Understanding the Basics of NFDRSv4

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This is an introduction to the National Fire Danger Rating System (NFDRS), with a focus on the basics of how the version 4 model works. The target audience is everyone in fire and resource management who needs an elementary understanding of NFDRS, primarily firefighters, but also managers, operations specialists, dispatchers, and public information specialists. In-depth model processes, output analysis, and applications for planning and operational decision-making are not covered here.

This introduction includes:

- The foundations of the NFDRS
- The basic structure of the National Fire Danger Rating System version 4 (NFDRSv4), including inputs and outputs.
- The general sensitivity of outputs relative to the inputs.
- Basic NFDRSv4 processor information.
- A list of acronyms.

Foundations of the NFDRS

Evolution of the Fire Danger Rating Model

The origins (around 1922) and subsequent development and revision of the fire danger rating model through the second half of the 20th century are described by Jolly *et al* (2024) and Schlobohm and Brain (2002). During the first two decades of the 21st century, key building blocks were established that would enable the release and adoption of the current model, NFDRSv4, in 2023 (Jolly, *et al*, 2024). These building blocks included installation of solar radiation sensors on the Remote Automatic Weathers Station (RAWS) network and the verification these data could be used to replace the manual entry of State of the Weather; and the development and publication of the "Nelson Model" (Nelson, 2000) for dead fuel moisture and the Growing Season Index (GSI) model (Jolly, *et al*, 2005) for live fuel moisture, both of which enable NFDRSv4 to be fully automated.

Defining Fire Danger Rating

Fire danger is a description of the potential for a fire to start, spread, and require a management response. Fire danger is based on a combination of constant and variable factors, including fuel type; fuel moisture; historical, current and forecasted weather; and topography.

A rating of that potential – a fire danger rating – is a numeric index or adjective representation designed to communicate relative status of the potential, as an aid to decision-making.

Fire danger ratings are reflective of the general conditions affecting an initiating fire, usually over tens of thousands of acres. Ratings are computed daily and hourly, for all available data, specifically:

- Historical data sets, such as the 2002-2025 Period of Record RAWS dataset, used for establishing climatology's, revealing historical trends, and supporting forecasts;
- Current observations, for current status and comparison to historical trends;
- Predicted values, such as the 7-day forecast, for estimating future conditions.

Ratings can be used to guide decisions several days in advance as well as to provide situational awareness by comparing the severity of one day or season to another.

Remote Automatic Weather Stations

The RAWS network consists of several thousand weather-monitoring stations distributed throughout the country which are owned by federal and state organizations. The purpose of the RAWS network is to support point and gridded applications of fire weather for fire program analysis, fire danger rating, fire behavior prediction, fire weather forecasting, and smoke management. RAWS are typically placed in or near areas susceptible to wildland fire activity, including remote locations in complex terrain, and have specific standards which govern their siting, sensor complementation, maintenance, data quality, etc. Stations are expected to comply with the NWCG Standards for Fire Weather Stations, PMS 426-3 (Interagency Standards for Fire and Fire Aviation Operations Group, 2025).

Terminology: System or Model?

Modeling, data and communication infrastructure, user/stakeholder relationships, and other features of a fire danger rating *system* are presented in Jolly, *et al* (2024), and Schlobohm and Brain (2002). The focus here is on the fire danger rating *model*, that is, the one part of the overall system which turns inputs like temperature into outputs like burning index. In this document, the acronym, phrase or word NFDRS, National Fire Danger Rating System, or System refer to the complete system needed to implement fire danger rating at a national scale. Fire Danger Rating Model or simply Model refer to the computations necessary to generate outputs. Different versions of the Model may be referred to as NFDRSv4 or NFDRSv2 for example. Some parts of the Model, such as the Dead and Live Fuel Moisture Models are referred to as Sub-Models. A set of numbers representing a fuel bed for the purpose of calculating fire danger ratings are referred to as fuel models.

Assumptions within the Fire Danger Rating Model

NFDRSv2, the 1978 release, defined four key assumptions upon which the Fire Danger Rating Model is built:

1. Model outputs relate only to the potential of an initiating fire, one that spreads, without crowning or spotting, through continuous fuels on a uniform slope.
2. Model outputs address fire activity from a containment standpoint as opposed to full extinguishment.

3. The ratings are relative, not absolute, and they are linearly related. In other words, if a component or index doubles, the work associated with that output doubles.
4. Ratings represent near worst-case conditions measured at exposed locations at or near the peak of the normal burning period.

Critical to these assumptions is that weather data input be standardized and comparable, including being reflective of "worst-case conditions measured at exposed locations at or near the peak of the normal burning period." Providing such weather input data is the intent of the interagency RAWS network.

For a variety of reasons, the RAWS network no longer meets that specific intention. The largest contributing factor is a lack of adherence to station siting standards, especially exposure, which compromised the 20-foot wind measurement and other standards over time. Additionally, the national processor (Fire Environment Mapping System or FEMS) now utilizes weather data input from other networks with slightly different standards to achieve better national coverage. Stations from the Automated Surface Observing System (ASOS) and state Mesonets represent most stations east of the Rockies used for NFDRS.

The result is a new perspective:

- Assumptions 1 and 2 are general and related to the science of NFDRS and its use of the Rothermel spread equation for an initiating fire, and the relationship of the Model output values to containment difficulty. These assumptions remain solid.
- Assumptions 3 and 4, however, are challenged by using non-standard weather input data. These assumptions no longer hold, and need to be validated at the station level, especially when combining or grouping stations.

The use of standard, comparable input weather data from gridded weather resources will potentially restore or modify these key assumptions in the coming years. This will require a paradigm shift away from the strict use of measured point-location station data, like from the RAWS network, towards the use of comprehensive gridded weather data. Further consideration, conversation and education will be required.

Scientific Basis

Mathematical models are used to calculate fire danger. These models represent basic principl es of combustion physics, plant physiology, and fuel moisture exchange. They incorporate some details beyond the scope of this document, such as the ignition temperatures of woody material, rates of combustion, the moisture of extinction of various types of plant material, the chemical properties of woody debris, and heat energy potential. For more details, see Deeming *et al*. (1977), Bradshaw *et al*. (1983), and Jolly *et al*. (2005.)

Comparison with US Fire Behavior Prediction System

With the adoption of NFDRSv4 in 2023, the underlying modeling computations for fire danger rating and fire behavior prediction are now performed from the same foundational science. Fuel model physical parameters in NFDRSv4 are taken directly from existing fuel models in the US Fire Behavior Prediction System (Jolly, *et al*., 2024). Both systems employ the Rothermel fire spread model. The principal difference is scale: fire danger rating is a broad scale assessment of what might happen somewhere over a large area while fire behavior offers discrete predictions of fire activity at a specific location. 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 prediction deals with an existing fire in a given time and space. Fire behavior describes the movement (rate of spread), intensity (flame length), and indicators of rapid combustion (spotting, crowning, and fire whirls) of that fire. It is expressed as real time or predicted conditions for ongoing or planned fires.

In summary, fire danger rating is a numeric scaling of the potential over a defined area for fires to ignite, spread, and require fire suppression action. It is derived by applying local observations of current or predicted conditions of fuel, weather, and topographic factors to a set of complex science-based equations. The outputs of a fire danger rating system are numeric measures of fire business that provide a tool to assist fire personnel in making appropriate fire preparedness and response decisions. The outputs are relative values best applied to tracking trends in potential, not absolute values expected to predict actual conditions.

Basic Structure of NFDRSv4

The structure of the Fire Danger Rating Model is comprised of inputs (location parameters and weather), intermediate fuel moisture calculations, and outputs (components or index). This section presents each part of the structure, depicted in Figures 1a and 1b.

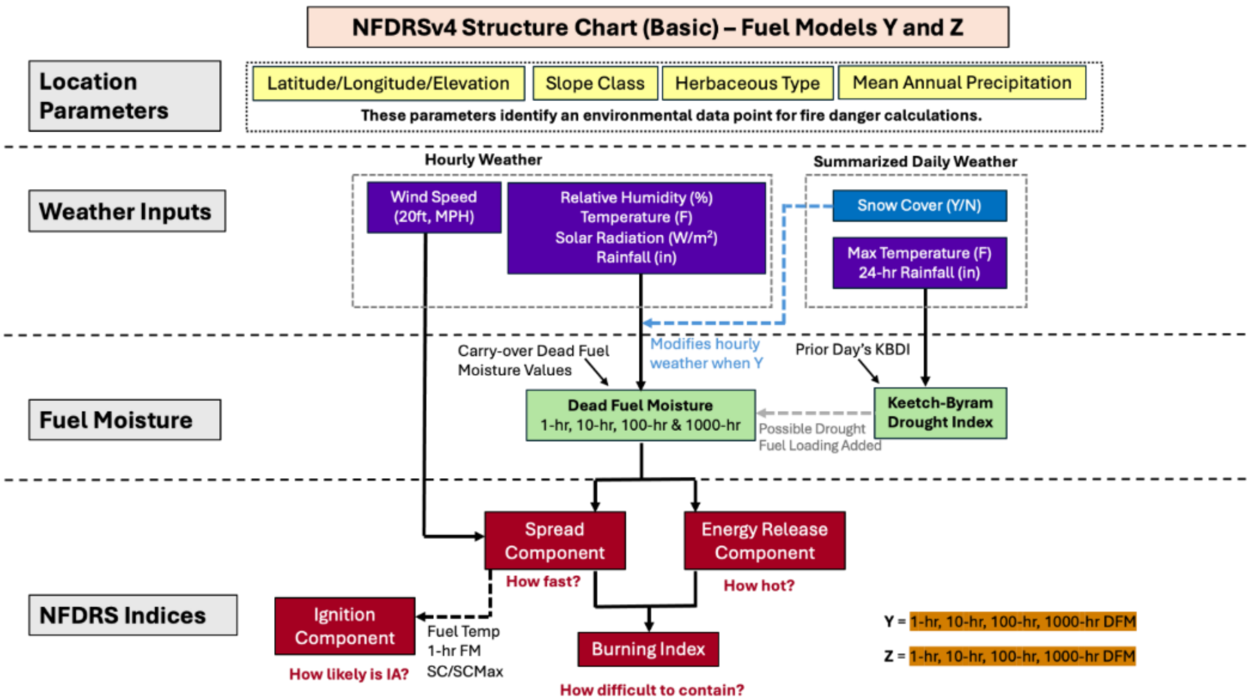

Figure 1a. Basic NFDRSv4 Structure (Fuel Models Y and Z, with dead fuels only)

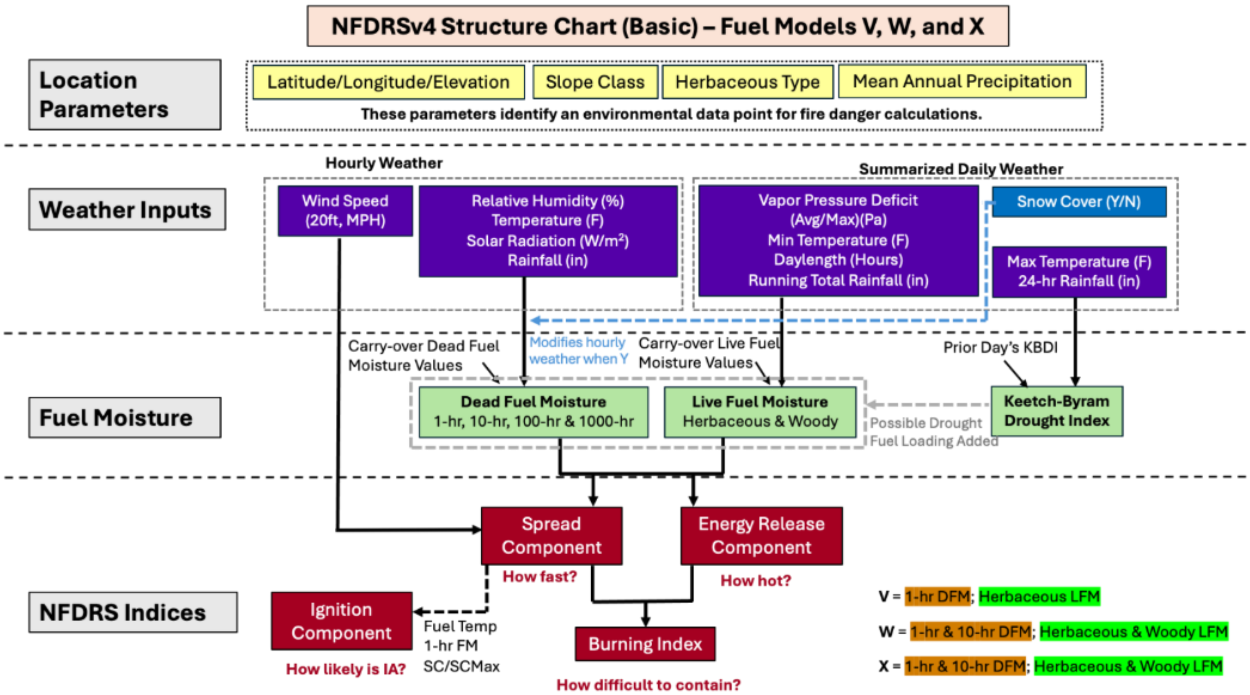

Figure 1b. Basic NFDRSv4 Structure (Fuel Models V, W, X, with mix of live and dead fuels)

Inputs

The data used to calculate model outputs come in two forms. The first is location metadata containing relatively constant site parameters; the second is frequently changing weather data (observations and/or forecasts).

Location Parameters

Location parameters describe the site or area for which fire danger ratings are calculated. They are significant contributors to the outputs of the Model.

Average Annual Precipitation - The average annual total precipitation for an area. It is necessary for computing the Keetch Byram Drought Index (KBDI). Average annual precipitation can come from a variety of sources, such as PRISM or calculating it at the weather station.

Elevation - Feet above mean sea level. With latitude and longitude, elevation is used to identify a physical location, such as for a weather station.

Herbaceous Type - The Model recognizes that there are seasonal differences in fire danger related to the type of grass vegetation present. Annual vegetation produces a different dynamic situation within the fuel complex than does perennial vegetation. Annuals sprout from a seed each year, grow, reach maturity and die usually all in one season. This process is not affected significantly by seasonal weather factors such as temperature or precipitation. Perennial grasses on the other hand, generally start in a dormant condition, grow, reach maturity, then go back into dormancy. Their cycle is greatly affected by temperature and precipitation. The loading of fine fuels associated with annual grasses shifts from live to dead and stays there for the duration of the season. For perennial grasses the shift from live to dead is much slower and may even stop or reverse if the right combinations of temperature and precipitation occur during the season. Where both annual and perennial grasses occur together select the type that predominates the site.

Latitude - The distance of a location north or south of the Earth's equator, measured in degrees from 0° (equator) to 90° (poles). With longitude and elevation, latitude is used to identify a physical location, such as for a weather station. With day of the year, latitude is used to calculate daylength, which is used to calculate the Growing Season Index.

Longitude - The distance of a location east or west of the prime meridian (0°), in Greenwich, England, measured in degrees (0° to 180°) via lines running between the poles. With latitude and elevation, longitude is used to identify a physical location, such as for a weather station.

Slope Class - Slope is the rise or fall in the terrain measured in the number of feet change per 100 feet of horizontal distance. It is expressed as a percentage. When determining slope class, size and scale need to be considered. Keep in mind that terrain is usually not uniform and that benches or small flats affect the average slope for an area. The Model groups slope into five classes: 0-25, 26-40, 41-55, 56-75, and greater than 75%. They are labeled numerically, 1 through 5. The effect of slope class is similar to the effect of windspeed: increasing slope means increasing potential for fire spread.

Weather Data Considerations

The reliability and accuracy of the outputs of the Model are dependent on consistent, high quality weather data. The nature of weather data serving the Model has undergone a scientific transformation over the past several decades such that quality, consistent weather data is now the norm.

Weather data input has evolved from sporadic daily manual observations (of point data), then hourly automated observations from weather station networks (RAWS, ASOS, Mesonets), to full-time, wall-to-wall, systematic sampling and processing (of gridded data) with increasing forecast capability.

The current national NFDRSv4 processor, FEMS, employs a paradigm of a continuous hourly stream of past, present and forecast weather data for station locations; created using both station observations and gridded analyses and forecasts. Quality controls are built in for historical data. Processes are now in place to ensure a continuous stream of weather data from the RAWS network. Details of these processes can be found here.

As NFDRS modeling continues to advance, the future could see a continuous hourly stream of past, present and future weather data for all 5000 grid-points in the domain that covers North America, with quality controls built in for all data and automatic integration into forecast processes.

Data quality and continuity, once the priority concern for input weather data, has been well solutioned by both science and technology on behalf of NFDRSv4 and FEMS.

The focus now is on functional alignment of point and gridded weather data to best serve NFDRS. That is, receiving data from different point observation networks and gridded models in a manner that efficiently feeds the NFDRSv4 model.

Standardized, well-maintained equipment is essential for high quality, reliable weather observation from automated stations. The NFDRS station standards (National Wildfire Coordinating Group, 2000) provide details on weather data collection standards, including observation and transmit times for automated weather stations. Finklin and Fischer (1990) is recommended for more information about maintaining quality weather observations.

Weather Data

Weather data collected hourly are dry bulb temperature, relative humidity, wind speed, wind direction, solar radiation, precipitation amount, and snow flag. Daily observations derived from hourly data are temperature maximum and minimum, and precipitation duration. Some inputs, like vapor pressure deficit and daylength are derived from other collected data.

Daylength - The number of photoperiod hours in a day, computed from site latitude and day of the year; used to compute the GSI.

Dry Bulb Temperature (DBT) - The temperature of the air measured in the shade 4 ½ feet above the ground.

Maximum and Minimum Dry Bulb Temperature - These are the highest and lowest values for temperature measured at the observation site during the preceding 24-hour period. The values are used to adjust the standard drying function of the Model algorithms to more nearly reflect actual conditions.

Precipitation Amount - The total amount of precipitation that occurred over a defined period (usually 1 or 24 hours).

Precipitation Duration - Time, in hours and fraction of hours, that a precipitation event lasts. More precisely, for fire danger rating purposes, the length of time that fuels are subjected to liquid water. This is a critical input into the calculation of Model outputs.

Relative Humidity (RH) - The ratio of the actual amount of water vapor in the air to the amount necessary to saturate the air at that temperature and pressure. It is expressed as a percentage. Note: the relative humidity for the hour of the daily maximum temperature also is used in the calculation of vapor pressure deficit.

Snow Flag - A daily toggle that tells the model to replace ambient weather conditions with values more appropriate for modelling fuel moisture when the fuels are covered by snow. When the snow flag is "on," fuel moisture moves incrementally towards saturation. Snow flag is derived from geosynchronous satellite data and SNOTEL data.

Solar Radiation - The amount of sunlight exposed to the fuels.

Vapor Pressure Deficit - An indicator of water stress influencing plant growth, computed from relative humidity and air temperature; used to compute the GSI.

Wind Direction - Compass direction from which the wind is blowing. Wind direction does not enter into any Model calculations but is used by fire weather forecasters in positioning weather systems on their charts and estimating effects of topography.

Wind Speed (WS) - Wind, in miles per hour, measured at 20 feet above the ground or the average height of the vegetative cover and averaged over at least ten minutes. Refer to the Weather Station Handbook (Finklin and Fischer, 1990) for procedures to adjust measurement height to account for surrounding vegetation.

Fuel Moisture Sub-Models

Dead Fuel Moisture

Dead fuels are those naturally occurring fuels whose moisture content is controlled by external environmental conditions such as temperature, humidity and precipitation. Dead fuels do not have a life cycle, so they don't green up or cure out; they are only affected by changes in weather conditions. Dead fuels are continually exchanging moisture with the surrounding atmosphere. When moisture leaves the fuel at the same rate at which it enters, the fuel is said to be in equilibrium with the surrounding atmosphere. When fuels are not in equilibrium with the atmosphere, which is nearly all the time, they will either extract moisture from it or release moisture to it, depending on whether they are relatively dry or relatively wet.

Dead fuel moisture is modeled for four timelag fuel classes (Figure 2). Timelag is the time necessary for a fuel particle of a particular size to lose approximately 63% of the difference between its initial moisture content and its equilibrium moisture content in its current environment. For more details, see this description of timelag in the S-290 Fuel Moisture Lesson Plan.

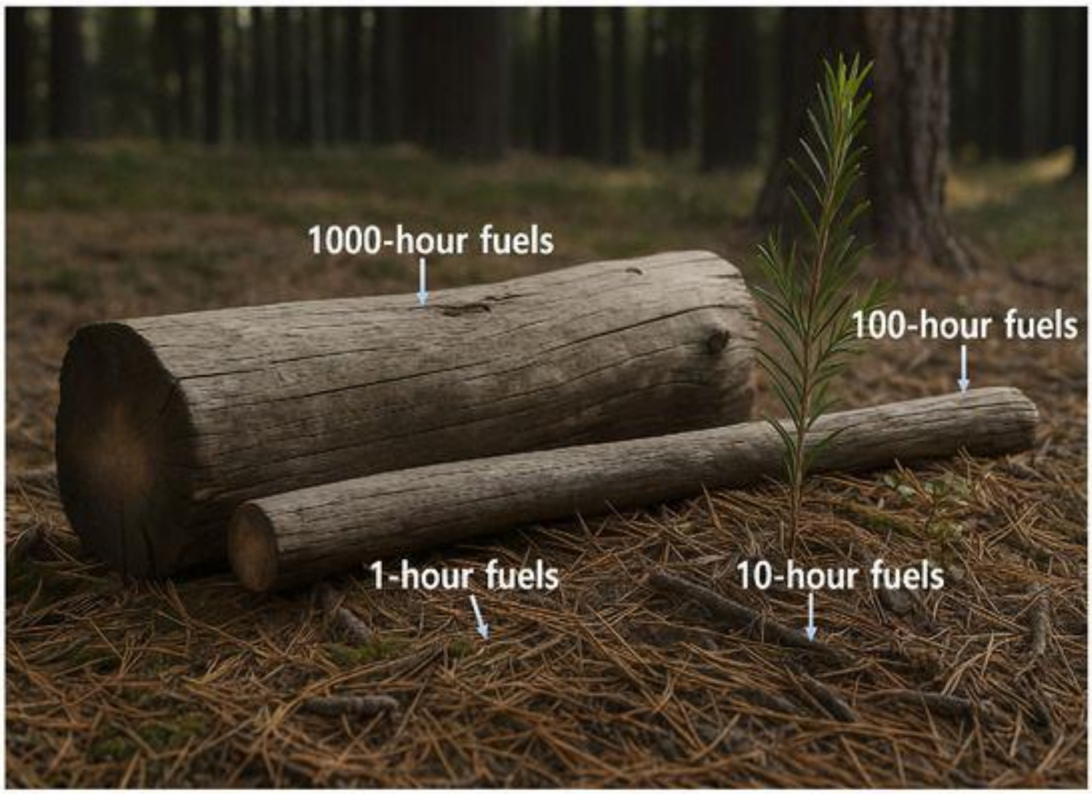

Figure 2: Fuel sizes representative of the four timelag fuel classes (Han *et al* 2026)

1-Hr Fuel Moisture Content - The 1-hour fuel moisture content represents the modeled fuel moisture of dead fuels from herbaceous plants or roundwood that is less than one-quarter inch in diameter. Also estimated is the uppermost layer of litter on the forest floor. Due to its size, this fuel is very responsive to the current atmospheric moisture content. It varies greatly throughout the calendar day and is principally responsible for diurnal changes in fire danger. Values can range from 1 to 80 percent.

10-Hr Fuel Moisture Content - This is the moisture content of dead fuels consisting of roundwood in the size range of one quarter to one inch in diameter and very roughly, the layer of litter extending from just below the surface to three-quarters of an inch below the surface. Ten-hour fuel moisture values vary somewhat with diurnal changes but vary more so with day-to-day changes in weather. Values can range from 1 to 60 percent.

100-Hr Fuel Moisture Content - The 100-hour fuel moisture value represents the modeled moisture content of dead fuels in the 1-to-3-inch diameter class. It can also be used as a very rough estimate of the average moisture content of the forest floor from three-quarters of an inch to four inches below the surface. The 100-hour timelag fuel moisture is a function of daylength, maximum and minimum temperature and relative humidity, and precipitation duration in the previous 24 hours. Values can range from 1 to 50 percent.

1000-Hr Fuel Moisture Content - This value represents the modeled moisture content in the dead fuels in the 3-to-8-inch diameter class and the layer of the forest floor about four inches below the surface. The value is based on a running 7-day average. The 1000-hour timelag fuel moisture is a function of daylength, daily temperature and relative humidity extremes (maximum and minimum values) and the 24- hour precipitation duration values for a 7-day period. Values can range from 1 to 40 percent.

Carry-over Dead Fuel Moisture Value - To model on-going physical processes of drying or wetting, calculated dead fuel moisture values for one hour are brought forward as input values for the calculation of dead fuel moisture for the next hour.

The Nelson Dead Fuel Moisture Model uses physically based models to describe the relationship of several meteorological variables to the temperature and moisture content of fuels. It quantifies the moisture gain or loss due to diffusive and capillary processes. NFDRSv4 provides hourly inputs to the Nelson model that include temperature, relative humidity, hourly precipitation and solar radiation. There are no user inputs to run the model, and it can be configured to estimate the moisture content of any size of fuel particle, from the smallest 1-hour fuels to the largest 1000-hour fuels.

References for dead fuel moisture section: National Wildfire Coordinating Group (2018a), Nelson (2000).

Live Fuel Moisture

Live fuels are those naturally occurring fuels whose moisture content is a function of plant growth, senescence, and dormancy processes influenced by the limiting factors of temperature, water, and light. NFDRSv4 recognizes two types of live fuels - herbaceous (grasses and forbs, annual or perennial) and woody (shrub stems and foliage).

Herbaceous Fuel Moisture - Calculated value representing the approximate moisture content of the vegetation expressed as a percentage of the oven dry weight of a sample. Range of values: 30-250%.

Woody Fuel Moisture - Calculated value representing the approximate moisture content of the vegetation expressed as a percentage of the oven dry weight of a sample. Range of values: 50-200%

Carry-over Live Fuel Moisture Value - To model on-going physical processes of drying or wetting, calculated live fuel moisture values for one hour are brought forward as input values for the calculation of live fuel moisture for the next hour.

The Growing Season Index in NFDRSv4, controls live fuel moistures, replacing the manual entry of green-up and curing or season codes and greenness factors, as well as the 1000-hour and X1000 controls in version 2 (1978) or 3 (1988). The range of values for herbaceous and woody fuel moisture and the behavior of annuals versus perennials are maintained.

GSI is a metric of plant physiological limits to photosynthesis. It is highly correlated to the seasonal changes in both the amount and activity of plant canopies. It predicts the green-up and senescence of live fuels and the influence of water stress events on vegetation. Increasing values of GSI indicate periods of improving conditions for live fuels and decreasing values indicate periods of detrimental weather conditions. GSI is calculated as a function of the three indicators of important weather factors that regulate plant functions. These indicators are combined into a single indicator that integrates the limiting effects of temperature, water, and light deficiencies. The importance of each of the three indicators is explained below.

Daylength (or Photoperiod): Daylength provides a plant with a reliable annual climatic cue because it does not vary from year to year at a given location. Daylength is assumed to provide the outer envelope within which other climatic controls may dictate foliar development. Studies have shown that daylength is important to both leaf flush and leaf senescence throughout the world.

Minimum Temperature: Many of the biochemical processes of plants are sensitive to low temperatures. Constraints on phenology appear to be closely related to restrictions on water uptake by roots when soil temperatures are not ideal.

Vapor Pressure Deficit (VPD): Water stress causes partial to complete stomatal closure, reduces leaf development rate, induces the shedding of leaves, and slows or halts cell division. VPD, an index of evaporative demand, is used as a surrogate for soil water balance.

References for the GSI section: Jolly *et al* (2005); Jolly *et al* (2024), National Wildfire Coordinating Group (2018b).

Keetch-Byram Drought Index (KBDI)

KBDI is a stand-alone index that can be used to measure the effects of seasonal drought on fire potential. The actual numeric value of the index is an estimate of the amount of precipitation (in 100ths of inches) needed to bring the soil back to saturation (a value of 0 is complete saturation of the soil). Since the index only deals with the top eight inches of the soil profile, the maximum KBDI value is 800, meaning 8.00 inches of precipitation would be needed to bring the soil back to saturation.

NFDRSv4 uses KBDI as a signal to adjust live and dead fuel loading. As the index value increases, the vegetation is subjected to increased stress due to moisture deficiency. At higher values, desiccation occurs and live plant material is added to the dead fuel loading on the site.

Fuel Models

A fuel model is a set of numbers representing the contribution to fire danger of the dead and live plant material representative of a location. It reflects the loading (tons/acre), surface-to-volume ratio (square feet/cubic feet), fuel heat content (BTU/lb), moisture of extinction (%), and wind adjustment factor of the fuel bed. A NFDRS fuel model provides a reasonable representation for fire danger rating purposes of local fuel bed conditions, with a different output and a different purpose than a fire behavior fuel model.

NFDRSv4 is built on 5 fuel models that are best described by their unique set of parameters as shown in Table 1 below. These physical parameters are taken directly from fuel models defined by Scott (2005) in the US Fire Behavior Prediction System (Jolly, *et al* 2024). Previous versions of the Fire Danger Rating Model were built on more fuel models, which Jolly has shown to be redundant, and Deeming (see this video) has long argued were unnecessary.

NFDRS Fuel Model	Based on Scott and Burgan..	Fuel Loading (tons ac^{-1})							Surface Area to Volume Ratio (ft^{-1})						Fuel Heat Content (BTU lb^{-1})	Moisture of Extinction (%)	Fuel Bed Depth (ft)	Wind Adjustment Factor (DIM)	Maximum SC
		1-hr	10-hr	100-hr	1000-hr	Herbaceous	Woody	Drought	1-hr	10-hr	100-hr	1000-hr	Herbaceous	Woody					
V	GR2	0.1	0	0	0	1	0	0								15	1	0.6	108
W	GS2	0.5	0.5	0	0	0.6	1	1								15	1.5	0.4	62
X	SH9	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
Y	TL1	2.5	2.2	3.6	10.16	0	0	5								25	0.6	0.2	5
Z	SB2	4.5	4.25	4	4	0	0	7								25	1	0.4	19

Table 1: The fuel models of NFDRSv4, including physical properties of each fuel model and their alignment with Scott and Burgan fire behavior fuel models.

Outputs

Components and Indices

NFDRSv4 has 4 primary outputs that address the range of potential threats posed by a wildfire that factor into response decision-making. Spread Component - “how fast will it spread?” - and Energy Release Component (ERC) - “how hot will it burn?” - are the core components and they influence the two other outputs. Ignition Component - “how likely will initial attack be necessary?” is a combination of probability of ignition and Spread Component. Burning Index - “how difficult to contain?” - is a combination of Spread Component “how fast” and Energy Release Component “how hot.”

Model outputs are relative in the sense that as the value of a component or index doubles, the activity measured by that component or index doubles. An ERC value of 24 represents a potential heat release twice that of an ERC of 12. This helps the users of the NFDRS interpret the meaning of the numbers produced, which is important because most of the primary outputs are expressed on an open-ended scale. Only Ignition Component is constrained to a scale of 0 to 100 by design, to represent the probability a firebrand will cause a fire requiring action if it contacts a receptive fuel. Remember, the outputs are relative, meant for comparison of potential to yesterday or the seasonal average, for example. They are not intended to predict actual conditions for a specific location and time.

All NFDRSv4 outputs are sensitive to fuel model, which determines the amount and proportion of dead and live fuel classes and other characteristics.

Dead Fuel Classes: Fuel models with a high ratio of 1-hr fuels will respond much more rapidly to changes in moisture and wind than fuel models with a high ratio of 1000-hr fuels.

Live Fuel Classes: Fuel models with live components respond in connection to the growing/curing process. The live herbaceous component cures faster and eventually responds to moisture and wind like 1-hr fuels, while the live woody component cures more slowly and eventually responds to moisture and wind like 10-hr/100-hr fuels.

Spread Component – (SC):

Definition: Relative rating of the forward rate of spread of a head fire.
Question Answered: "How fast?"
Primary Influencing Inputs: Wind speed (weather), slope class (location parameters)
Other Important Inputs: Fuel moisture (most weather inputs), fuel model
Response/Memory: Fast response, short memory. Reacts quickly to changes in wind speed and weather inputs controlling 1-hr and herbaceous fuel moistures.

Ignition Component – (IC):

Definition: Probability (0-100%) that a firebrand will cause a fire requiring suppression action
Question Answered: "Will a response be necessary?" or "How likely is initial attack?"
Primary Influencing Inputs: Fuel temperature, 1-hr fuel moisture, Spread Component
Other Important Inputs: Fuel moisture (most weather inputs), fuel model, SCMax
Response/Memory: Fast response, short memory. Reacts quickly to changes in wind speed and weather inputs controlling 1-hr and herbaceous fuel moistures.

Note: Ignition Component is calculated from

- The probability of ignition P(I)
- The observed Spread Component divided by the maximum probable Spread Component (SC/SCmax)

Fuel Temperature and 1-hr FM drive P(I), which is intended to reflect ignition probability in "receptive fuels". The SC/SCmax relationship is fuel model- and location-dependent, and is intended to factor burning conditions into the mix to estimate the probability that the ignition results in a fire requiring a response.

Energy Release Component - (ERC):

Definition: Relative rating of the available energy per unit area (BTU per square foot) within the flaming front at the head of a fire
Question Answered: "How hot?"
Primary Influencing Inputs: Fuel moisture (most weather inputs)
Other Important Inputs: Fuel model
Response/Memory: Fuel model dependent

- ERC from fuel models with higher proportions of 100-hr/1000-hr and live woody fuels responds relatively slowly to changes in moisture and has higher maximum values. Values from the more heavily loaded fuel models (X, Y, Z) can be effective indicators of drought due to their slow response and long memory.
- ERC from fuel models with higher proportions of 1-hr/10hr and herbaceous fuels responds more quickly and has lower maximum values.

Burning Index (BI):

Definition: Relative rating of the contribution of fire behavior to the effort of containing a fire.
Question Answered: "How difficult (to contain)?"
Primary Influencing Inputs: Spread Component and Energy Release Component
Other Important Inputs: Fuel model
Response/Memory: Blends fast response/short memory of SC with fuel model dependent response/memory of ERC for an overall moderate response and memory. SC (via wind speed) drives day-to-day changes while ERC (via fuel moisture and fuel model) determines seasonality.

Processors

Fire Danger Rating Model calculations were originally performed by hand using look-up tables, nomograms and slide rules. These were replaced by handheld programmable calculators, then mainframe and laptop computers. Under the management of the USFS Missoula Firelab, the processes behind the calculations were translated into computer code. The code allowed for standard, systematic, large-scale processing of Model inputs into outputs. This is befitting of a national system!

Technically, any system capable of running the code and correctly computing Model outputs from inputs is an "NFDRS Processor". With NFDRSv3, the code was employed within the Weather Information Management System (WIMS) and the FireFamily Plus desktop analysis software package. The function of WIMS was to produce operational NFDRS values, while FireFamily Plus was focused on evaluation and learning.

NFDRSv4 brought updated science, including the shift to using hourly input instead of daily, and necessitated a significant code update. (Nelson model, etc.) These changes, along with the amount and nature of hourly data required, led to consideration of new operational systems for NFDRS. These considerations were incorporated into the development of the Fire Environment Mapping System (FEMS), along with networked cloud computing capability, to build a robust NFDRSv4 processing and display platform. In 2025, FEMS (https://fems.fs2c.usda.gov/) replaced the WIMS in the United States as the national processor of fire danger information.

Official code, documentation and processors for NFDRSv4 are presented below:

Code

Source code for the US National Fire Danger Rating System Version 4.0, https://github.com/firelab/NFDRS4

Technical Documentation

Model documentation for NFDRSv4 can be found here: Modernizing the US National Fire Danger Rating System (version 4): Simplified fuel models and improved live and dead fuel moisture calculations

1978 National Fire-Danger Rating System: technical documentation: https://research.fs.usda.gov/treesearch/29615. (The core science and calculations behind the indices/outputs did not significantly change with NFDRSv4.)

NFDRS Processors

Fire Environment Mapping System (FEMS) - Operations

FEMS is the official processor for federal land management agencies to run the Model and apply the outputs in the United States. FEMS maintains national catalogs of location parameters, gathers weather inputs from several weather station networks, calculates dead and live fuel moistures, and computes NFDRS component and index outputs hourly and daily. These outputs are displayed for the user in interactive maps, charts, and tables. For more information about FEMS processing, see the FEMS User Guide on the FEMS Portal.

FEMS Application
FEMS Portal

FireFamily Plus (FFP, v5.0) – Evaluation

FFP, an agency-independent Windows application, is a primary tool in the fire behavior/fire danger suite of programs which share data and models that are used in a variety of environments to address a range of business needs. FFP matches the calculations and outputs of FEMS. FFP supports the spectrum of fire weather/fire danger/fire climate/fire occurrence analysis tools required by fire managers to successfully use the NFDRS.

FFP can be used to compute components and indices of the NFDRS from weather climatology data. FFP is also used to apply these outputs to climatology and fire occurrence data for planning and decision-making purposes.

FFP Application

Other Processors

NFDRSv4 has enabled full automation of the model calculations. With automation and public domain access to code and documentation, third parties are integrating NFDRSv4 into other processors. For example, Technosylva Company and NOAA's Storm Prediction Center have incorporated NFDRSv4 into their own processors. Knowing what models are used in the processor for an application is a recommended best practice.

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Appendix

Acronyms

ASOS	Automated Surface Observing System
BI	Burning Index
BTU	British Thermal Unit
DFM	Dead Fuel Moisture
ERC	Energy Release Component
FEMS	Fire Environment Mapping System
FFP	FireFamily Plus
FM	Fuel Moisture
GSI	Growing Season Index
IA	Initial Attack
IC	Ignition Component
KBDI	Keetch-Byram Drought Index
LFM	Live Fuel Moisture
Mesonet	Mesoscale Network
MPH	Miles Per Hour
NFDRS	National Fire Danger Rating System
NFDRSv4	National Fire Danger Rating System version 4
NWCG	National Wildfire Coordinating Group
PMS	Publications Management System
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RAWS	Remote Automatic Weather Station
RH	Relative Humidity
SC	Spread Component
SCMax	Spread Component Maximum
SNOTEL	Snowpack Telemetry Network

USDA	United States Department of Agriculture
VPD	Vapor Pressure Deficit
WIMS	Weather Information Management System
WS	Wind Speed