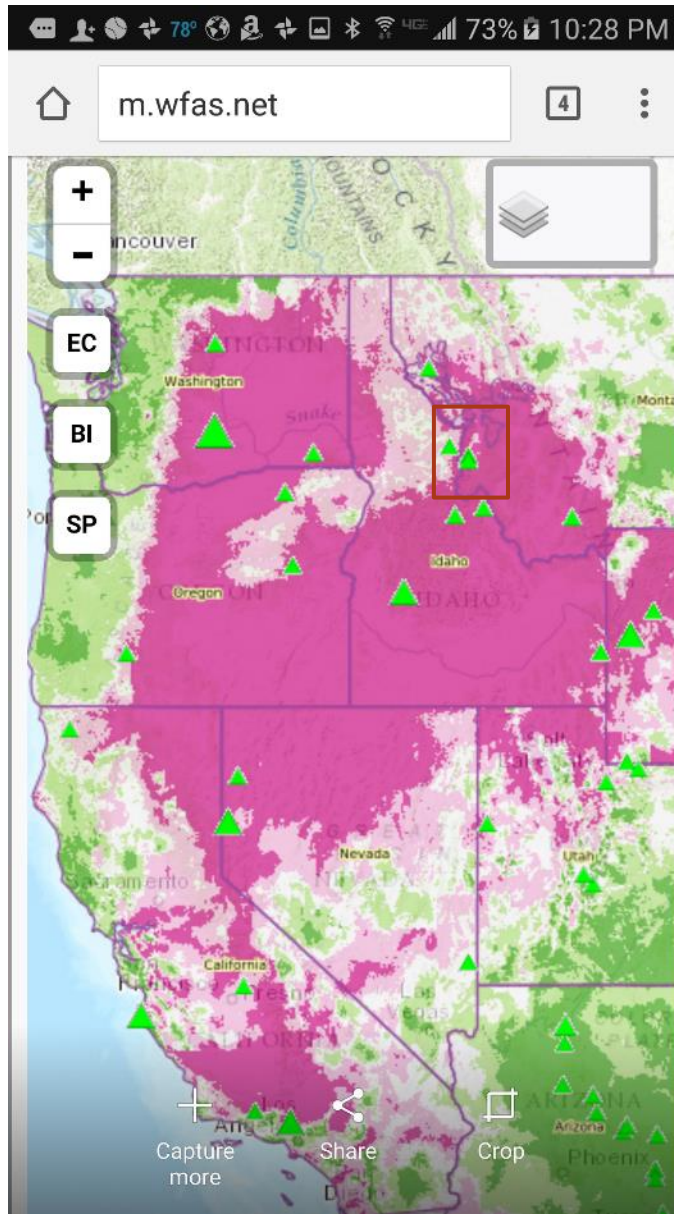


<https://m.wfas.net>

- ▶ Mobile-enabled but works on everything
- ▶ Geo-located in the future
- ▶ Incorporates GeoMAC fire locations and perimeters, MODIS and VIIRS active fire products from RSAC Active Fire Mapping Program, fuels and slope maps
- ▶ Operational and available daily @ ~0630MT
- ▶ Currently provides forecast for next three days



# Severe Fire Weather Potential Map Examples



<https://www.youtube.com/watch?v=NIj4b1nRfds>

m.wfas.net

WFAS - Severe Fire Weather Potential Mapping System

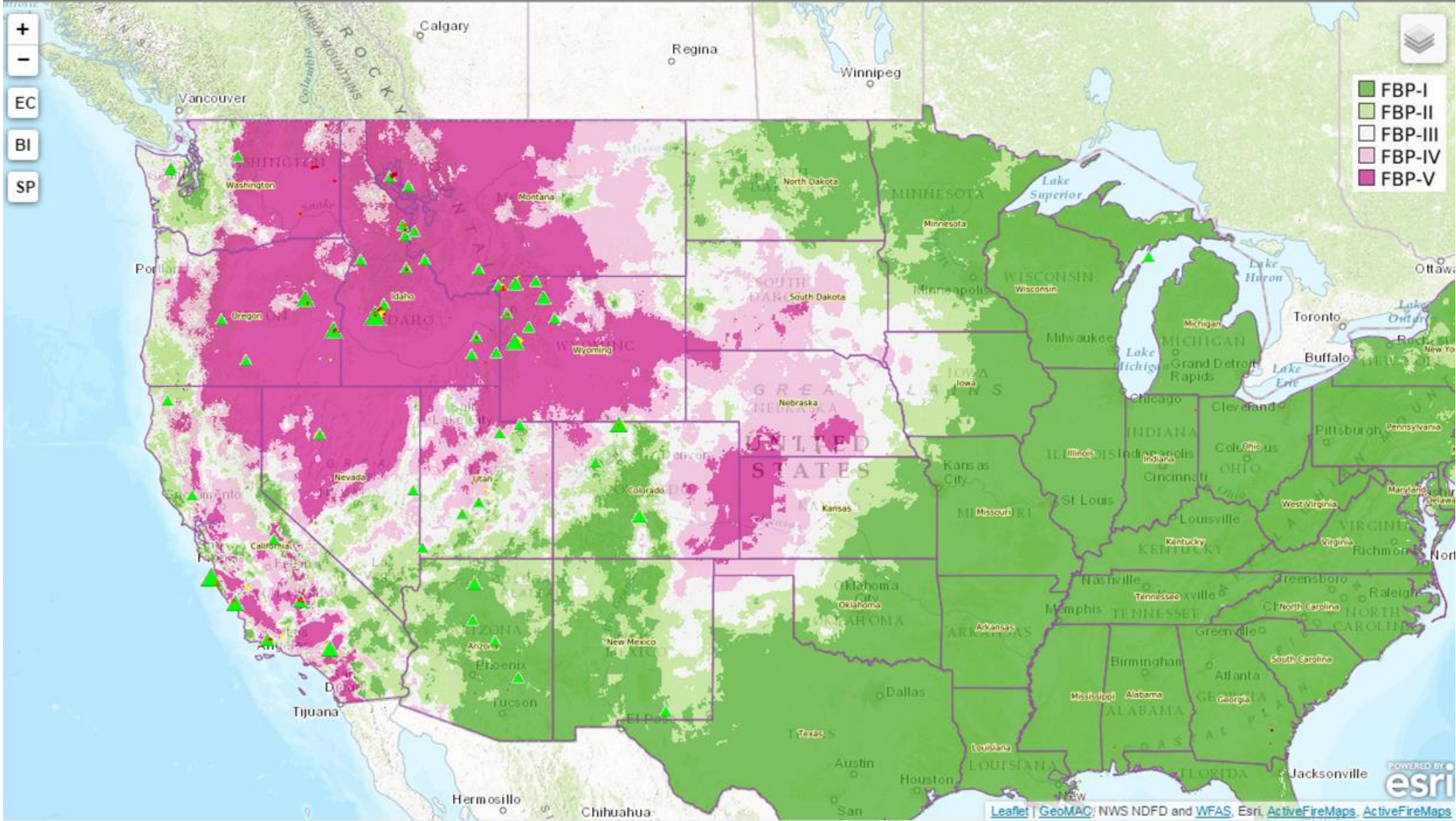
Derived by WFAS using the National Digital Forecast Database and RAWS surface weather observations

esri

Leaflet | GeoMap, NWS NDFD and WFAS, Esri

Screenshot\_201608...png

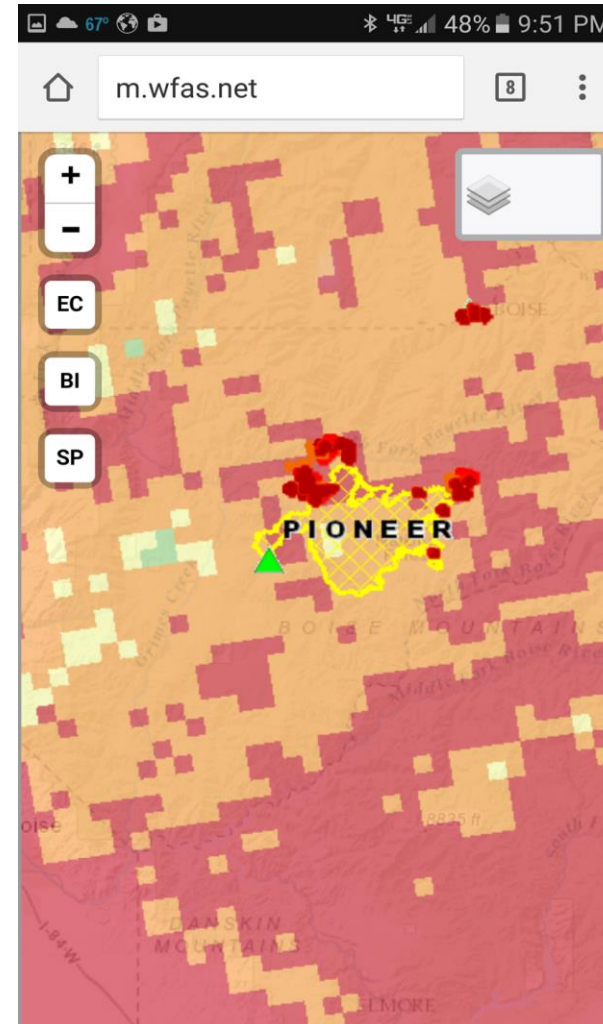
# WFAS - Severe Fire Weather Potential Mapping System



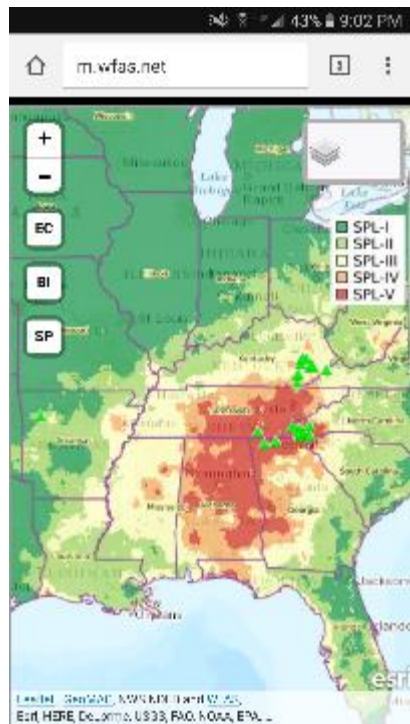
Derived by WFAS using the National Digital Forecast Database and RAWS surface weather observations



# Pioneer Fire



# Southeast fall fire season 2016



CDSIAP December 4, 2016, 10:45 PM

## Death toll from Tenn. wildfires rises to 14

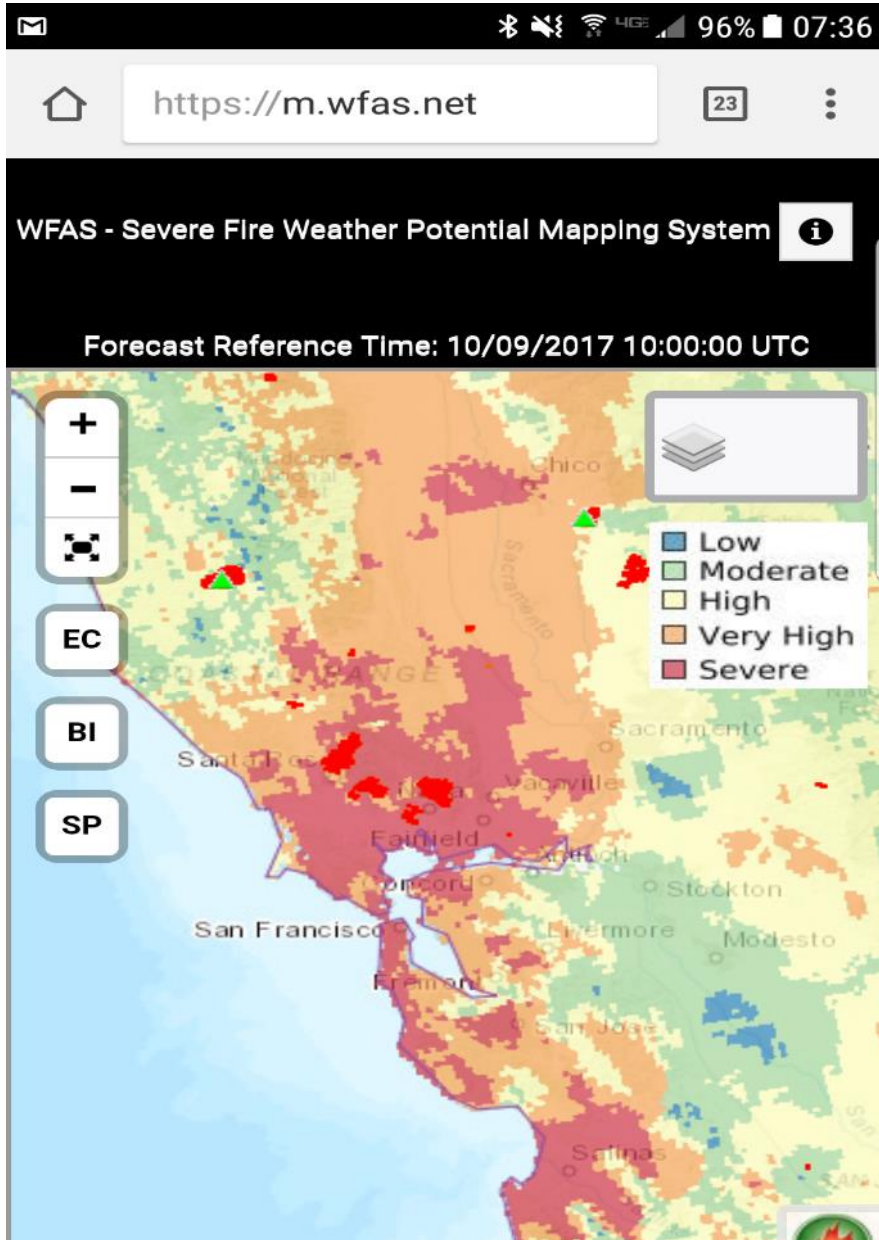


Some walls of a burned-out business remain Wednesday, Nov. 30, 2016, in Gatlinburg, Tenn., after a wildfire swept through the area Monday. **MARK HUMPHREY/AP**

[Share](#) / [Tweet](#) / [Reddit](#) / [Flipboard](#) / [Email](#)

**GATLINBURG, Tenn.** -- The death toll from the **Gatlinburg area fires** has risen to 14.

# Fires in Sonoma County leave at least nine dead and about 180 more missing



**Phil Willon** ✓  
@philwillon



Sonoma County Sheriff Rib Giardano confirms nine fire-related death in the wildfires. Still many people missing,he said

3:19 PM - Oct 10, 2017

♥ 3 👤 See Phil Willon's other Tweets



# Thomas Fire, 2017



## GREEN SHEET

### Fatality Firefighter Entrapment

12/14/2017

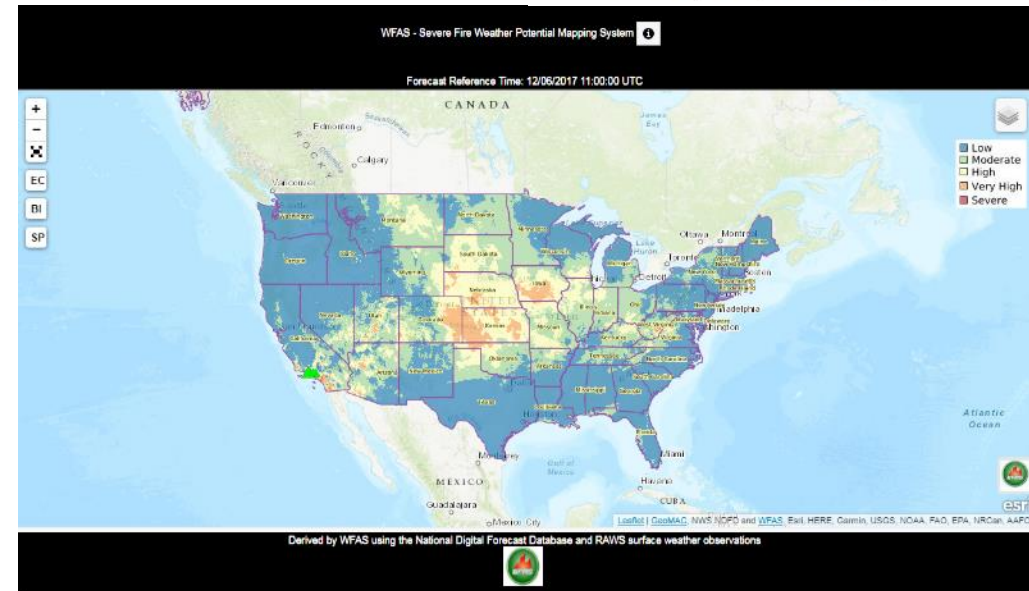
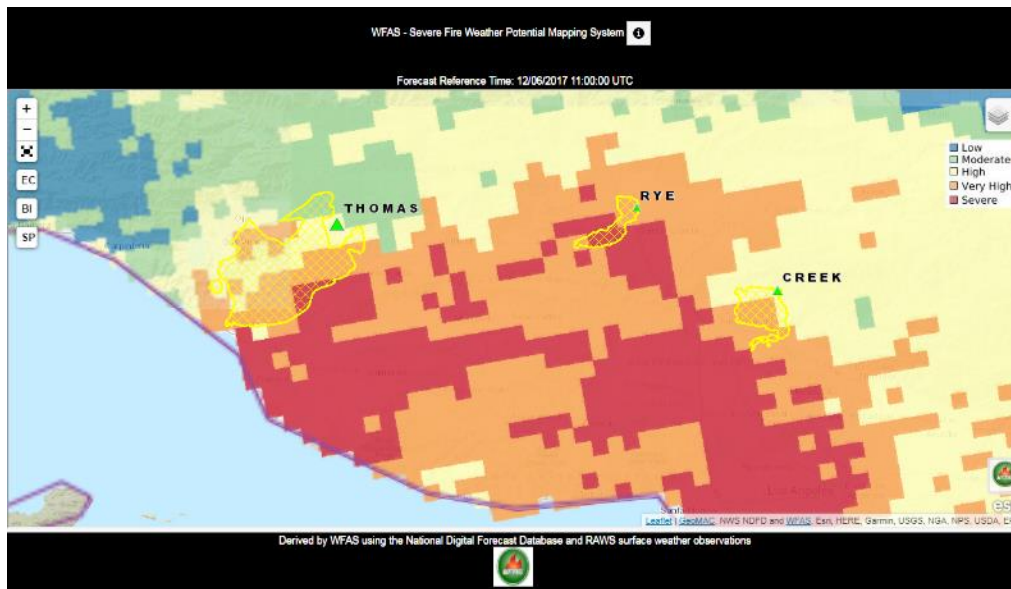
Thomas Fire

17-CA-VNC-103156

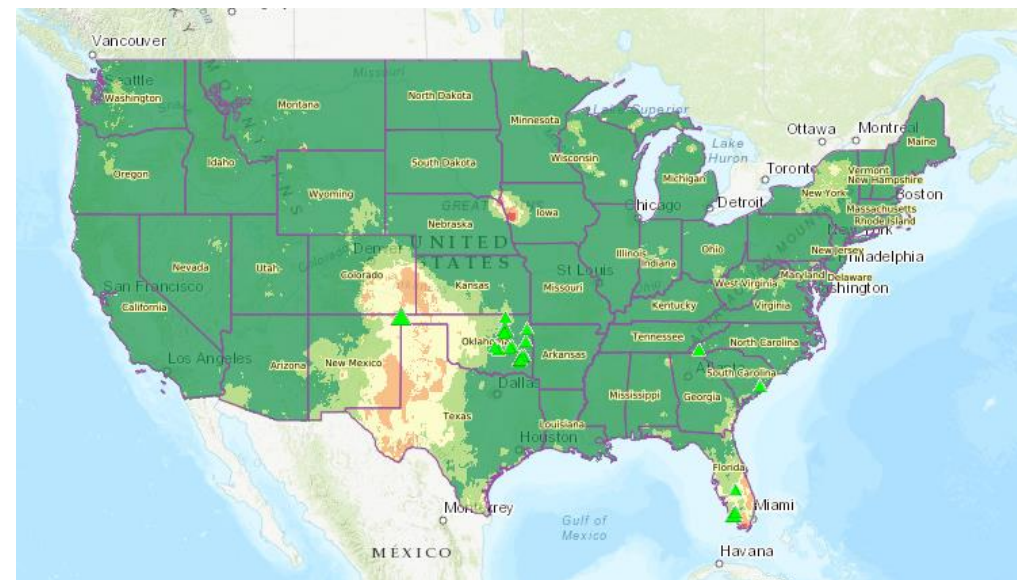
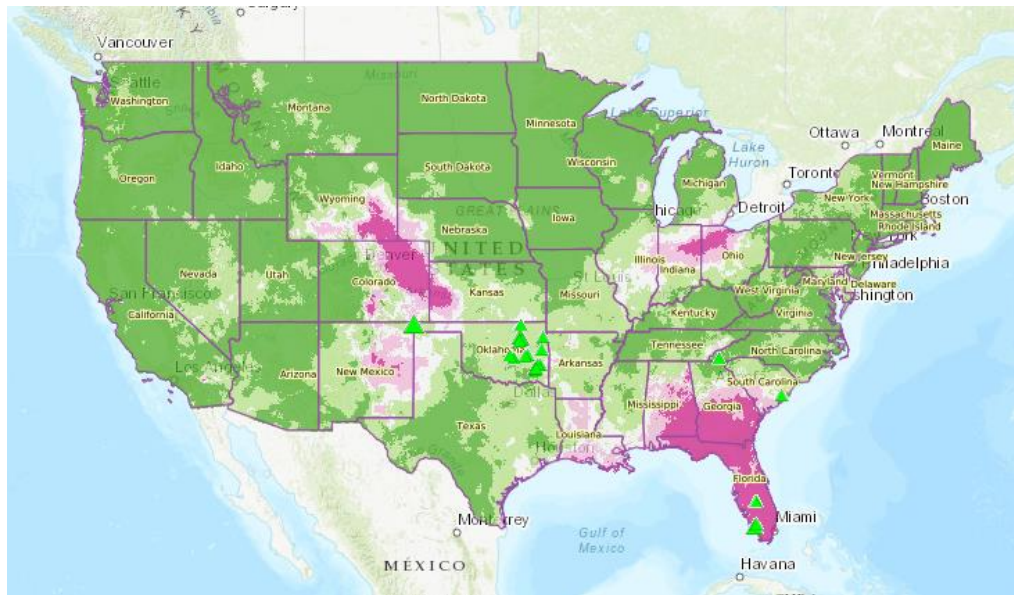
California Southern Region

#### SUMMARY

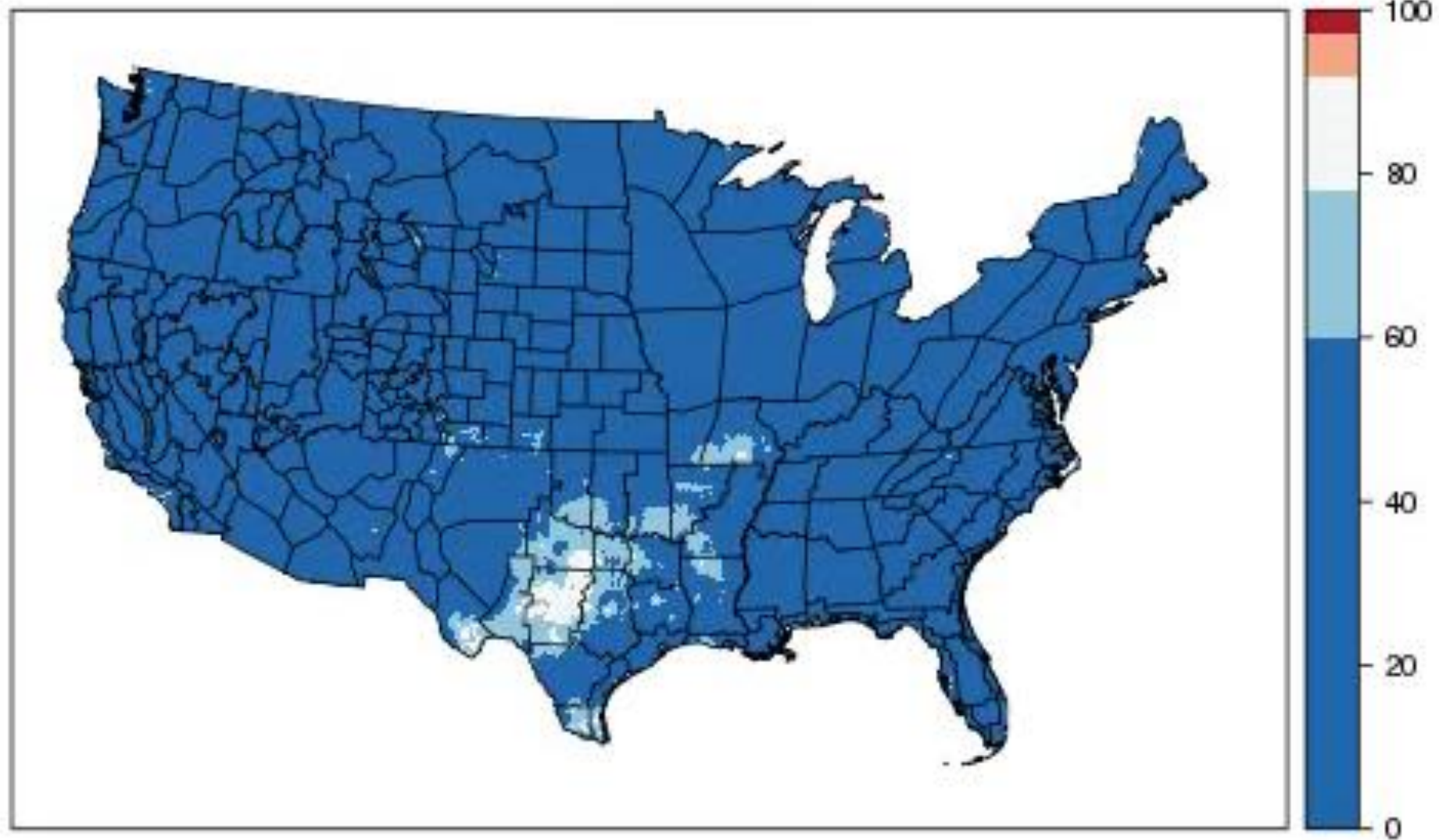
On December 13, 2017, a CAL FIRE Engine Strike Team (STEN1), with a leader (STL1) from the San Diego Unit (MVU) was assigned to Branch III, Division X of the Thomas Fire above the community of Fillmore in Ventura County, California. On the morning of December 14, 2017, a Fire Apparatus Engineer (FAE1) and four Fire Fighter I's (FF1, FF2, FF3 and FF4) from STEN1 were engaged in the placement of a hose/line in support of a dozer line with fire established above the line. At approximately 9:27 AM, while attempting to suppress spot fires below the dozer line, FAE1 became entrapped and suffered fatal injuries. The four firefighters on the dozer line retreated up their escape route without injury.



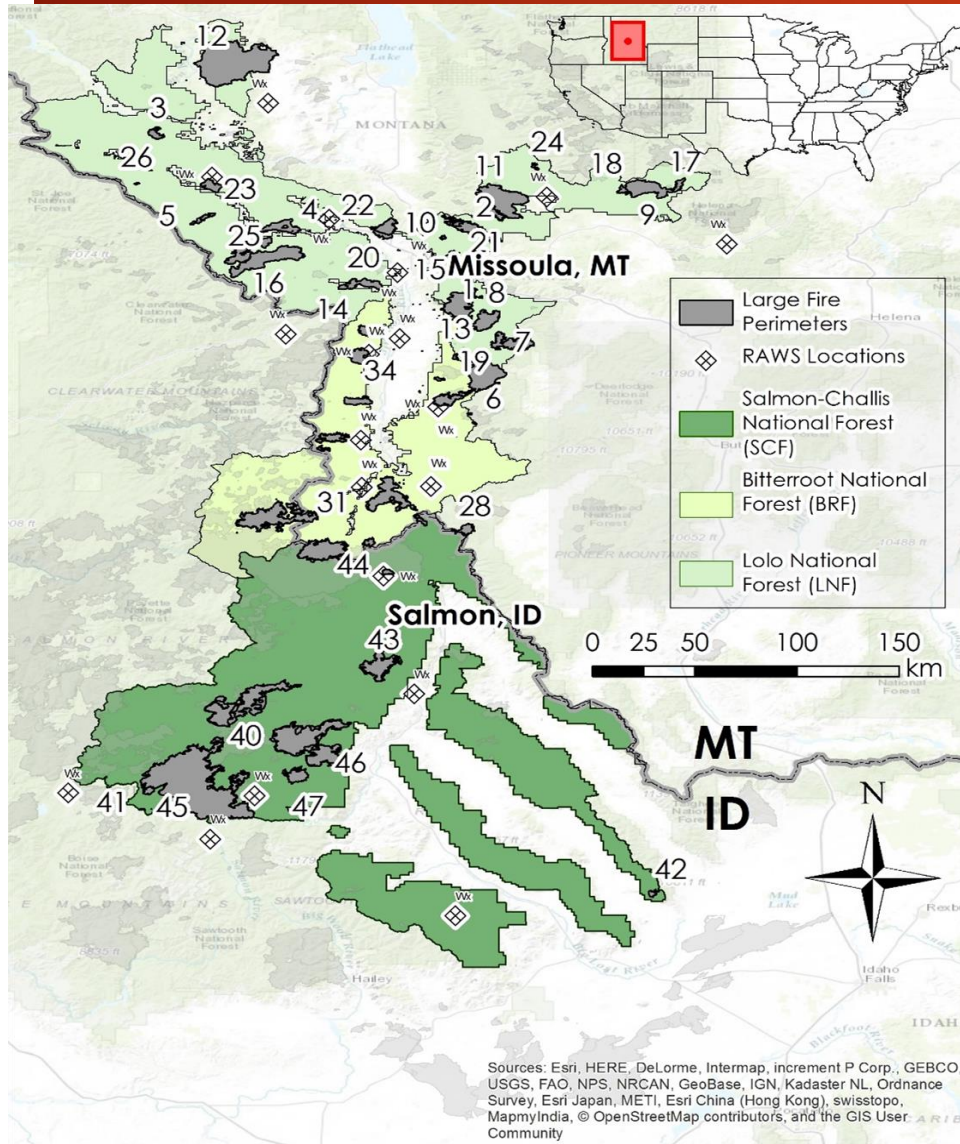
20 Mar 2018



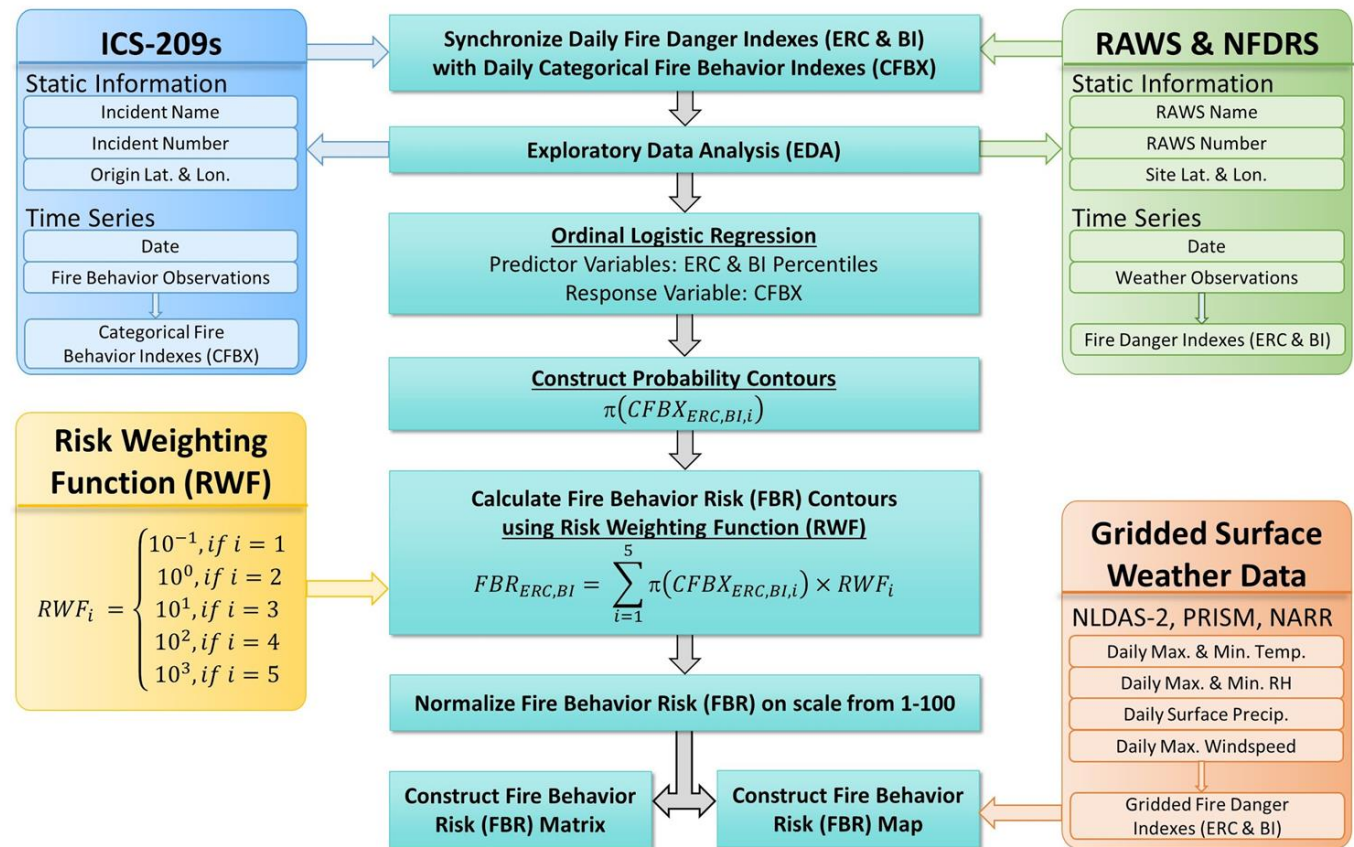
2016035

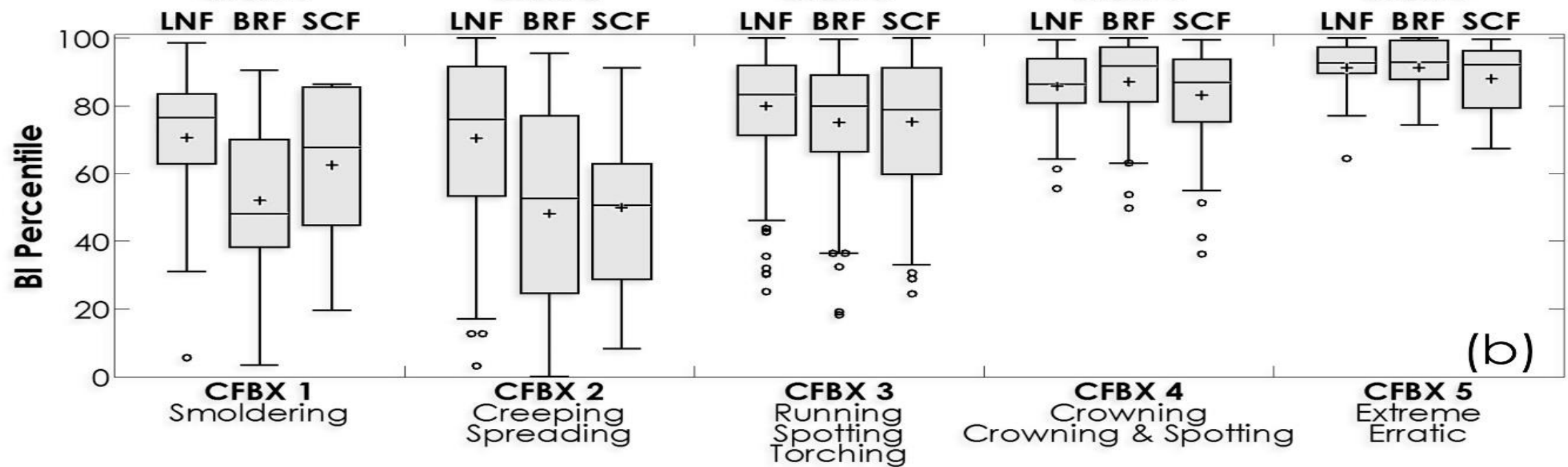
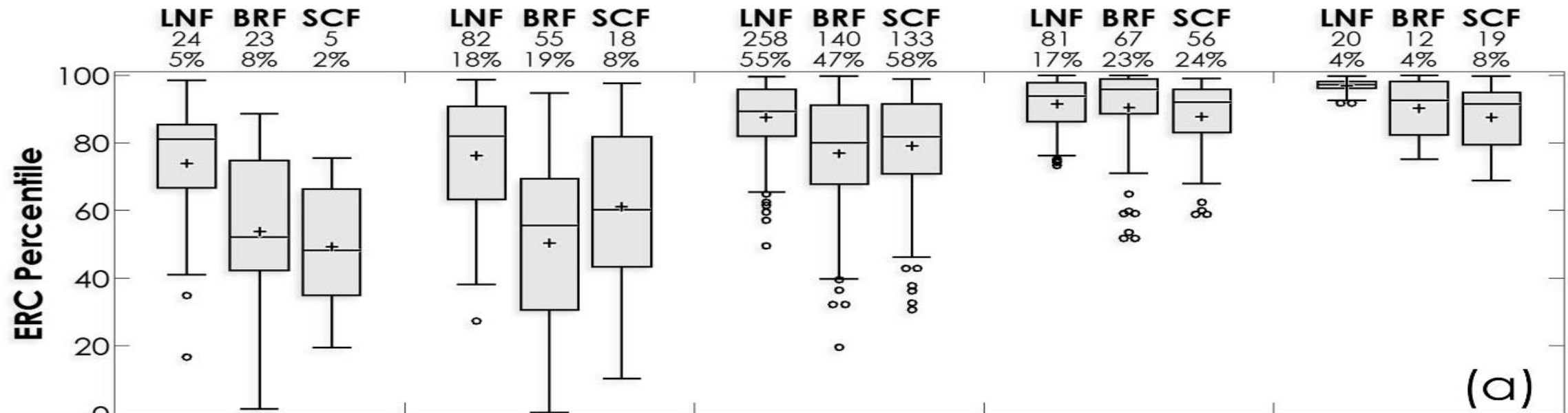


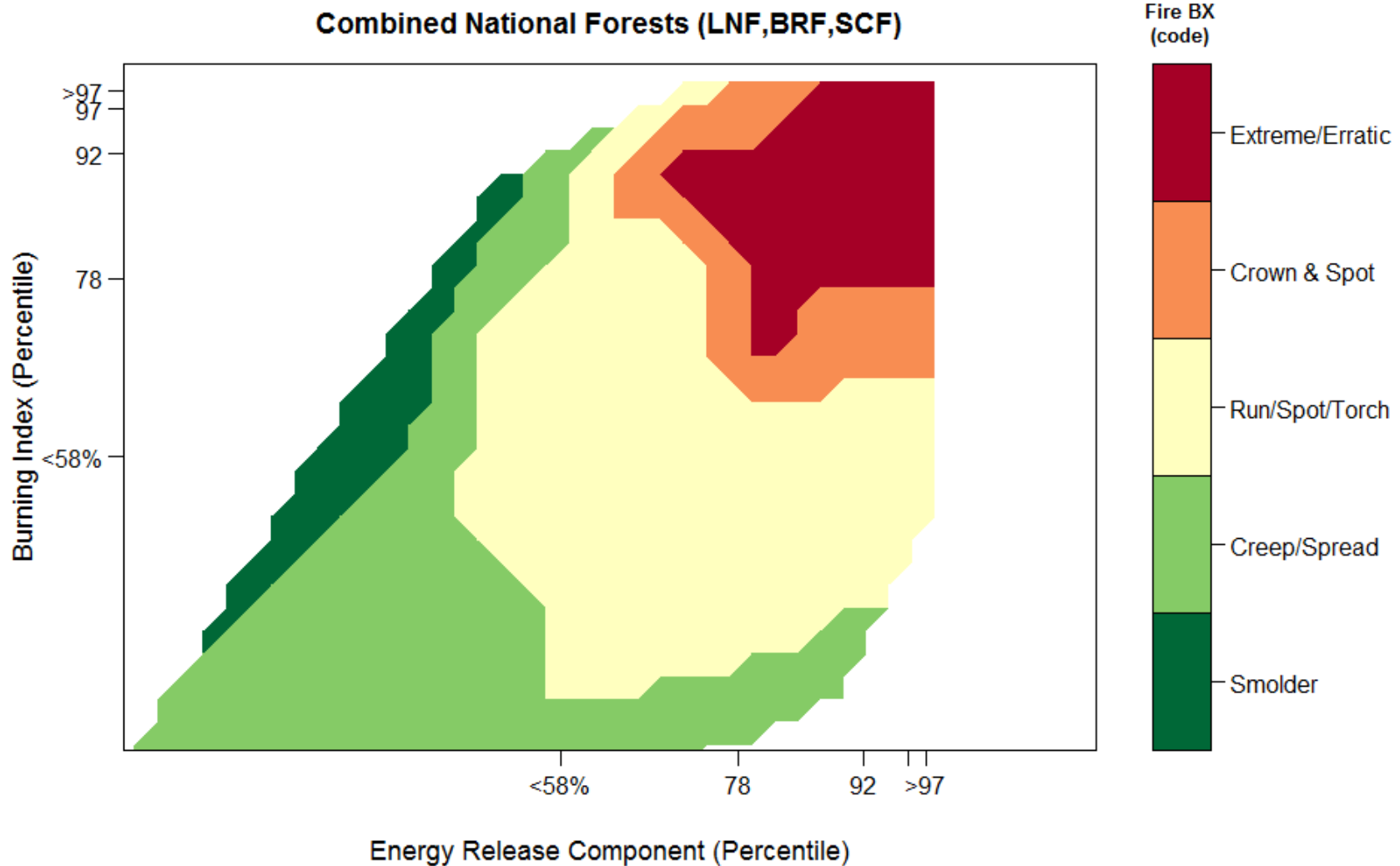
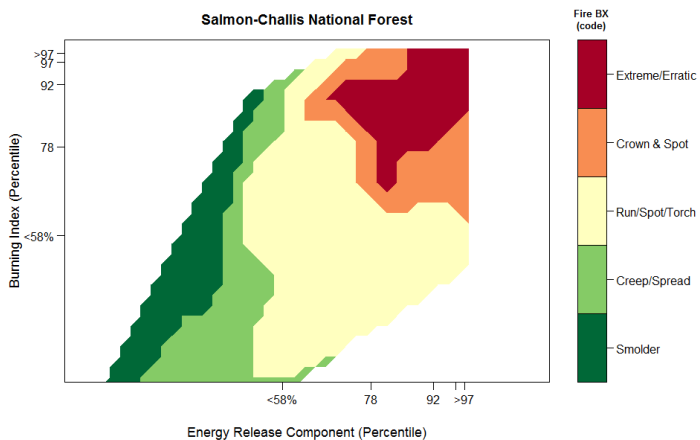
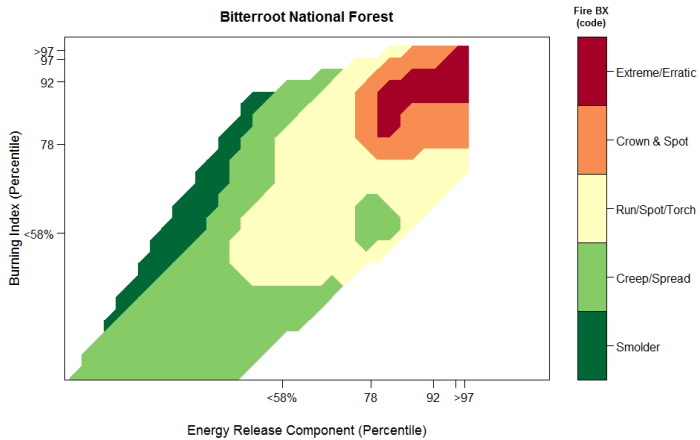
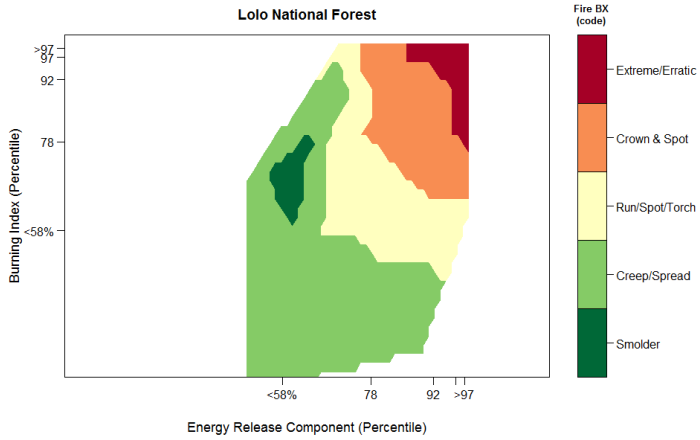
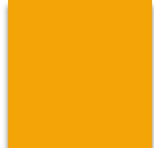
# From Fire Danger to Fire Behavior



This process can be followed by any National Forest. All the necessary data already exists.







Smoldering

Creeping  
Spreading

Running  
Spotting  
Torching

Crowning  
Crowning & Spotting

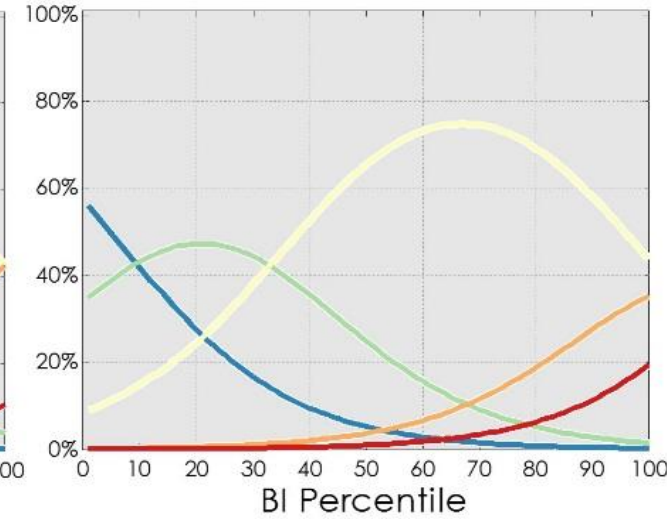
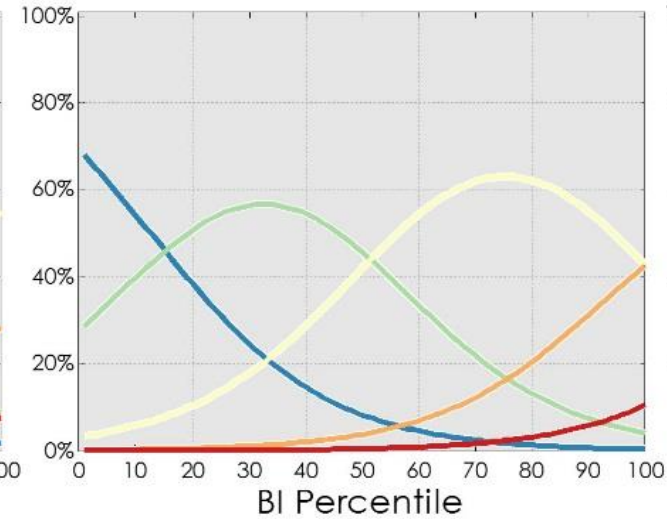
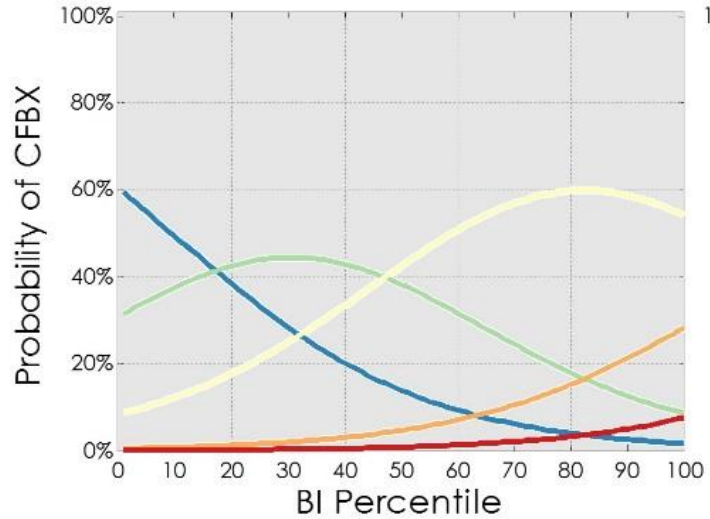
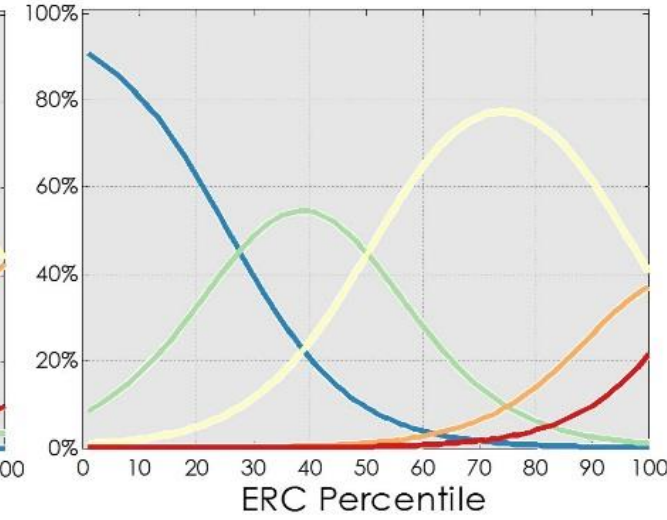
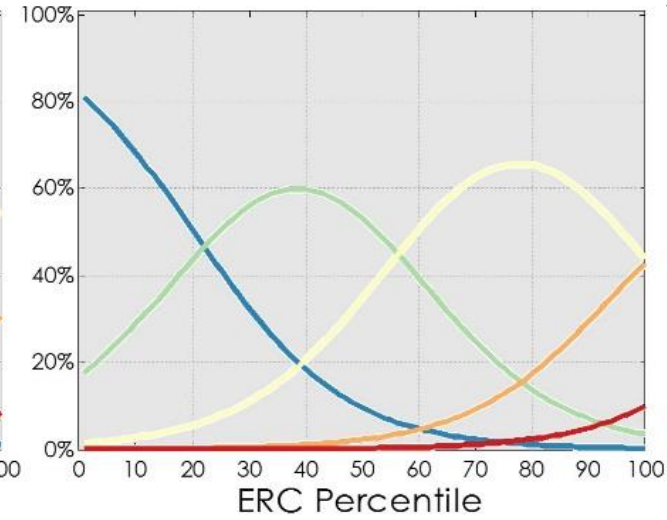
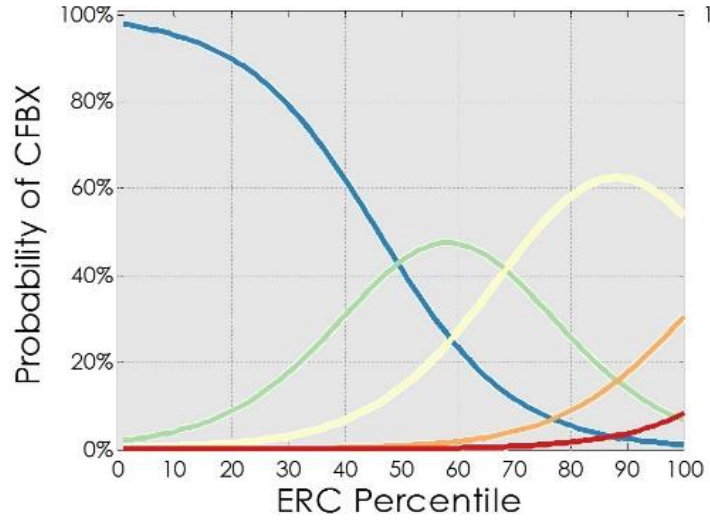
Extreme  
Erratic



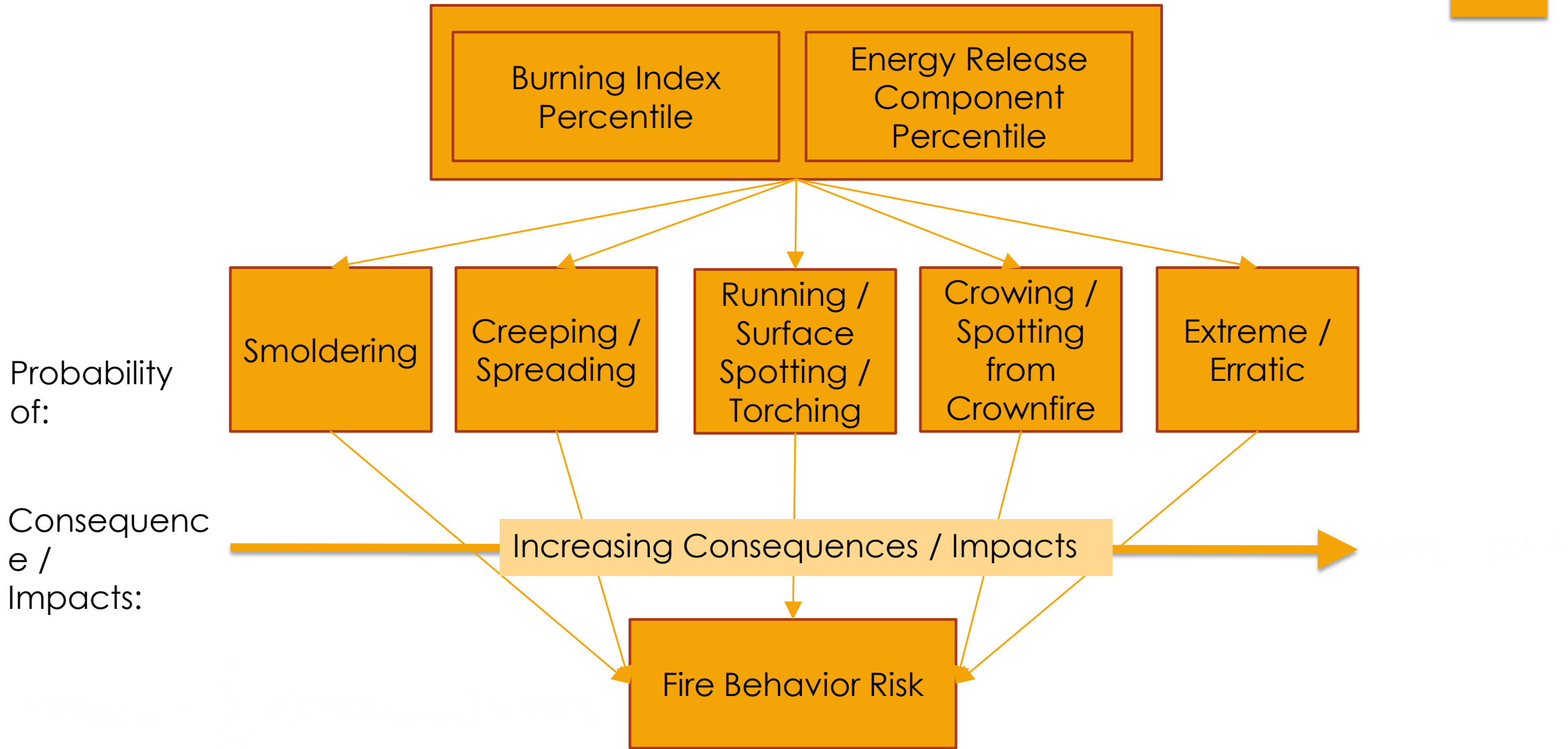
**LNF**

**BRF**

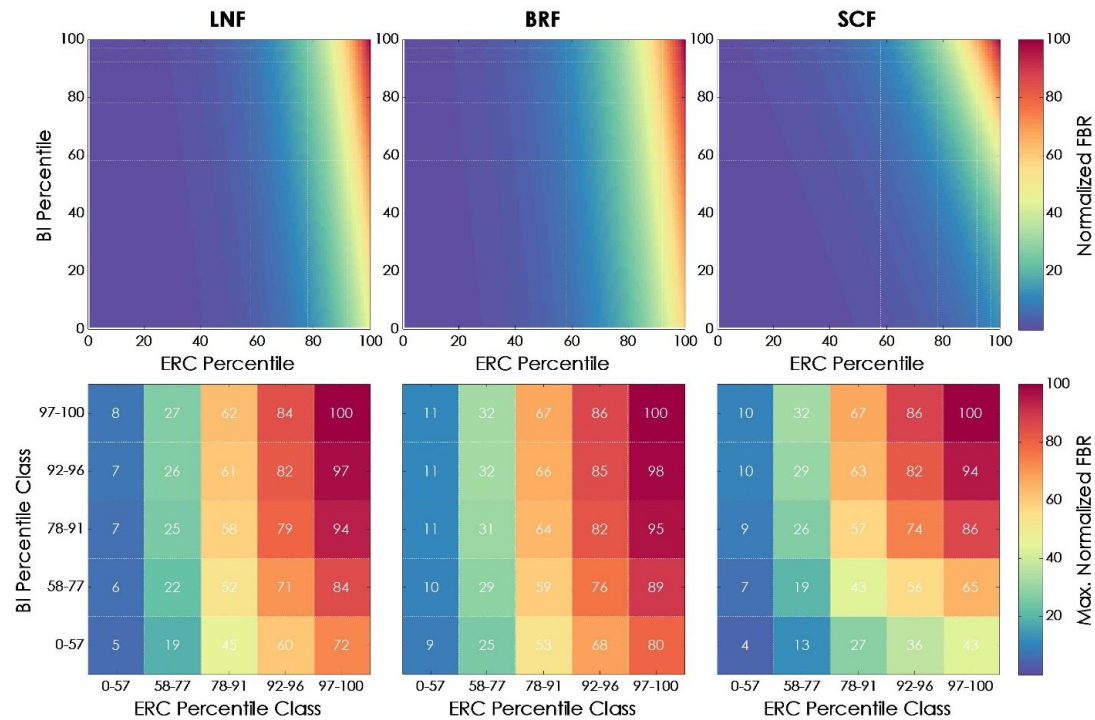
**SCF**





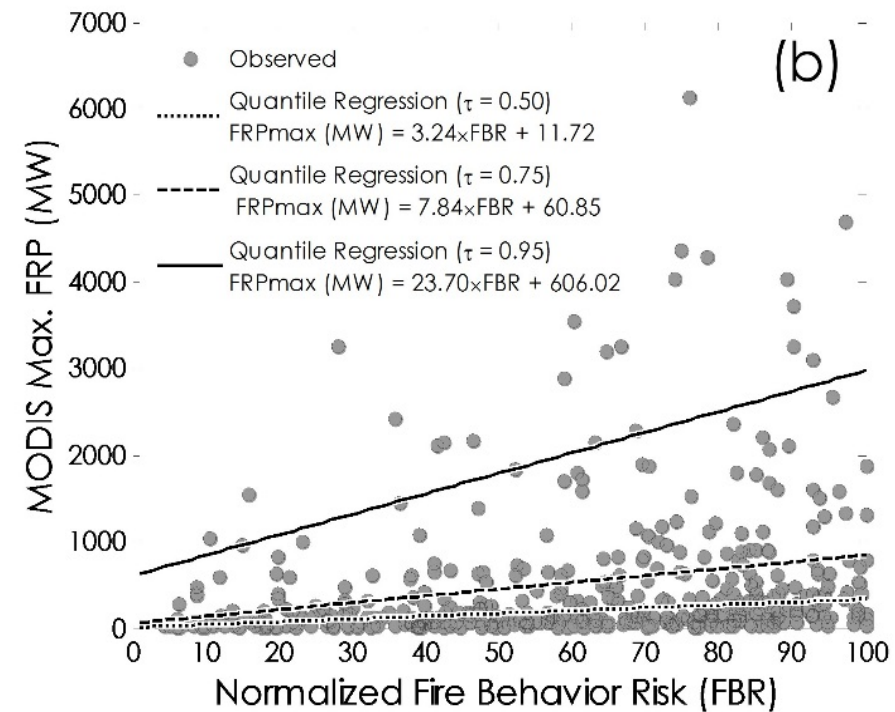
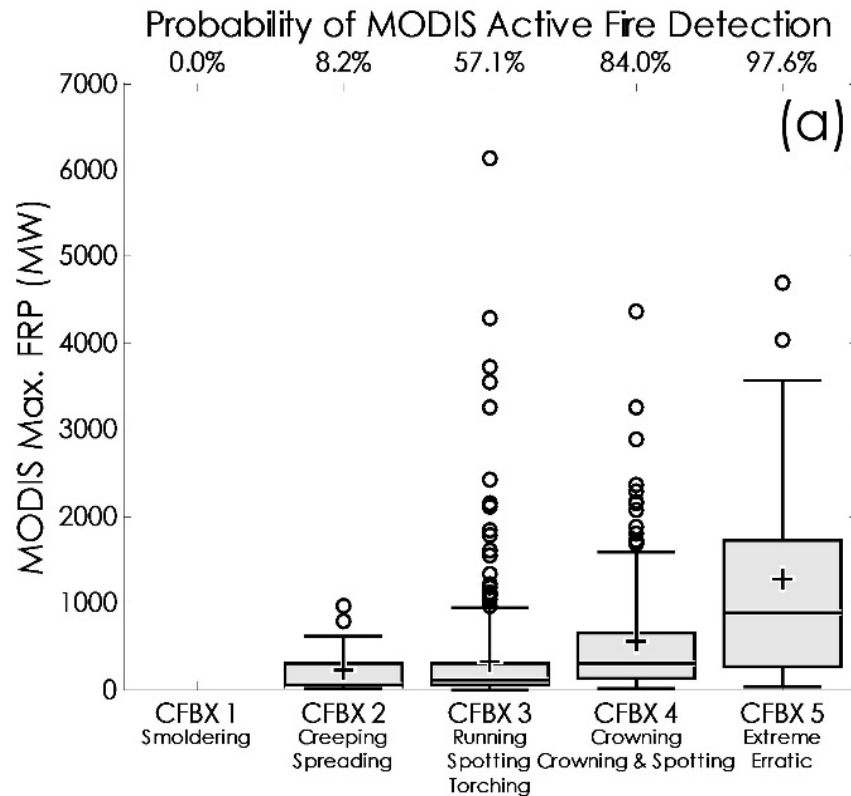


# From CFBX probabilities to Fire Behavior Risk

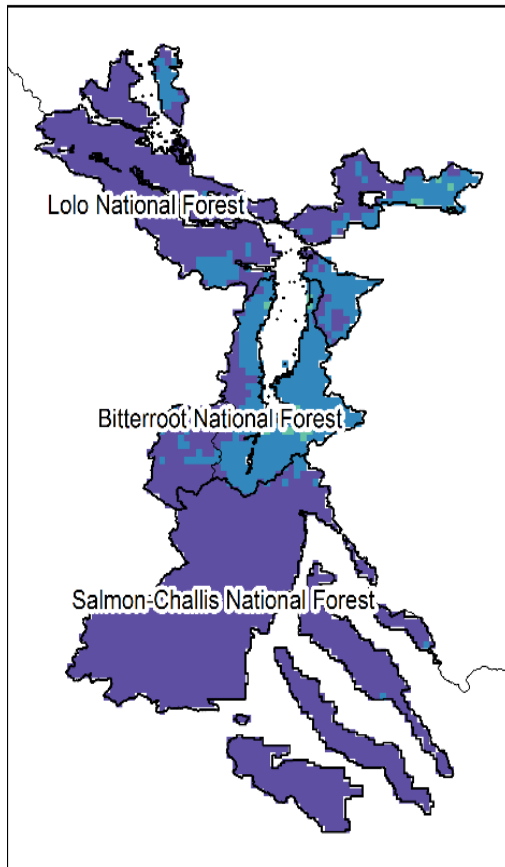


Different sensitivity  
To windspeeds

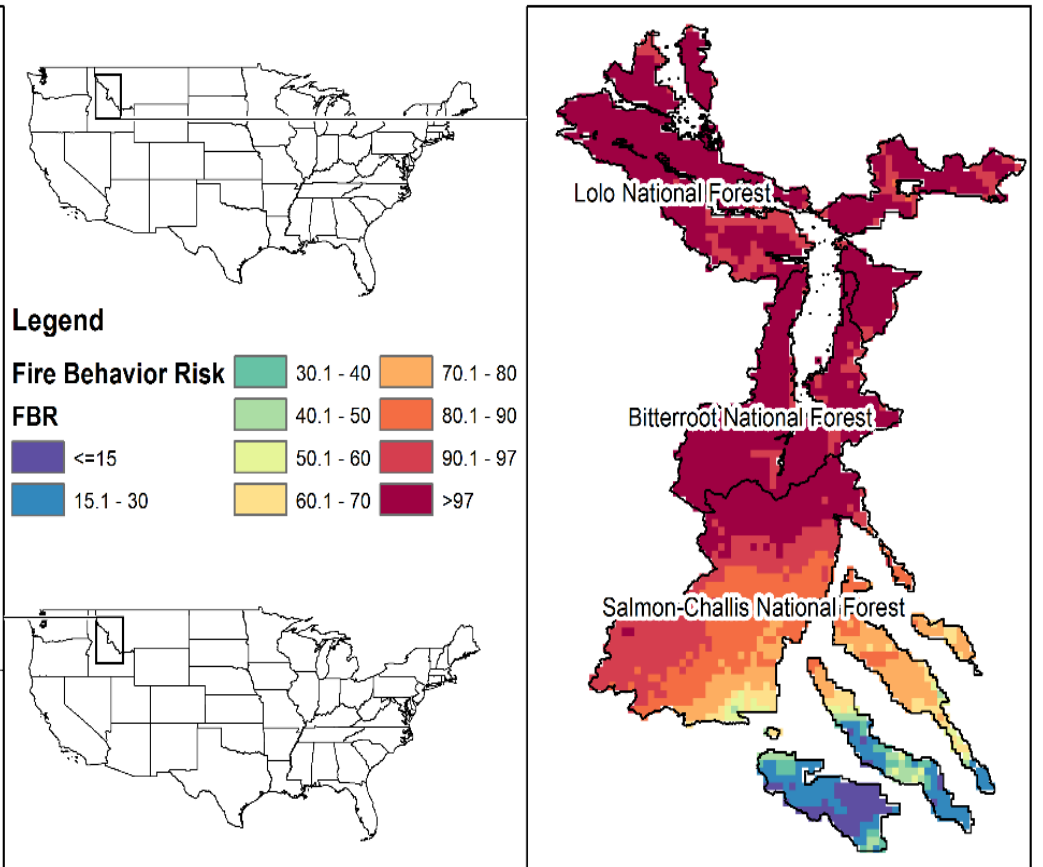
# Fire behavior observations also compare well with satellite-derived fire intensity



Fire Behavior Risk 09 April 2015 (Yearday 100)



Fire Behavior Risk 27 August 2015 (Yearday 240)



**Legend**

Fire Behavior Risk	
30.1 - 40	70.1 - 80
40.1 - 50	80.1 - 90
50.1 - 60	90.1 - 97
60.1 - 70	>97

FBR	
<=15	15.1 - 30

# How do we make this part of daily business?

- ▶ Mobile-enabled maps are made available before the start of the duty day
- ▶ Contributes to a common operating picture
- ▶ Use of information is written into the Delegation of Authority (DOA) letters for Type 3,4 and 5 ICs and Duty Officers
- ▶ Used to brief at the National, Regional, State, Forest and District levels
- ▶ Fire management, line officers and cooperators have a common picture

# Fire Management Decision Support Continuum

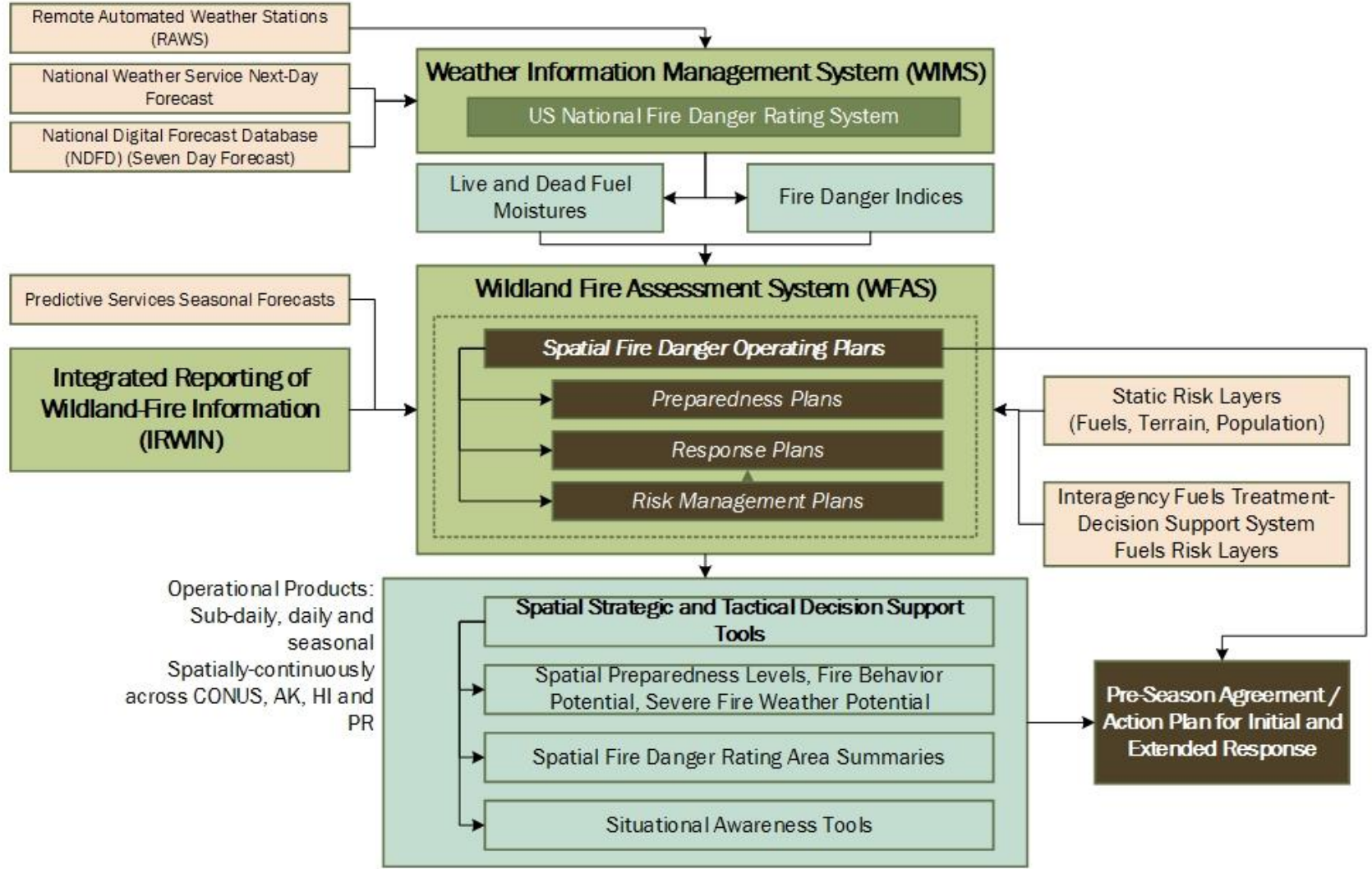
Pre-season  
planning

Real-time  
Monitoring

Initial  
Response

Extended  
Response /  
Large Fire  
Management

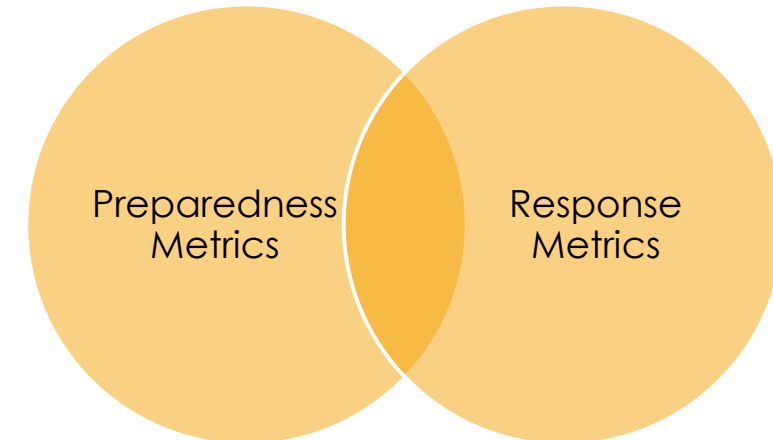
# National Wildland Fire Preparedness and Response System

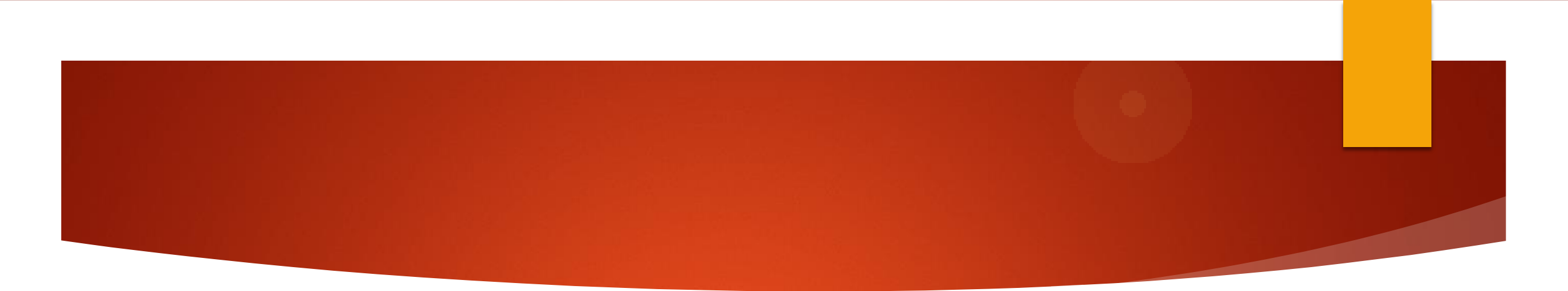


Energy Release Component Percentile  
Southern Area Coordination Center



October 26, 2016, 8:19 am MDT  
Wildland Fire Assessment System (WFAS)



- 
- ▶ Build a culture of LEARNED centered around NFDORS and its applications
  - ▶ Create a community of users that can learn together
  - ▶ Learn to adapt to change because more is coming!



# Slack

- ▶ <https://nfdrs2016.slack.com/>
- ▶ All online and open to the anyone
- ▶ Mobile-friendly

The screenshot displays a Slack workspace for NFDRS2016. The interface includes a sidebar with channels such as #general, #dri\_fw13, #fdop, #ffp, #ffp\_dev, #ffp\_helpdesk, #ffp\_power\_users, #modeldev, #pocketcards, #random, #wfas\_helpdesk, #wims, #wims\_dev, and #wims\_helpdesk. The main window shows a message from user 'wmjolly' in the #general channel, dated April 4th, 2017. The message contains two line graphs: '099802-OKEFENOKEE W JONES I 2002 - 2017' showing 'Burning Index' and '099802-OKEFENOKEE W JONES I 2002 - 2017' showing 'percent'. A 'Files' panel on the right shows a file named '241213-THOMPSONFALLS AIRPOR 2006 - 2016' with a '1000-Hour Fuel Moisture' graph. The bottom of the screen shows a Windows taskbar with various application icons and the system clock at 8:15 AM on 4/30/2018.

https://www.wfas.net/nfdrs2016



## US National Fire Danger Rating System (NFDRS2016)

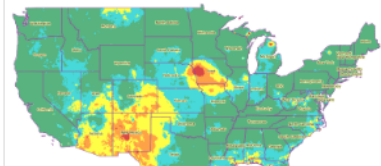
Search ...

[Home](#) [NFDRS Intro](#) [NFDRS2016](#) [NFDRS2016 Tasks & Status](#) [Downloads](#) [Prototype Products](#) [NWCG Fire Danger Subcommittee](#)

### The latest on the US National Fire Danger Rating System and NFDRS2016 implementation...

*Welcome! Subscribe to our blog or check back often for news, information and tips related to the evolution and successful implementation of NFDRS2016. Look for updates related to the NFDRS itself, related training & education, applying NFDRS to make fire management decisions, prototype products & applications, related technology, and more! Browse the top menu bar for some preliminary information, to view some prototype products, and check out our downloads section. Comments and questions encouraged!*

Home Search... [Icons: Home, Mail, RSS, Lock]



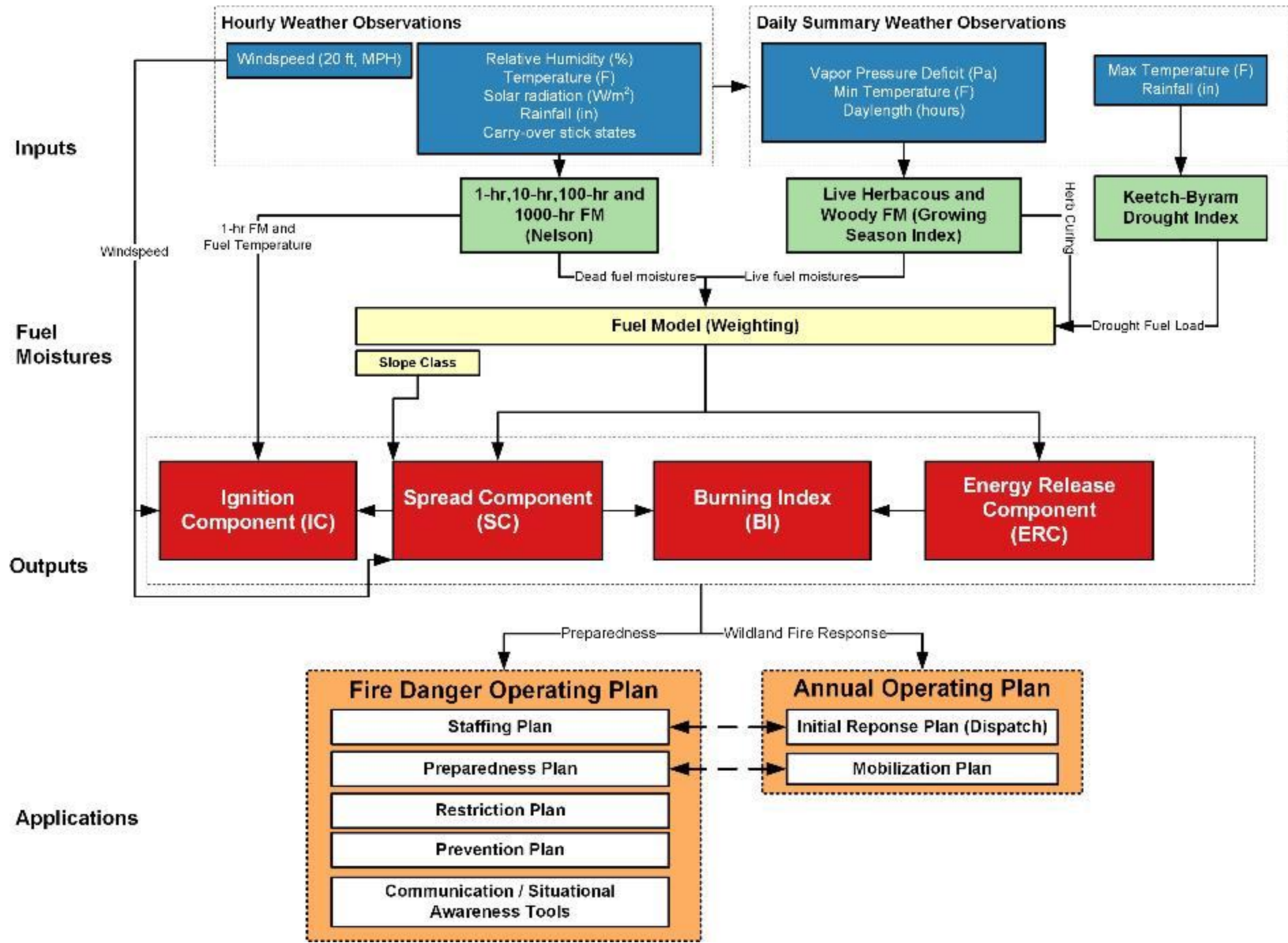
#### NFDRS Intro

Super User Uncategorized

To develop consistency among protection agencies, the National Fire Danger Rating System (NFDRS) was developed in the early 70's. It was designed around four basic guidelines. The research charter said the National Fire Danger Rating System would be... More

## TOPOFIRE: A topographically resolved drought and wildfire danger monitoring system for the conterminous United States

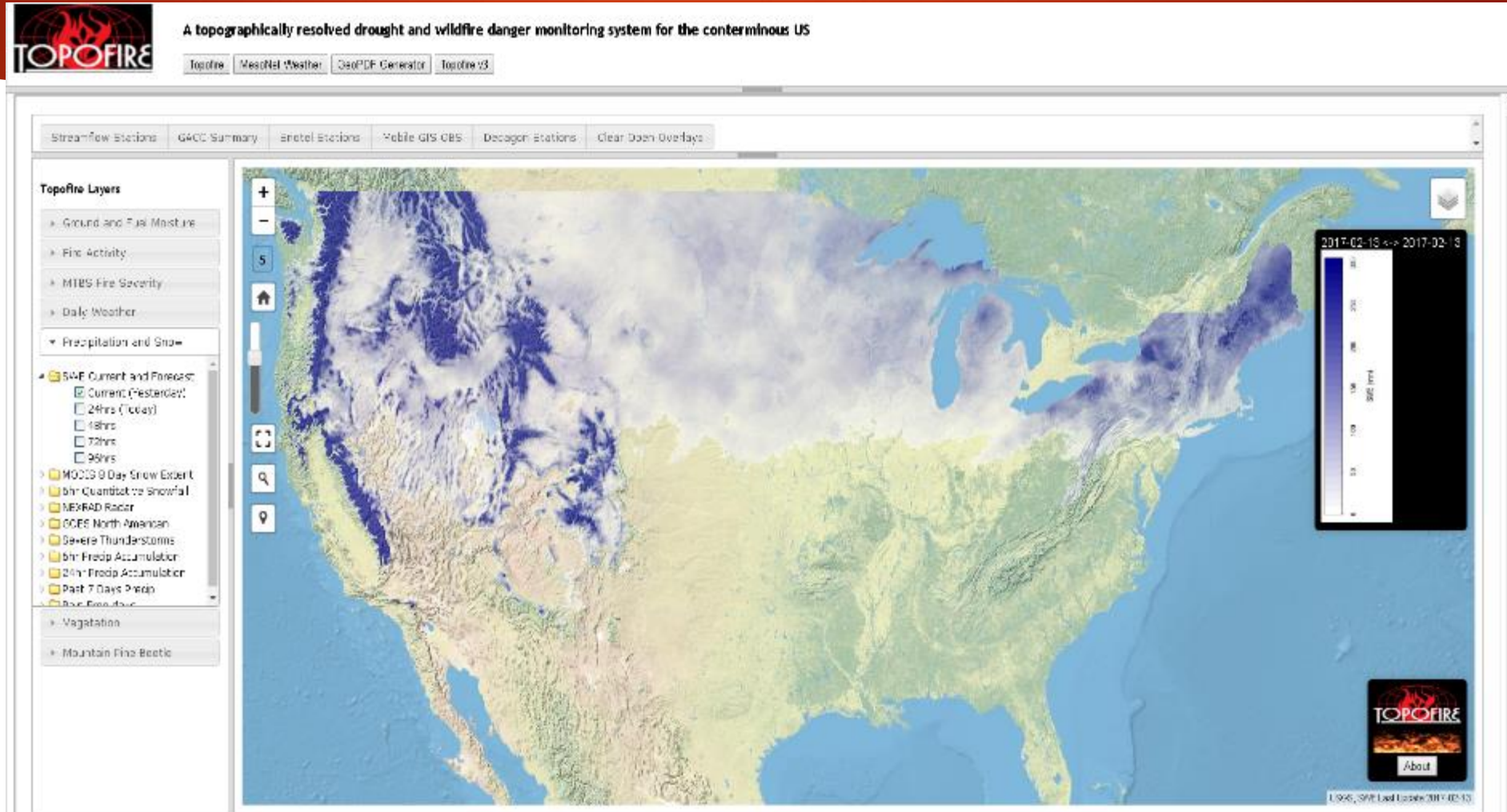
- ▶ NASA Applied Sciences Funding (ROSES A.35)
- ▶ Project Goals:
  - ▶ Develop topographically resolved gridded fire danger products for the USA to support the Wildland Fire Assessment System (WFAS) and Wildland Fire Decision Support System (WFDSS)
  - ▶ Integrate eco-hydrologic indices into wildfire danger assessment



# TOPOFIRE: A topographically resolved drought and wildfire danger monitoring system for the conterminous United States

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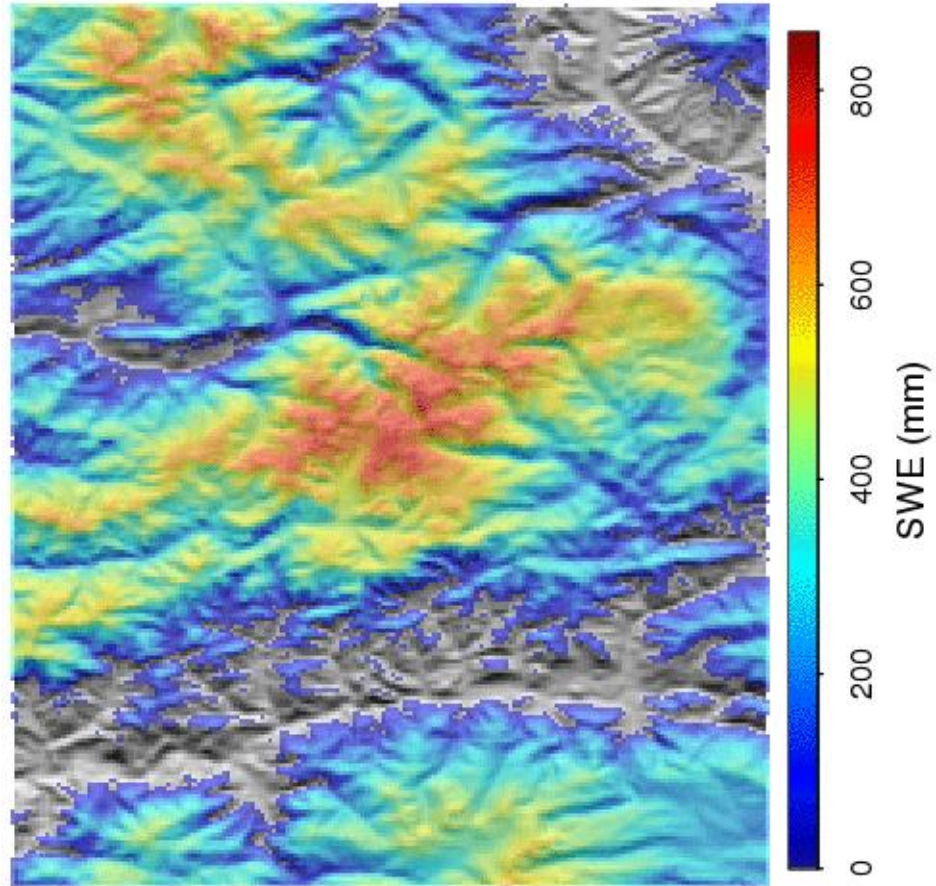
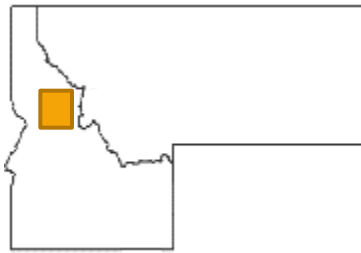
# Modified SWAT snow model calibrated with gridded radiation data



Modeled SWE – current + 4 day forecasts

# Snowmelt timing and topography

20150421



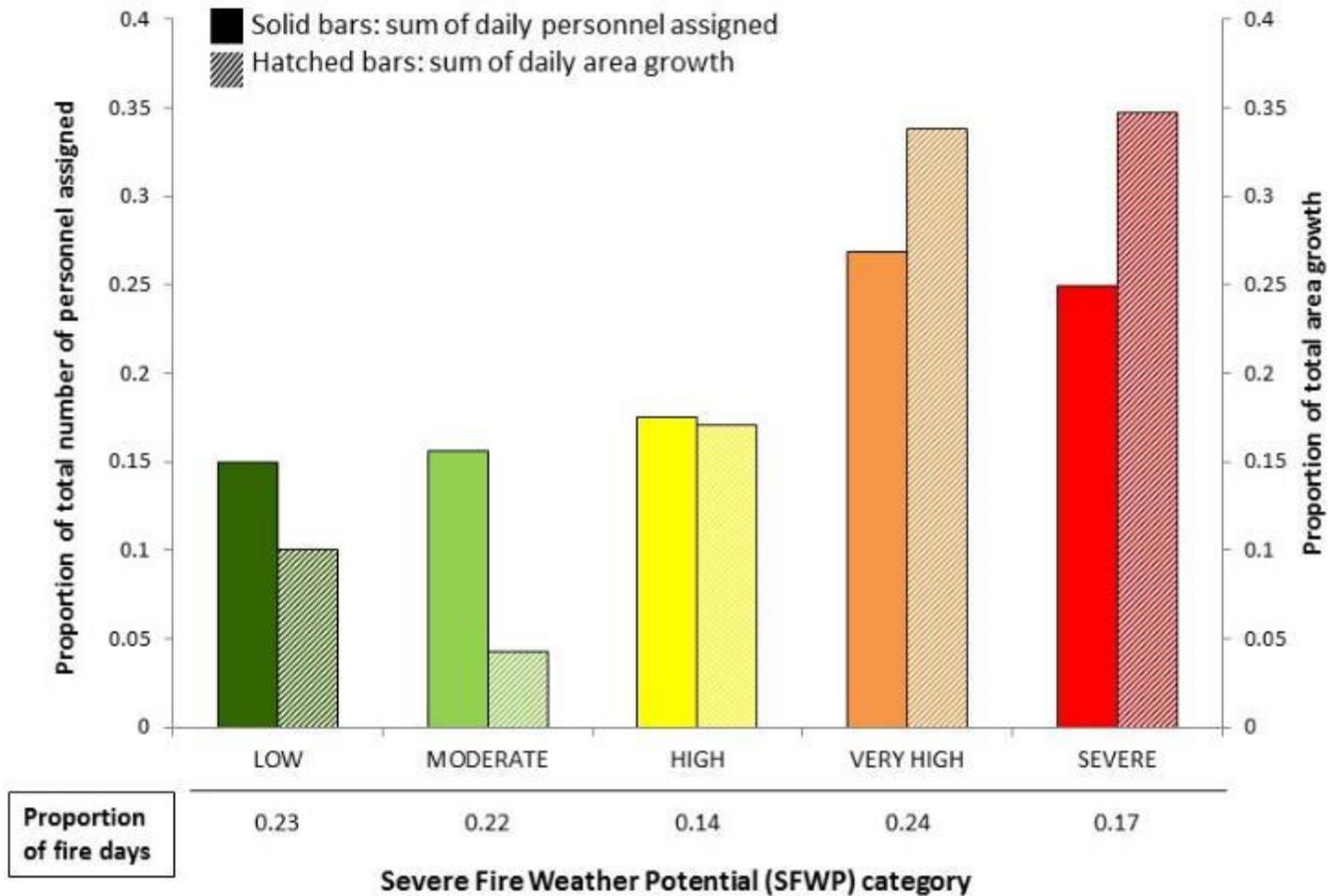


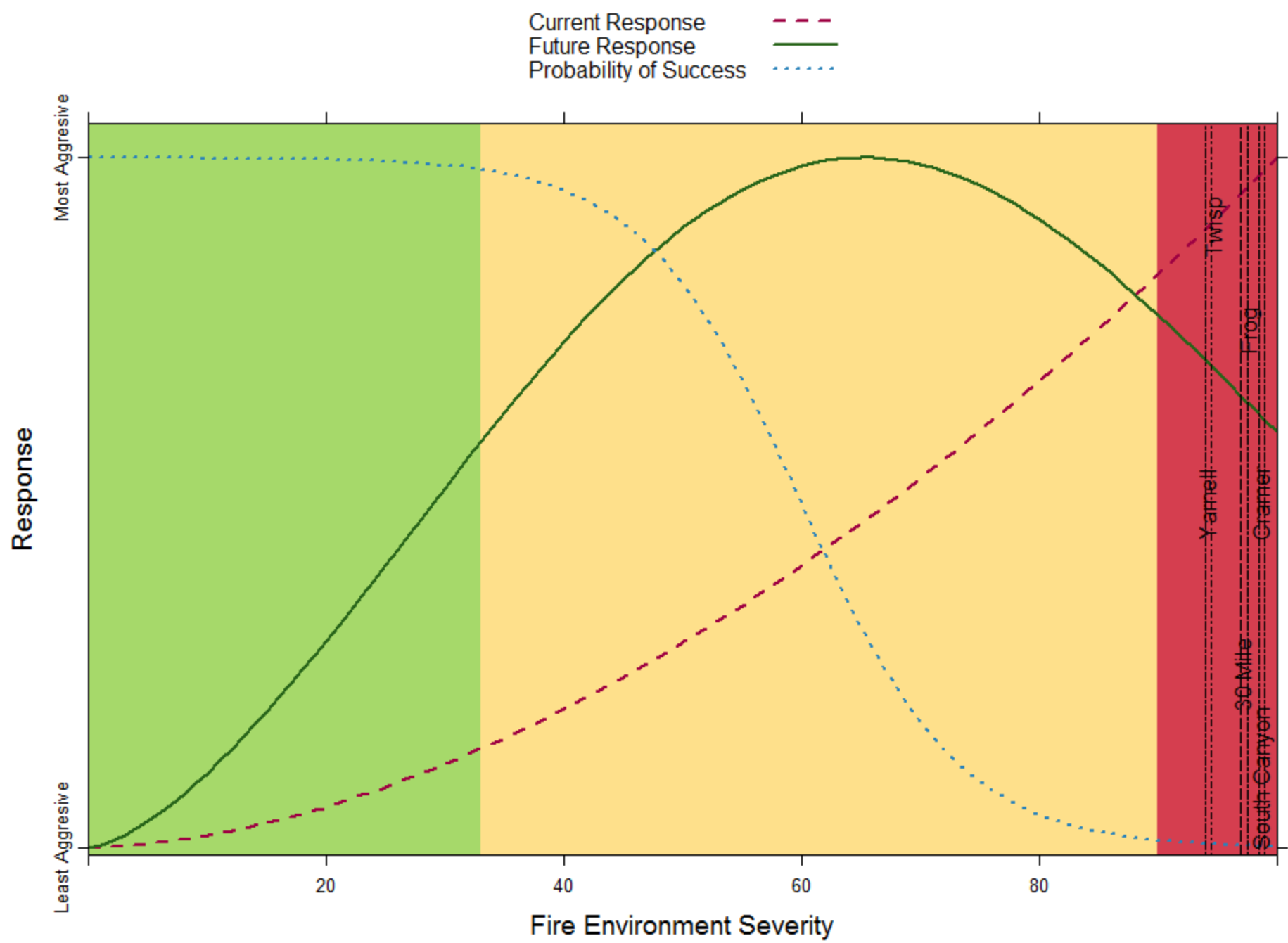
Why does it matter?



**Cumulative daily area growth and personnel assigned (from ICS-209) by Severe Fire Weather Potential (SFWP) category for 2016 USFS Level 3 fire review incidents:**

*Beaver Creek (CORTF), Copper King (MTKNF), Juniper (AZTNF), Lava Mountain (WYSHF), Mormon (AZCOF), Mule Ridge (AZCNF), Observation (MTBRF), Pioneer (IDBOF), Pony (CAKNF), Rail (ORWWF), Saddle (UTDIF)*

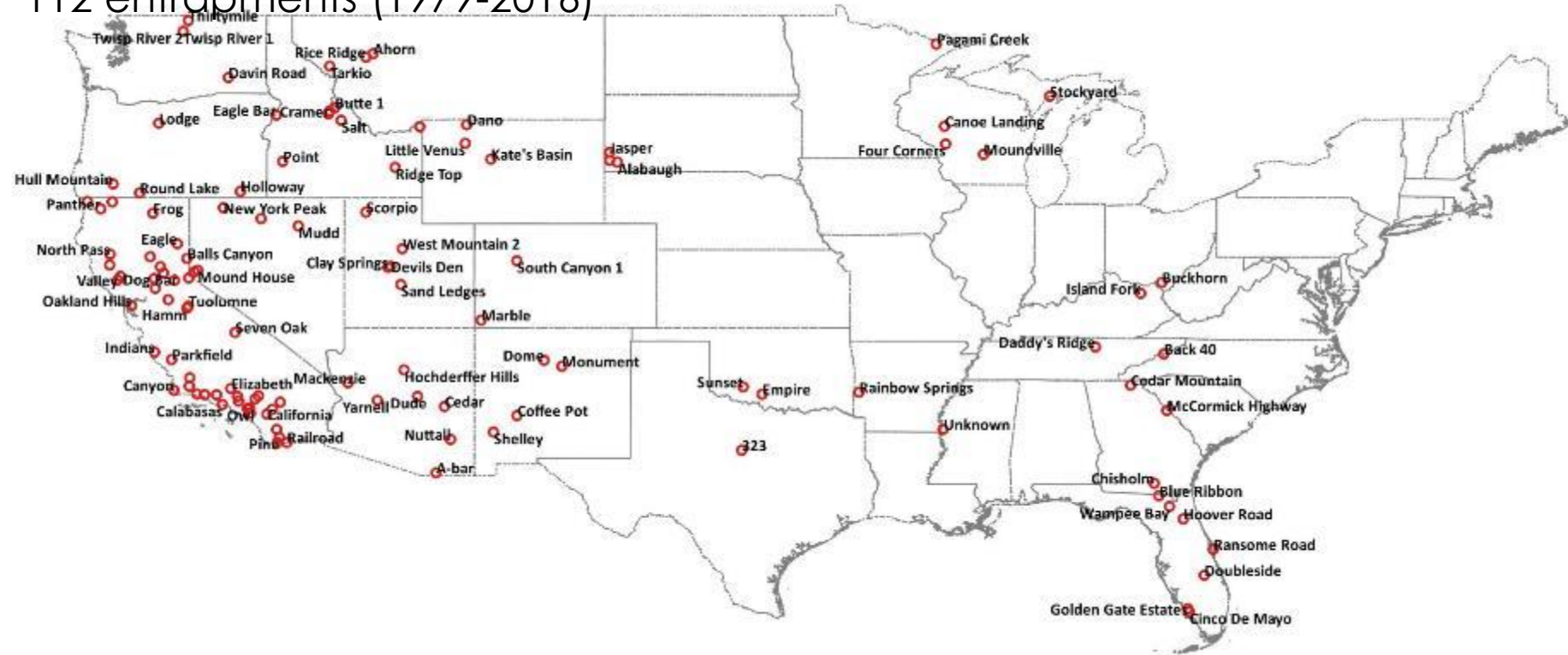




Success Probability



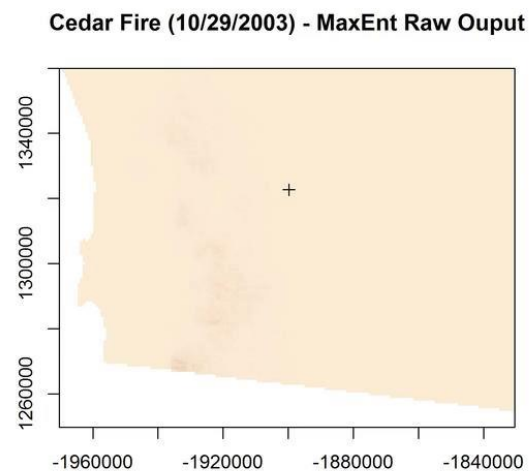
# 112 entrapments (1979-2016)



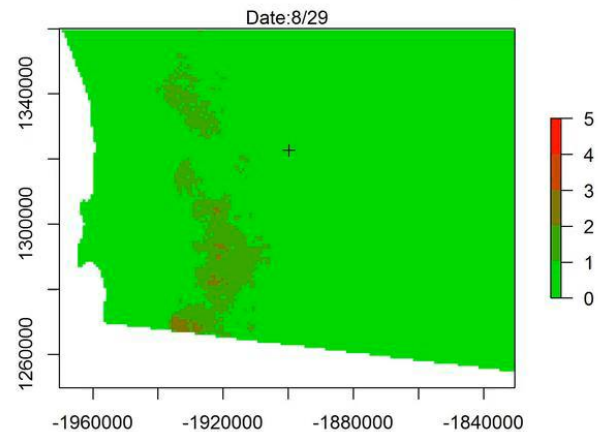
## Fuel and topographic influences on wildland firefighter turnover fatalities in Southern California

Wesley G. Page<sup>A</sup> and Bret W. Butler<sup>A</sup>

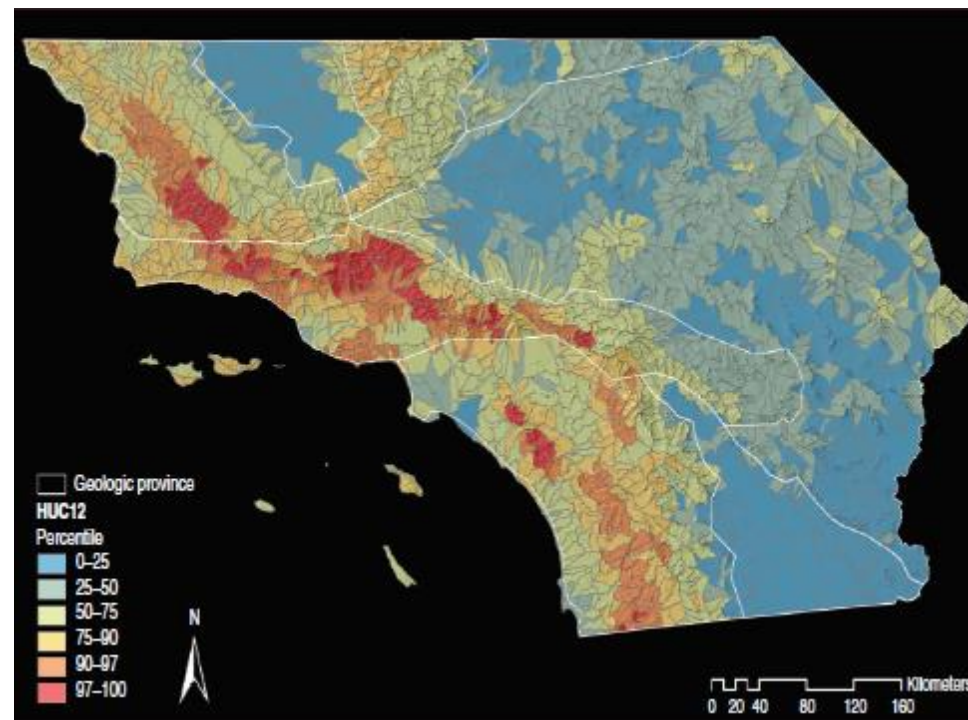
<sup>A</sup>USDA Forest Service, Rock  
5775 Highway 10 W, Miss  
<sup>B</sup>Corresponding authors. En



Percentile: 1:0-57%, 2:58-78%, 3:78-92%, 4:92-97%, 5:>97%

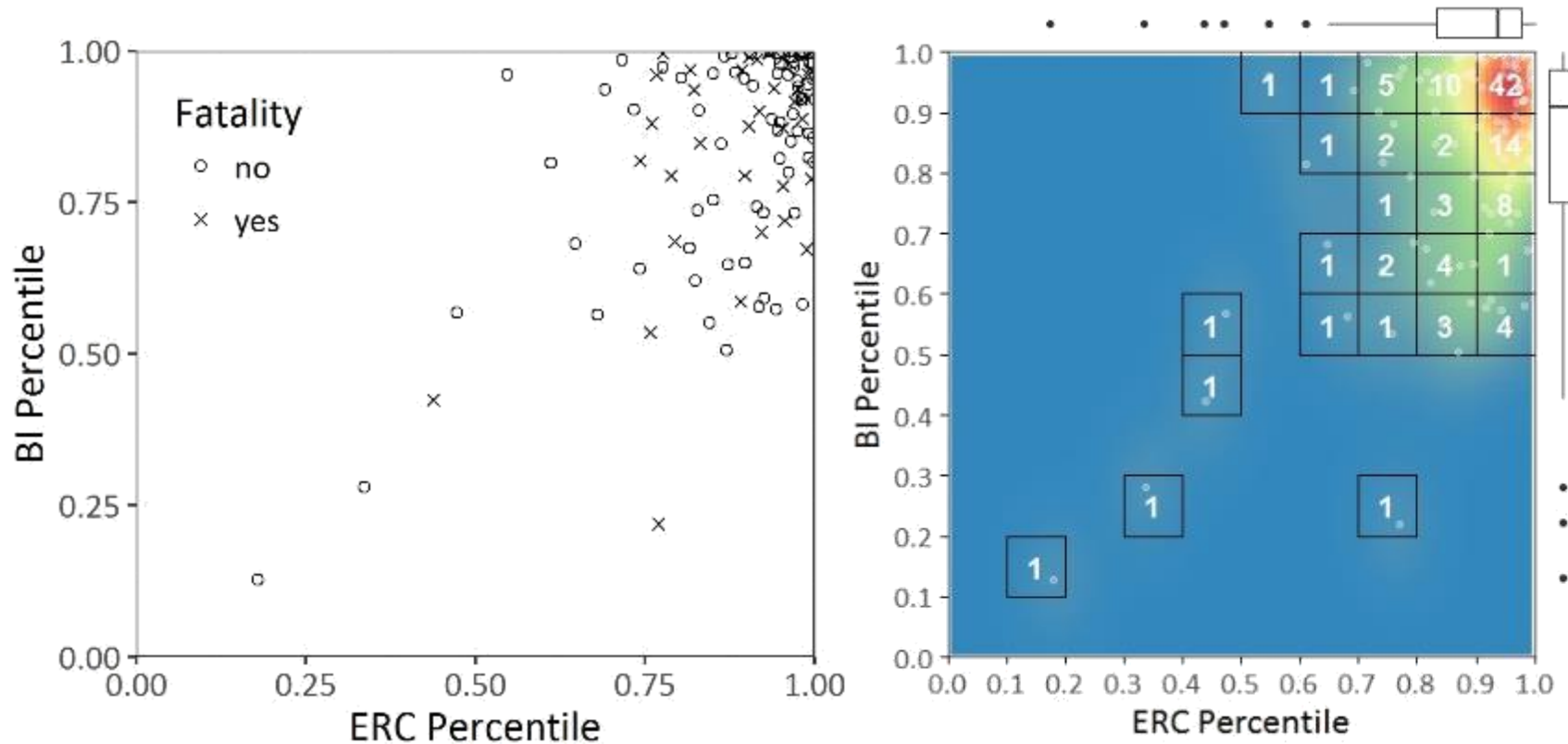


Cedar Fire 2003: By the time the fire was fully contained on November 4, it had destroyed 2,820 buildings (including 2,232 homes) and killed 15 people, including one firefighter.<sup>[2]</sup>

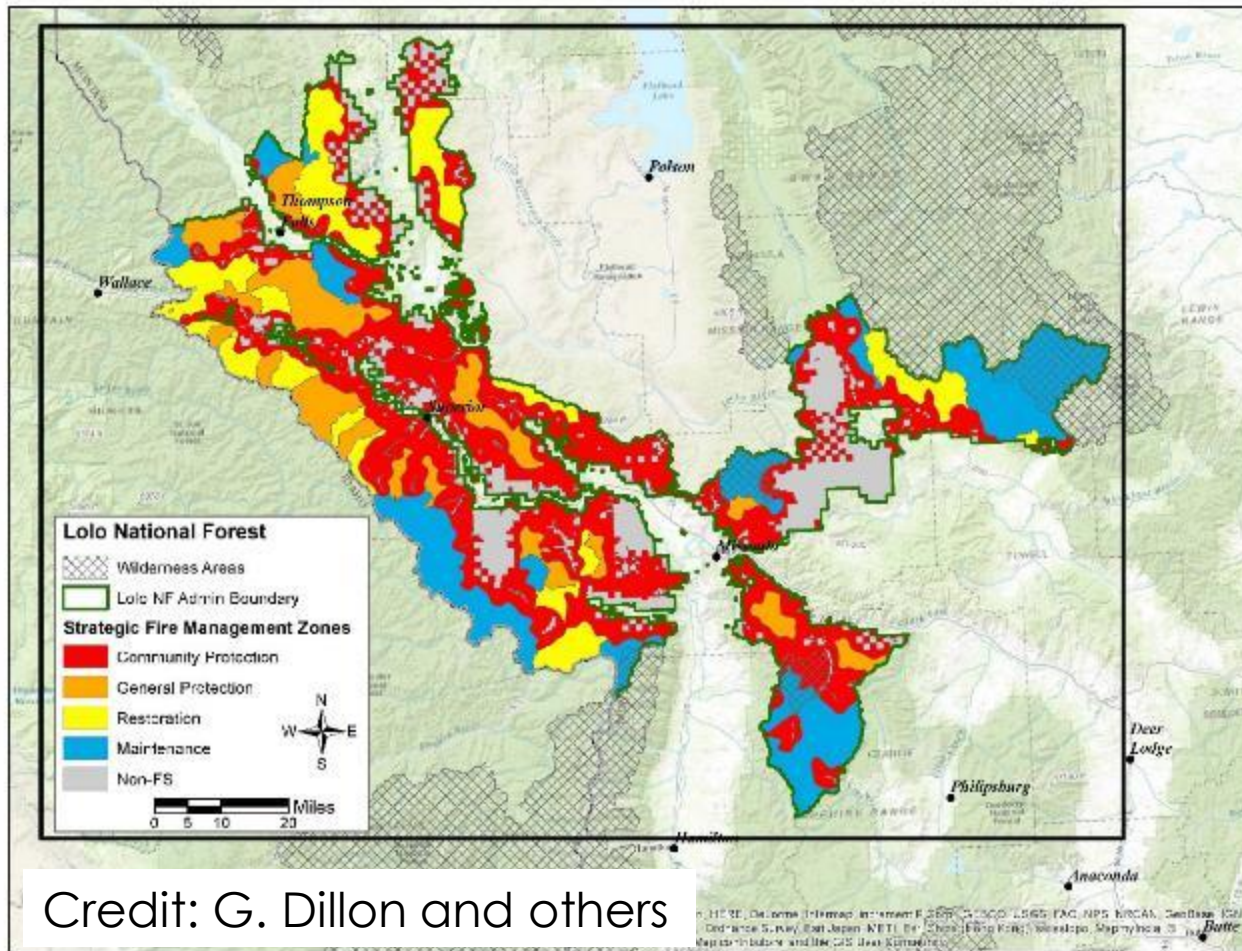


# Relationships between fire danger indices and firefighter entrapments

Page, Freeborn and Jolly, Unpublished Data



# Forest-wide risk assessment for the Lolo National Forest



# Framework for discussion

Fire Environment	Low/Moderate	High/Very High	Extreme
Risk Zones			
Community Protection			
General Protection			
Restoration			
Maintenance			

What strategies usually work?

How would tactics be modified? (Line production, Burnouts, etc..)

Thank you..... Question?

[MJOLLY@FS.FED.US](mailto:MJOLLY@FS.FED.US)



Thanks

