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Next Generation FWI: *FWI2025*

SUMMARY

The Canadian Forest Fire Danger Rating System (CFFDRS) has remained largely unchanged since the early 1990s. Meanwhile, research, technology, and fire management strategies have continued to evolve. The Next Generation CFFDRS (CFFDRS2025) addresses some of these developments. The updated Fire Weather Index System (FWI2025) includes key changes like new weather input timing and the addition of a grassland stream for more comprehensive fire danger assessments. This modernization allows for more representative fire danger calculations by capturing the impact of short-term weather fluctuations.

The following provides historical context for the FWI System as well as the key changes in FWI2025.

GUIDING PRINCIPLES

⇒ All inputs, even hourly observations, provide an *estimate* of the conditions on the landscape throughout the day.

⇒ FWI2025 outputs are still meant to be used in regional level planning. The calculation of the FWI System at a *finer time scale* does not translate into the interpretation of the FWI System outputs over a *finer landscape scale*.

⇒ The FWI System models have been designed to estimate fuel moisture and fire behaviour in a consistent and understandable way. They are models and as such, are simplifications of reality that produce estimates of important elements of the wildland fire environment agencies track.

INSIDE THIS ISSUE

THE 1PM WEATHER OBSERVATION ORIGIN

The original fuel moisture estimation methods used a large steel 'pan' of water placed within a forest and the amount of evaporation was measured at the end of the afternoon or early evening.

This measurement directly integrated environmental conditions experienced within a forest over the entire day to provide estimates of the practical effect of the day's condition in terms of fuels drying. However, this measurement provided this information only towards the end of the day.

As forest fire management became more organized, planning earlier in the day became an essential part of operational success. To facilitate daily planning, the 1pm (LDT) observation was introduced in the late 1930 to provide estimated fire danger information earlier in the day. This 1pm observation allowed estimation of the total expected amount of fuel moisture change for the day and provided a way of estimating the potential conditions during the expected late afternoon peak of fire activity.

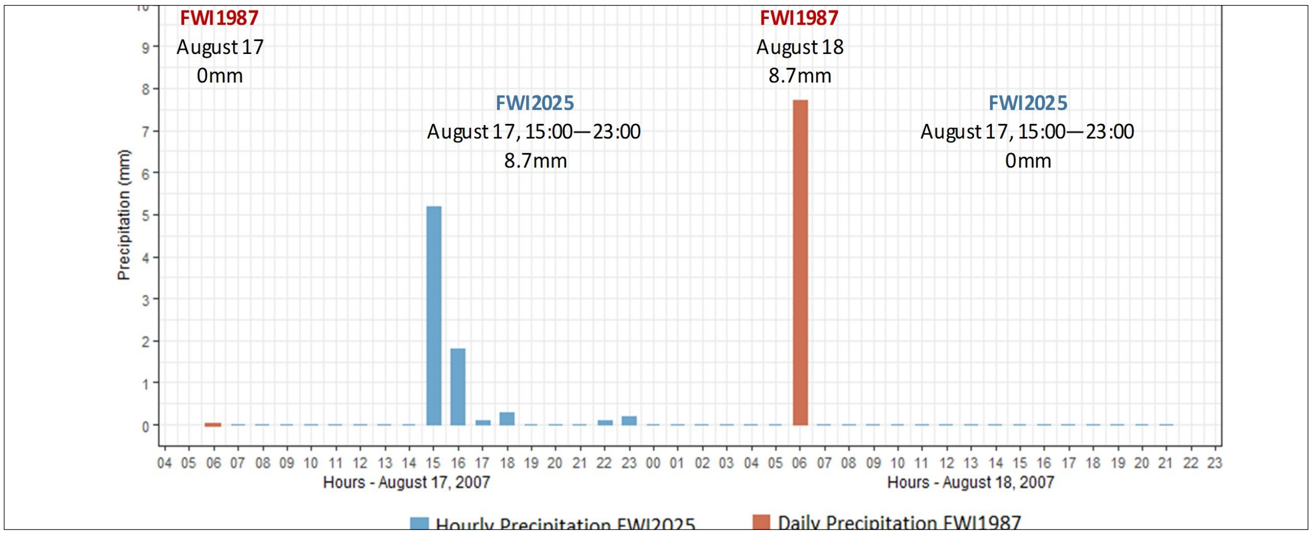


Figure 1: Hourly precipitation (FWI2025) accumulation and FWI1987 1pm observation.

FROM DAILY TO HOURLY

The FWI2025 calculations will now be done hourly. The reliance on a single daily weather observation time to the early afternoon has been part of the System since the late 1930s (Beall, 1939) and making this change to earlier versions would have been unpractical as the outputs were estimated by hand using look up tables (CFS, 1984).

The characterization of the hourly weather variation for the day should allow more accurate assessment of drying throughout the fire season and over a range of latitudes, better reflecting the longer periods of daylight in the Far North on the moisture indices.

In addition, in the provinces and territories that span a wide range of longitude, issues around the timing of the 1pm LDT fire weather observations such as time zone boundaries and the range in the timing of solar noon across their jurisdictions, should be eliminated.

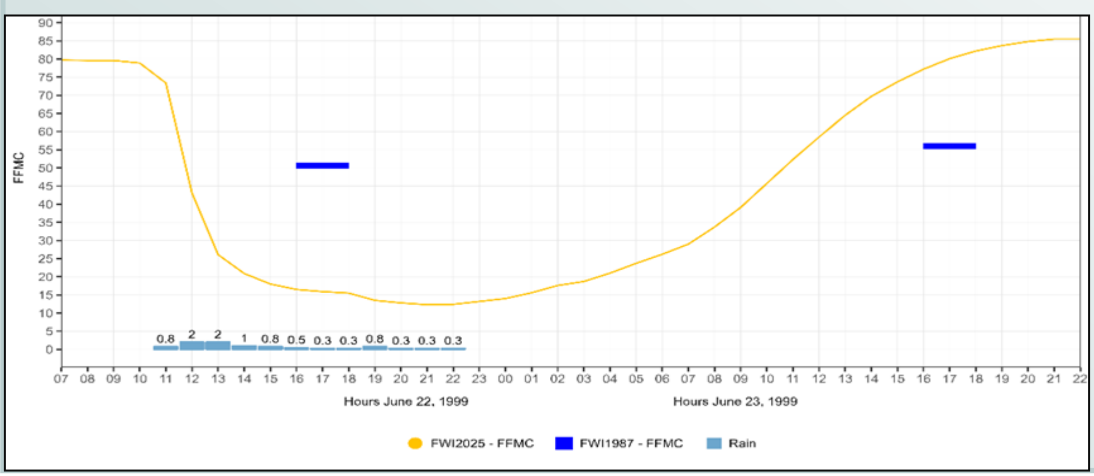


Figure 2:

FWI2025 model's response to precipitation and subsequent recovery of the FFMC.

MOISTURE AND FINE FUELS

The hourly FFMC in FWI2025, like the daily FFMC in FWI1987, relies on the traditional concept of exponential drying and wetting towards an equilibrium moisture content determined by environmental conditions. The hourly calculation in FWI2025 has been modified from the original hourly version from Van Wagner (1977) and provides a better approximation of the change in moisture throughout the day

Some of the changes include:

⇒ For the canopy interception of rainfall, the daily FFMC threshold assumes the first 0.5 mm of rainfall is held up in the canopy and doesn't reach the surface litter. In the new hourly FFMC, it's cumulative. During a rainfall period that can last several hours, the first 0.5 mm of rainfall is held up in the canopy and all further rain falls through the canopy to potentially wet the litter on the ground. When the rainfall ends, the canopy begins to dry. A time constant of 6 hours is introduced to capture the approximation of drying, so 6 hours after a rainfall ends, the forest canopy is assumed to be dry again and the canopy interception process starts over.

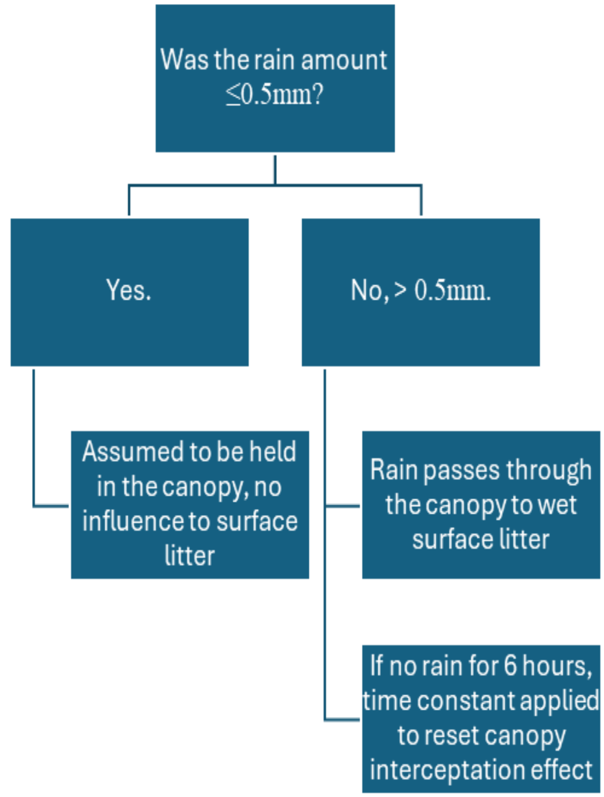


Figure 3: FFMC rain threshold decision chart

MOISTURE AND HEAVY FUELS

The use of hourly data necessitated the introduction of an hourly calculation for the DMC and DC. The hourly methods for these two indices focused on keeping the time lag in the fuel layer consistent with the original daily version and retaining the original effective rainfall model.

Regarding drying, the DMC and DC follow the same exponential drying towards a very dry equilibrium state that has been used in their original formulation. For rainfall, the new models for estimating effective rainfall in the hourly DMC and DC treat it as cumulative throughout the day following the FWI1987 System thresholds of **>1.5 mm for the DMC** and **>2.8 mm for the DC**. The canopy holding capacity is applied to both indices 6 hours after the rainfall ends, like the FFMC. Any rainfall after 6 hours will again need to surpass the rain thresholds before it begins to wet any forest floor fuel.

The introduction of a time constant to reset the canopy intercept after 6 hours will lead to a lower amount of rain on the organic layer, compared to FWI1987, if there is more than one rain event in a day.

NEW DAILY OUTPUTS

FWI2025 hourly calculations can be summarized daily to create the opportunity to produce daily products for operational planning.

Time of Peak Burn:

Peak burn is currently defined as being the hour corresponding to the maximum ISI, representing a mathematical maximum and not an indication of how sharp or flat that peak is.

⇒ Shifting away from a fixed output time (e.g., 17:00) allows for a more accurate communication of peak fire potential throughout the day, better aligning with real-world conditions faced by fire suppression crews

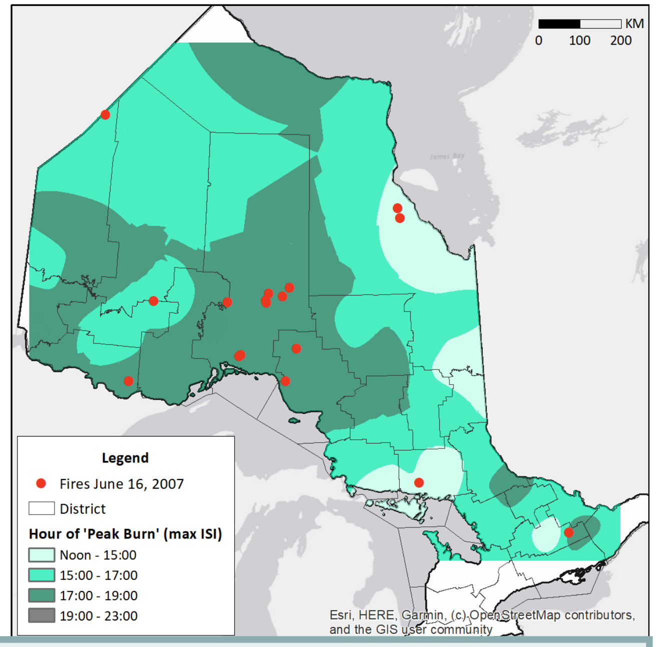


Figure 4: Map of peak burn hours for June 16, 2007

FWI2025 STRUCTURE

Daily inputs:

Date

Longitude and Latitude

Curing/greenness **(grasslands only)**

Hourly inputs:

Temperature

Relative humidity

Wind speed (WS)

Rainfall

Solar radiation **(grasslands only)**

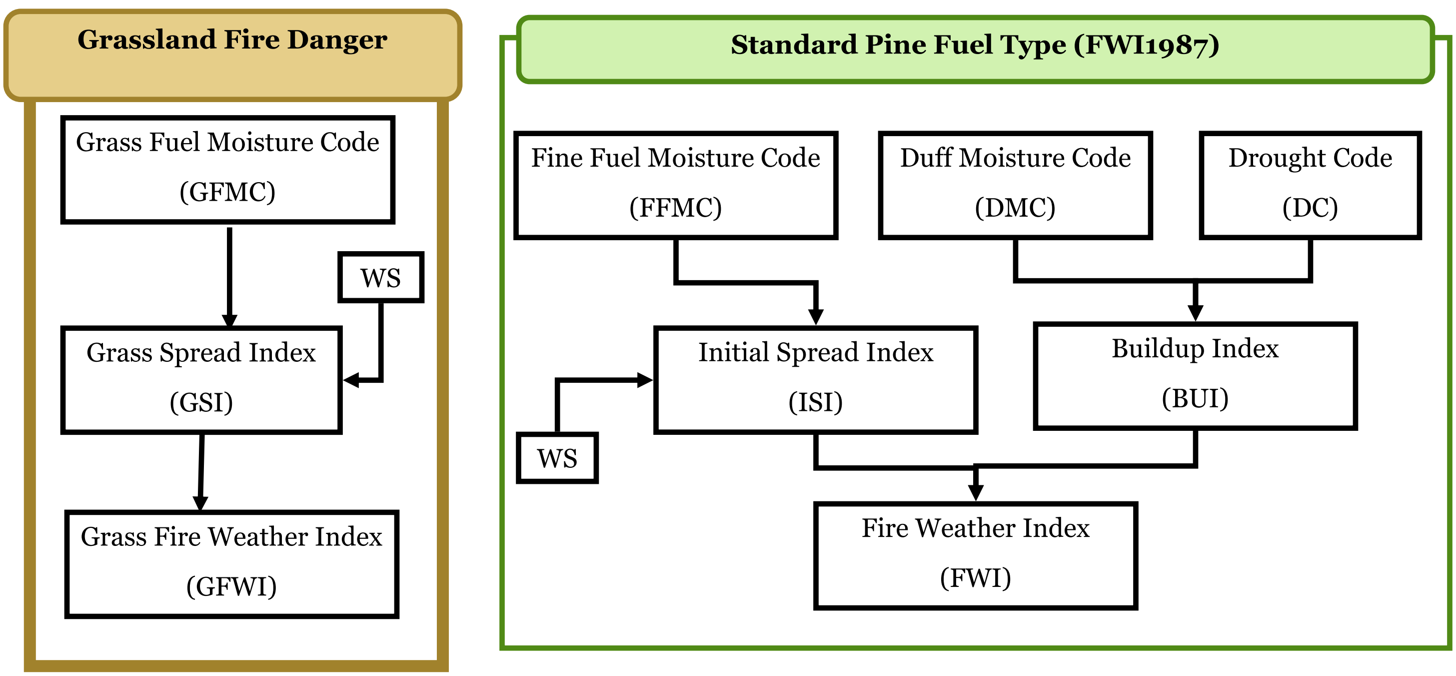


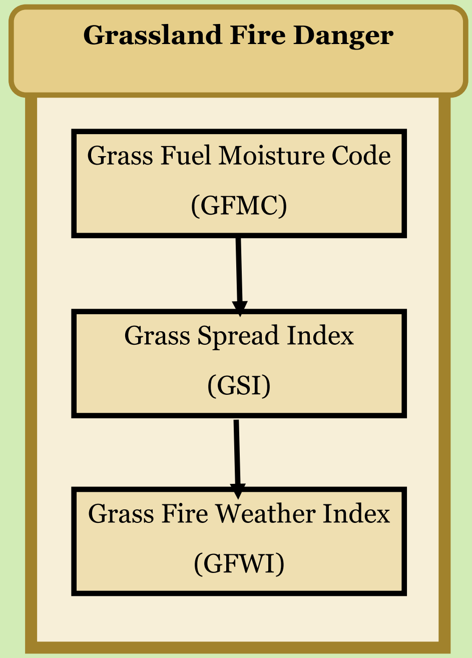
Figure 5: General structure of the inputs and outputs of the FWI2025. In forest green, we have the FWI1987 structure. In the yellow-brown color, we present the new grassland inputs and model.

A NEW GRASSLAND SUBSYSTEM

FWI2025 provides users the option to directly estimate fire potential in grasslands.

Many operational users, particularly those involved in springtime prescribed burning in grassland, have identified situations where the FWI1987 System doesn't work well in grasslands. Estimating fire potential in grasslands throughout an entire fire season requires making an estimate of the state of greenness of the present fuel complex. Lush annual green vegetation can inhibit fire spread if it becomes a significant component of the fuel complex.

In the new grassland model, we consider the entire fuel complex to be made of grasses: fully cured, live and/or senescing grasses holding considerable moisture. Fully cured fuels exchange moisture rapidly with the environment throughout the day whereas green and senescing grasses hold higher levels of moisture which do not change much with the daily weather cycle. Assessing the level of curing of grassland fuels is an input for the grassland indices of FWI2025 System.



The focus of the grassland indices is to provide indicators of different aspects of fire potential in exposed grasslands.

GRASSLAND INDICES

The grassland indices rely on a moisture model designed to track moisture content in fully cured, exposed fine fuels in a grassland.

The conversion of grass moisture content to its associated code, the Grassland Fuel Moisture Code (GFMC) incorporates the estimate of live vegetation present in the grassland into the calculation to indicate an 'effective moisture content' consistent with the expected effect of greenness on the probability of sustained ignition, not an estimate of the average moisture content of the fuel complex. Users will see the GFMC output vary with the seasonal change in greenness, and it is designed to be a good indicator of the probability of sustained ignition in a grassland.

Like the ISI, the Grassland Spread Index (GSI) is a relative indicator of spread and accounts for the state of curing in the fuel complex using the standard curing function used in the FBP System incorporating moisture content of cured grass, percent curing, and open wind speed.

The Grassland Fire Weather Index (GFWI) is a scaled, unitless transformation of estimated grassland fire intensity designed to be consistent with the FBP System grass fire behaviour models.

NEW INPUTS FOR GRASSLANDS

To support the new grassland calculation stream in FWI2025, two new inputs have been developed: solar radiation and grassland curing/greenness.

⇒ Direct solar radiation can heat fuels to more than 20-30° above ambient air temperatures. Three potential sources for collecting observed and forecasted solar radiation data are:

  ⇒ Direct measurement at a weather station equipped with a pyranometer

  ⇒ Solar radiation data from numerical weather models

  ⇒ Estimation using location, time, and environmental conditions

⇒ The curing state of a grassland relies on an assessment of the relative amount of dry/cured grasses compared to new green growth. There are three recommended ways to estimate the state of curing in grasslands:

  ⇒ Direct local observations of the grassland

  ⇒ Remote sensing products such as the Normalized Difference Vegetation Index (NDVI)

  ⇒ Using a default value based on the time of year and a regional historical analysis.

Picture from Parks Canada: Prescribed fires - Grasslands National Park

SUMMARY OF CHANGES TO FWI1987

The core changes to the FWI1987 System are summarized below:

New weather input timing:

◊ FWI2025 uses hourly input weather to include variations in daily weather patterns.

◊ FWI2025 indices are calculated each hour.

Daily Output Timing: Daily mapped and tabular outputs can be generated based on the estimated peak burn time for a specific day.

Grassland Fire Danger: A grassland stream has been added to FWI2025 to calculate fire danger for grassland areas. Since grasslands are more exposed to wind and the direct heating of solar radiation, solar radiation and curing inputs have been added to the FWI2025 System for the grassland stream.