Prometheus Fire Growth Model Update

Design and Incorporation of Spotting and Breaching of Fire Break Functionality

Chisholm, DogRib, and Lost Creek Fires
Post-Fire Research Workshop
April 27, 2005
Kurt Frederick

Prometheus Breaching of Barriers - Workshop

September 23, 2004, Provincial Forest Fire Centre, Edmonton, AB

PARTICIPANTS

Marty Alexander
Greg Baxter
Jen Beverly
Don Cousins
Kurt Frederick
Dennis Quintilio
Cordy Tymstra
Terry Van Nest
Dennis Yuan

Prometheus Breaching of Barriers - Workshop

September 23, 2004, Provincial Forest Fire Centre, Edmonton, AB

OBJECTIVES

- Review and discuss currently available knowledge
- Define the requirements of the Spotting and Breaching function(s)
- Define the applications of the Spotting and Breaching function(s)
- Discuss and choose the best (most appropriate) approach
- Define rules based on the chosen approach
- Construct a preliminary flow chart or appropriate product to visualize the rules for the model.

Wildfire Breaching of Barriers - Mechanisms

- Spotting
  - Mass transport of embers ahead of fire front

Wildfire Breaching of Barriers - Mechanisms

- Thermal Radiation
  - Either by pilot (firebrand) or spontaneous ignition

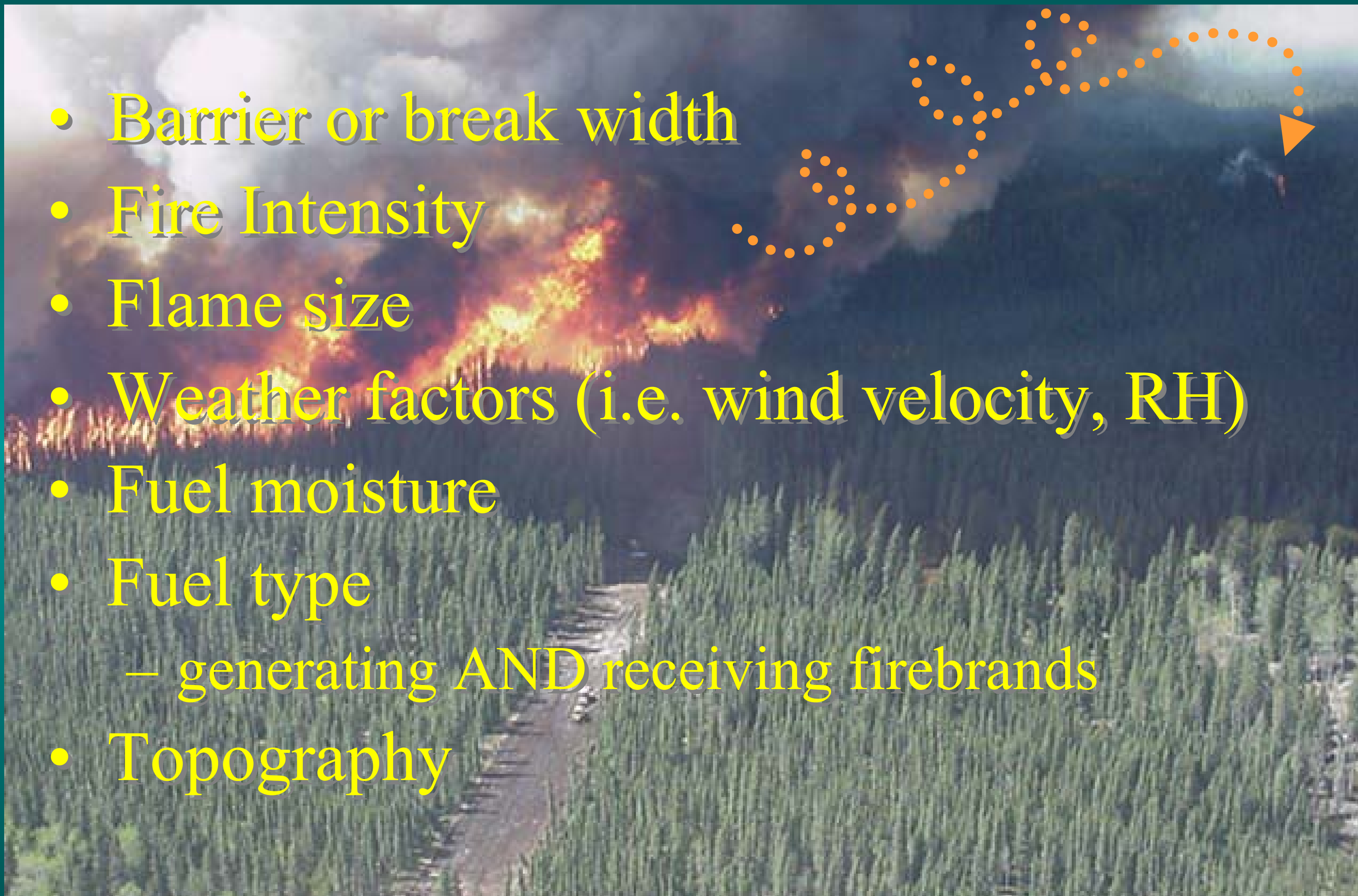
Wildfire Breaching of Barriers - Mechanisms

- Direct Flame Contact by fire’s leading edge

Wildfire Breaching of Barriers - Mechanisms

- Fire Whirls

Wildfire Breaching of Barriers - Variables

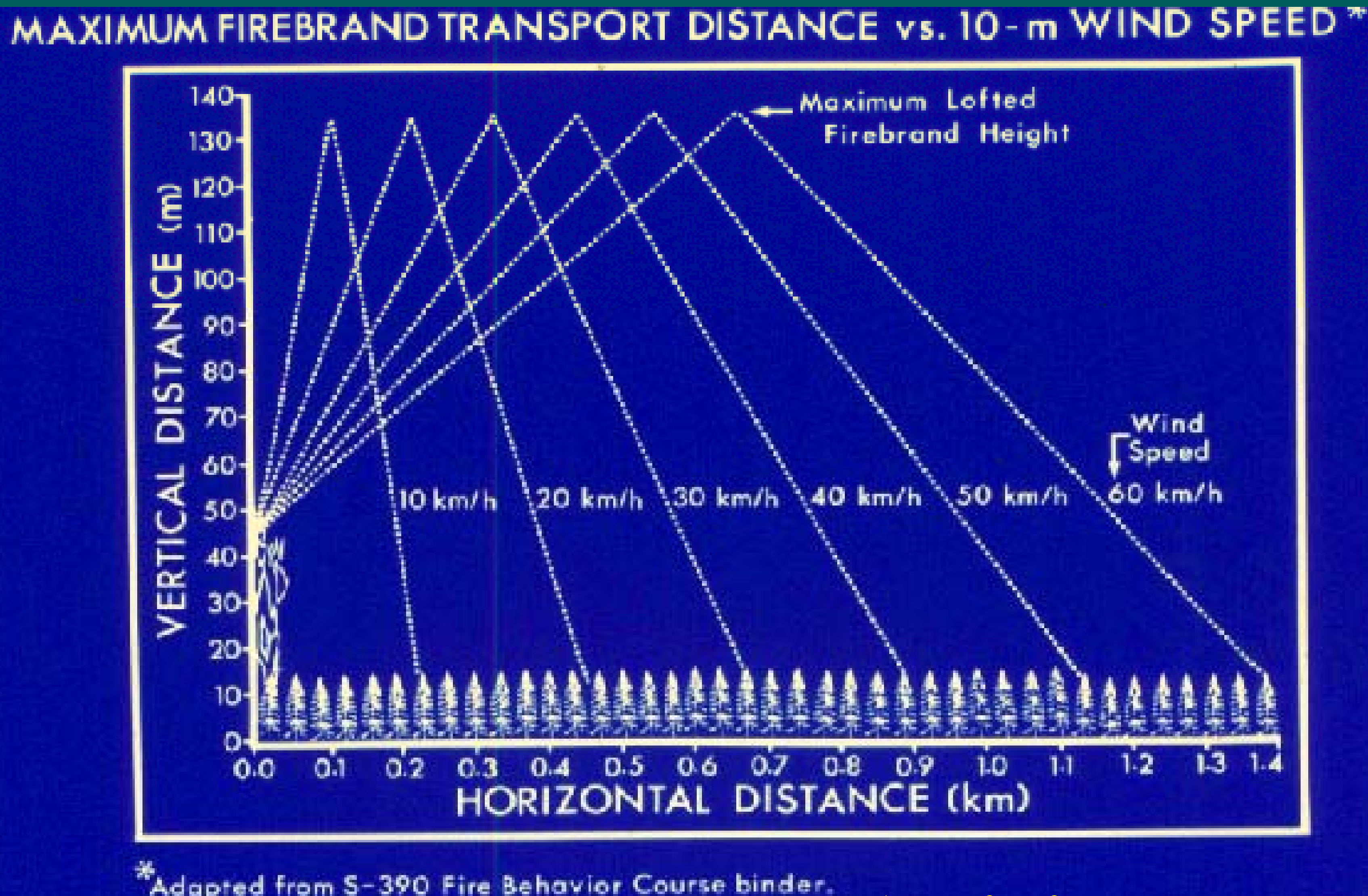


- Barrier or break width
- Fire Intensity
- Flame size
- Weather factors (i.e. wind velocity, RH)
- Fuel moisture
- Fuel type
  - generating AND receiving firebrands
- Topography

Wildfire Breaching of Barriers - Research

- Dr. Frank A. Albini's Mathematical Models
  - Maximum distance of firebrand transport from four sources
    - Single or group tree torching
    - Burning piles of woody debris
    - Wind-driven surface fires in open fuel types
    - Active crown fires

Wildfire Breaching of Barriers - Research



From Frank Albini

Wildfire Breaching of Barriers - Research

The Albini spotting distance models do not include:

1. The likelihood of firebrand material.
2. Availability of optimum firebrand material.
3. The probability of spot fire ignition.
4. The number of spot fires.

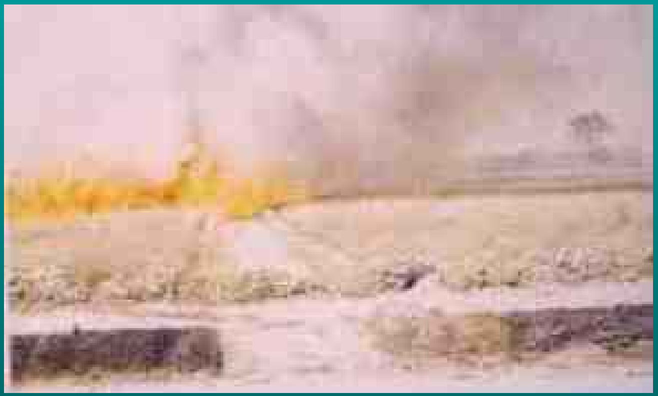
The Albini models are not applicable to fire whirls.

LIMITED TESTING UNDERTAKEN OF THESE MODELS

Wildfire Breaching of Barriers - Research

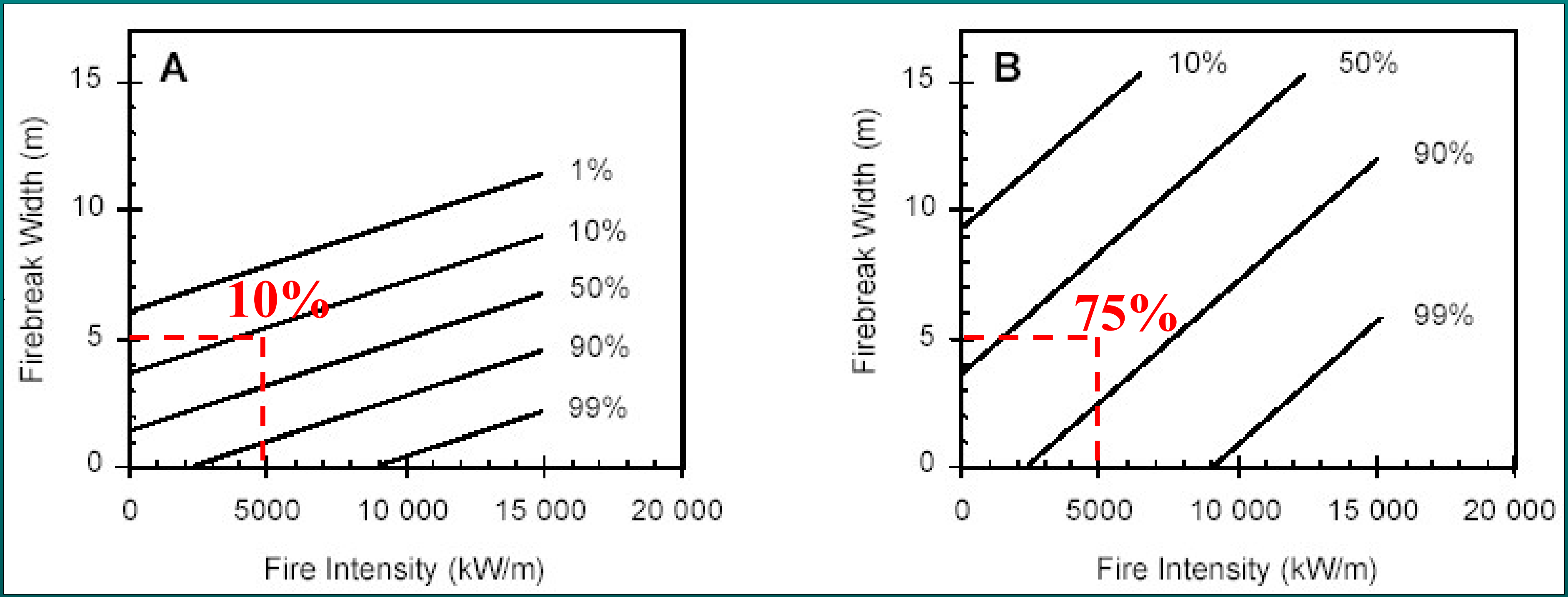
- Northern Australian Field Study (Wilson 1988)
  - Grass fuel type
  - Probability of firebreak breaching by grass fires as a function of
    - fire intensity
    - firebreak width
    - whether trees are present within 20 m of the firebreak
  - Basis for a “Grassland Fire Behavior” Pocket Card

% Probability of Grass Fire Breaching Mineralized Firebreak vs. Fire Intensity & Firebreak Width Model from Experimental Fires, Northern Territory, Australia



Wildfire Breaching of Barriers - Research

Probability of grass fire breaching a mineralized firebreak for trees absent (A) or present (B) within 20 m of the upwind side of the firebreak based on Wilson's (1988) model

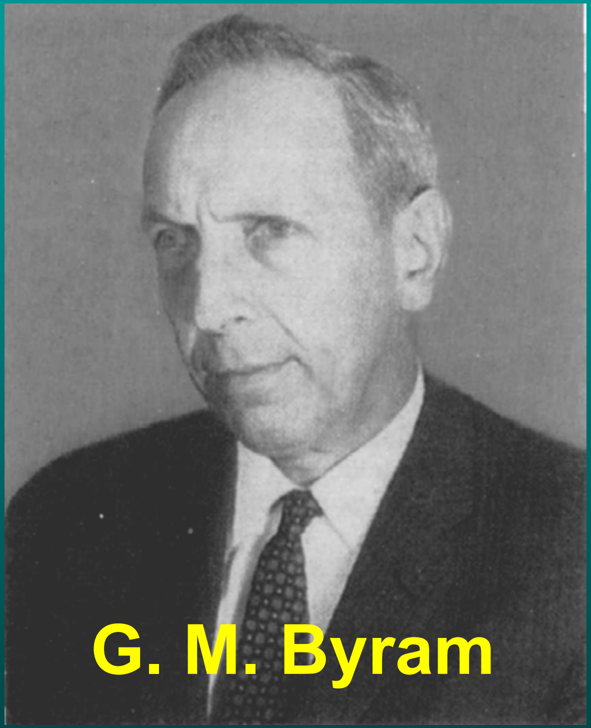


Trees absent (A) **Trees present (B)**

Fire Intensity Equation

$$I = H \times W \times R$$

I	H	W	R
Fire Intensity (kW/m)	Heat of Combustion (18 000 kJ/kg)	Fuel Consumed (kg/m^2)	Rate of Fire Spread (m/sec)



Fire Intensity Equation

$$I \quad = \quad H \quad x \quad W \quad x \quad R$$

I	H	W	R
Fire Intensity (kW/m)	Heat of Combustion (18 000 kJ/kg)	Fuel Consumed (kg/m^2)	Rate of Fire Spread (m/sec)

Fire Intensity Spectrum

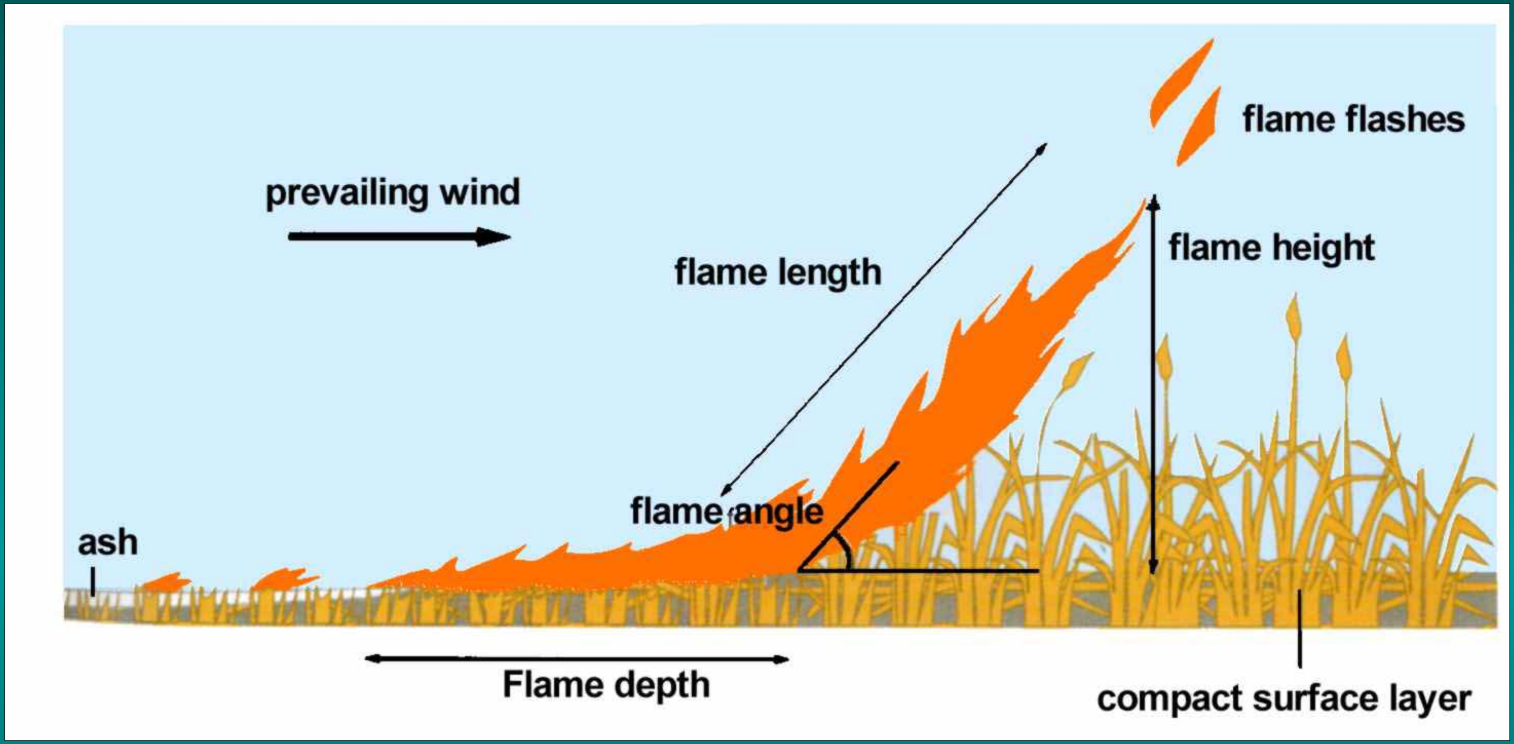
10 kW/m – Lower limit of surface fire spread

1000 kW/m – Limit of suppression capability by hand crews

10 000 kW/m – Active crown fires have developed

100 000 kW/m – Major conflagrations

Fire intensity is related to size of flames



Simple Formula for Field Use

(For surface fires & intermittent crown fires)

$$I = 300 \times (L)^2$$

***L* = Flame Length (metres)**

For crown fires, flame height approximately 2X stand height

Radiation Intensity from Fire Intensity

$$Q = 60(1 - exp[- I / 3000\, D])$$

Q = Radiation Intensity (kW/m^2) *I* = Fire intensity (kW/m)

D = Distance from Flame Front (m)

Fire Intensity (kW/m)	Distance From Flame Front (m)									
	1	5	10	20	30	40	50	60	70	80
	Radiation Intensity (kW/m^2)									
500	9.2	2.0	1.0	0.5	0.3	0.2	0.2	0.2	0.1	0.1
1000	17.0	3.9	2.0	1.0	0.7	0.5	0.4	0.3	0.3	0.2
2000	29.2	7.5	3.9	2.0	1.3	1.0	0.8	0.7	0.6	0.5
3000	37.9	10.9	5.7	2.9	2.0	1.5	1.2	1.0	0.9	0.7
4000	44.2	14.0	7.5	3.9	2.6	2.0	1.6	1.3	1.1	1.0

- 1.0 kW/m^2: firefighters can withstand indefinite skin exposure
- 7.0 kW/m^2: maximum exposure for a firefighter with PPE for 90 sec
- 52.0 kW/m^2: fibreboard will spontaneously ignite

Wildfire Breaching of Barriers - Research

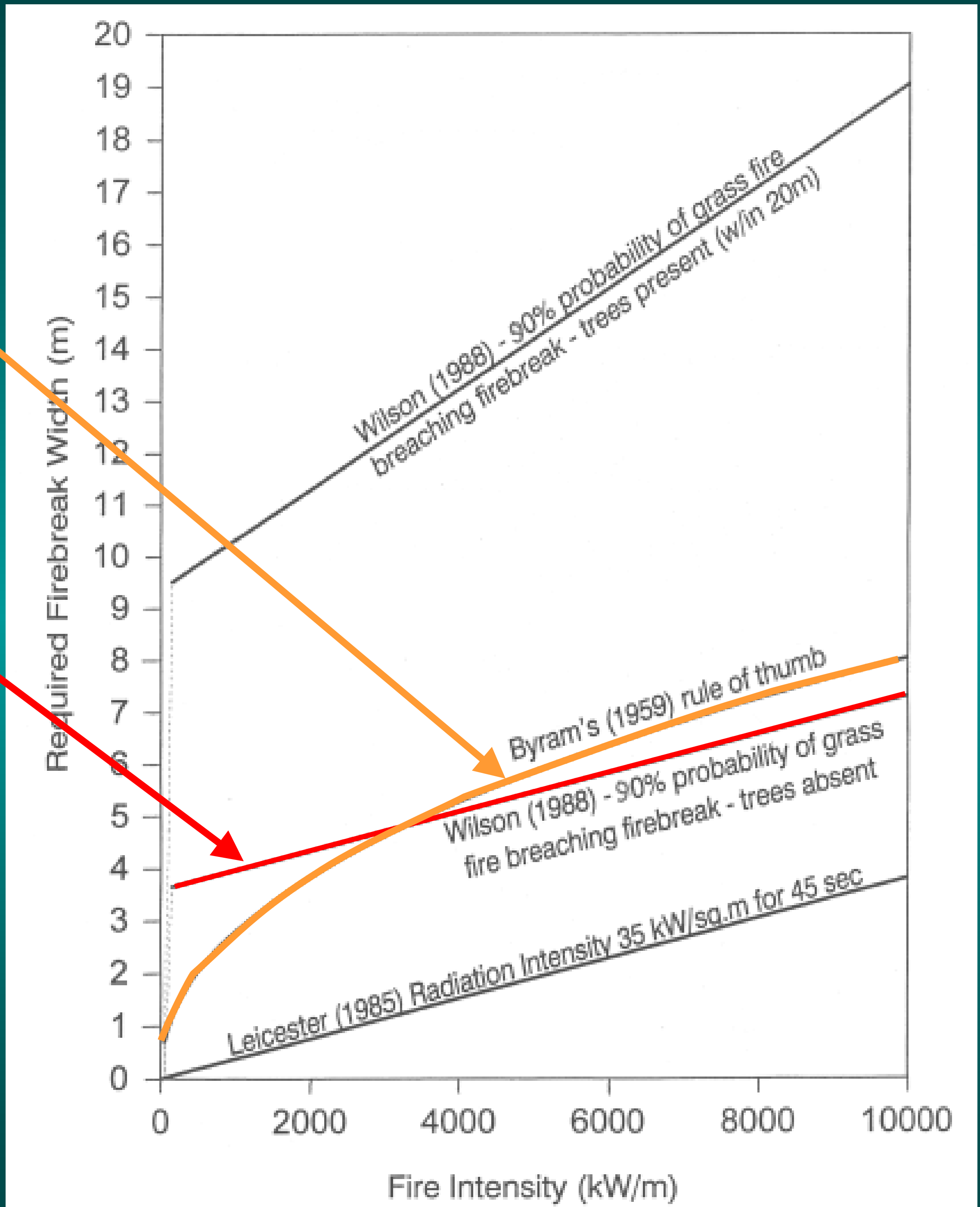
Byram's (1959) Rough Rule of Thumb
(in the absence of severe spotting)

Minimum Firebreak or Fireguard Width =
Flame Length X 1.5

Byram's (1959) Rule of Thumb

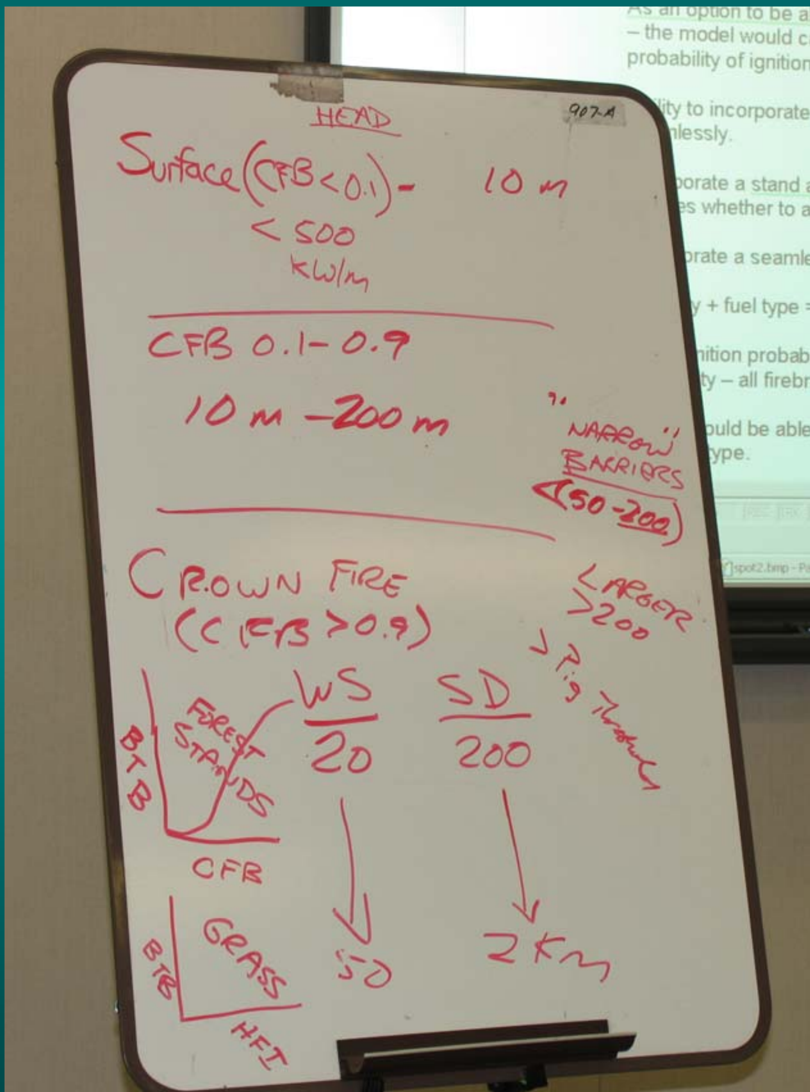
Minimum Firebreak or Fireguard Width = Flame Length X 1.5

Probability of grass fire breaching a mineralized firebreak for trees absent within 20 m of the upwind side of the firebreak based on Wilson's (1988) model



Prometheus Breaching of Barriers - Workshop

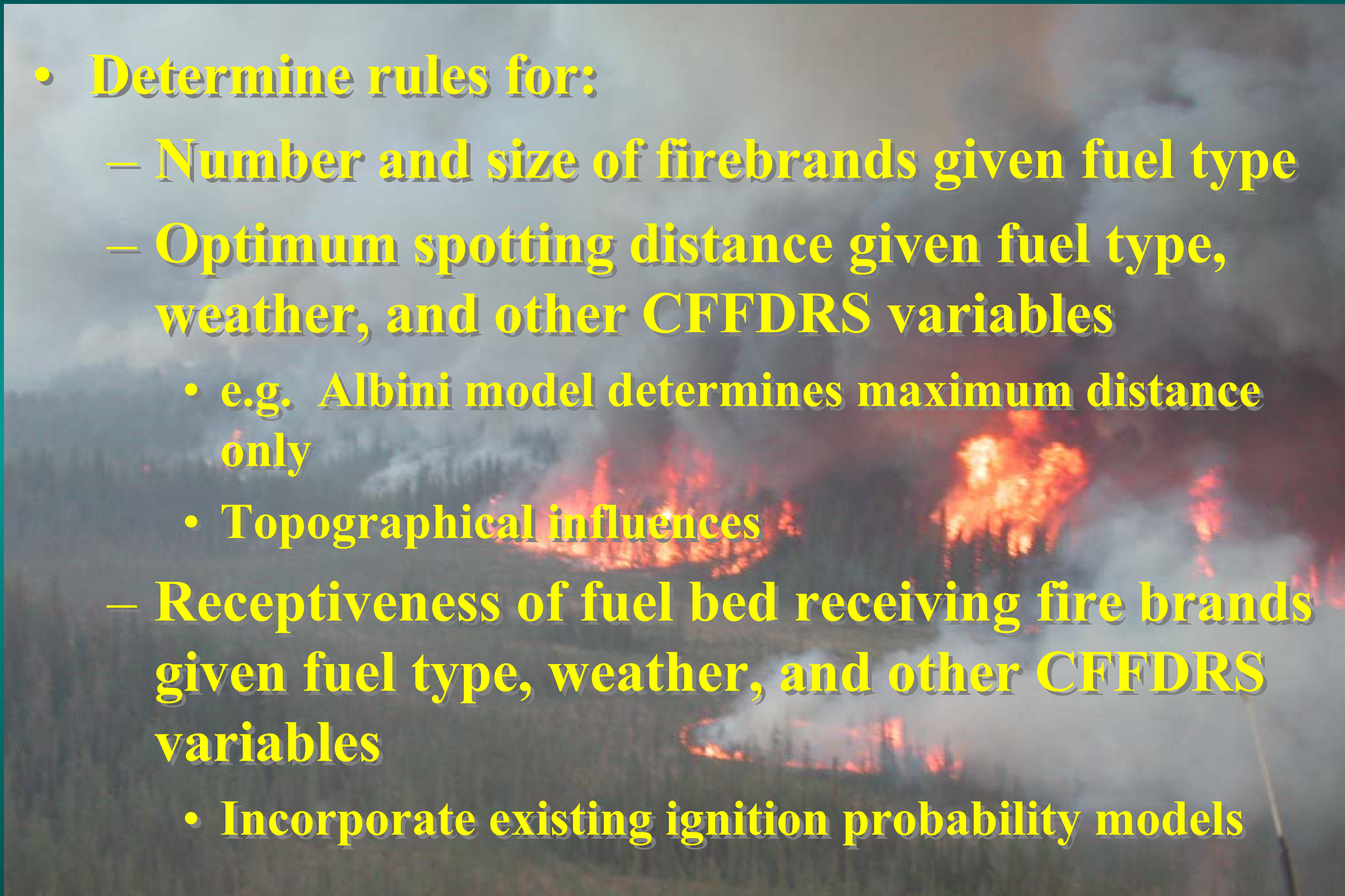
September 23, 2004, Provincial Forest Fire Centre, Edmonton, AB



CONCLUSIONS

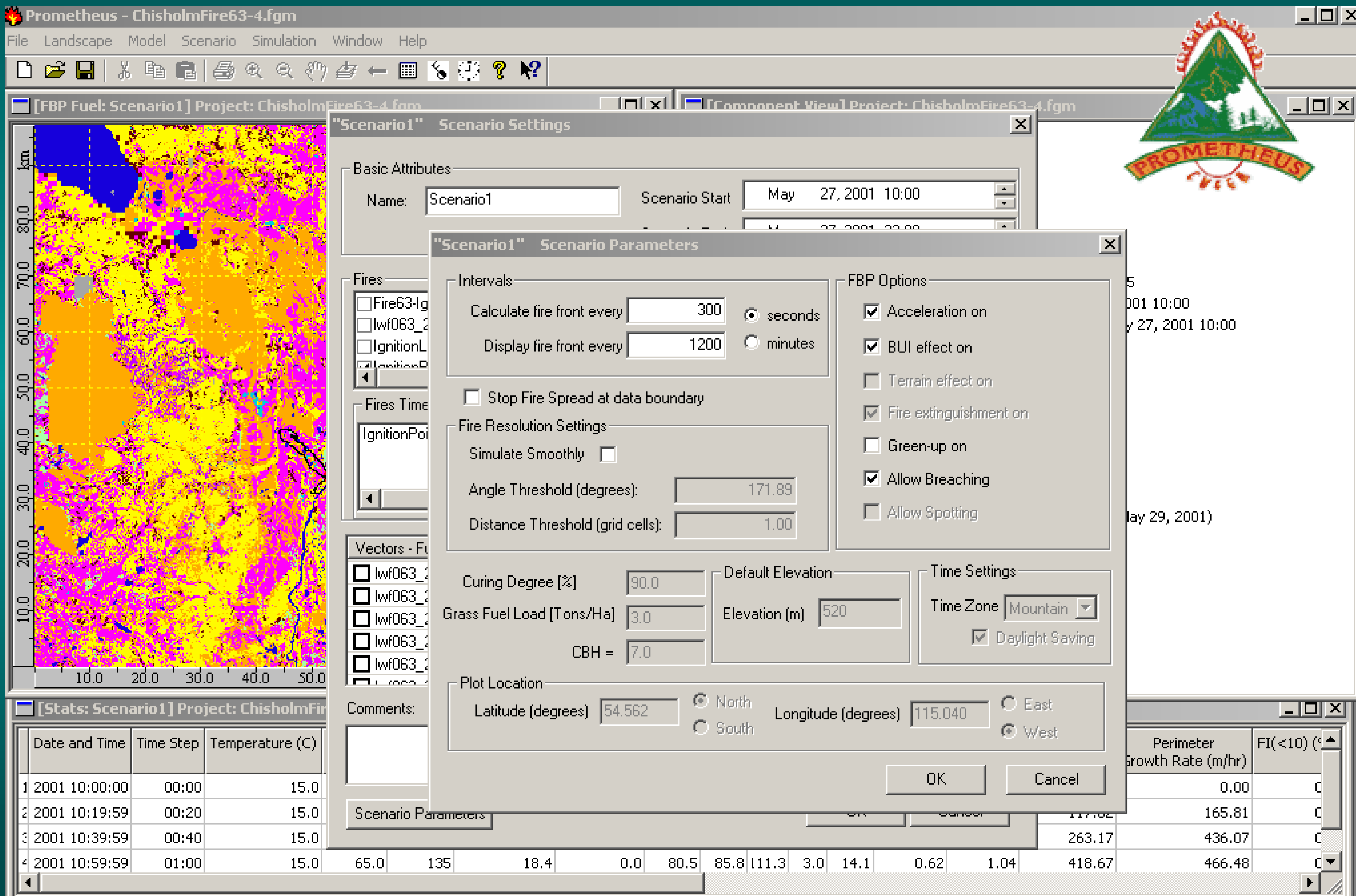
- Incorporate Byram's simple rule of thumb immediately
- Include Albini's spotting model in the form of an auxiliary calculator allowing the user an option of adding new ignition points when and where appropriate
- Continue with research to derive rules based on analysis of wildfire case studies and expert opinion for determining breaching by massive spotting.

Modeling Spotting & Breaching in Prometheus Challenges



- **Determine rules for:**
  - **Number and size of firebrands given fuel type**
  - **Optimum spotting distance given fuel type, weather, and other CFFDRS variables**
    - **e.g. Albini model determines maximum distance only**
    - **Topographical influences**
  - **Receptiveness of fuel bed receiving fire brands given fuel type, weather, and other CFFDRS variables**
    - **Incorporate existing ignition probability models**

Prometheus Breaching of Barriers - Interface



Wildland Fire Operations Research Group (WFORG) - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media Links Address

FERIC

Wildland Fire Operations Research Group

Home Head Office Eastern Division Western Division

Home
About WFORG
Projects
Forums
Resources
Conference Presentation

Senior Researcher with FERIC Wildland Fire Operations Research Group Collaborates with ASRD Forest Protection Division Staff in the Continuing Development of *PROMETHEUS*

PROMETHEUS is a computer-based, wave propagation fire growth model designed to work in Canadian fuel complexes, utilizing the major modules of the Canadi ... *EUS* is also a national interagency project endorsed by the Can ... cies. The CIFFC Fire Science and Technology Working Group p ... ideas. Alberta Sustainable Resource Development (ASRD) is the le ... in February 2000. The initial version of *PROMETHEUS* was released in March 2002. The latest version (3.2.3) was released on October 27, 2004. Further details on *PROMETHEUS* are available on the project's website (http://www.firegrowthmodel.com).

http://fire.feric.ca/

Fire breaching a dirt road

PROMETHEUS CWFGM

Spot fire development

The Chisholm/Dogrib Fire Research Program was established to study fire behaviour characteristics and post-fire impacts of two major Alberta fires — the Chisholm Fire and Dogrib Fire (http://www.fmf.ca/pa_CDFR.html). The Chisholm Fire overran the hamlet of

Internet

foothills
MODEL FOREST
research growing into practice

Chisholm/Dogrib Fire Research Initiative
Quicknote 6

November 2004 By: M.E. Alexander, C. Tymstra & K.W. Frederick

Incorporating breaching and spotting considerations into *PROMETHEUS* – the Canadian wildland fire growth model

http://www.fmf.ca/CDFR/CDFR_Qn6.pdf

Pl
we
modules of the Canadian Forest Fire Danger Rating System, namely the Canadian Forest Fire Weather Index (FWI) System and the Canadian Forest Fire Behaviour Prediction (FBP) System. The wildland fire environments to which *PROMETHEUS* is applied include both natural (e.g., water bodies, rock outcrops, particular fuel types, recent burns) and man-made barriers (e.g., roads, plowed fields, irrigated pastures, planned firebreaks) to fire spread. These discontinuities in the fuel type mosaic are treated as "non fuel" in the model (i.e., unburnable).

Barriers to fire spread either: (1) stop fire growth; (2) hinder fire growth (i.e., fire spreads laterally around an unburnable patch of ground); or (3) temporarily halt or delay maximum fire growth potential (e.g., the development of new, discrete ignition points across a wide water body as result of "mass transport" need time to reach their equilibrium rate of fire spread). Models like *PROMETHEUS* must be capable of dealing with these barriers to fire spread in order to realistically simulate the growth of free-burning wildland fires. *PROMETHEUS* presently handles the first two cases except for roads and narrow water bodies. The breaching or crossing of a barrier can occur by one, all or any combination of the following mechanisms:

- Spotting (i.e., sparks or embers are carried by the wind and start new fires beyond the zone of direct ignition by the main advancing fire front)
- Thermal radiation, either by pilot (firebrand) or spontaneous ignition
- Direct flame contact by the fire's leading edge
- Fire whirls

PROMETHEUS

QUESTIONS

PROMETHEUS

foothills
MODEL FOREST
research growing into practice.