NFDRS2016 FUEL MODEL CONSOLIDATION

Contents

OBJECTIVE(S)

Upon completion of this lesson, participants will be able to:

1. Provide and update of the NFDRS2016

NARRATIVE

I.   INTRODUCTION

A. Fuel Model Consolidation

In 1978 John Deeming, the lead developer of the NFDRS in use today, proposed reducing the nine fuel models in the 1972 system to four in the proposed 1978 update. He was pressured to develop more than the fire behavior fuel models; as a result, 20 NFDRS fuel models were developed. It was not clear however which ones were truly unique.

After conducting ERC calculations for stations across the entire country to evaluate possible differences or similarities between fuel models. It was discovered that some sets of fuel models are in fact perfectly correlated (Figure 1). This high degree of correlation was found among other groups of fuel models (i.e. A and L; G and H; B and F). The results of this analysis showed that there are five unique groups of fuels that tell us something different about how fuels respond to changing weather conditions. Thus, it was determined that the 40 fuel models being used in NFDRS could be consolidated down to five essential fuel models.
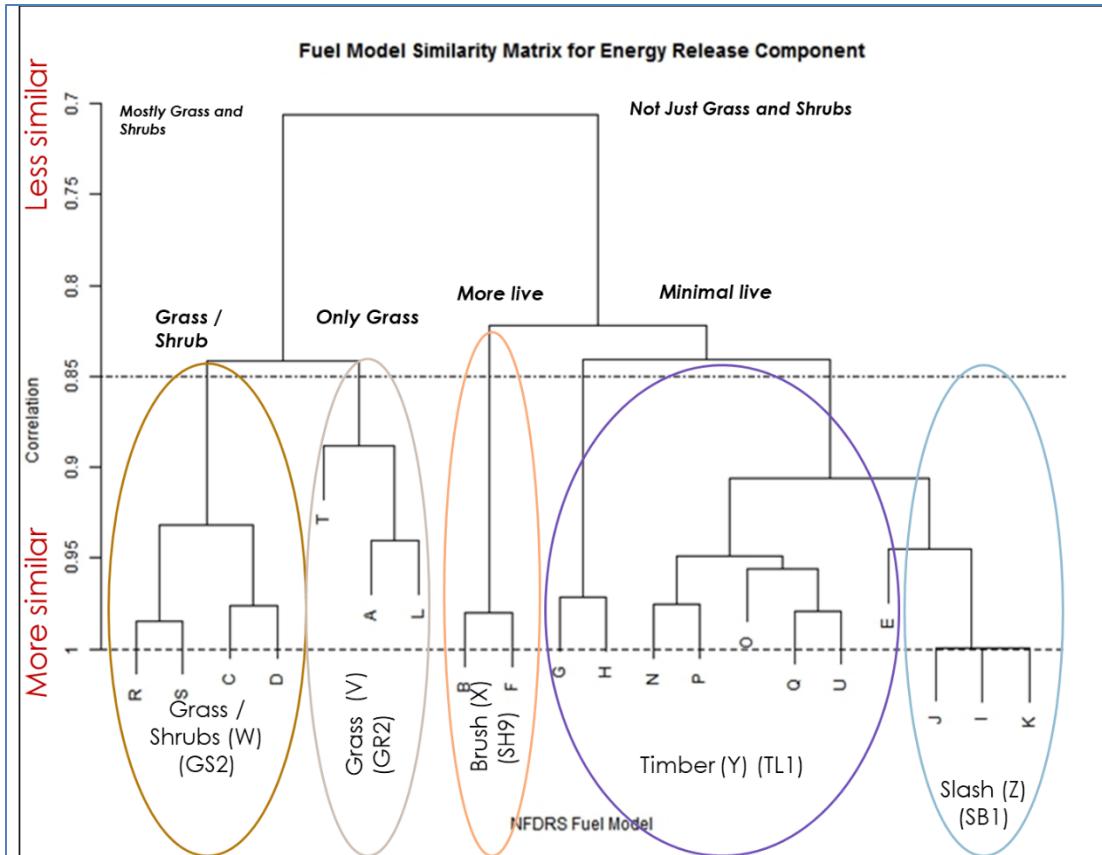
Figure 1. *Similarity plot of the correlation matrix for Energy Release Component calculated for all 20 NFDRS fuel models across 20 widely-spaced weather stations throughout the United States. The lowest correlation between ERC for any fuel model pair was 0.7 and the highest correlations approached unity. The 0.85 correlation line is displayed to indicate the cut-off commonly used to test for autocorrelation of variables and it suggests that there are five fuel model groups that are most unique and that can offer differing views of the seasonal responses of fire danger to varying weather conditions.*

To make transitions between fire behavior and fire danger easier, it was decided to leverage existing fuel models from the fire behavior prediction system Scott and Burgan fuel models (SB40) rather than to have a new set of fuel models just for fire danger. Each of the five fuel types map back to one of the SB40 fuel models (Table 1).

NFDRS 2016 Fuel Type	NFDRS 2016 Fuel Model	SB40 Equivalent	Equivalent NFDRS 1978 Fuel Model
Grass	**V**	GR2 – Grass	A, L, T
Grass/Shrub	**W**	GS2 – Grass/Shrub	R, S, C, D
Brush	**X**	SH9 – Brush	B, F
Timber	**Y**	TL1 - Timber	G, H, N, P, O, Q U, E
Slash	**Z**	SB1 - Slash	I, J, K

Table 1. *Equivalent fuel models to use when translating from previous NFDRS versions to NFDRS 2016.*

II.   NFDRS CALCULATOR

The NFDRS calculator in FireFamilyPlus (FFP) is a tool that allows users to calculate NFDRS indices based on the information the user provides. Although you must have FireFamilyPlus version 5.0 installed on your computer, you can use the NFDRS calculator by itself or in conjunction with other fire analysis software applications. The NFDRS calculator allows users to:
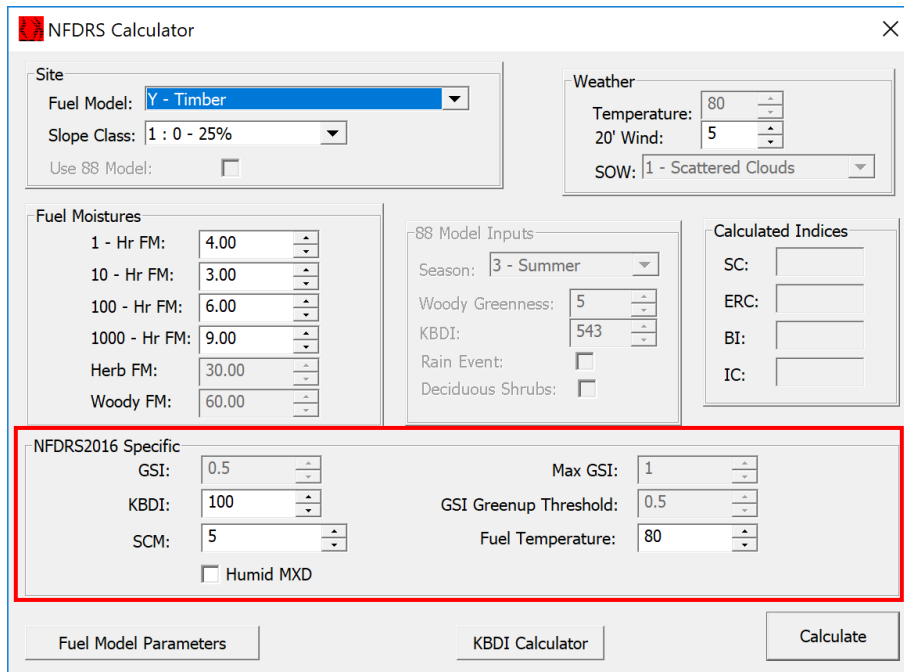
1. Perform NFDRS sensitivity analysis.

2. Compare outputs between fuel models, such as comparing fuel model "G" to "Y", or the NFDRS 78/88 models with the NFDRS2016 model inputs and outputs.

3. Calculate Keetch-Byrum Drought Index (KBDI). Review and compare parameters among fuel models.

This lesson will focus on using the NFDRS calculator to view and compare the 78/88 fuel models with the NFDRS2016 fuel models. This tool can help illustrate the different variable inputs used to calculate index outputs.

To use the NFDRS calculator

1. Click **'NFDRS Calculator'** icon on the FireFamilyPlus toolbar.

    Or you can select the NFDRS calculator from the **'Weather'** menu.

The user selects the fuel model of interest from the drop-down menu at the
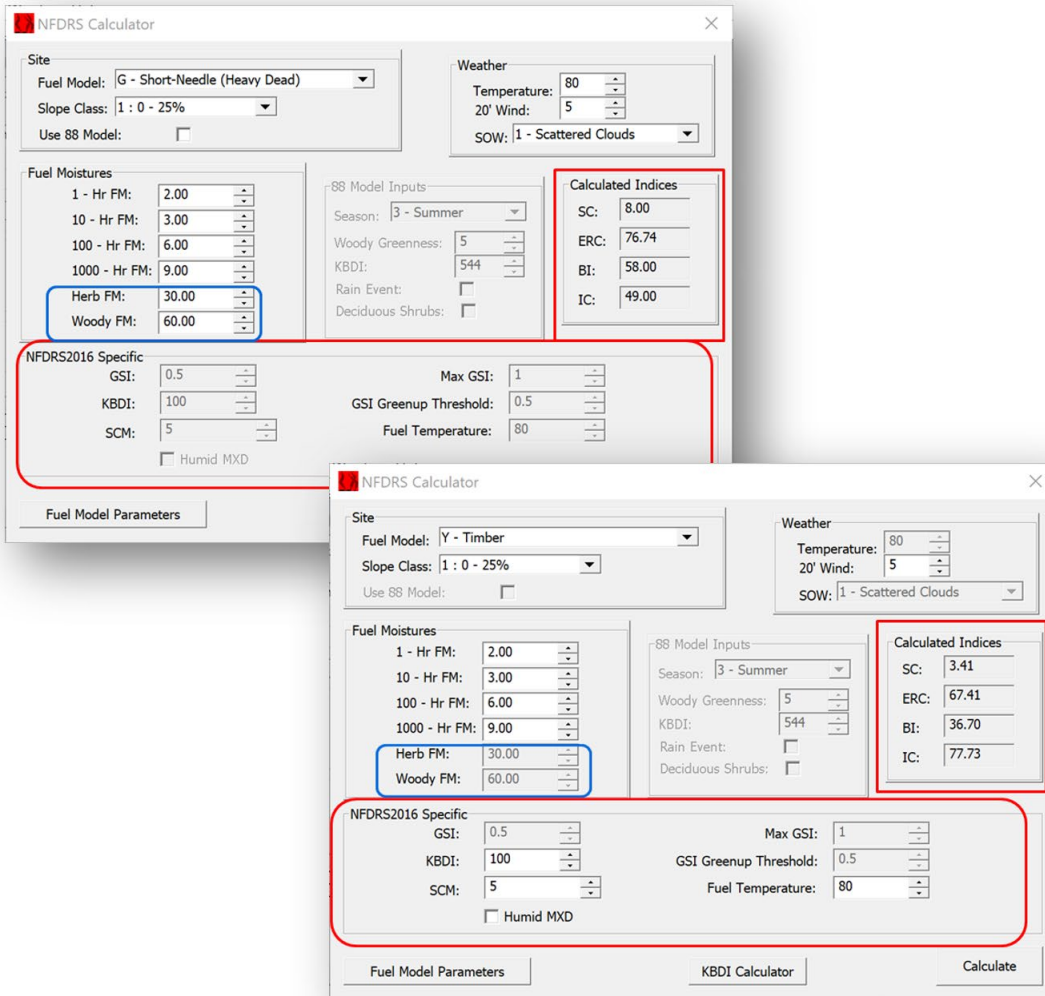
top of the display. Note the NFDRS2016-specific variables in the lower part of the dialog box. These input variables only apply to the new NFDRS2016 fuel models when calculating index outputs. Sections or boxes that are grayed-out indicate variables that are not used to calculate index outputs.

2. If you wish to view or compare fuel model parameters, click on the **'Fuel Model Parameters'** button (lower left) to bring up the following dialog box.

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	☐	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	☐	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

3. Here you can select a fuel model. Each time you click **'Add to Table'** a row is added to the table with the model parameters. The example above shows the differences between fuel models G (*Short-Needle [Heavy Dead]*) and Y (*Timber*). The information table is available as long as the Calculator application is open.

III. TIMBER MODEL COMPARISON: FUEL MODELS G AND Y

1. Note the differences in the calculated indices for each fuel model. Fuel model Y uses the NFDRS2016 Specific input variables as opposed to fuel model G. As stated earlier in Lesson 4 the original fuel moisture calculations in NFDRS lacked the ability to depict seasonal changes in live and dead fuels without substantial user interaction. New enhancements to the NFDRS 2016 model are intended to alleviate some of these limitations. NFDRS2016 applies the Growing Season Index (GSI) to calculate live fuel moisture values and the Nelson Dead Fuel Model to calculate dead fuel moisture values.

2. Differences and similarities can also be demonstrated when viewing the **'Fuel Model Parameters'** in the NFDRS Calculator.

Note similarities as well as differences between fuel models G and Y. The dead fuel loading values are relatively similar (1-, 10-, 100-, and 1000-hour). However, Fuel model Y does not use live fuel loading input values therefore it does not use GSI as part of the index output calculations. Fuel model Y does use a drought fuel loading value where fuel loading is added to fuel moisture in response to drought.

IV. GRASS MODEL COMPARISON: FUEL MODELS A, L, AND V

1. Fuel models A and L utilize the 1-hour and herbaceous live fuel moisture values in the index calculations.

2. Fuel model V uses GSI inputs as part of the index calculations. Note and discuss the calculated indices for each fuel model. Why are the calculated outputs different?

3. Differences and similarities can also be demonstrated when viewing the **'Fuel Model Parameters'** in the NFDRS Calculator.

Note similarities and differences between fuel models A, L, and V. These models are very similar to each other. The grass models do not use 10, 100-, 1000-hour, or Live Woody fuel loading values. None of these fuel models use a drought fuel loading value as part of the calculated index outputs. Also note the differences in the Max Spread Component default values for each fuel model.

V. BRUSH MODEL COMPARISON: FUEL MODELS F AND X

1. Fuel model F utilizes 1-, 10-, 100-, and Woody fuel moisture values to calculate NFDRS outputs.

2. Fuel model X utilizes GSI data to calculate NFDRS outputs. Note and discuss the calculated indices for each fuel model. Why are the calculated outputs different?

3. Fuel model X utilizes GSI data to calculate NFDRS outputs. Note and discuss the calculated indices for each fuel model. Why are the calculated outputs different?

Fuel Model Parameters

Model Selection
Fuel Model: X - Brush   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
F	☐	2.5	2	1.5	0	0	9	0	700	109	30	8	1	1,250	9,500	15	4.5	0.5	24
X	☐	4.5	2.45	0	0	1.55	7	2.5	2,000	109	30	8	2,000	1,500	8,000	25	4.4	0.4	104

Note the similarities as well as the differences between fuel models F and X. Fuel model X does not include 100-hour fuel loading; neither model includes a 1000-hour fuel loading value. Fuel model X does include Herbaceous, Woody, and Drought fuel loading. Fuel model F *does not* utilize Herbaceous or Drought fuel loading values to calculate index outputs. The Max Spread Component default value for fuel model X is significantly higher than the value for fuel model F.
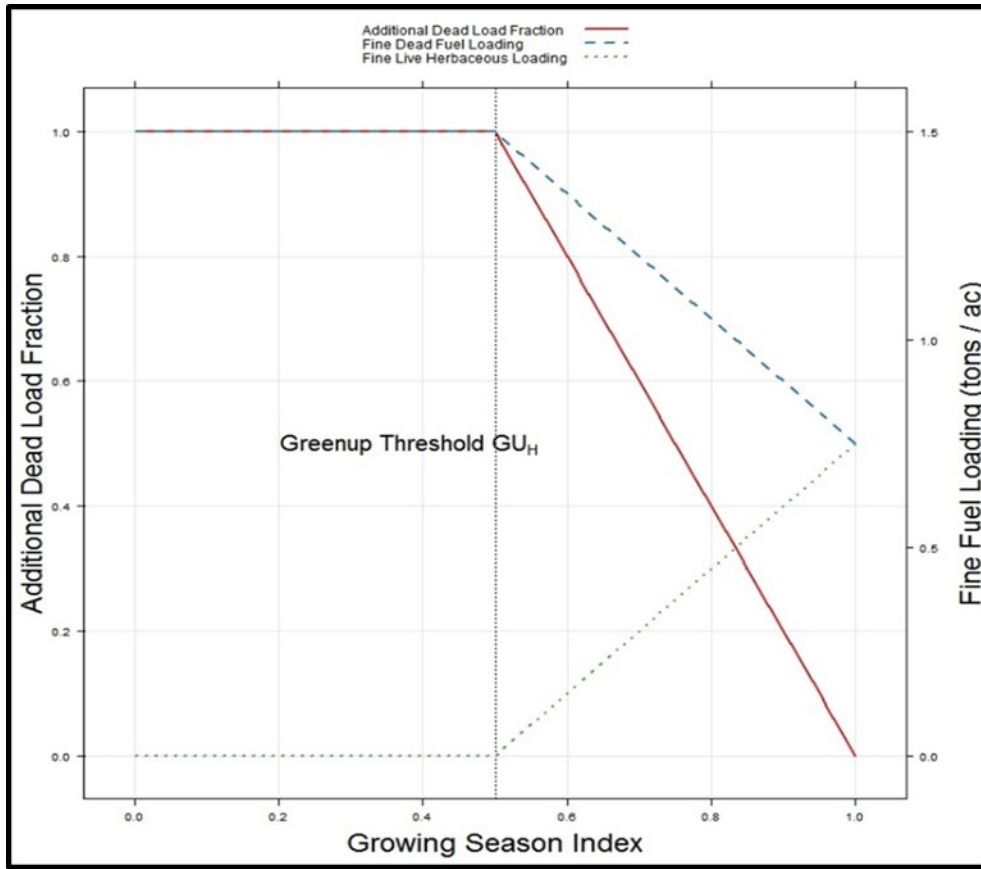
VI. MINOR CHANGES TO THE SYSTEM

There are a few minor changes to the system that simplify existing logic and positions the new NFDRS2016 model to leverage NFDRS for future applications:

1. GSI-driven curing function (replaces load transfer logic).

   a. Curing can be predicted using the Growing Season Index:
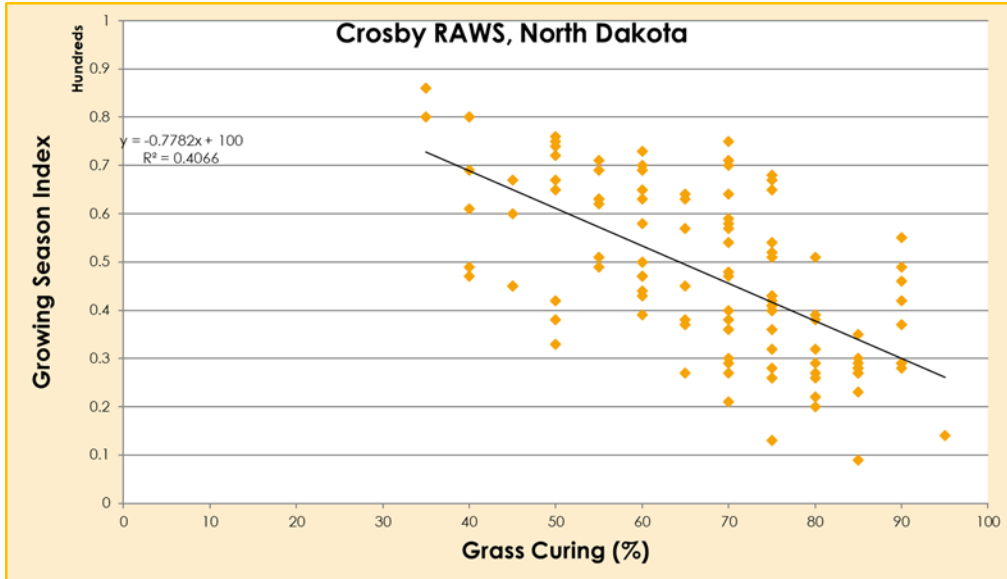
b. GSI will be used calculate the additional dead fuel load as fuels begin to cure and dry out. This will be driven by the Curing Percentage, which represents the ratio of dead fuel to total fuel. This only applies to fuel models that have a live herbaceous loading component.

Curing is expressed at the ratio of fine dead fuel to the total loading. Additional loading is calculated based on the running average of the herbaceous GSI value. If GSI is below the green-up threshold, the curing fraction decreases to zero.

2. Drought fuel loading was added to the 1988 NFDRS model. It simply adds more available fuel as a function of drought which increases the baseline fire index values (Example 1). Drought fuel loading is currently driven by the Keetch-Byram Drought Index (KBDI) however other drought indices will be evaluated in the future. In other words, KBDI is currently being utilized as a "place-holder" for improved drought metrics.
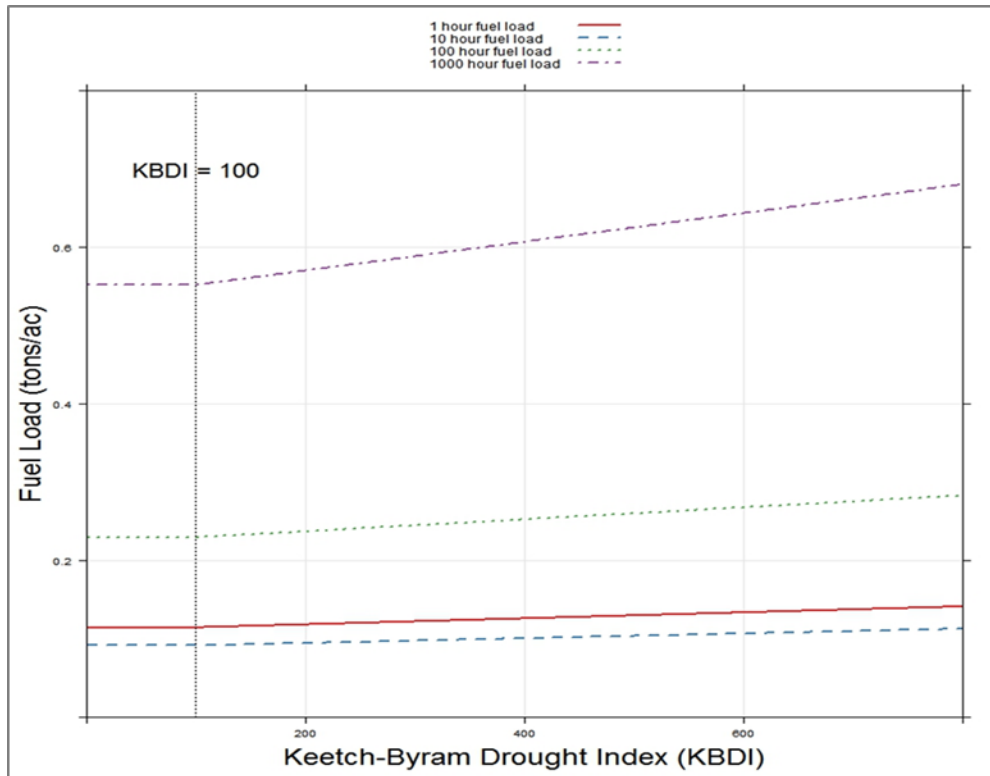
Example 1. This graph illustrates an increase in fuel load for fuel model Y (Timber). As the KBDI value increases, calculated fuel loading for the 1-, 10-, 100-, and 100-hour fuel classes increase as well.

3. Moisture of extinction values for all fuel models are too low to allow proper system operation in more humid areas. A "humid" switch has been added to WIMS to allow users to set the Moisture of Extinction (MXD) value to 40%.

4. Allow for site-specific maximum spread component and variable slope input.

   a. Adjective Rating calculations often work poorly in humid regions where the Spread Component does not approve the SCMax value of the fuel model. NFDRS2016 provides the ability to allow SCMax to vary by location.

   b. NFDRS2016 has added an option to allow the direct input of slope into NFDRS. This paves the way for gridded fire danger applications in the future.

VII. SUMMARY

Over the last four decades the NFDRS has been used extensively to support fire management decisions nationwide. During that time, several system deficiencies have been identified and many lessons have been learned. In order to address these identified needs, three major changes are being implemented in the NFDRS: replacing the dead fuel moisture model, replacing the live fuel moisture model and reducing the number of fuel models.

The NFDRS 2016 model has been updated to a more automated system to aid fire managers and agency administrators with fire management related decisions. The NFDRS 2016 model upgrade is designed to eliminate personal bias from being introduced into the calculations and the resulting NFDRS indices portray an appropriate representation of fire potential. In summary, there is no longer a need for:

- Climate Class
- No required manual entries (i.e. green-up, freeze, dormant dates, and state-of-the weather)
- All revisions in the 1988 system (i.e. deciduous WAF, season codes, greenness factors, 1hr=10hr)
- Weighted sticks
- Fosberg 1- and 10-hour fuel moisture model
- 100- and 1000-hour dead fuel moisture model
- Burgan live fuel moisture model
- Dynamic Load Transfer
- Total of 35 fuel models eliminated

The new system works just as well, or better than the previous system. What does not change:

- Most of the same weather inputs (solar radiation has been incorporated)
- All of the same output components and indices: we still have ERC, BI, SC, and IC
- The look, feel, and use of both FireFamilyPlus and WIMS

The new system is better in that it is fully automated and more consistent; improved response to drought; more easily applied to gridded weather; and ready for future work.
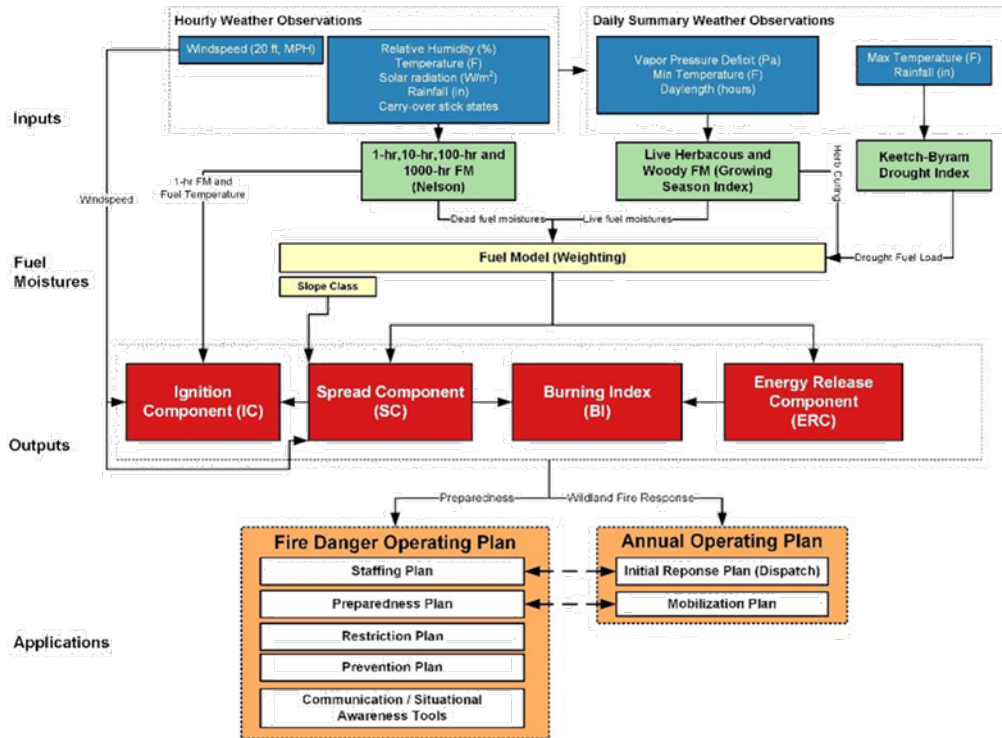
REVIEW OBJECTIVE(S)

Upon completion of this lesson, participants will be able to:

1. Provide an update of the NFDRS2016

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