**Lake States Fire Science Consortium**

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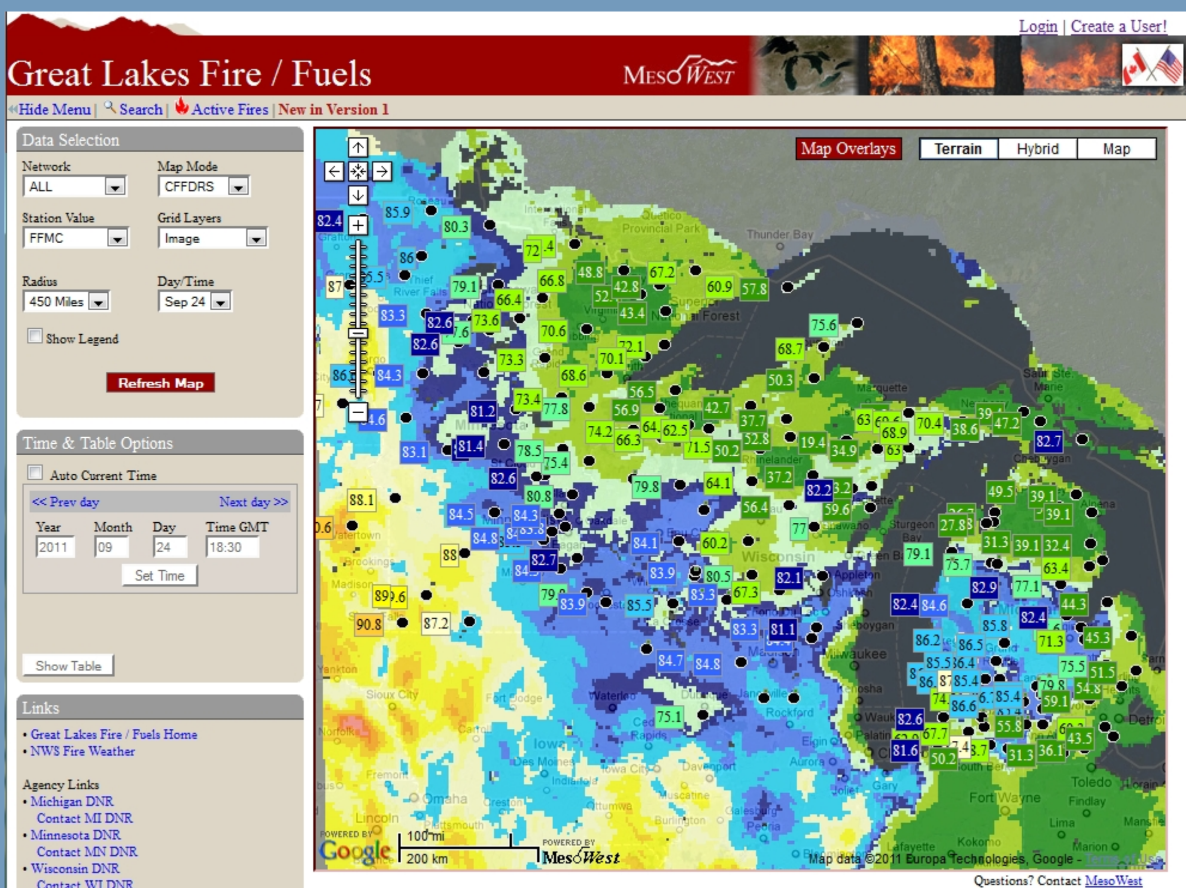
Technical Guide 11-1

# Working With the Great Lakes Fire and Fuels Information System Tools in Lake States Fire Management





**Robert Ziel**

Lake States Fire Science Consortium

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Accelerate the awareness, understanding, and adoption of wildland fire science information by federal, tribal, state, local, and private stakeholders across the Lake States and adjacent Canada.

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# Working With the Great Lakes Fire and Fuels Information System Tools in Lake States Fire Management

## Technical Guide 11-1


## ABSTRACT

Providing a comprehensive set of weather information, and integrating it with modeled fire danger, behavior, and effects information in a single information system provides an important resource for decision-makers and can be used as an aid in developing research questions. Great Lakes Fire/Fuels provides such a resource, with data from a variety of weather recording station networks and National Weather Service (NWS) gridded products. Improved access to displays in both geographic and historical contexts helps fill gaps in traditional data sources and forecast horizons. The system recognizes the importance of weather, fuels, and fire behavior interpretations to fire management decisions before, during, and after the fire event. Placing this variety of data sources and associated interpretations in context will suggest a wide range of research questions related to data quality, model applicability and user accessibility.


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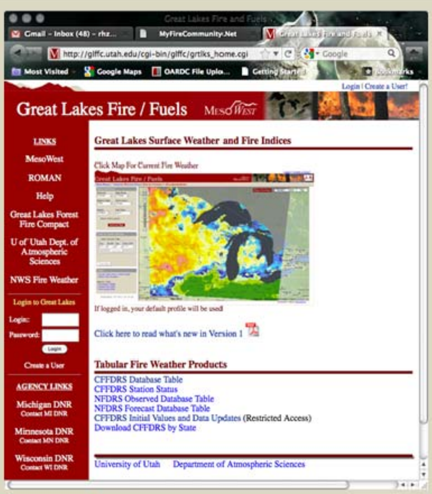
## INTRODUCTION

Beginning in 2008, Mesowest (http://mesowest.utah.edu) and the state Natural Resource agencies from Michigan, Minnesota, and Wisconsin began work on a web-based fire weather and fire danger information system that produces and displays a variety of information intended to support wildland fire decision-making in the Lake States. With the project approaching completion, Great Lakes Fire/Fuels (http://glffc.utah.edu/glffc) focuses on the Canadian Forest Fire Danger Rating System (CFFDRS); though a limited complement of National Fire Danger Rating System (NFDRS) outputs are provided for display. The site is available publicly to anyone interested in the information. With a wealth of hourly weather observations from hundreds of recording stations throughout the three states and a variety of products to choose from, configuring the site to specific uses is important. With many in the Lake States still not comfortable with CFFDRS, some background and interpretation may be appropriate. This brief summary and synthesis of the science embedded in Great Lakes Fire/Fuels is intended to help with the orientation.

### The User Interfaces – Two Views

**The Welcome View**

http://glffc.utah.edu/glffc



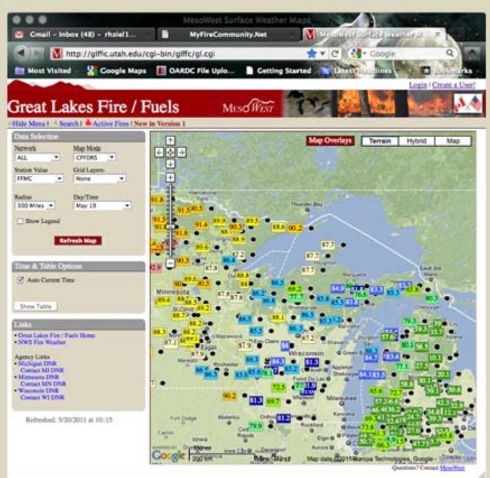
The ***Welcome View*** provides best access to the database of all observations and forecasts.

The ***Map View*** put's "current" forecasts and observations into a landscape context. It provides quick access to tables and graphs for a given station.

Both provide access to important links and either can serve as your initial screen

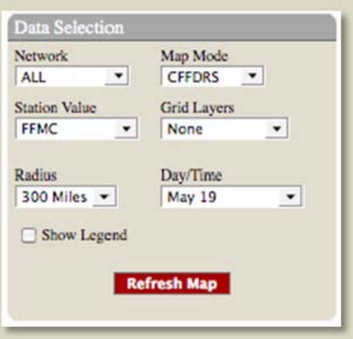
**The Map View**

http://glffc.utah.edu/cgi-bin/glffc/gl.cgi



Once in the Map View, the ***Data Selection*** box controls what is displayed:

- ***Network*** determines which group of stations is displayed
- ***Map Mode*** allows selection of CFFDRS, NFDRS, or Mesowest modes
- ***Station Value*** allows selection of the item displayed on the map
- ***Grid Layers*** allows the display of 5km grid for the selected station value
- ***Radius*** provides a means to adjust the radius for station selection around a point. Point may be selected by click on map or ***Search*** link found above.
- ***Day/Time*** allows user to select among the last daily observation day, the current hourly observation time, or one of the next two daily forecasts.



## SUGGESTED READING

de Groot, W.J. 1987. ***Interpreting the Canadian Forest Fire Weather Index (FWI) System***. Pages 3-14 in Proceedings: Fourth Central Regional Fire Weather Committee Scientific and Technical Seminar. April 2, 1987, Winnipeg, Manitoba. Canadian Forestry Service, Northern Forestry Centre, Edmonton, Alberta.

Glahn, H.R., and Ruth, D.P. 2003. ***The New Digital Forecast Database of the National Weather Service***. Bulletin of the American Meteorology Society. **84**: 195-201. DOI: 10.1175/BAMS-84-2-19

Horel, J., et al. 2002: ***Mesowest: Cooperative Mesonets in the Western United States*****.** Bulletin of the American Meteorology Society. **83**: 211–225. doi: 10.1175/1520-0477(2002)083<0211:MCMITW>2.3.CO;2

Lawson, B.D., and Armitage, O.B. 2008. ***Weather guide for the Canadian Forest Fire Danger Rating System***. Nat. Res. Can., Can. For. Serv., North. For. Cent., Edmonton, AB.

Manikin, G.S. 2009, ***Challenges with the Real-Time Mesoscale Analysis (RTMA)***; In 23rd Conference on Weather Analysis and Forecasting/19th Conference on Numerical Weather Prediction – Session 1A: Real-Time Modeling and Analysis

Taylor, S.W., and Alexander, M.E. 2006. ***Science, technology, and human factors in fire danger rating: the Canadian experience***. International Journal of Wildland Fire **15**: 121-135.

## SYSTEM COMPONENTS

### Data Sources

Mesowest was selected to construct this system because of its underlying access to numerous networks of weather recording stations that are providing real time data. Users have access to the full suite of Mesowest sites and data elements for a given station by selecting ***Mesowest*** for the Map Mode in the data selection box.

The ***CFFDRS database*** has access to the complete set of weather recording stations available at Mesowest. Selected stations among NWS, RAWS, and Enviroweather (MAWN) stations are currently being used. The database includes only the four weather elements (Temperature, Relative Humidity, Surface Windspeed, and Hourly Precipitation Amounts) required for Fire Weather Index (FWI) System calculations. Hourly data is accommodated and available for display. Observation data is collected each hour and 48 hours of updated National Digital Forecast Database (NDFD) forecasts are collected four times each day. Rainfall totals for the next daily observation combine observed totals so far with expected amounts for the rest of the 24-hour period ending at 1800 GMT. FWI codes and indices are updated from these observations and forecasts as they are collected. Selected users have the ability to initialize and/or edit observations to manage calculations

***5-km Grids*** of Real-Time Mesoscale Analysis (RTMA) and NDFD Forecast data for the three Lake States are used to calculated updated daily FWI codes and indices four times each day.  These grids are stored in a database and may be displayed and queried when the data source is in CFFDRS Map Mode.

The ***NFDRS database*** is populated directly from the Weather Information Management System (WIMS) operated nationally in the United States. Only data collected at 1300 Local Standard Time is provided. Underlying data becomes available only after WIMS system users update observation records each day in a timely manner and subsequent point forecasts are submitted. There is no attempt to make independent calculations from observations or integrate NDFD forecasts. It is displayed as is for user convenience.

**CFFDRS Fire Weather Index (FWI) System**

Although deGroot (1987) and Lawson and Armitage (2008) provide more detail about the system, a few words here may help system users in making initial choices.

The FWI system integrates four very basic weather observations:

1. Temperature
2. Relative Humidity
3. Windspeed
4. Accumulated Rainfall

The basic system is based on observations collected at midday, when the sun is at its highest point in the sky.  With this information, the system is calibrated to estimate fuel moisture and fire behavior conditions for the peak period at approximately 1600 Local Standard Time.

There are three (3) ***fuel moisture codes*** calculated with these weather observations (Fig. 1).  Like other accounting systems, the FWI system combines knowl-

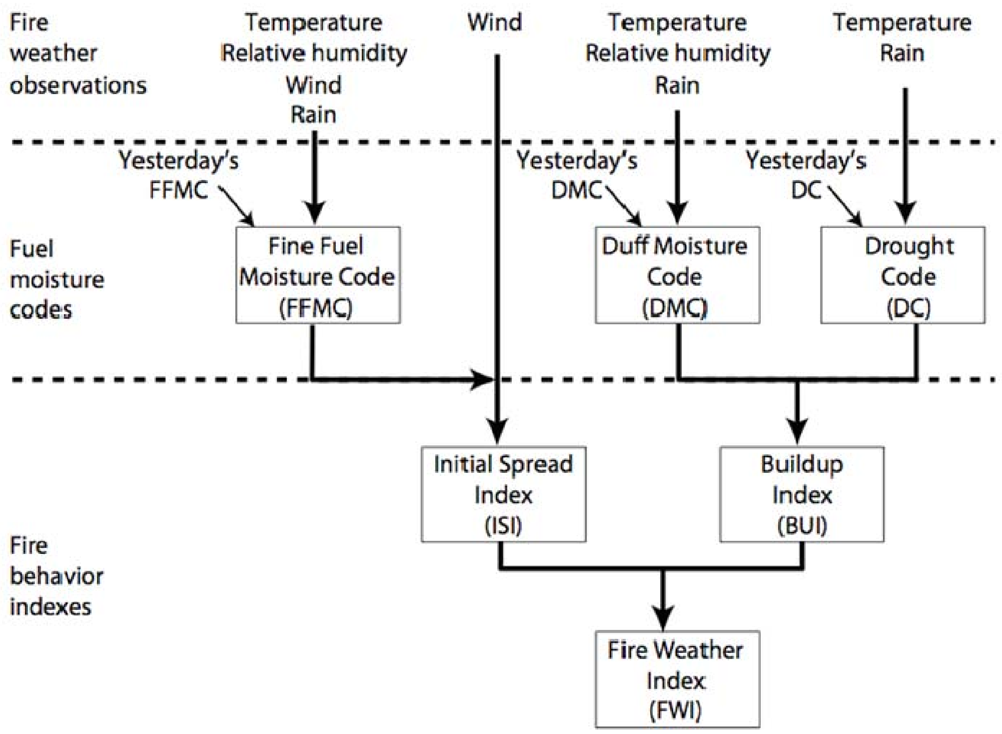



**Fig. 1.** Structure of the Canadian Forest Fire Weather Index System (from Lawson & Armitage, 2008).

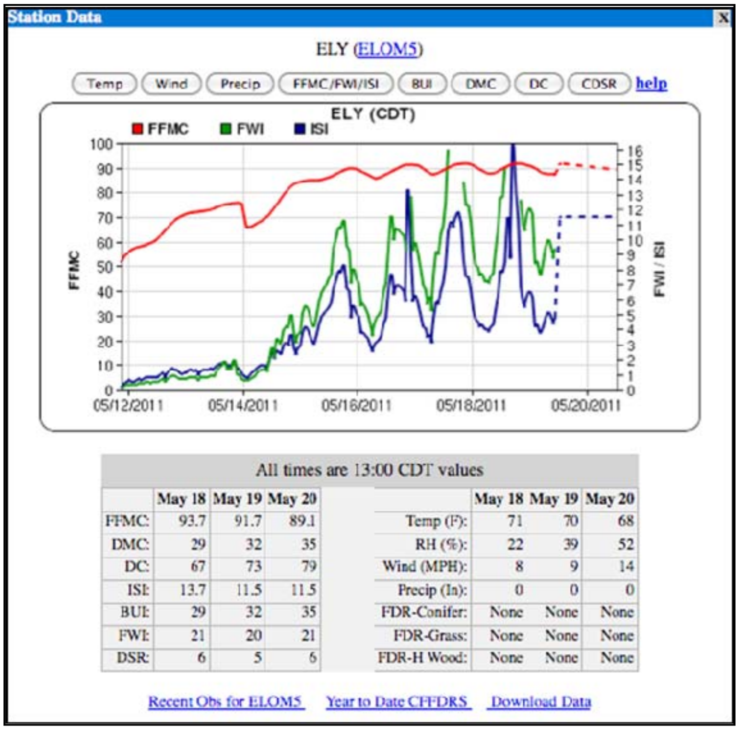
edge of yesterday's (or last hour's) fuel moisture conditions with the influence of air temperature, atmospheric moisture, wind, and precipitation since then. The ***Fine Fuel Moisture Code (FFMC)*** represents fuel moisture of forest litter fuels under the shade of a forest canopy. It is intended to represent moisture conditions for the equivalent of 16-hour timelag fuels. It ranges from 0-101, with a practical maximum of 96 in the Lake States. Subtracting the FFMC value from 100 can provide an estimate for the equivalent fuel moisture content. The ***Duff Moisture Code (DMC)*** represents fuel moisture of decomposed organic material underneath the litter. System designers suggest that it is represents moisture conditions for the equivalent of 12-day (or 288 hr) timelag fuels. It is unitless, with a practical range of 0-120 in the Lake States. The ***Drought Code (DC)***, much like the Keetch-Byrum Drought Index, represents drying deep into the soil. It approximates moisture conditions for the equivalent of 52-day (1,248 hour) timelag fuels. It is unitless, with a maximum value of 1,000. Extreme drought conditions in the Eastern Upper Peninsula have produced DC values near 650.

Similarly, there are three (3) ***fire behavior indices*** intended to represent spread, fuel consumption/heat release, and fire intensity. The ***Initial Spread Index (ISI)*** integrates fuel moisture for fine dead fuels and surface windspeed to estimate a spread potential. It is unitless, with a practical maximum of 30 in the Lake States. The ***Buildup Index (BUI)*** combines the current DMC and DC to produce an estimate of potential heat release in heavier fuels, somewhat similar to the Energy Release Component in NFDRS). It is unitless, with a practical maximum of 175 in the Lake States. It may provide insight to moisture stress in live fuels. The ***Fire Weather Index (FWI)*** integrates current ISI and BUI to produce a unitless index of general fire intensity potential. Again, unitless, it has a practical maximum of 60 here.

Because these codes and indices are unitless and are not normalized, interpretations should be considered in a historical context, based on thorough calibration. They were designed for the boreal forest, but have been calibrated effectively for a variety of climates and landscapes around the world.

### Effective Display of Forecasts with Current & Past Observations

While map displays effectively compare current conditions throughout a landscape and database tables provide comprehensive listings, comparing the recent past, current conditions, and forecasted situations is accomplished for specific weather observing sites by clicking on the point from the Map View (Fig. 2).




| | May 18 | May 19 | May 20 | | May 18 | May 19 | May 20 |
|---|---|---|---|---|---|---|---|
| FFMC: | 93.7 | 91.7 | 89.1 | Temp (F): | 71 | 70 | 68 |
| DMC: | 29 | 32 | 35 | RH (%): | 22 | 39 | 52 |
| DC: | 67 | 73 | 79 | Wind (MPH): | 8 | 9 | 14 |
| ISI: | 13.7 | 11.5 | 11.5 | Precip (In): | 0 | 0 | 0 |
| BUI: | 29 | 32 | 35 | FDR-Conifer: | None | None | None |
| FWI: | 21 | 20 | 21 | FDR-Grass: | None | None | None |
| DSR: | 6 | 5 | 6 | FDR-H Wood: | None | None | None |

**Fig. 2.** Station Data Popup Window, requested with mouse click on station location.

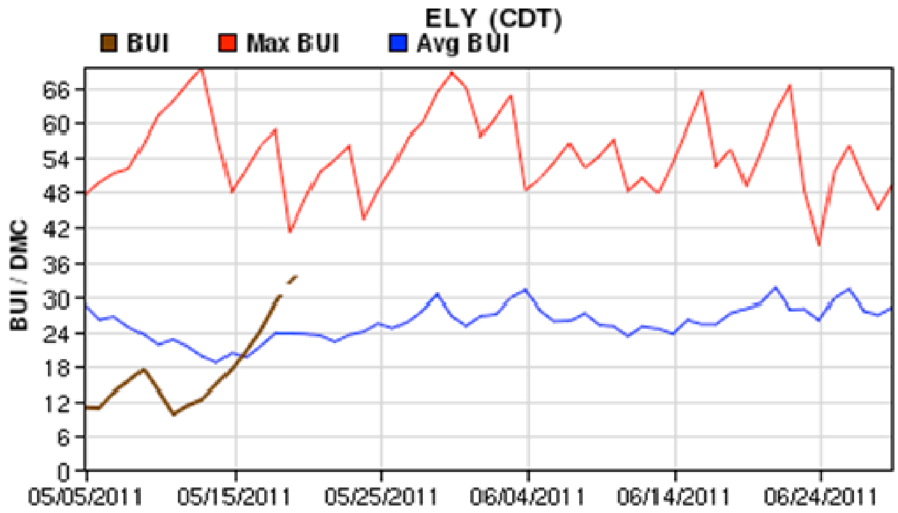



**Fig. 3.** Graph in Station Data Popup, requested with mouse click to button(s) above graph.

By default, views of hourly values (weather elements, FFMC, ISI, and FWI) include the past seven days and the next two daily forecasts. These allow users to quickly identify day to day variations and peak events in the past week.

Below the graph area, a display of all weather elements and daily CFFDRS codes for the most current observation and the next two daily forecasts. Fuel based fire danger interpretations may also be displayed. Links to facilitate access to the more comprehensive Mesowest observation database, the CFFDRS database table and data download procedures.

### Climatological Context for Current Conditions

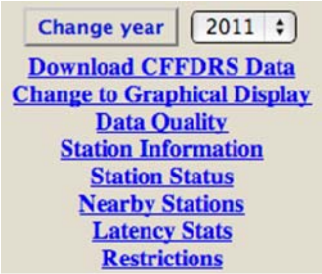
From this same display of station data, graphs of codes and indices that represent a more seasonal, or cumulative, look (DMC, DC, BUI, CDSR) include the past two weeks, the two daily forecasts, and six weeks of climatological maximum and average trends to provide a context into the outlook period.

Combined with 6-10 day, 8-14 day and/or 30-day outlooks, these trends can suggest fuel moisture and fire behavior potential into the future (Fig. 3).

### Archive of Historical Data for Retrospective Analysis

From the CFFDRS or NFDRS database tables for any station (linked in the Welcome View); the available historic record can be accessed. Simply select one of the available years and click the ***Change Year*** button. If the date in the table is displayed as a blue hyperlink, hourly codes are available for display as well.

Reviewing FWI codes and indices for weather conditions associated with known fire events provides for calibration exercises and understanding of the sensitivities of each code and index.



## Using RTMA & NDFD Data to Localize Interpretations

There are two valuable resources for background information on developing localized interpretations, including the Real-Time Mesoscale Analysis (Maniken 2009) and the National Digital Forecast Database (Glahn and Ruth 2009). As shown here, these gridded weather data elements and the CFFDRS codes and Indices calculated from them can be displayed across the three states (Fig. 4). The scale is rather coarse, with each grid cell representing approximately 25 square kilometers (9 square miles). However precipitation patterns, which are not always understood by looking at recording station data, play an important role in determining fuel moistures and fire behavior potential, especially during the growing season. These patterns can be easily seen here (Fig. 4).

Unlike other map depictions, these grids are not smoothed contours derived from the recording station data. They are, instead, using modeled RTMA "observations" and NDFD forecasts provided individually for each 5-km grid cell to calculate daily CFFDRS codes and indices. Though these tools are still being evaluated and modified, they represent a part of the future for integrating climate, weather and landscape analysis.

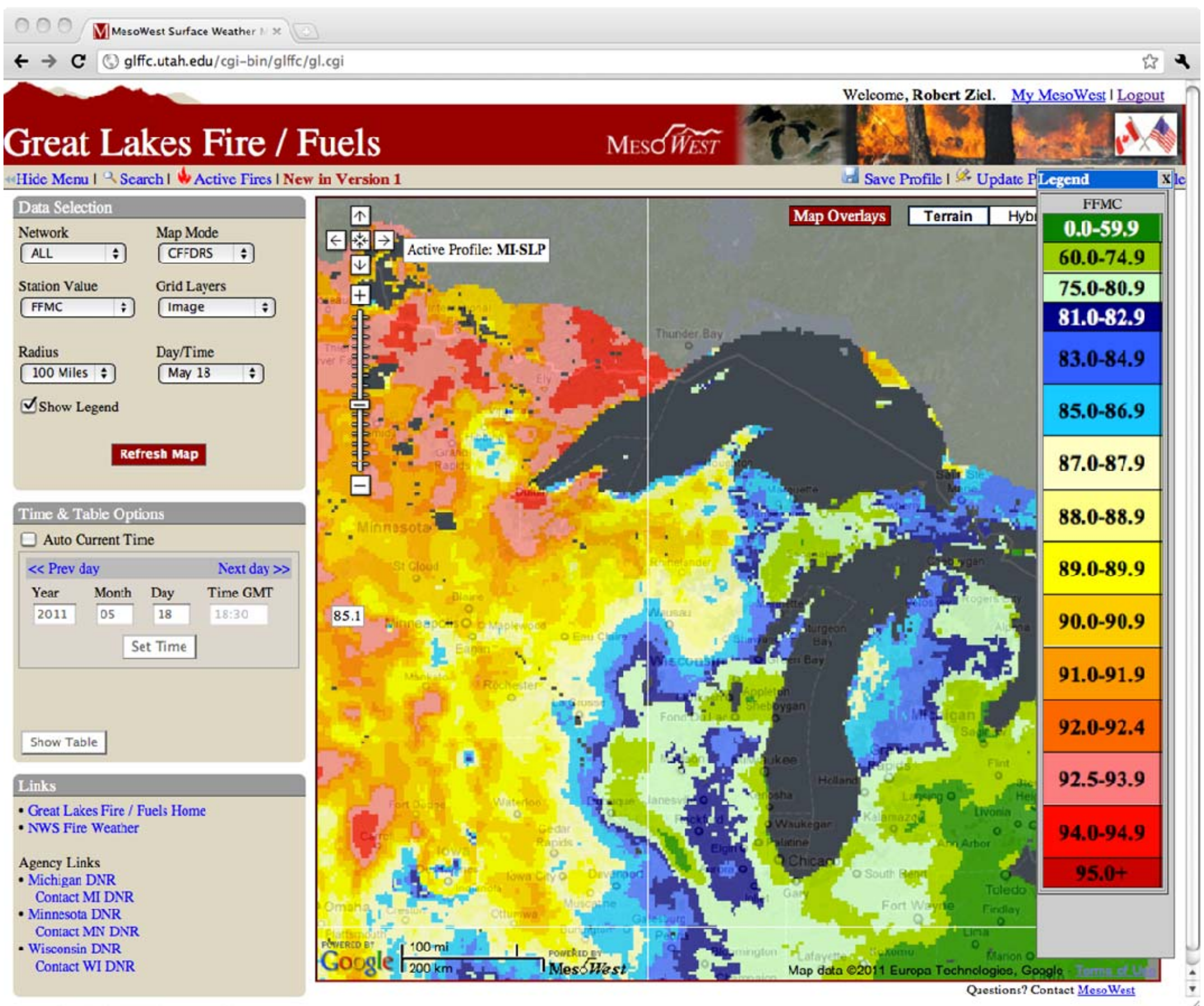



**Fig. 4.** Map View with gridded Fine Fuel Moisture Codes (FFMC) displayed. Values derived from RTMA weather inputs are updated daily. Forecast grids are updated from NDFD inputs that are revised three times a day with updated model outputs.

**Creating, Saving, and Loading User Profiles**

With the variety of data elements and display configurations available in the data selection box, it could take several steps to customize and localize the display to a particular need. User profiles are provided to make it easy to recall customized displays.

On the left hand panel of the Welcome View, there is a login box including both space for registered users to login and new users to register as a regular user.  The registration process is simple and the information is not re-distributed without permission. It does provide two important benefits.

- Registered users, if logged in, can create, save and use custom profiles that remember settings in the data selection box, the display scale, and the center point for station selection.  One of these profiles can be selected as the default profile which is used automatically in the Map View.
- Data downloads are restricted to limit demands on the system processors.  Registered users have somewhat expanded capabilities.


## APPLICATIONS & IMPLICATIONS

### Thresholds & Color Coding of Indices

The color scale depicted here represents the standard colors and descriptors for the National Fire Danger Rating System (NFDRS) adjective level. While the CFFDRS scale reverses the blue and green colors for the “low” and “moderate” categories, the design team decided to retain the NFDRS color scheme to maintain consistency with the network of fire danger signs located throughout the three states.

As departures from the WIMS implementation of NFDRS approach to fire danger rating in the U.S., two important modifications in threshold criteria have been implemented by the three states as a part of Great Lakes Fire/Fuels.

First, there are 15 identified classes for each of the CFFDRS fuel moisture codes and fire behavior indices.  They are grouped into the 5-color NFDRS scheme with 3 shades of each base color.  These 15 classes are based on thresholds established from a variety of sources, including: (1) the Ontario class structure for each of the codes/indices; (2) the MIDNR fire danger rating criteria; (3), the WI DNR fire danger rating criteria for pine, hardwoods, and grass; and (4) a Fire Behavior Quick Reference used by the MN DNR.


Second, the Fire Danger Rating (FDR) is based on a combination of codes and indices intended to represent the changing character of the fire problem as the danger level increases.  These criteria use codes, such as FFMC (spring) and BUI (summer), to determine potential for ignition as the first thresholds for fire concern, subsequently adding ISI and FWI as indicators of fire spread and fire intensity as the overall danger increases.

Providing these additional thresholds suggests opportunities for tailoring interpretations and decisions more specifically to different burn windows and fire management decisions.

**Legends for the Fuel Moisture and Fire Behavior Codes & Indices**

| FFMC | DMC | DC | ISI | BUI | FWI |
|---|---|---|---|---|---|
| 0.0-59.9 | 0.0-5.9 | 0.0-14.9 | 0.0-1.9 | 0.0-9.9 | 0.0-1.9 |
| 60.0-74.9 | 6.0-9.9 | 15.0-49.9 | 2.0-2.9 | 10.0-14.9 | 2.0-3.9 |
| 75.0-80.9 | 10.0-12.9 | 50.0-79.9 | 3.0-3.9 | 15.0-18.9 | 4.0-4.9 |
| 81.0-82.9 | 13.0-19.9 | 80.0-99.9 | 4.0-5.9 | 19.0-24.9 | 5.0-7.9 |
| 83.0-84.9 | 20.0-24.9 | 100.0-199.9 | 6.0-6.9 | 25.0-29.9 | 8.0-9.9 |
| 85.0-86.9 | 25.0-27.9 | 200.0-209.9 | 7.0-7.9 | 30.0-33.9 | 10.0-13.9 |
| 87.0-87.9 | 28.0-33.9 | 210.0-229.9 | 8.0-8.9 | 34.0-39.9 | 14.0-15.9 |
| 88.0-88.9 | 34.0-39.9 | 230.0-249.9 | 9.0-9.9 | 40.0-49.9 | 16.0-18.9 |
| 89.0-89.9 | 40.0-41.9 | 250.0-273.9 | 10.0-10.9 | 50.0-53.9 | 19.0-20.9 |
| 90.0-90.9 | 42.0-49.9 | 274.0-299.9 | 11.0-13.9 | 54.0-61.9 | 21.0-23.9 |
| 91.0-91.9 | 50.0-59.9 | 300.0-329.9 | 14.0-16.9 | 62.0-69.9 | 24.0-29.9 |
| 92.0-92.4 | 60.0-62.9 | 330.0-359.9 | 17.0-18.9 | 70.0-76.9 | 30.0-32.9 |
| 92.5-93.9 | 63.0-69.9 | 360.0-399.9 | 19.0-21.9 | 77.0-79.9 | 33.0-34.9 |
| 94.0-94.9 | 70.0-79.9 | 400.0-499.9 | 22.0-24.9 | 80.0-99.9 | 35.0-44.9 |
| 95.0+ | 80.0+ | 500+ | 25.0+ | 100.0+ | 45.0+ |

Looking at these legends for each of the codes and indices will suggest a few important interpretations.

- Unlike fuel moistures in the U.S. system, all of these values start with zero (0) as the lowest potential for the applicable fire behavior characteristic, increasing to indicate growing potential.
- These thresholds were calibrated to weather observations and associated fire occurrence in the northern Lake States. Despite that, maximum values and common ranges across the southern portions of the three states since the system came online suggest that the scales established here generally bound the range of possibilities. More work needs to be done to validate calibrations for these areas.
- Where possible, the upper and lower classes within each color group suggest that the value is in transition to (or from) the adjacent color group. These tend to include narrower bands of values.
- It is possible to have “extreme” conditions in one code and “low” conditions in another. For example, spring FFMC values can quickly reach elevated levels with a few days of drying, while DMC and DC generally require weeks or months to reach levels of concern.

### Fire Danger Interpretations

Fire danger rating systems, like many other danger rating systems, are designed to alert user groups to prompt specific responses. Fire danger ratings have broad applications, ranging from prevention decisions and actions, to specific instructions for agency readiness and response to wildfires. They generally are calibrated to identify day-to-day changes and the responses that are necessary to address them.

In the **spring**, ignition and initial spread are the primary differences in day-to-day changes that dictate fire danger decisions. FFMC and ISI represent these differences effectively. Only when these conditions have reached elevated states, does using FWI factor in the overall difficulty of control.

In the **summer**, live fuel conditions are responsible for much of the variability. It continues to be represented temporally through day to day weather as represented by ISI. However, drought conditions provide important insight for what overall potential the current weather can influence. BUI represents the influence of drought on live vegetation and the availability of litter and duff fuels for burning. Further, the implemented criteria recognize how different ecosystems respond differently to these influences.

In the **autumn**, moisture conditions in the duff as well as litter fuels are represented through use of the BUI. FFMC is still important to day-to-day variation, though it is embedded as part of the ISI value in the criteria. Perennial vegetation can still hold moisture and retard fire spread.

Although each fire management agency in the Lake States has established their own danger rating criteria, this system (as implemented in Great Lakes Fire/Fuels) presents a good example and reference for other calibrations.

### Fire Behavior & Fire Effects Interpretations

Users seeking specific estimates of these fire behavior parameters and projections will find that CFFDRS includes an integrated Fire Behavior Prediction System (FBP) that utilize estimates of Initial Spread Index (ISI) and Buildup Index (BUI) in the prediction of ignition, spread, and intensity. However, consider these tools to help characterize Fire Behavior and Fire Effects (see page 13).

| FIRE BEHAVIOR FACTOR | PARAMETERS MONITORED IN GREAT LAKES FIRE/FUELS | UTILITY AND INTERPRETATION |
|---|---|---|
| Live Fuel Flammability | Date Criteria<br>Duff Moisture Code (DMC)<br>Buildup Index (BUI) | During the summer, live fuel conditions are the first factor driving potential for active fire behavior. Understanding and following transitions in the spring and fall, and tracking moisture stress during the growing season, can be aided by calibrations of DMC and/or BUI. |
| Spotting & Ignition | Fine Fuel Moisture (FFMC)<br>Duff Moisture Code (DMC)<br>Wind Speed<br>Wind Direction<br>Ambient Air Temperature | FFMC is the primary means of evaluating ignition probability in the system, though it probably responds to drying conditions more slowly after rains than grass fuels demonstrate. DMC may indicate lightning ignition potential at values above 20 and duff fuel availability at values above 40. |
| Spread Potential | Initial Spread Index (ISI) | ISI, as displayed in the danger rating criteria, needs to be scaled according to live fuel conditions. Values of 4, 8, and 12 are significant thresholds captured in the danger rating criteria. As stated above, DMC and BUI can be used to indicate the transition of live fuels from heat sink to heat source. |
| Resistance to Control | Fire Weather Index (FWI)<br>Duff Moisture Code (DMC)<br>Buildup Index (BUI)<br>Drought Code (DC) | Though the traditional criterion for control problems is fireline intensity (FWI in this case), increasing contributions from litter, duff, and organic soils can be important factors. |

| FIRE EFFECTS FACTOR | PARAMETERS MONITORED IN GREAT LAKES FIRE/FUELS | UTILITY AND INTERPRETATION |
|---|---|---|
| Vegetative Sensitivity | Date Criteria | Many species exhibit seasonal variation in their sensitivity and response to fire on the landscape. CFFDRS codes and indices need to be calibrated to account for these periods of dormancy, active development and mature physiology. |
| Fuel Consumption, Residence Time, Duration of Burn | Duff Moisture Code (DMC)<br>Buildup Index (BUI)<br>Drought Code (DC) | Fuel consumption (and associated smoke production) requires understanding of on the ground fuels. With that, DMC, BUI, and DC can be indicators of consumption, as well as post-frontal burning. |
| Crown Scorch Bole Damage | Initial Spread Index (ISI)<br>Fire Weather Index (FWI)<br>Air Temperature | The heat pulse, or fireline intensity, at the fire front is responsible for most crown scorch and bole damage. It is best represented by FWI, or simply ISI in the spring, though Air Temperature is a significant factor. |

### Adjusting Data From Recording Stations for use at Remote Locations

While the complement of weather recording stations is dramatically increased with the inclusion of selected NWS and other network stations, users will still find many situations where fuel moisture conditions and fire behavior potential are still uncertain. Using interpolation and interpretation techniques with the recording station data and/or grid outputs provided by Great Lakes Fire/Fuels can provide insight to onsite conditions and increase confidence in decisions. Of course, this technique requires on-site validation based on local weather, landscape and fire behavior observations.

An example is provided in Fig. 5. The first image suggests an estimate for FFMC in the location of interest (red pin) in the upper 80's. With the grid of FFMC overlaid, more detailed information suggests that it would be significantly lower.

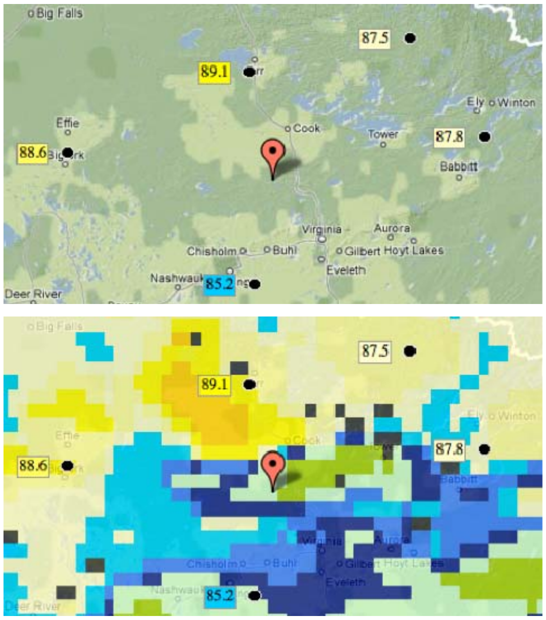



**Fig. 5.** Simulated fire location. TOP — only forecasted FFMC values from surface observation locations; BOTTOM — includes forecast grid for FFMC.

### Creating a Dataset for Remote Locations

This is how the ***Map View*** might be set up to serve this purpose:

1. Identify the location of interest and the surrounding weather recording stations by searching for a Lat/Long using the ***Search*** input.
2. Narrow the ***Radius*** to a smaller number (25 or 50 miles) to limit the set of stations displayed around the location.
3. Zoom to an area that shows the location and the surrounding stations of interest.
4. Selecting "*Image*" or *"Image + Data"* for ***Grid Layers*** Option will allow display of most recent observed value or one of the next two forecasted grids for the selected Station Value.
5. Clicking on the ***Show Table*** Option in the Time and Tables Box will display a summary table of the most recent observed weather, fuel moisture codes and fire behavior indices as well as the next two days of forecasted daily values.

Once the appropriate complement of recording stations and reference area are selected, comparison of observations and forecasts is given a geographic context.

- **FFMC** values are most influenced by current conditions. If the FFMC values for the surrounding stations are all similar, then estimation through averaging makes sense. If there are significant differences, consider the local influences (recent rain, lake effect, etc.) that might rule some values out. Look at the grid value to validate the estimate.
- **DMC** and **DC** values are more influenced by accumulated rainfall totals. As such, there will likely be more variability than found for FFMC. Grid values may more effectively represent the distribution of rain events. They may be used directly as estimates for the location of interest, or used as a reference to suggest which of the surrounding stations would be most appropriate for use in adjusting estimates.
- **FFMC** and **ISI** will vary over time at the site location, depending primarily on local windspeed and time of day. Because they are the most important indicates of short-term changes in fire ignition and spread, field tables for updating estimates and calibrating to observations are necessary once reaching the field location.

## MANAGING THE DATA & CONFIGURING THE PRODUCTS

The system compensates for many common data issues. The 1800 GMT observation, when not collected at the sensor, is estimated by interpolating between adjacent hourly observations. Hourly FWI codes are automatically restarted at 2200 GMT using the daily moisture codes for that day if gaps in observations cause the calculations to stop. However, not all issues can be resolved automatically. The following four items represent user inputs required by the system to maintain full functionality and best operation of the CFFDRS system. Only users authorized by system managers have access to these edit tools.

- *Startup CFFDRS Fuel Moisture Codes:* Unlike the RTMA grids, many surface observation stations cannot calculate FWI codes and indices throughout the year. Many rain gauges cannot effectively measure winter precipitation. In most cases, calculations are discontinued late in the year. Each year, they restarted with assumed moisture codes in the early spring by station, group of stations, or state as a whole. When stations are out of service for extended periods during the fire season, startup values will need to be initiated again.
- *Managing Data Gaps and Errors:* Sensors sometimes fail to report observations and produce observation errors. These are not corrected automatically. Weather observations maintained in the system are editable.
- *Fire Danger Rating Criteria:* Each CFFDRS observation station has a table of criteria (outlined above) used in calculating fire danger ratings. Authorized users can edit the criteria for any station, group of stations or state as a whole.
- *Forecast Wind Adjustment Factor:* Forecast 1800 GMT windspeed may be adjusted using a multiplier that can be set by authorized users. They may be set by station, group of stations, or state as a whole.

## NEED FOR FURTHER STUDY & DEVELOPMENT

### Wind Observation and Forecasts

Wind is the most important factor in estimating fire spread and controllability. Despite that, there is considerable variability in the ways that the atmosphere imposes it, the landscape influences it, the sensors measure it, and models implement it. Great Lakes Fire/Fuels provides an important opportunity to evaluate wind observations and forecasts across a significant landscape dynamic.

- Bringing a variety of networks together, with the variety of standards they impose, will create a variance in estimates, especially for ISI and FWI.
- Within network variations produce important potential errors as well. Use of RTMA winds may provide a level of unbiased data for comparison among stations and the factors that control their observations.
- NDFD forecasts are used for a variety of purposes, among the most important accurate and timely warnings across the United States. Great Lakes Fire/Fuels, and its database of data for specific observation stations, may facilitate how NDFD forecasts relate to local conditions.

## RTMA and NDFD Data Quality

Integrating gridded weather depictions into estimations of fire potential parameters for this effort is not novel. However, it still requires further study, given the data sources, the known weaknesses, and the unknown long-term relationship to weather recording station data.

- 25 $km^2$ (9 $mi^2$) resolution may not produce the detail required for site-specific application. Both RTMA and NDFD data may be downscaled in the near future to a 6.25 $km^2$ (2.25 $mi^2$) resolution, producing significantly higher detail.
- RTMA Precipitation estimates derived by the River Forecast Center's Multisensor Precipitation Estimator depends on the quality of radar estimates. At the margins of each radar sensor's effective radius, additional processing is intended to improve the quality. However, the cumulative effect of precipitation on DMC and DC will need to be examined to determine overall effectiveness by comparing weather recording stations and grid estimates.
- NDFD forecast precipitation estimates include both probability and quantity estimates. Great Lakes Fire/Fuels uses only the quantity estimate, frequently overestimating the effect of forecasted rain events. Utility of the probability estimate could significantly improve forecast moisture codes.
- Weather Forecast Office (WFO) boundary effects are clearly visible in the forecast grids. Smoothing of the contours in the weather grids could improve some viewability issues.

## Climatological Displays

The historic datasets included are important, especially for the RAWS network, with manual data for some locations dating back nearly 40 years. Great Lakes Fire/Fuels provides important climatological looks for certain data elements. Additional tools may need to be developed.

- Wind roses need to incorporate query tools that allow multi-year datasets and filtering for dates and hours within that period.
- Though storage of the historic set of gridded data may be more than can be maintained by Great Lakes Fire/Fuels, techniques for capturing and compressing this data to allow for climatological references for grid cell locations may provide important information about local effects such and lake influence, influence on landscape and ecosystems, and cumulative effects on fuels.

## Detecting Seasonality

Although Great Lakes Fire/Fuels is essentially a system designed to process weather data into indicators of fire potential, the Lake States landscape varies importantly as each ecosystem transitions through the seasons, from dormancy, through greenup and the growing season, to fall dormancy and winter snow pack conditions.

- Integration of increasing and decreasing snowpack conditions could provide important insight to the beginning and end of fire season.
- Sensors that detect important phonological changes can trigger changes in interpretation of these, and other weather based elements that are responsible for day-to-day changes. Cur-

rent depictions of NDVI “greenness” are too coarse and too influenced by cloud cover.

- Integration of landscape fuels information will make it possible to produce fire behavior as well as fire weather indices.

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