U.S. BEHAVE System

Unit IV-F
Wildland Fire Behavior Specialist Course
February 2008

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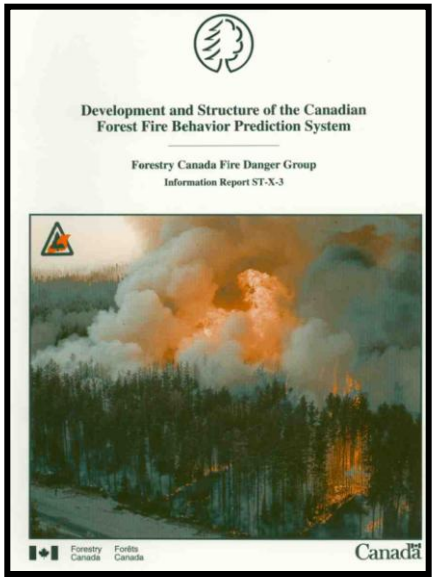
CIFFC
CANADIAN INTERAGENCY FOREST FIRE CENTRE
CENTRE INTERSERVICES DES FEUX DE FORÊT DU CANADA

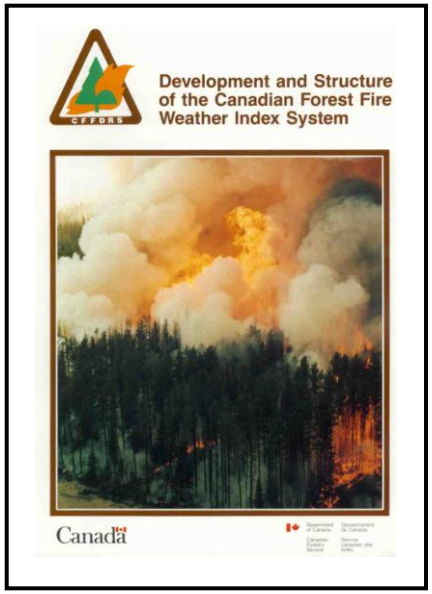
Unit IV-H Objectives:

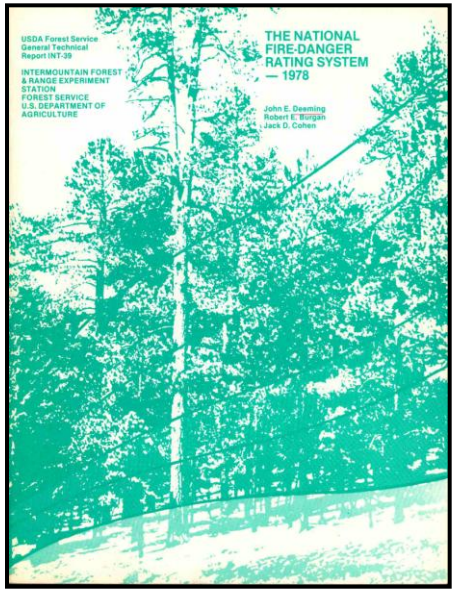
1. **Appreciate the similarities and differences between the U.S. BEHAVE fire behavior prediction system and the Canadian Forest Fire Behavior Prediction System.**

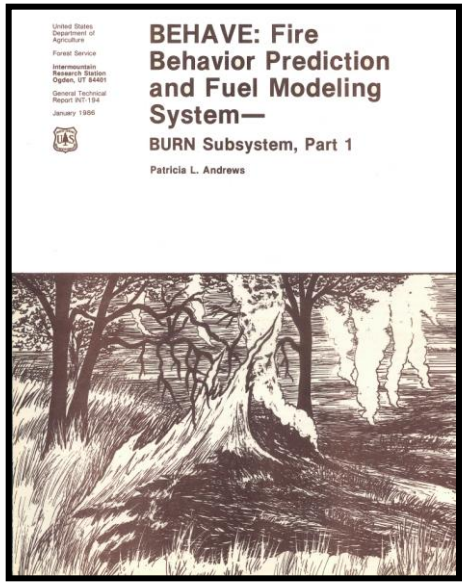
2. **Understand how to make calculations using the BEHAVE software.**

Basic Similarities & Differences Between Canadian & U.S. Systems









Fire Environment Inputs: Fuels

- **Canadian**
  - **16 Fuel Types**

- **U.S.**
  - **13 Fire Behavior Fuel Models**
  - **20 Fire Danger Fuel Models**
  - **Customized Fuel Models**

USDA United States Department of Agriculture

Forest Service

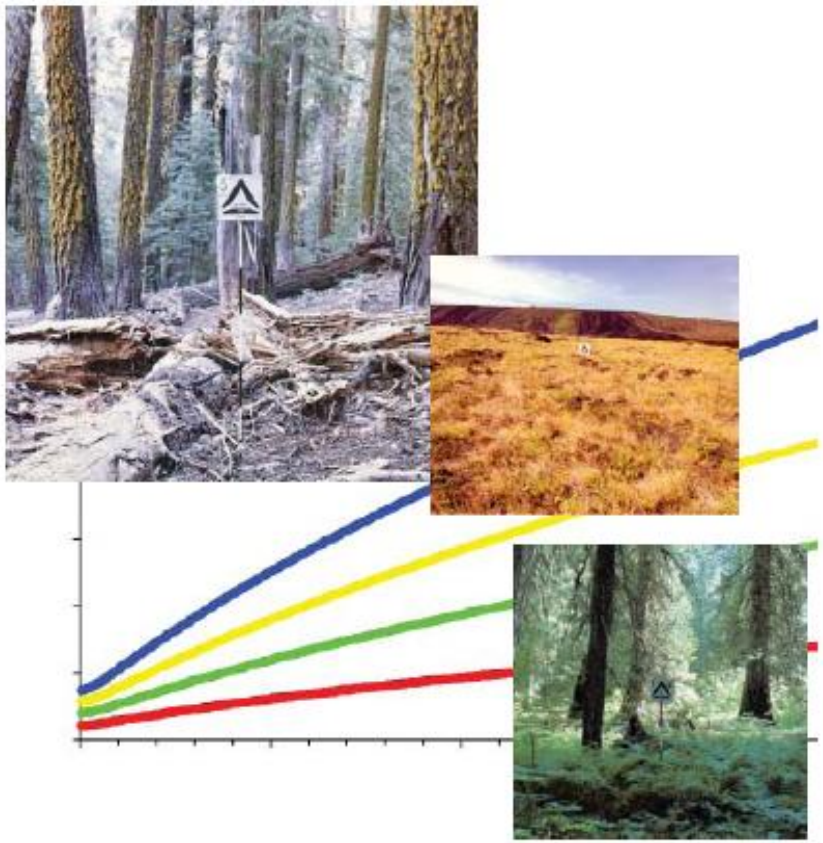
Rooky Mountain Research Station

General Technical Report RMRS-GTR-153

June 2005

Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model

Joe H. Scott
Robert E. Burgan



Number of fuel models in U.S. recently expanded to ~ 40 new models.

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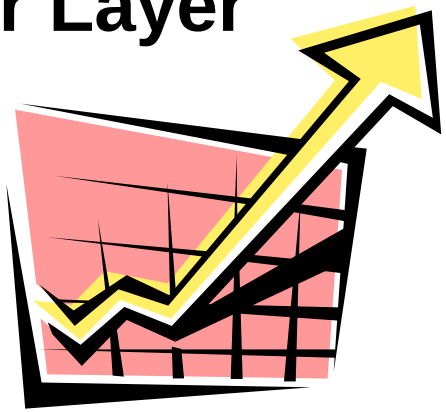
Fire Environment Inputs: Live Fuel Moisture

- **Canadian**
  - **Conifer Foliar MC Estimated From Calendar Date, Location (Lat./Long) and Elevation**
- **U.S.**
  - **Understory Live Moisture Content (Herbaceous & Woody) Estimates Based on Phenology Required for Certain Fuel Models.**

Fire Environment Inputs: Dead Fuel Moisture

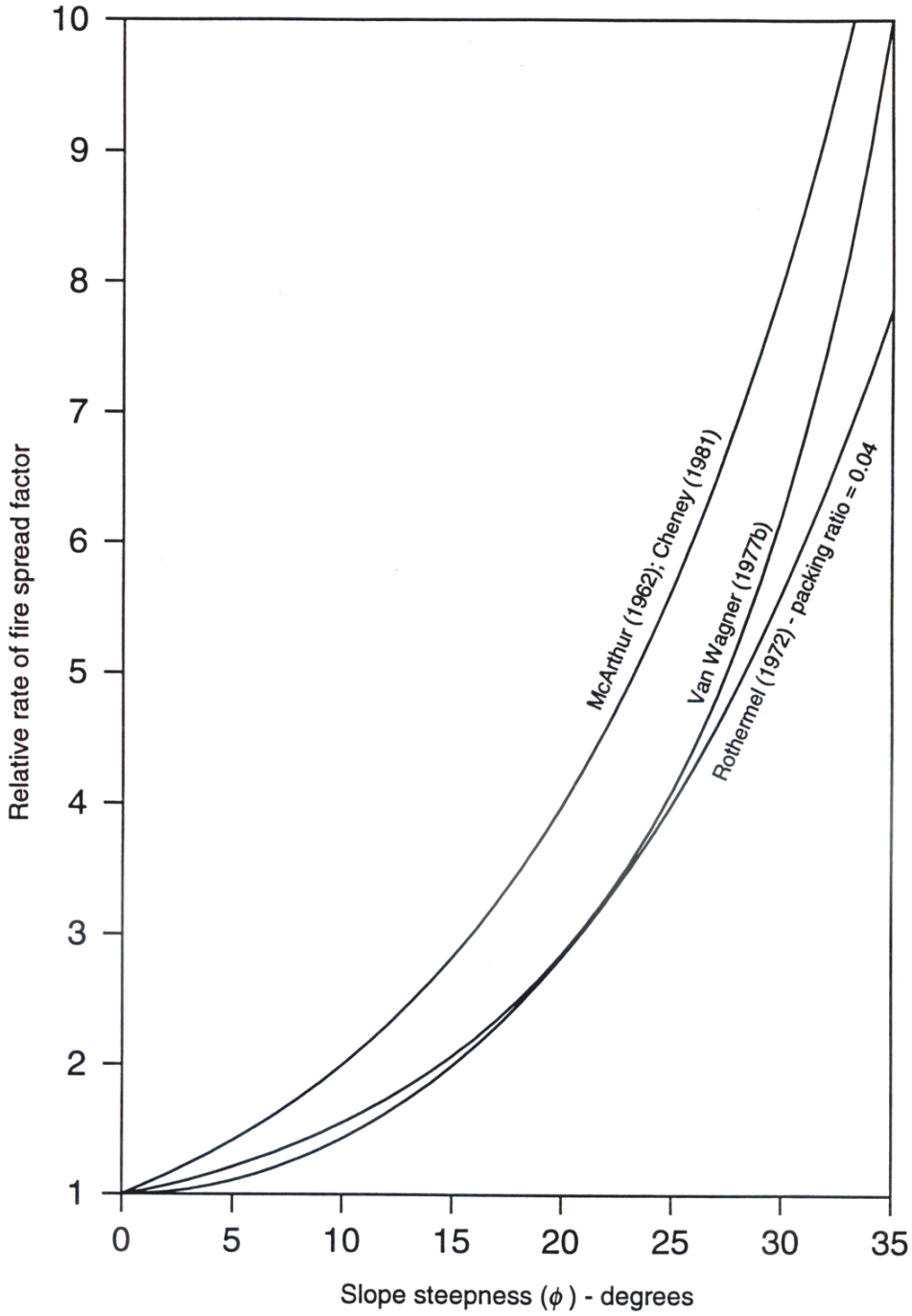
- **Canadian**
  - **FWI System Fuel Moisture Codes Dependent on the Continuity of Daily Wx. Readings**
  - **Emphasis on Forest Floor Layer**



- **U.S.**
  - **Dead Fuel Moisture Content (1-hr, 10-hr, 100-hr, 1000-hr TL's) Calculated From Current Wx. Observations Plus Other Environmental Variables**
  - **Emphasis on Herbaceous & Woody Vegetation & Dead-Down Roundwood Fuels**

Fire Environment Inputs: Topography

- **Canadian**
  - **Considers the Mechanical Effects of % Slope on Fire Behavior**
  - **Uses a Vectoring Approach For Cross-Slope Situations**
- **U.S.**
  - **Considers the Mechanical Effects of % Slope on Fire Behavior**
  - **Uses Basic Vectoring for Cross-Slope Situations**



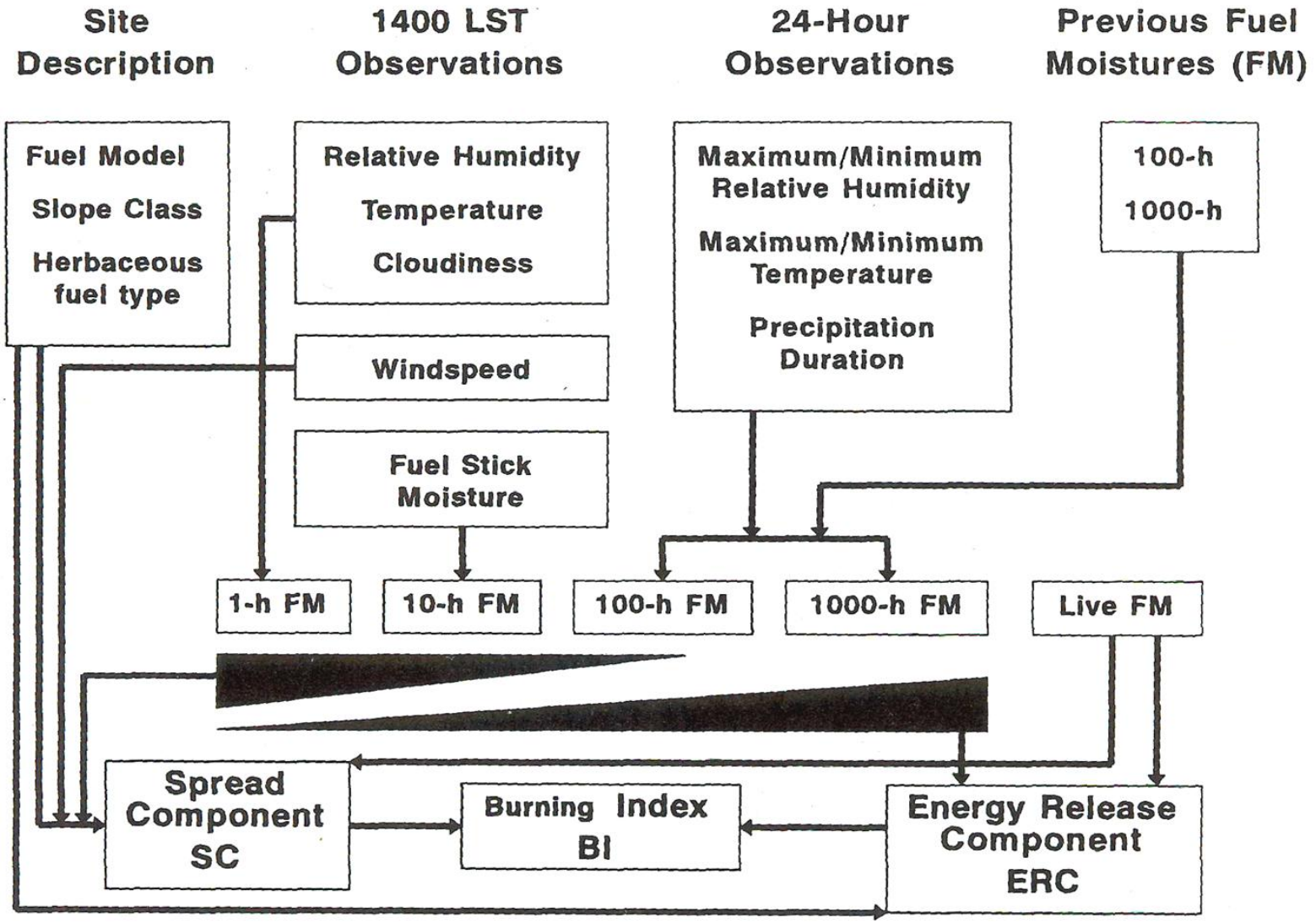
The effect of slope steepness on uphill rate of fire spread of free-burning wildland fires in the absence of wind according to Australian (McArthur 1962; Cheney 1981), Canadian (Van Wagner 1977b) and American (Rothermel 1972) authorities

Fire Environment Inputs: Weather

- **Canadian**
  - **Open Wind Measured at 10-m Height**

- **U.S.**
  - **Open Wind Measured at 20-ft (6.1-m) Height**
  - **Open Wind Adjusted for Vegetative Cover & Topographic Position to “Mid-flame” Wind Speed**

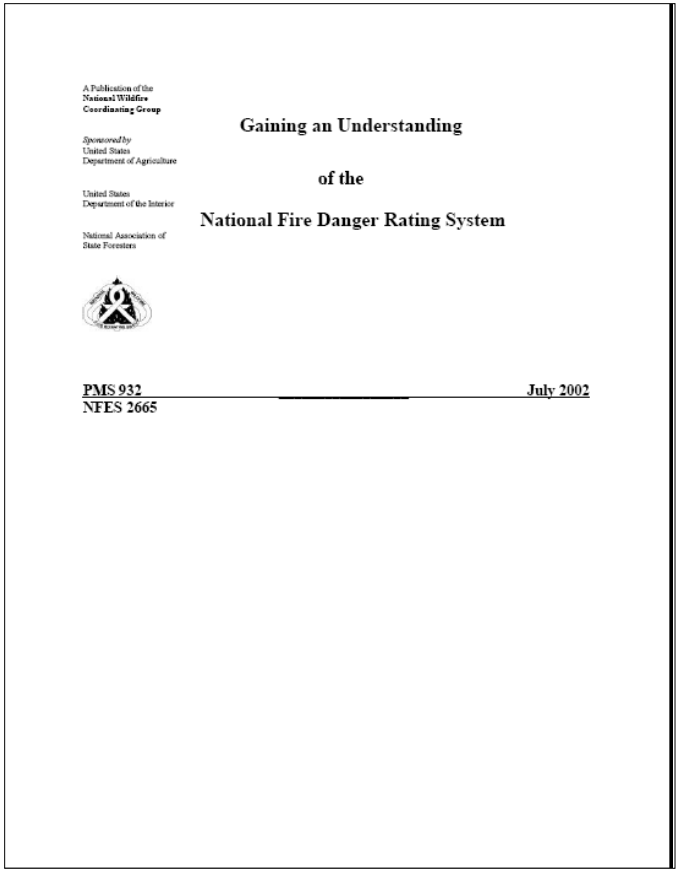
U.S. NFDRS System Structure



Fire Danger Index Equivalencies

Canadian	U.S.
• FFMC	• IC
• DMC/BUI	• ERC
• DC	• KBDI
• ISI	• SC
• FWI	• BI

U.S. National Fire Danger Rating System



A Publication of the
National Wildfire
Coordinating Group

Sponsored by
United States
Department of Agriculture

United States
Department of the Interior

National Association of
State Foresters

Gaining an Understanding

of the

National Fire Danger Rating System

PMS 932 July 2002
NFES 2665

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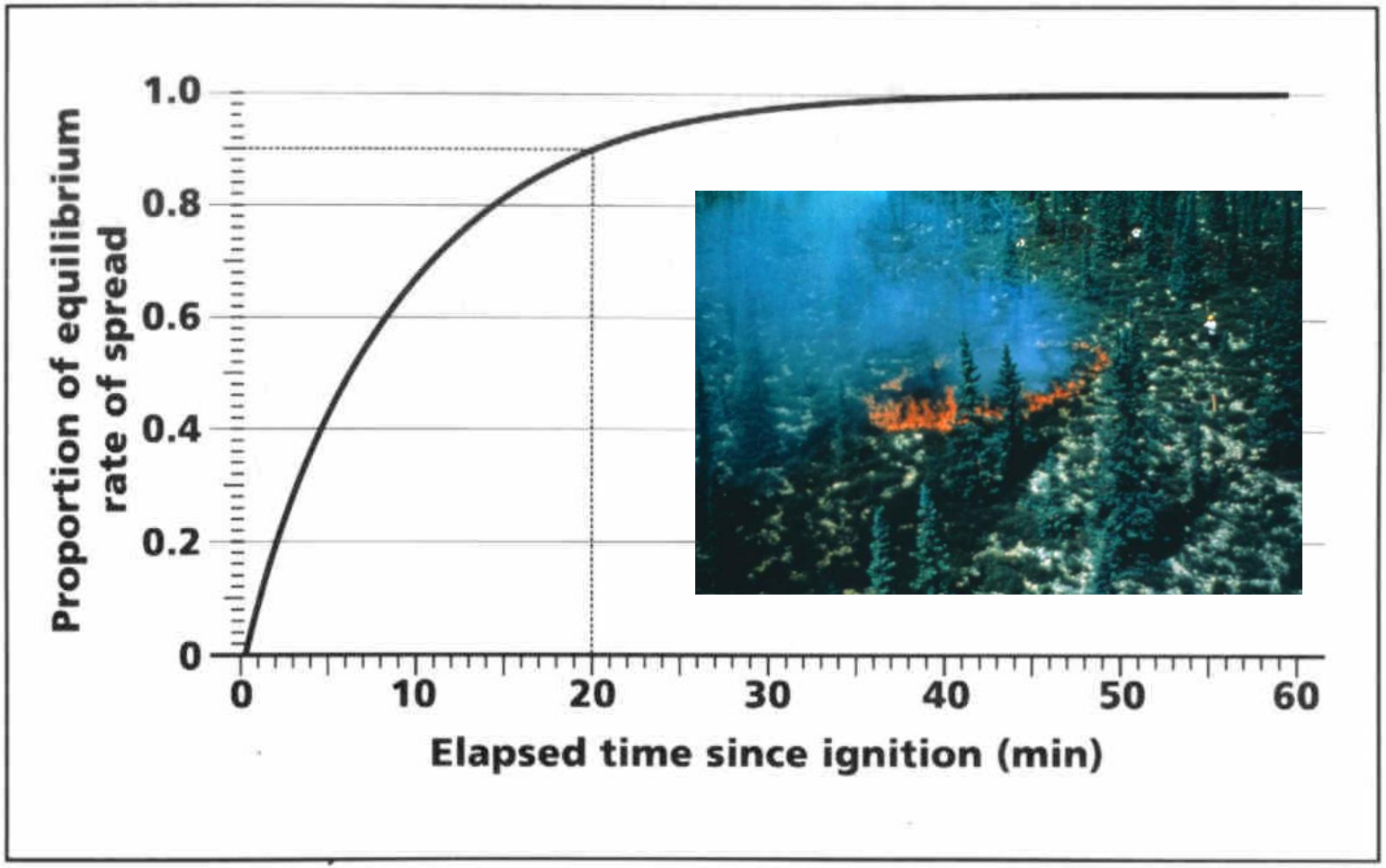
For more information:
National Fire Equipment System (NFES)
(http://www.nwcg.gov/pms/pubs/pubs.htm)

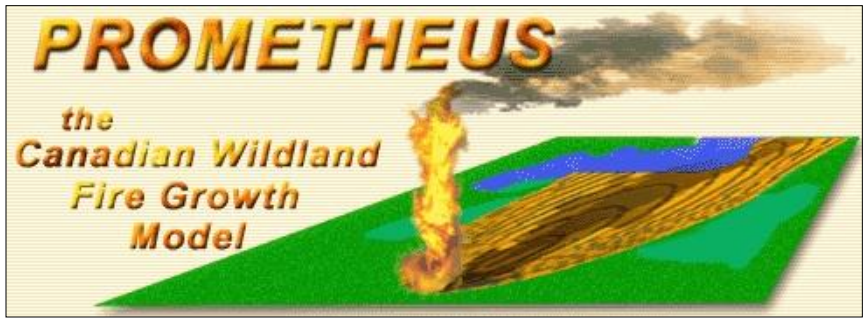
- **National Fire Danger Rating System Reference Material – Publication NFES 2687**

Fire Behavior Outputs

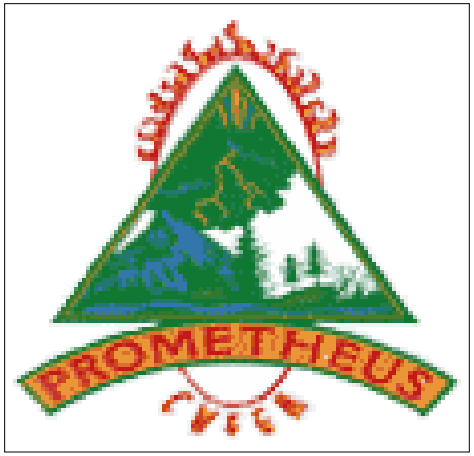
- **Canadian**
  - **Produces Estimates of ROS & Intensity**
  - **Predicts both Surface & Crown Fire Within a Given Fuel Type**
  - **Predicts Fuel Consumption**
  - **Allows for Acceleration From A Point Source Ignition**
- **U.S.**
  - **Produces Estimates of ROS & Intensity/Flame Length**
  - **Primary Prediction by Fuel Model is for Surface Fire**
  - **No Estimates of Fuel Consumption**
  - **No Allowance for Acceleration**

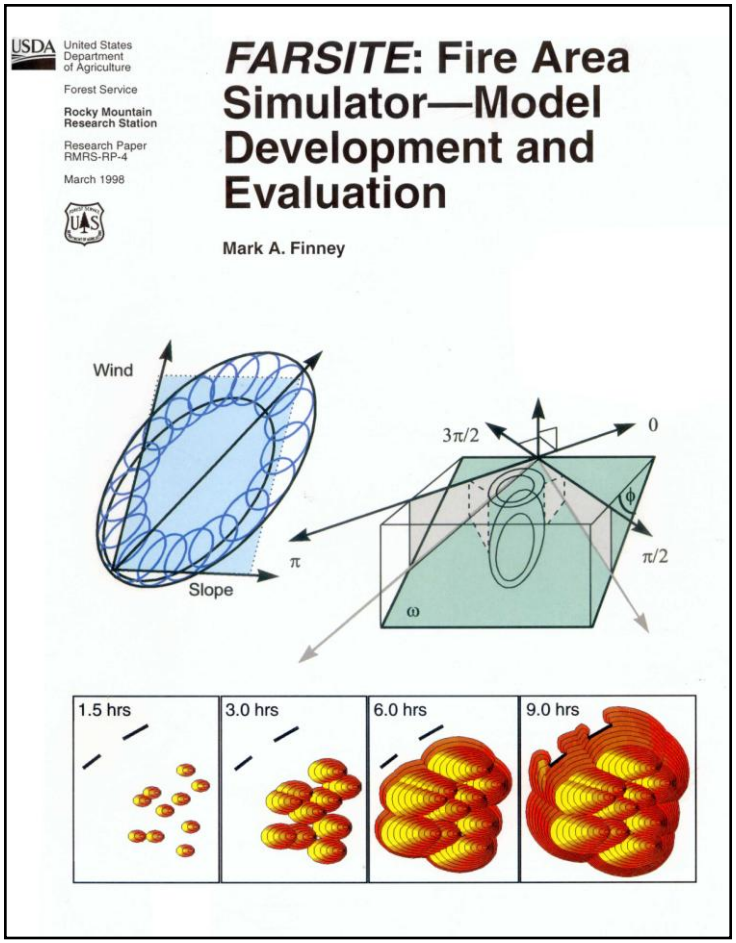
Acceleration curve for open canopy fuel types showing the proportion of equilibrium rate of spread as a function of elapsed time since ignition.



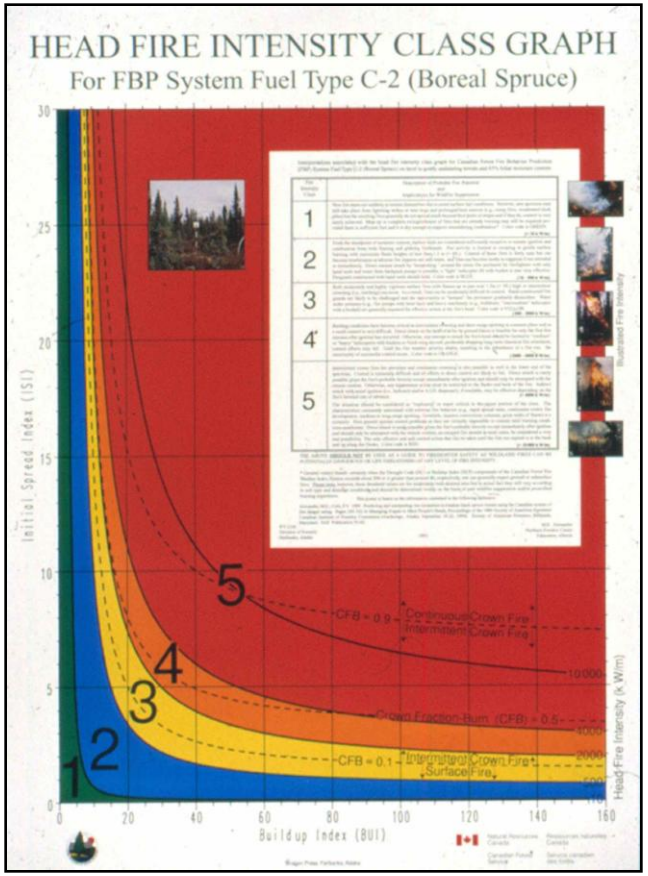


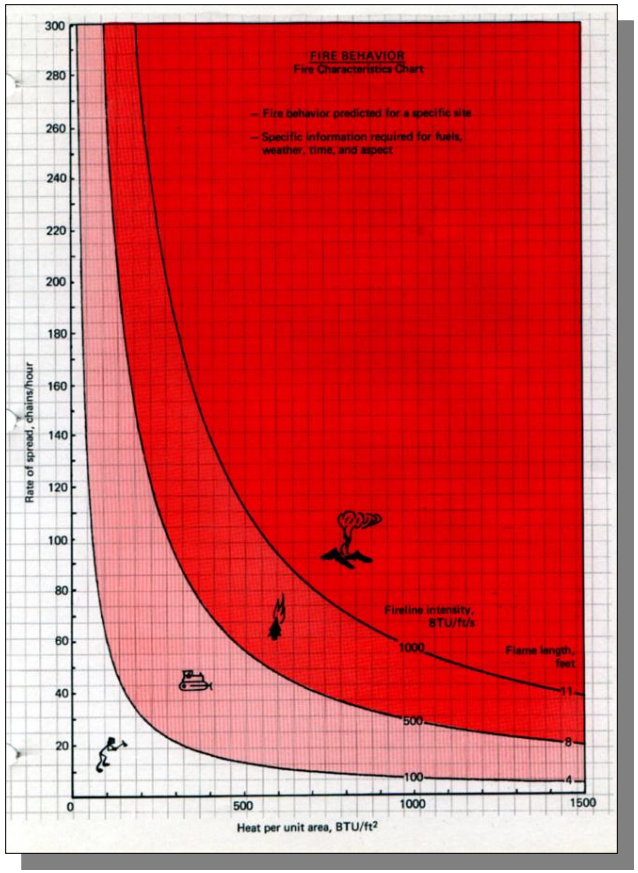
http://www.firegrowthmodel.com/





Fire Behavior Outputs:
Fire Intensity Class Graphs vs.Hauling Charts





Technical Basis

- **Canadian**
  - **System Largely Derived From Empirical Data Coupled With Simple Logic**
- **U.S.**
  - **System Based on Laboratory Fires & Physical Theory**

In his comparison of the 1972 National Fire Danger Rating System and the Canadian FWI System, Van Wagner (1975) concluded that:

The American system is probably at its best in the open, grassy forests or brush types with little or no duff layer common in many parts of the United States, but not well represented in Canada. The Canadian system, on the other hand, is at its best in forests with fairly complete canopy and a substantial layer of litter and duff but no marked seasonal variation in herbaceous vegetation.

Blackstone Prescribed Burn in Bog Birch Shrubland Fuels, west-central Alberta - October 11, 1991

Observations by Bill de Groot (Canadian Forest Service, Edmonton, AB)

Temperature: 18.8 ºC
Relative Humidity: 21%
Wind measured at a height 1.3 m in the "open": 10.9 km/h

Observed Rate of Fire Spread (3-min interval): 21.9 m/min

Blackstone Prescribed Burn in Bog Birch Shrubland Fuels, west-central Alberta - October 11, 1991

BEHAVE PREDICTIONS

1-hr TL FMC = 5%
10-hr TL FMC = 5% + 1% = 6%
Live Woody Moisture = 50%
(as per Rothermel 1983, p. 13, Table II-2)
Fuel Model 5 - Brush (2 ft)

Predicted Rate of Spread: 22 m/min
Predicted Flame Length: 3.1 m

United States Department of Agriculture

Forest Service

Pacific Northwest Forest and Range Experiment Station

Research Note PNW-401 October 1982

Predicting Wildfire Behavior in Black Spruce Forests in Alaska

Rodney A. Norum

Abstract

The current fire behavior system, when properly adjusted, accurately predicts forward rate of spread and flame length of wildfires in black spruce (*Picea mariana* (Mill.) ...bserved and quantified, adjustment ...ted fuel models to correct the ...lues. Spotting distance models ...ections and assumptions are made.

...ruce, *Picea mariana*.

...tial for making tactical plans for ...e (*Picea mariana* (Mill.) B.S.P.)

...Rothermel (1972) fire spread ...eans of predicting fire behavior. ...the model, in the form of ...are not adequately described by the ...t and adaptation of the model are ...forecast. The typical black spruce/ ...ens-Pleurozium schreberi*) forests of

...omographs to predict wildfire ...ior officer for a fire in an area of ...r Alaska. The fire burned for several ...rom flat to 32 percent under a ...a surface fire, presenting an ideal ...me lengths under varied conditions ...e availability of an accurate ...l moisture meter (McLeod 1976) ... of fuels collected near the fire. ...nd direction of the wind were ...lected. Everything necessary to ...vailable for comparison with values

...st

The Rosie Creek Fire

By

Glenn P. Juday*

Introduction

The winter of 1982-83 was mild in interior Alaska. Aside from an early, heavy snowfall in October and November which insulated the ground against deep freezing, it was a dry winter as well. The weather station at the Fairbanks International Airport recorded below-normal snowfall from December through March. Breakup came early; the Tanana River at Nenana lost its ice cover on April 29. The average temperature for the month of April 1983 was 7.2°F above normal. By the end of May, the combination of early snowmelt, very low spring precipitation, warm weather, and drying winds produced a high fire danger.

Many people near Fairbanks were looking ahead to a busy construction season or to establishing or expanding cultivated areas. They took advantage of the warm, dry early spring to clear land. Most obtained open-burning permits from the state Division of Forestry (DOF) to burn the slash and clearing debris. Most followed common sense and stopped burning when warm temperatures and high winds caused extreme fire danger after May 28. But on Sunday, May 29, a man set fire to his land-clearing debris on the Tanana River lowlands near the mouth of the Rosie Creek. Carried by a powerful east wind, the fire escaped and began to race across the highly flammable black spruce-covered permafrost flats, headed west. Above the flats to the north, on the deep wind-deposited silt soils of the south-facing ridges, grew some of the largest and most productive white spruce forests in northern Alaska. The demand for forest products in interior Alaska had made these stands among the most important for forest management in this region of the state. Even more alarming, if the fire shifted to the east, its path would cross a rural residential area that had expanded greatly in population in the last few years.

What follows here is a reconstruction of the events of the Rosie Creek Fire, taken from the fire narrative (Alaska Department of Natural Resources, Division of Forestry, 1983a, b) and fire night reports. The chronology of this fire provides a good opportunity to see how a modern, wildland-fire-control organization works.

*Visiting Associate Professor and Coordinator, Rosie Creek Fire Research Project, Agricultural and Forestry Experiment Station, Fairbanks.

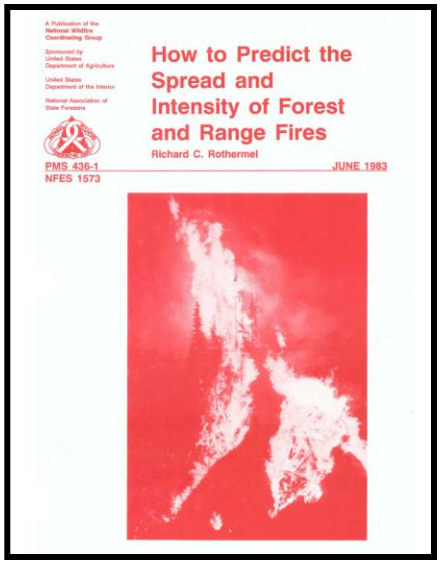
Vol. 17, No. 1, 1985 11

Rod Norum found that Fire Behavior Fuel Model 9 Rate of Spread X 1.2 worked best for predicting head fire spread rates in Alaskan black spruce. For flame lengths and in turn fire intensities he recommended using Fire Behavior Fuel Model 5.

1983 Rosie Creek Fire, Fairbanks, Alaska
BEHAVE Predictions

Estimating 1-hr Time Lag (TL) Fuel Moisture Content (FMC) as per Rothermel (1983)

Temperature: 23.3 deg ^{o}C
Relative Humidity: 33%



Reference Fuel Moisture: 5%
Adjust for shading, time of year (i.e., month), time of day, slope steepness, aspect and elevation: 3%

Dead Fuel Moisture Content: 5% + 3% = 8%

Assumptions (as per Rothermel 1983):
10-hr TL = 8% + 1% = 9%
100-hr TL = 8% + 2% = 10%

Assume 100% for Live Moisture Content as per Rothermel (1983, Table II-2, p. 13)

1983 Rosie Creek Fire, Fairbanks, Alaska
BEHAVE Predictions

Estimating the Mid-flame Wind Speed

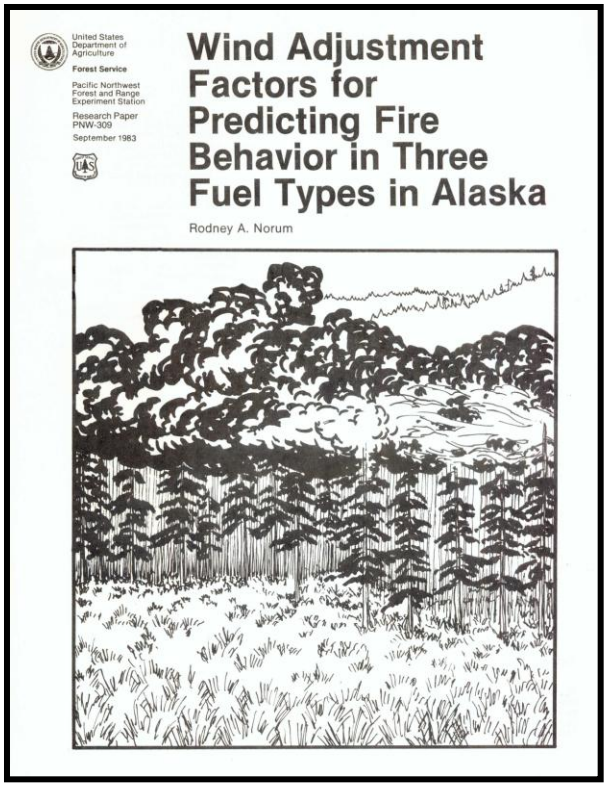
20-ft (6.1) Open Wind Speed: 13 mph (20.9 km/h)

Rod Norum has suggested a Wind Reduction Factor of 0.2 for Alaskan black spruce.

Dick Rothermel has suggested a Wind Reduction Factor of 0.4 for Fire Behavior Fuel Model 5

Mid-flame Wind Speed = 13 x 0.2 = 2.6 mph for Fire Behavior Fuel Model 9

Mid-flame Wind Speed = 13 x 0.4 = 5.2 mph for Fire Behavior Fuel Model 5



1983 Rosie Creek Fire, Fairbanks, Alaska

Rosie Creek Fire near Fairbanks, Alaska June 2, 1983

Fire Behavior Characteristic	BEHAVE System	CDN FBP System
Head Fire Rate of Spread (m/min)	1.2	31.4
Flame Length (m):	1.0	10+
Fire Intensity (kW/m) :	259	41 995

BEHAVE Training

S-490 Course
Advanced Wildland Fire Behavior Calculations

Course Offerings:

(http://www.fire.nps.gov/firetraining/)

BEHAVE Software

BehavePlus **(windows based)**
Available free from U.S. Forest Service
(http://www.fire.org/)

Behave **by** ***Remsoft***
(http://www.remsoft.com)

United States Department of Agriculture

Forest Service

Rocky Mountain Research Station

June 2006

BehavePlus fire modeling system

Version 3.0

User's Guide

Patricia L. Andrews
Collin D. Bevins
Robert C. Seli

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