Updating Canada’s Fire Danger Rating System

Mike Wotton, CFS-NRCan
University of Toronto (Forestry)
mike.wotton@utoronto.ca

Presented at ICLR Friday Forum
Aug 7, 2020
Stepping back a little

What are the main things that influence day-to-day fire activity?
Stepping back a little

What are the main things that influence day-to-day fire activity?

- Ignition sources (fire brands)
- Fuel
- Weather
Stepping back a little

What are the main things that influence day-to-day fire activity?

- Ignition sources (fire brands)
- Fuel
- Weather
Stepping back a little

What are the main things that influence day-to-day fire activity?

• Ignition sources (fire brands)
• Fuel
• Weather
Stepping back a little

What are the main things that influence day-to-day fire activity?

• Ignition sources (fire brands)
• Fuel
• Weather

• Another way to frame this question is as...
What’s might happen in the fire environment ?

• Are fuels ready to ignite and burn ? Will they be ready later?

• How many fires might occur today? tomorrow? Where might each of those fires be?

• Will fires grow today? How quickly might new fires grow? How big will the flames be? (will they even be suppressible???)

These are questions you might consider if you were a decision-maker in a fire management agency, needing to prepare and plan for and respond to fires in your region.
So...whats the CFFDRS??

- The **Canadian Forest Fire Danger Rating System** houses the science and methods we use to turn basic inputs like weather and forest fuels into information that describes important aspects of the fire environment.

Formalities (...from the CIFFC Glossary(2017) ):

- **Fire Danger**: A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control, and fire impact.

- **Fire Danger Rating**: The process of systematically evaluating and integrating the individual and combined factors influencing fire danger

- **Fire environment**: The surrounding conditions, influences, and modifying forces of topography, fuel, and fire weather that determine fire behaviour (*actual or potential*)
This is the output of the Canadian Forest Fire Danger Rating System that the public is most familiar with.
.....really it’s the only one most of the public ever sees
Canadian Forest Fire Danger Rating System

Overview in Stocks et al (1989) *Forestry Chronicle*
Canadian Forest Fire Danger Rating System

FOREST FIRE DANGER
Danger d'incendie de forêt

Report All Fires
Signalez tout incendie

Zenith 5555 • CB 9

Canada
FIRE WEATHER INDEX (FWI)
Fire Fuel Moisture Code (FFMC)

Duff Moisture Code (DMC)

Drought Code (DC)
FIRE WEATHER
(Air Temperature, Relative Humidity, Wind speed, Rainfall)

- Fire Fuel Moisture Code (FFMC)
- Duff Moisture Code (DMC)
- Drought Code (DC)
Lightning-caused fire
The Fire Weather Index (FWI) System

- Fire Weather Observations
  - Temperature
  - Relative Humidity
  - Wind
  - Rain

- Fuel Moisture Codes
  - Fine Fuel Moisture Code (FFMC)

- Fire Behavior Indexes
  - Initial Spread Index (ISI)
  - Buildup Index (BUI)

- Drought Code (DC)

- Fire Weather Index (FWI)
Fire Weather Observations

Fuel Moisture Codes

Temperature Relative Humidity
Wind Rain

Wind

Fine Fuel Moisture Code (FFMC)

Duff Moisture Code (DMC)

Drought Code (DC)

Temperature Relative Humidity
Rain

Buildup Index (BUI)

Fire Weather Index (FWI)
Initial Spread Index
Indice de propagación inicial

2020-08-06

0 - 2
2 - 5
5 - 10
10 - 15
>15
Nil / s.o.

Map created at 00:16 (UTC) on 2020-08-07
Carte créée le 2020-08-07 (UTC) à 00:16
Canadian Forest Fire Danger Rating System

The CFFDRS’ FBP System

• Is about more specific (and quantitative) prediction of fire behaviour in the fire environment

Will it be this......

...... or this?
Structure of the Canadian Forest Fire Behavior Prediction (FBP) System

**Inputs**
- FBP System
  - Fuel Type
- FFMC, ISI & BUI
  - Wind Speed & Direction
- Percent Slope
  - Upslope Direction
- Elevation
  - Lat./Long. Date
- Elapsed Time
  - Point or Line Ignition

---

**Outputs**
- **Primary**
  - Head Fire Rate of Spread
  - Fuel Consumption
  - Head Fire Intensity
  - Fire Description (Crown Fraction Burned & Type of Fire)
- **Secondary**
  - Head, Flank & Back Fire Spread Distances
  - Flank & Back Fire Rates of Spread
  - Flank & Back Fire Intensities
  - Elliptical Fire Area & Perimeter
  - Rate of Perimeter Growth
  - Length-to-Breath Ratio
Structure of the Canadian Forest Fire Behavior Prediction (FBP) System

**Inputs**
- FBP System Fuel Type
- FFMC, ISI & BUI Wind Speed & Direction
- Percent Slope Upslope Direction
- Elevation Lat./Long. Date
- Elapsed Time Point or Line Ignition

**Outputs**
- Primary
  - Head Fire Rate of Spread
  - Fuel Consumption
  - Head Fire Intensity
  - Fire Description (Crown Fraction Burned & Type of Fire)
- Secondary
  - Head, Flank & Back Fire Spread Distances
  - Flank & Back Fire Rates of Spread
  - Flank & Back Fire Intensities
  - Elliptical Fire Area & Perimeter
  - Rate of Perimeter Growth
  - Length-to-Breath Ratio
Canadian Forest Fire Danger Rating System

What has lead to CFFDRS usage??

• Scale and simplicity
  • Observing/measuring **key processes** in the field
    • Decades of extensive field-based campaigns

• Development of **modular** “empirically-based” models of process
  • Using very simple physics/physical reasoning to frame model structure and calibrated to real-world observation

• Creation of **simple interpretative tools**/applications and an extensive tech transfer effort
CFFDRS – modernization needed

• Simple Issues (but important for an empirically-based system)
  • Higher resolution of data is now commonly available...
    • Temporal and spatial resolution of weather
    • Spatially-detailed, fine resolution forest composition data

• New sources of information exist...
  • Remotely sensed observations (e.g., greenness)
  • Spatially detailed fuel structure
  • Direct, real-time measurement of fuel moisture
  • Modelled forecast weather
  • ...
  • Ease in accessing, synthesizing, integrating and displaying/using large amounts of information

• ALSO, of course, ongoing advances in fire science
CFFDRS – modernization needed

• More Complex issues driving the updating of the CFFDRS

• The CFFDRS has been in widespread use - and also unchanged - for decades
  • It continues to work well providing foundational situation intelligence to help inform fire management decisions ....BUT...

• The challenges in the wildland fire management decision-making environment have changed and necessitate a broader risk management approach
  • Growing wildland-urban interface and need community risk reduction, changing fuels and forest health, climate change, public expectation

• The new paradigm in wildfire management is more about understanding uncertainty, risk evaluation and management than it has been historically in most of Canada
6) Fire Management Tools and Spatially detailed Applications
   - Fire Growth Modelling Systems, plume rise, Fire emissions, Smoke Models

Detailed CIFFC talk:
https://ciffc.adobeconnect.com/_a1147217903/p7ple7ffe3yr/?launcher=false&html-view=false&proto=true
CFFDRS-NG program at a high level

The NG-CFFDRS R&D program will focus mainly on three areas

1. New inputs and drivers to danger rating/risk assessment
   • Core information/data needs of modernized CFFDRS

2. Core components of the CFFDRS (modeling and integration)
   • e.g., Fire Behaviour, fuel moisture, fire ignition, fire occurrence

3. Direct links to integrated science and management applications both directly with agencies and CFS/EMS elements
   • e.g., fire growth, Emissions modelling, smoke modelling
...Some proposed changes

- There are many changes at various levels... e.g.
  - New more detailed fuel characterization
  - Changes in FWI System weather input timing
  - Additions optional outputs in FWI System
  - More flexibility to modify stand structure in FBP

- A priority is to maintain the simplicity in the system that most users rely upon...
  - BUT also have the flexibility that some users can take advantage of for specific fire predictions or situations
6) Fire Management Tools and Spatially detailed Applications
-Fire Growth Modelling Systems, plume rise, Fire emissions, Smoke Models

https://ciffc.adobeconnect.com/_a1147217903/p7ple7ffe3yr/?launcher=false&html-view=false&proto=true
A fuels management example:
With the proto-type pine spread rate model

Conifer with low CBH
A fuels management example:
With the proto-type pine spread rate model

Pine with pruning
SOLID line is Spread rate (Pine with a lot of ladder fuel)

C-3
FFMC=91
BUI=60
FMC=120%
CBH=4 m

MC\text{litter}=10\
\text{Wind}_\text{IN}=25%\
CBD=0.15 \text{ kg/m}^3
SOLID line is Spread rate (Pine with pruning)

C-3

FFMC=91
BUI=60
FMC=120%
CBH=8m

$MC_{\text{litter}}=10\%$
Wind$_{\text{IN}}=25\%
CBD=0.15 \text{ kg/m}^3$
Standard closed canopy Pine stand (pruned to 8m)
.......Now thinned (removing 2/3rds of the stems!!!)
Standard closed canopy Pine Stand (pruned to 8m)

C-3
FFMC=91
BUI=60
FMC=120%
CBH=8m

$M_{C_{litter}}=10\%$
$\text{Wind}_{IN}=25\%$
$\text{CBD}=0.15\text{kg/m}^3$
Now... thinned the canopy- >2/3rds reduction

C-3
FFMC=91
BUI=60
FMC=120%
CBH=8m

$MC_{\text{litter}} = 8\%$

$\text{Wind}_{IN}=45\%$

CBD=0.05kg/m³
Some other modifications of the FBP System

• The last couple slides showed some initial results of ONE specific example.....

• We are working over the next couple years on, for example....
  • Some basic characterization of spot fire probability
    • This is an area that needs much research!

• Enhanced understanding of crown fire initiation

• Better models that capture nighttime fire behaviour

• Filling gaps (where we have little observational evidence...yet) with understanding from more complex physical modelling systems
  • E.g., mixedwood, fuel management,

• Integration and testing of various models (“how models hang together”)
General Summary

• Our current NG-CFFDRS work is currently being laid out as a 4 year project
  • But the system should/will continue to evolve

• CFFDRS models rely strongly on the observations that are used to calibrate the model forms

• Observations of fire behavior in real field conditions are really valuable to improvement and validation
  • Experimental burning
  • Prescribed burning
  • Case studies and other observations
General Summary....cont’d

• We would like to find groups/users in fire management agencies who can use/evaluate interim sub-components and products as they are developed.

• We are trying to find the balance between giving users early information about new models and ensuring models are well-formed and grounded.
  • May introduce an ~quarterly technical update on specific elements

• An CFFDRS-NG Overview document is in (hopefully) final stages of drafting and ideally done this summer
  • That being said....This is an ongoing research program, so feedback that can help us prioritize and potential redirect effect are always welcome
The CFS CFFDRS Working group

**PFC (Victoria)**
- Steve Taylor
- Dan Perrakis
- ...

**NoFC (Edmonton)**
- Dan Thompson
- Ginny Marshall
- Brian Simpson
- ...

**GLFC (Sault Ste Marie)**
- Mike Wotton
- Chelene Hanes
- Natasha Jurko
- Jordan Evens
- ...

**LFC (Quebec)**
- Jon Boucher
- ...

+ various others
Updating Canada’s Fire Danger Rating System

Mike Wotton, CFS-NRCan
University of Toronto (Forestry)

mike.wotton@utoronto.ca

Presented at ICLR Friday Forum
Aug 7, 2020