NATIONAL FIRE DANGER RATING SYSTEM (NFDRS) Briefing Paper Sept. 17, 2014

Background

The United States NFDRS was first implemented nationwide in 1972. It was updated significantly in 1978 and was updated again in 1988. The updates in 1988 were primarily an attempt to improve the assessment of live fuels, primarily in the Southeast US. From the beginning, it was recognized that when new technology became available the system should be updated, yet it has remained essentially static for almost 40 years.

Fire Danger Rating provides Information on current and predicted fire danger conditions over very large areas. This information is calculated using observed or forecasted weather and mathematical models to estimate fuel moisture and fire potential, based primarily on the Rothermel (1972) Fire Spread Model, which remains the principal fire model for most fire management systems in the US.

- Fire danger rating is a numeric scaling of the potential over a large area for fires to ignite, spread, and require fire suppression action.
- It is derived by applying current or predicted conditions of fuel, weather, and topographic factors to a set of complex science-based equations.
- A NFDRS fuel model is not intended to be a perfect match to the local fuel bed conditions, but should be a reasonable representation across a very large area for the purpose of rating fire danger.
- Within NFDRS, fuel models are a component of "Fire Danger Rating Areas", a geographic area that can be tens of thousands of acres in size; is relatively homogenous in climate, fuels, and topography.

NFDRS Outputs: The fire danger rating of an area gives the manager a tool to assist in the day-to-day "fire business" decisions. NFDRS Outputs provide information to help managers:

- Establish staffing levels, preplanned dispatch actions, and daily adjective fire danger ratings,
- Helps define preparedness levels at local, geographic, and national levels.
- Supports severity requests, wildland fire go/no go decisions, and Fire Danger Pocket Cards.

The **Weather Information Management System (WIMS)** houses software for computing daily NFDRS fuel moistures and indices for some 2,000 fire weather stations from the Remote Automated Weather Station (RAWS) network in the US. The WIMS combines the fire danger processor with a national fire weather database to provide graphical and tabular displays of recent, current, and forecasted fire danger.

Difference between Fire Danger Ratings and Fire Behavior Predictions: Since many of the factors (fuels, weather and topography) and terminology (spread and intensity) that are part of fire danger rating are very similar to those that affect fire behavior predictions, fire danger and fire behavior are often confused and misused. **The principle difference is that fire danger is a broad scale assessment while fire behavior is site specific.**

- **Fire danger ratings** describe **conditions that reflect the potential, over a large area**, for a fire to ignite, spread, and require suppression action.
- **Fire behavior** deals with an existing fire in a given time and space. It is expressed as real time or predicted conditions for ongoing fires. Fire Behavior Fuel models were originally 13 models in four groups (Grasses, Shrubs, Timber, and Slash). An additional 40 fuel models have been recently added to this system.

Overall Proposal:

The NWCG Fire Danger Sub-Committee and the NWCG Fire Environment Committee are recommending updates to the United States National Fire Danger Rating System. With over 40 years of data and experience with the existing system, new fuel moisture models allow for significant improvements while eliminating much of the daily interaction with the system. The following proposals were not developed overnight. They have been tested across the country and compared against the existing models for a number of years with good results.

Proposal #1: Incorporate the Growing Season Index (GSI) to compute live fuel moistures

The Growing Season Index is a meteorological based phenology model (Jolly, 2005) that predicts seasonal changes to live fuels. Increasing values of GSI indicate periods of increasing live fuel moisture and decreasing values indicate periods of moisture stress. GSI provides estimates that are closer to measured values than the current NFDRS calculations without the constant "care and feeding" required by the current model. It uses standard observation elements from the RAWS network.

The Wildland Fire Decision Support System (WFDSS) has been using the Growing Season Index (GSI) to model live fuels moisture for two years. GSI live fuel calculations, based on selected RAWS, are used in all WFDSS fire behavior models to populate the woody and herbaceous fuel moisture inputs. Lessons learned from WFDSS are being used to calibrate GSI parameters to a local RAWS for optimal model performance when the model is implemented in WIMS. GSI user interface and algorithms are now being tested in the WIMS Test system.

GSI will be used to replace the existing NFDRS live herbaceous and woody fuel moisture models. This will eliminate the need for managers to enter a green-up date each year because GSI predicts green-up of live fuels from weather observations. The live fuel moisture models in NFDRS have always been cited as the weakest component of the system and this change will significantly improve fire danger rating in areas where live fuels dominate. GSI will provide the improved live fuel modelling needed for the southeastern states to increase their confidence in fire danger outputs.

Highlights:

- **Provides a significantly better live fuel moisture model using elements from a standard fire weather observation.**
- **Requires no constant human intervention yet accurately reflects within season and season-to-season live fuel conditions.**

Proposal #2: Incorporate the Nelson Model to compute fine dead fuel moisture

Developed by Ralph Nelson (Nelson, 2000) it is a model designed to use frequent (hourly or less) weather observations that include temperature, relative humidity, solar radiation, and precipitation amount to compute fine (1 and 10 hour) dead fuel moisture (DFM). The current algorithms for fine DFM in the National Fire Danger Rating System (NFDRS) were originally developed by Mike Fosberg in the 1970s. They use once-a-day weather information and require manual entry of 'state-of-the-weather' and 'fuels wet' codes. These early algorithms were calibrated to estimate fine DFM for mid-afternoon conditions. Legacy DFM models are generally referred to as the "Fosberg" models.

Based upon extensive validation studies in cooperation with Oklahoma State University and the Oklahoma Mesonet (Carlson and others 2005, 2007), the Nelson model was extended from its original formulation of predicting 10-hour fuel moisture to being configurable for any diameter/time lag dead fuel. It constitutes a significant improvement over existing NFDRS DFM algorithms for the 1 and 10 hour fuel moistures. The ability of the Nelson model to predict diurnal fuel moisture and higher levels of fuel moisture than the Fosberg model (e.g. >30%) is useful.

Evaluation is still in progress for the performance of 100 and 1000 hour moistures in the Nelson model and we are not proposing to replace the easy to compute and highly reliable Fosberg solutions at this time.

In December 2010, the production version of WIMS started running the Nelson model, in a prototype mode, for all RAWS stations. It computes fine fuel moisture values and associated NFDRS indices four times per day, 365 days/year. These values are stored in the WIMS database separate from values from the operational Fosberg model to facilitate statistical comparisons.

Highlights:

- **Provides a better fine dead fuel moisture model that accurately models diurnal fine DFM using elements from hourly fire weather observations.**
- **Requires no daily human intervention for state of weather and fuels wet entries**

<u>Proposal #3: Reduce the number of fuel models in the NFDRS.</u>

The first National system (1972) contained 9 fuel models. John Deeming, the lead developer of the 1978 update lobbied for four fuel models, to clearly differentiate between the Fire Danger Rating and Fire Behavior Prediction systems, which were both under development in the mid 1970's. Other forces prevailed however and the 1978 NFDRS was released with 20 fuel models. Local fire management input from the Southeast identified that the 1978 version was not responsive to their fuels, particularly with respect to live fuel moisture. The 1988 update added extra parameters (i.e. drought fuel loads) and modified values (i.e. fuel loads) to the existing fuel models, creating in essence, 20 more fuel models. But it did not fundamentally change the live fuel moisture model; it only gave the user the opportunity (or burden) of manipulating the live fuel moisture model on a daily basis. A comprehensive fix for the live fuel moisture calculations is addressed in Proposal #2.

The demand for more fuel models stemmed from the thought that models with subtle differences would provide an increase in accuracy of outputs, but this was found to unrealistic considering the vast areas being assessed by the NFDRS. Using 10 years of weather data, and computing Energy Release Component distributions for each of the original 20 fuel models (same weather) a statistical similarity analysis shows that the outputs between the various models were highly correlated. In fact, the three slash models are perfectly correlated with each other. By cluster analysis of the correlations, outputs fall into three or four unique fuel model response groups: grass, brush, slash, and timber/litter.

It is proposed that the new system will have four fuel types that reflect the response time of fuels to weather conditions. These models are Short, Medium, Long, and Very Long. These four models correspond to the four Fire Behavior Fuel Model (FBFM) groups: grasses, brush, timber, and slash. These four FBFMs groups are also the fuel models used in WFDSS.

Highlights:

- **Eliminates the '78 vs '88 fuel model distinction/confusion.**
- **Changing from 40 to four NFDRS fuel models will <u>not</u> produce a reduction in model accuracy or outputs.**
- **Simplifying the fuel models used in NFDRS will increase the ability of field personnel to understand and apply fire danger information.**