Using FIRETEC to Further our Understanding of Fire Science

Canadian Forest Service

And

Los Alamos National Laboratory

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Natural Resources Canada Ressources naturelles Canada

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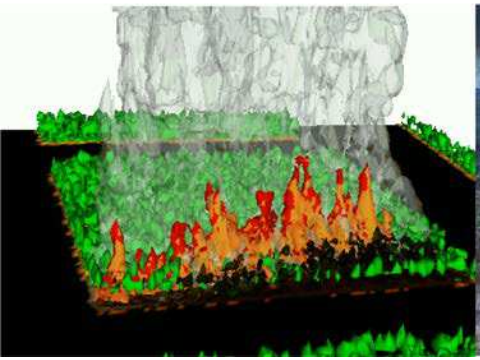
Background

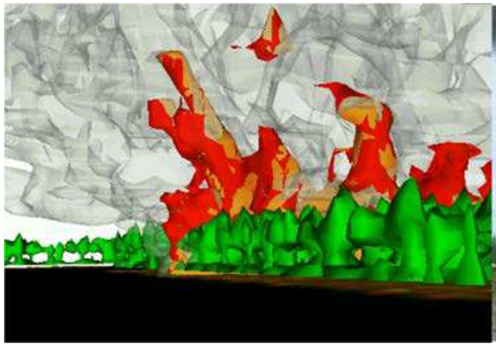
Background

FIRETEC is a coupled atmosphere wildfire model developed at the Los Alamos National Laboratory in New Mexico. It is aimed at studying and understanding fire behaviour at the stand level.



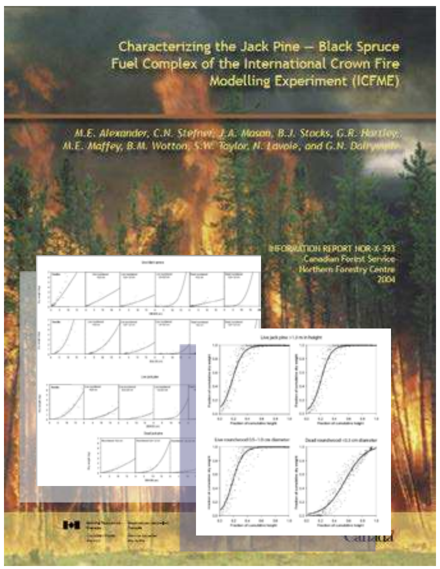

Using FIRETEC, there is an opportunity to expand our understanding of fire science, thus improving our ability to predict critical aspects of fire behavior and its response to local environmental conditions.

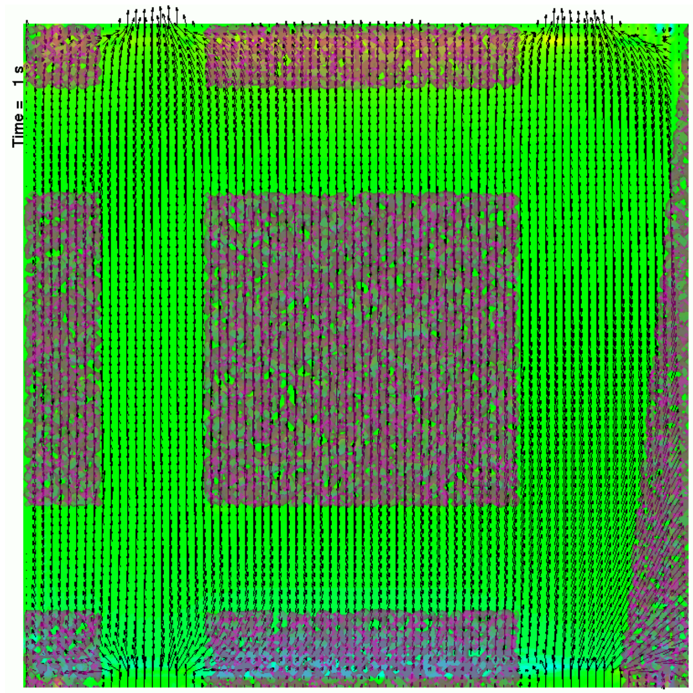
Through this type of modeling, virtual experiments can be conducted that normally are difficult to plan or expensive to replicate.



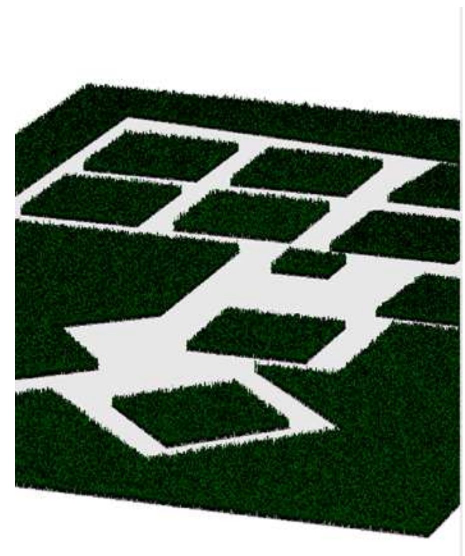

Past Studies

Comparison with ICFME experiments





FIRETEC simulations of the International Crown Fire Modeling Experiment (ICFME) plot 1.



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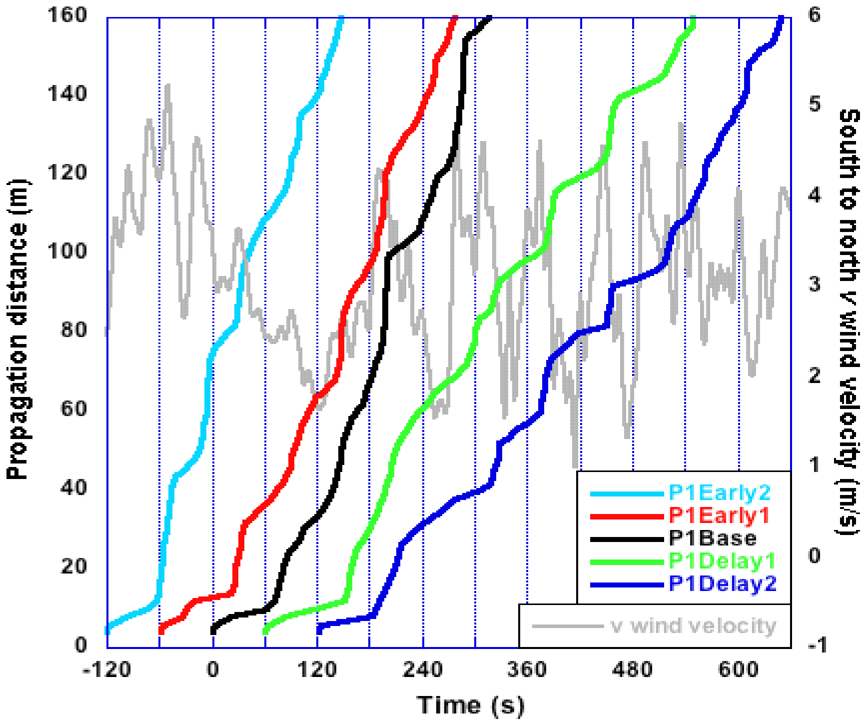
Linn *et al.* (2005) AMS Forest and Fire Meteorology Symposium

Linn *et al.* (2012) Canadian Journal of Forest Research

Analysis of coupled fire/atmosphere behavior in ICFME

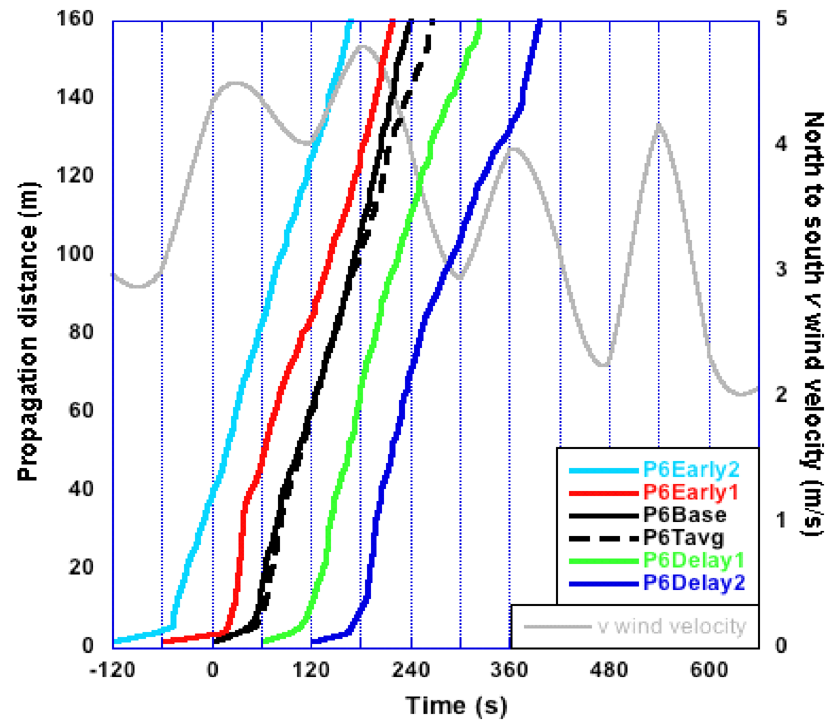


Plot 1

5 sec wind data

ROS_{obs} = 35.3 m/min

(0.588 m/s)



Plot 6

60 sec wind data

ROS_{obs} =36.0 m/min

(0.600 m/s)

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Linn *et al.* (2012) Canadian Journal of Forest Research

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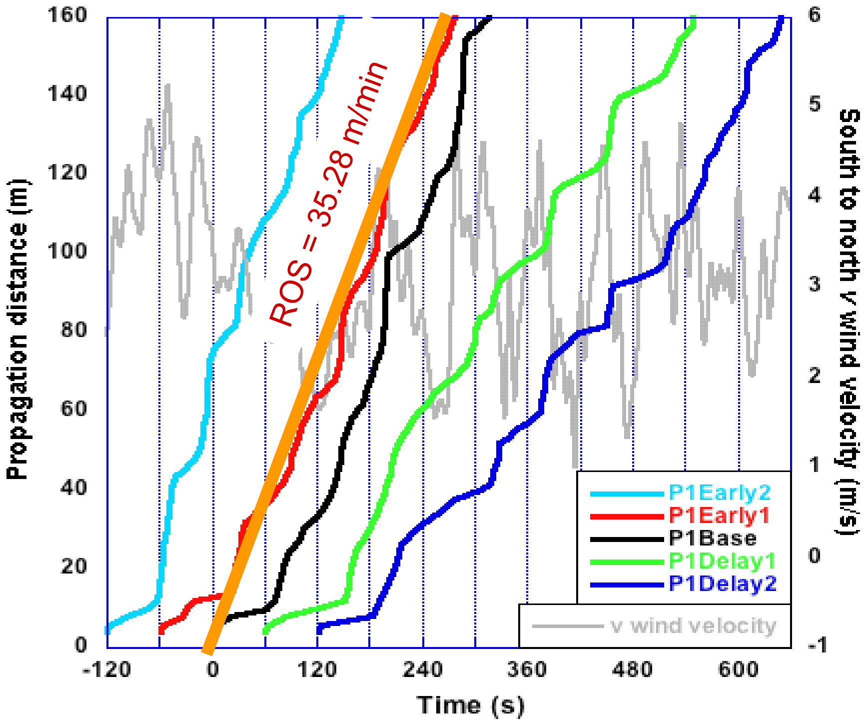
Analysis of coupled fire/atmosphere behavior in ICFME



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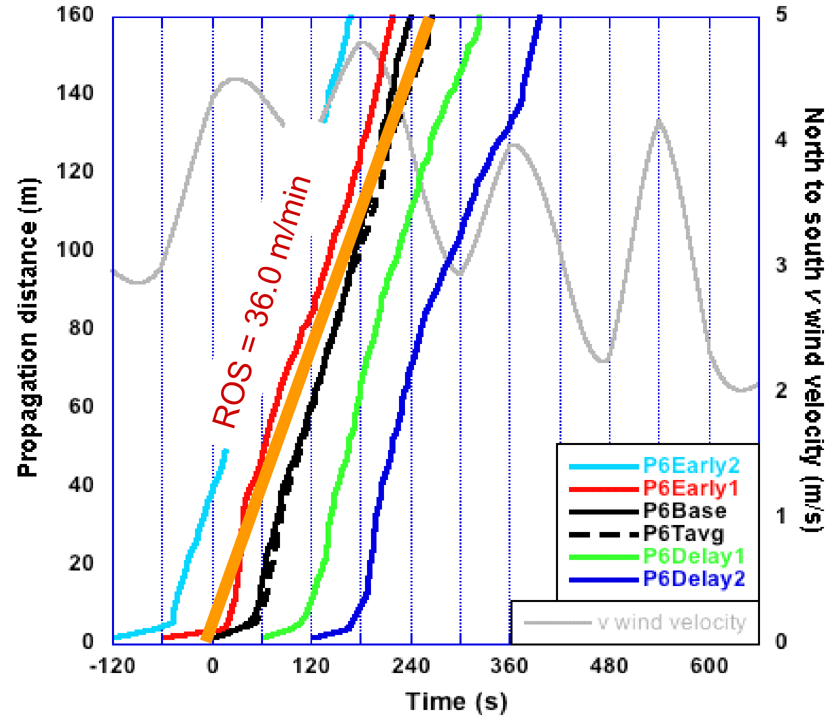

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Other examples of predicted vs. observed spread rates for various fuel types

Kermès Oak guarrigue (INRA exp., France):

Beauchamp site

FIRETEC: 4.8 m/min

Obs: 3.5 m/min

Fuel height (cm)	30
Fuel load (kg/m^2)	0.5
Fuel moisture (%)	80
Fire front width (m)	10
Wind speed (m/s)	2.7 at 2 m

Trou du rat site

FIRETEC: 6 m/min

Obs: 3.5 m/min

Fuel height (cm)	40
Fuel load (kg/m^2)	0.9
Fuel moisture (%)	140
Fire front width (m)	10
Wind speed (m/s)	5.5 at 6 m

Galician Maquis (CIFAL exp., Spain):

FIRETEC: 2.34 m/min

Obs: 2.58 m/min

Fuel height (cm)	50
Fuel load (kg/m^2)	2.2
Fuel moisture (%)	65
Fire front width (m)	25
Wind speed (m/s)	2.1 at 2 m

Australian Grassland (Cheney et al. 1993)

Wind 10.8 km/hr at 2 m

FIRETEC: 42 m/min

Obs: 42-48 m/min

Wind 36 km/hr at 2 m

FIRETEC: 168 m/min

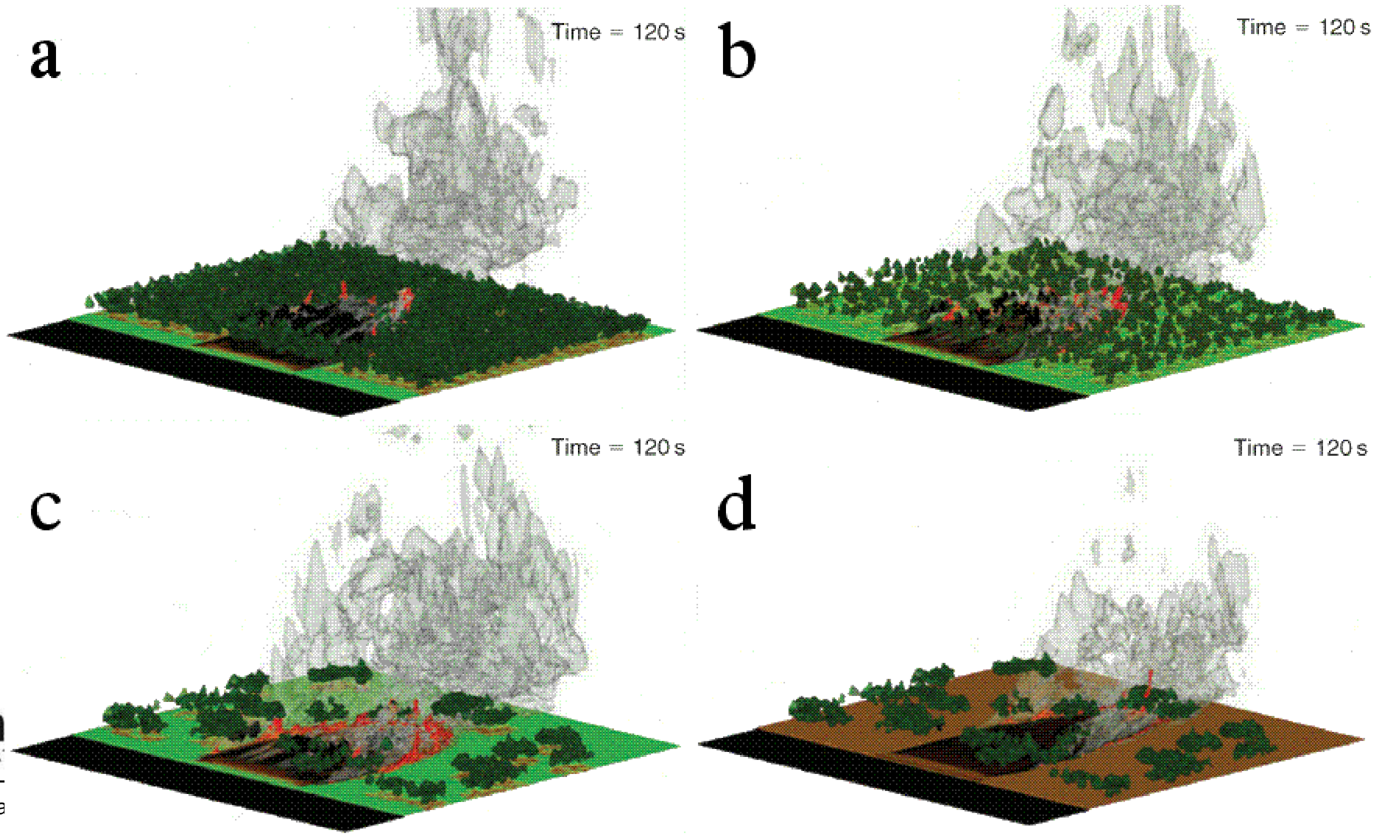
Obs: 108-162 m/min

Fuel height (cm)	70
Fuel load (kg/m^2)	0.7
Fuel moisture (%)	5
Fire front width (m)	50

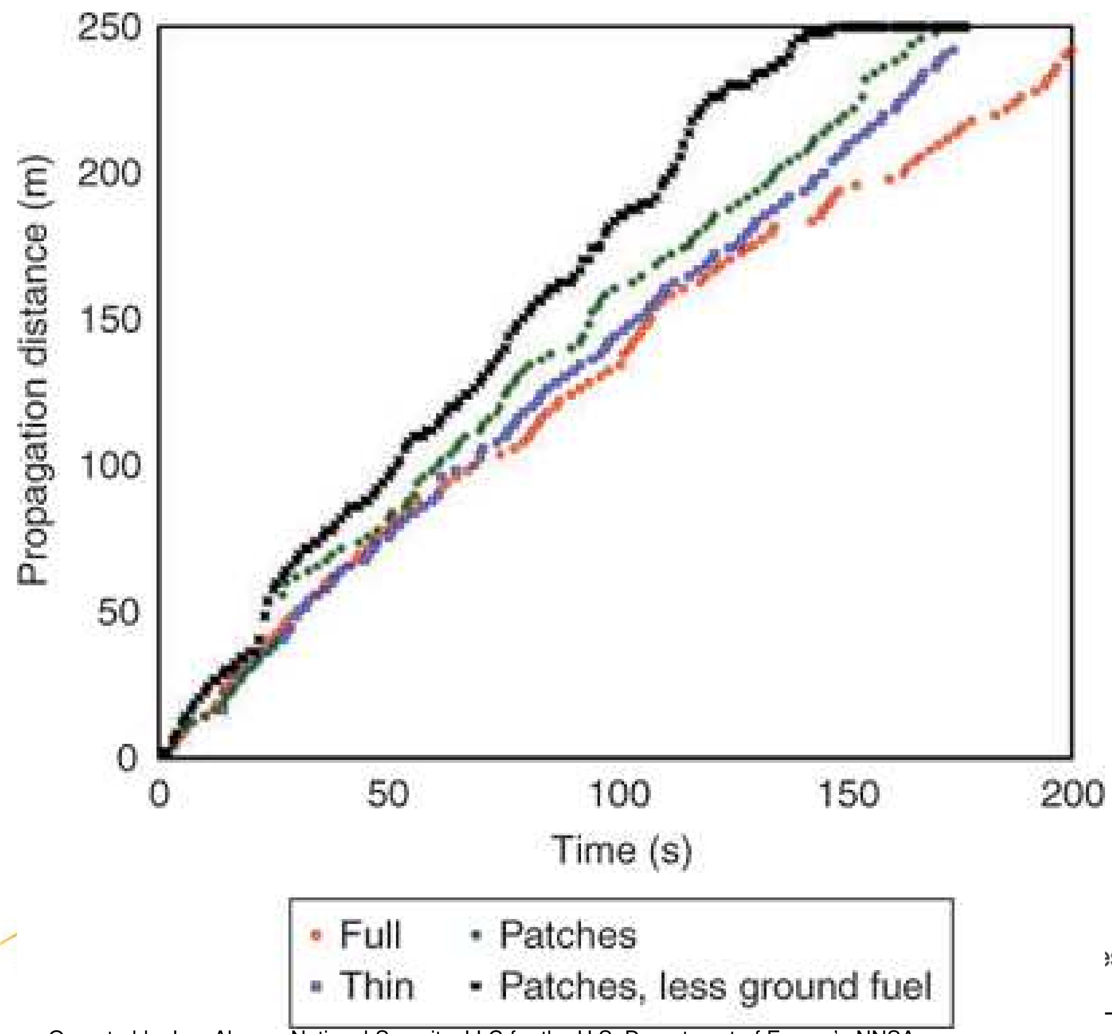
This exploration performed by Pimont and Dupuy at INRA (France)

Stand Density

Linn et al. (2002) first tested the model on grass fuels and then Linn et al. (2005) conducted simulations varying the stand and surface fuel density.



Stand Density



These factors varied the fire spread rate substantially.

This illustrates the significance of stand characteristics on fire behaviour.

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Alberta fire risk analysis using FIRETEC

Canadian Forest Service

Los Alamos National Laboratory

Alberta Agriculture and Forestry

Alberta fire risk analysis using FIRETEC

The Alberta fire risk analysis using FIRETEC is a project funded by the Alberta Wildfire Management Science & Technology program.

For Alberta, FIRETEC will be used to assess fuel treatment (such as stand thinning) on potential fire behavior in the Wildland-Urban Interface.

This project proposes to address the following Wildfire Management Science & Technology strategic directions, research themes, and questions: "*What are the most effective and efficient treatments to manage fuels?*"; "*Effectiveness and efficiency of FireSmart treatments and decision support tools for FireSmart treatments*" as recommended by the Flat Top Complex Wildfire Review Committee.

Methodology

A matrix of scenarios is being constructed (fuels x treatment type x weather) to test the effectiveness of such treatments under a range of observed fire weather conditions guided by input from area staff and provincial fire behaviour specialists.

Area fire prevention staff are being consulted to gain details as to the preferred and common methods for fuel management (e.g.strip mulching vs inter-tree spacing vs hand thinning vs stand conversion). Consultation will identify priorities and the matrix will provide guidance for model use through time.

Input data on fuel loading and characteristics for simulations will largely be derived from fuel treatment data already collected by the ESRD Wildland Fuels Inventory program.

Matrix Example

Weather

Fuels

Treatments

ISI = 10; C-2; Thinning	ISI=15	ISI=20	ISI=25
C-3			
M-1			

Weather scenarios

Weather scenarios will cover high and low values of the wind speed and FFMC (i.e. ISI)

		Wind Speed	
		Low ~15 km/h	High ~25 km/h
FFMC	Low <90	Low-Low FWI ~ 19	Low-High FWI ~ 25
	High >90	High-Low FWI ~ 25	High-High FWI ~ 30

Weather scenarios

T	RH	WS	FFMC	ISI	BUI	FWI	DSR
21.1	55	13	88	6.2	40.9	14.1	2.9
19.7	50	22	87.6	9.3	41.6	19.2	5.1
20.8	45	24	88.1	10.9	45.2	22.5	6.7
21.6	38	25.9	89.6	15	30.4	23.2	7.1
25.4	34	27.8	90.7	19.4	63.5	39	17.9

Weather associated with these FWI will be pulled from the historical data

Fuels

Following the Hinton workshop, priority fuels were identified:

1) Lowland C-2 with feathermoss (Red Earth Creek PB)
2) Decadent leafless aspen (parkland?)
3) Young pine regen (~5-20 years, sub C-4) ICFME
4) Boreal mixwood
5) Mature pine

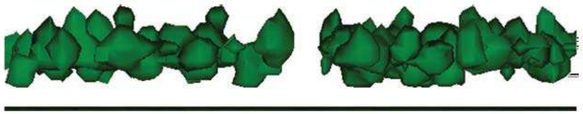
Treatments

1. C-2 lowland spruce
a. Control
b. Strip mulch narrow – 5 m corridors
c. Strip mulch wide – 10 m
d. Large cluster mulching – width 2x tree height
e. Small cluster mulching - width = tree height
2. Decadent aspen
Control – no treatments proposed
3. Pine regen
Control ~10,000 stems/ha (measured at ICFME 2016)
Thinning (brush saw) 2,500-5,000 stems/ha

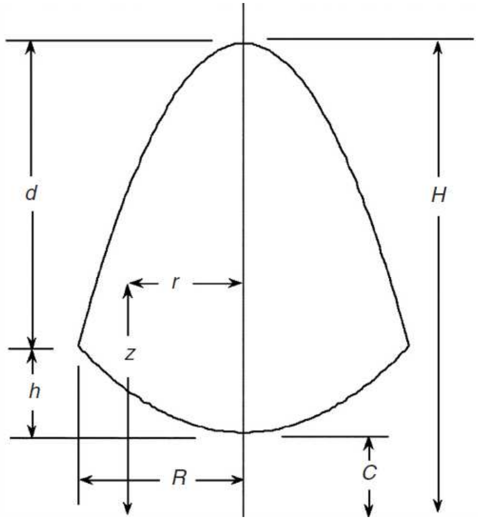
Requirements

What is required to perform FIRETEC simulations?

- **Fuels**
  - *Basic representations*:



    - Each tree used in the set is described with: tree height, crown base height, crown radius and nominal bulk tree-crown density for species
    - Trees are located using known distributions (for lowland spruce, see Kettridge et al (2013).
    - Foliar and surface fuel moisture prescribed



  - *More complete representation*:
    - Canopy: stem mapped list of trees with above descriptors and bulk tree-crown density
    - Surface fuels: spatially heterogeneous surface fuels as function of canopy cover
    - Can account for masticated fuels and shrubs

What is required to perform FIRETEC simulations?

- **Winds**
  - Simple form: single wind measurement at known height
    - RAWS station, airport, or fire tower
  - More complete form:
    - Measured upwind vertical wind profiles including wind direction and speed; Instruments available within CFS
- **Topography**
  - Simple: assume flat
  - More complete approach: Use true topography in the form of high-resolution digital elevation maps (DEMs are publically available)

What is required to perform FIRETEC simulations?

- **Computational Facilities**
  - 125 core cluster: database, data analysis
  - 2000 core cluster: high performance computing dedicated to computational materials and process simulations
  - Large scale, large systems, long times, parametric studies
  - Can access remotely in Edmonton

NRCan operates a CRAY computer at its CanMET office in Hamilton, ON

Questions?

Potential Projects with BC

Potential Projects

The effectiveness of fuel treatments in a ponderosa pine (C-7) forest

Ponderosa Pine is a prominent forest type in the interior of British Columbia. Developing strong mitigation plans to protect these communities is vital for the safety and security of British Columbians.

Proposal: evaluate the effectiveness of fuel treatments in C-7 fuels using FIRETEC.

Potential Projects

Characterizing BC fuel types that are not modelled within the CFFDRS

Many of the dominant forest types in BC are not captured in the current version of the CFFDRS, such as Interior Cedar-Hemlock (ICH), Engelmann Spruce – Sub-Alpine fir (ESSF), and Interior Douglas-Fir (IDF)

Proposal: model these fuel types in FIRETEC to create better estimates of fire behavior for the next generation of the Canadian Forest Fire Danger Rating System.

Potential Projects

Assessing Spruce Beetle impacts on Fire Behaviour in mature spruce stands in BC

Spruce beetle infestation has recently increased in northeastern BC, and primarily threatens mature spruce stands.

Proposal: use FIRETEC to model changes in fire behaviour in mature spruce stands in various stages and intensities of spruce beetle infestation.

Potential Projects

Assessing mountain pine beetle impacts on fire behaviour in mature lodgepole pine stands in BC

Spruce beetle infestation has recently increased in northeastern BC, and primarily threatens mature spruce stands in valley bottom mature spruce stands

Proposal: use FIRETEC to model changes in fire behaviour in lodgepole pine stands in various stages and intensities of mountain pine beetle infestation.