Crown Fire Behavior in Conifer Forests Synthesis

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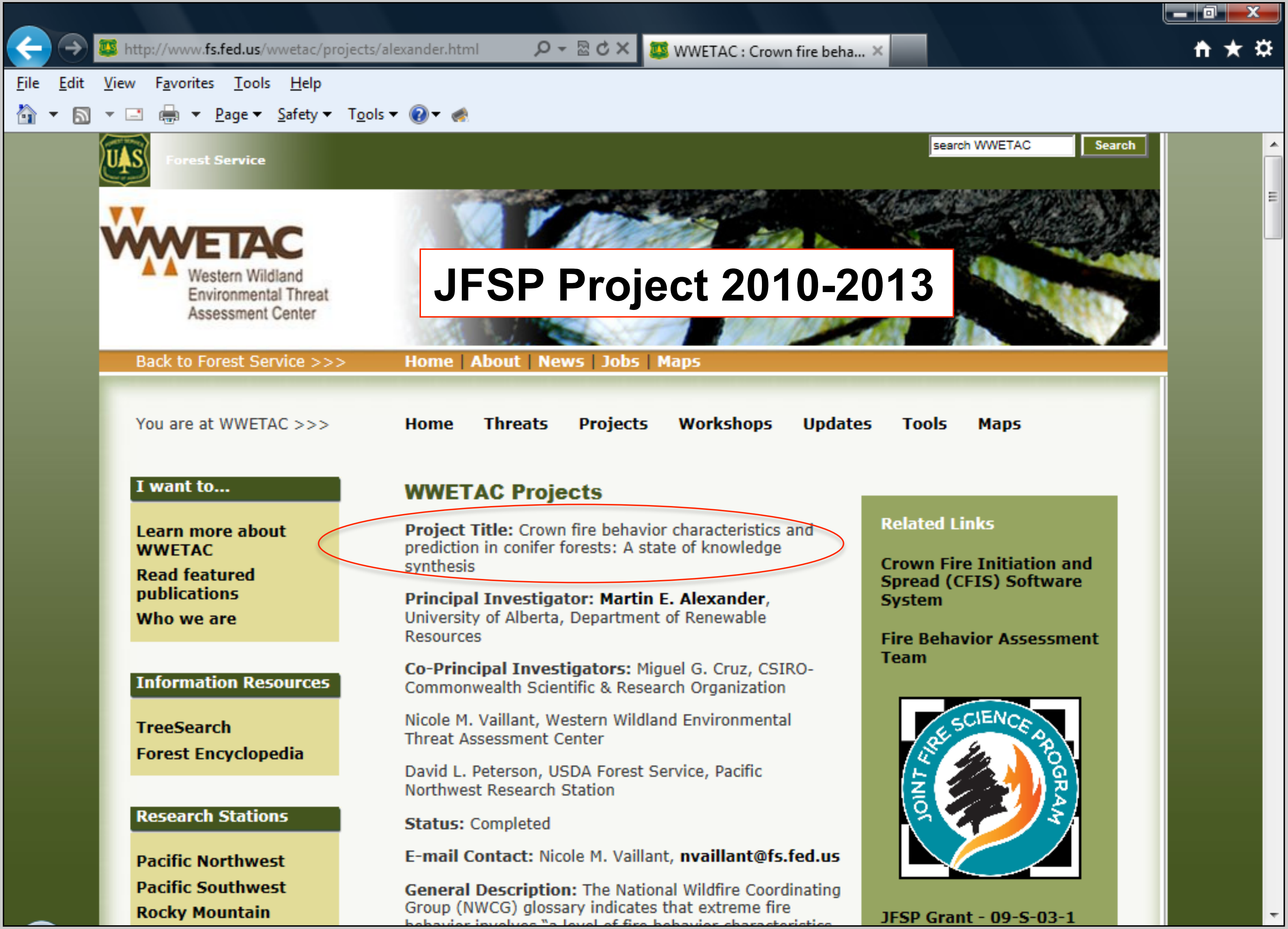
Alaska Fire Science Consortium

CFFDRS in Alaska Summit – October 28-30, 2014
Fort Wainwright, AK

JOINT FIRE SCIENCE PROGRAM



JFSP Project 2010-2013

http://www.fs.fed.us/wwetac/projects/alexander.html

WWETAC : Crown fire beha...

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WWETAC Projects

Project Title: Crown fire behavior characteristics and prediction in conifer forests: A state of knowledge synthesis

Principal Investigator: Martin E. Alexander, University of Alberta, Department of Renewable Resources

Co-Principal Investigators: Miguel G. Cruz, CSIRO-Commonwealth Scientific & Research Organization

Nicole M. Vaillant, Western Wildland Environmental Threat Assessment Center

David L. Peterson, USDA Forest Service, Pacific Northwest Research Station

Status: Completed

E-mail Contact: Nicole M. Vaillant, **nvaillant@fs.fed.us**

General Description: The National Wildfire Coordinating Group (NWCG) glossary indicates that extreme fire

Related Links

- Crown Fire Initiation and Spread (CFIS) Software System
- Fire Behavior Assessment Team

JOINT FIRE SCIENCE PROGRAM

JFSP Grant - 09-S-03-1

Recent Syntheses on Crown Fires

November 2011

United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

General Technical Report PNW-GTR-854

November 2011

Synthesis of Knowledge of Extreme Fire Behavior: Volume I for Fire Managers

Paul A. Werth, Brian E. Potter, Craig B. Clements, Mark A. Finney, Scott L. Goodrick, Martin E. Alexander, Miguel G. Cruz, Jason A. Forthofer, and Sara S. McAllister

A SUMMARY OF KNOWLEDGE FROM THE Joint Fire Science Program

Chapter 8: Crown Fire Dynamics in Conifer Forests

Martin E. Alexander and Miguel G. Cruz[1]

As for big fires in the early history of the Forest Service, a young ranger made himself famous by answering the big question on an exam, "What would you do to control a crown fire?" with the one-liner, "Get out of the way and pray like hell for rain."—Norman Maclean (1992)

Introduction

Three broad types of fire are commonly recognized in conifer-dominated forests on the basis of the fuel layer(s) through which they are spreading:

- Ground or subsurface fire
- Surface fire
- Crown fire

Ground or subsurface fires spread very slowly and with no visible flame. Heading surface fires can spread with the wind or upslope, and backing surface fires burn into the wind (fig. 8-1 A) or downslope. A crown fire is dependent on a surface fire for both its initial emergence and continued existence. Thus, a crown fire advances through both the surface and tree canopy fuel layers with the surface and crown fire phases more or less linked together as a unit (fig. 8-1 B and C). The term "crowning," therefore, refers to both the ascension into the crowns of trees and the spread from crown to crown.

From the perspective of containing or controlling wildfires or unplanned ignitions, the development and subsequent movement of a crown fire represents a highly significant event as a result of the sudden escalation in the rate of advance and the dramatic increase in flame size and thermal radiation as well as convective activity, including fire-induced vortices and, in turn, both short- to long-range spotting potential. As a consequence, crown fires are dangerous for firefighters to try to control directly by conventional means. Suppression actions and options

[1] **Martin E. Alexander,** Department of Renewable Resources and Alberta School of Forest Science and Management, University of Albert, Edmonton, Alberta, Canada. **Miguel G. Cruz,** Bush Fire Dynamics and Applications, CSIRO Ecosystems Sciences–Climate Adaptation Flagship, Canberra, ACT 2601, Australia.

Figure 8-1—Variations in fire behavior within the jack pine/black spruce fuel complex found at the International Crown Fire Modeling Experiment study area near Fort Providence, Northwest Territories, Canada: (A) surface fire, (B) passive crown fire, and (C) active crown fire. For additional photography carried out on experimental basis, see Alexander and De Groot (1988), Alexander and Lanoville (1989), Stocks and Hartley (1995), and Hirsch et al. (2000).

Coming soon …

Volume II for Fire Behavior Specialists, Researchers and Meteorologists

Chapter 9: Crown Fire Dynamics in Conifer Forests

P.A. Werth, B.E. Potter, M.E. Alexander & others. 2014.
USDA Forest Service General Technical Report PNW-GTR-891.
(more detail, more pages, etc. than Volume I)

http://bcs.wiley.com/he-bcs/Books?action=index&bcsId=85788

Scott, Bowman, Bond, Pyne...

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January 2014

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Scott, Bowman, Bond, Pyne, Alexander:
Fire on Earth: An Introduction

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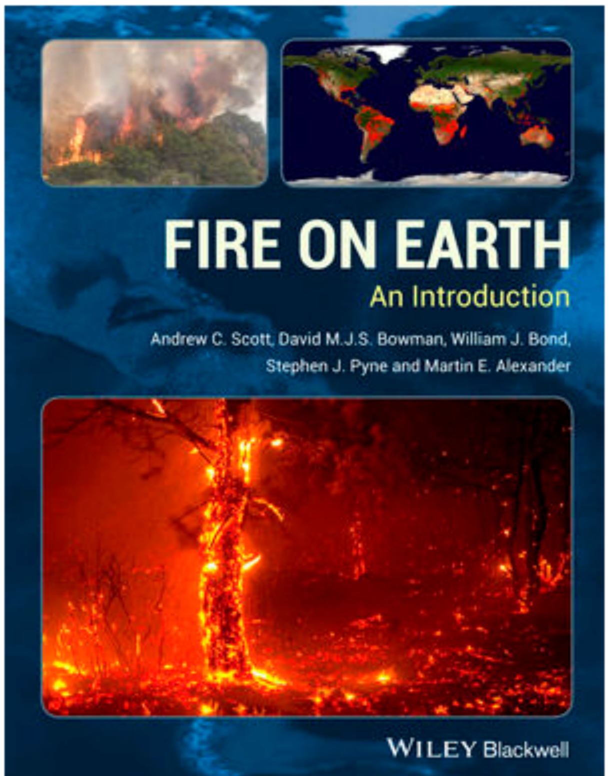


Welcome to the Instructor Companion Site for

Fire on Earth: An Introduction

Welcome to the website for **Fire on Earth: An Introduction** by Andrew C. Scott, David M.J.S. Bowman, William J. Bond, Stephen J. Pyne and Martin E. Alexander. This website gives you access to the rich tools and resources available for this text.

On this website you will find:

- Powerpoints of all figures from the book for downloading.
- PDFs of all tables from the book for downloading.
- Links to additional resources including key fire websites, videos and podcasts.
- Additional teaching material – an exercise in using charcoal data.

Resources are displayed in two ways:

- Using the menu at the top, select a chapter. A list of resources available for that particular chapter will be provided.
- Using the menu at the top, select a resource. This will allow you to access a particular resource section. You will then have the option of selecting resources within the section or going directly to a specific chapter.

PART FOUR

The Scienc & Art of Wildland Fi Behaviour Prediction

9 summary articles in special issue of FMT

August 2014

Fire Management *today*

Volume 73 • No. 4 • 2014

On the Cover:

Crowning associated with the major run of the Cottonville Fire in central Wisconsin at 5:11 p.m. CDT on May 5, 2005, in a red pine plantation. Photo taken by Mike Lehman, Wisconsin Department of Natural Resources.

The USDA Forest Service's Fire and Aviation Management Staff has adopted a logo reflecting three central principles of wildland fire management:

- *Innovation:* We will respect and value thinking minds, voices, and thoughts of those that challenge the status quo while focusing on the greater good.
- *Execution:* We will do what we say we will do. Achieving program objectives, improving diversity, and accomplishing targets are essential to our credibility.
- *Discipline:* What we do, we will do well. Fiscal, managerial, and operational discipline are at the core of our ability to fulfill our mission.

Firefighter and public safety is our first priority.

Contents

Short Features

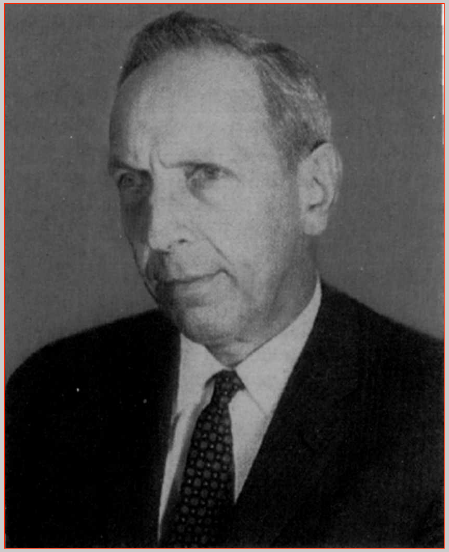
Introduction to Basic Concepts of Crown Fires

Fireline Intensity (Byram 1959)

$$I = H \times w \times r$$

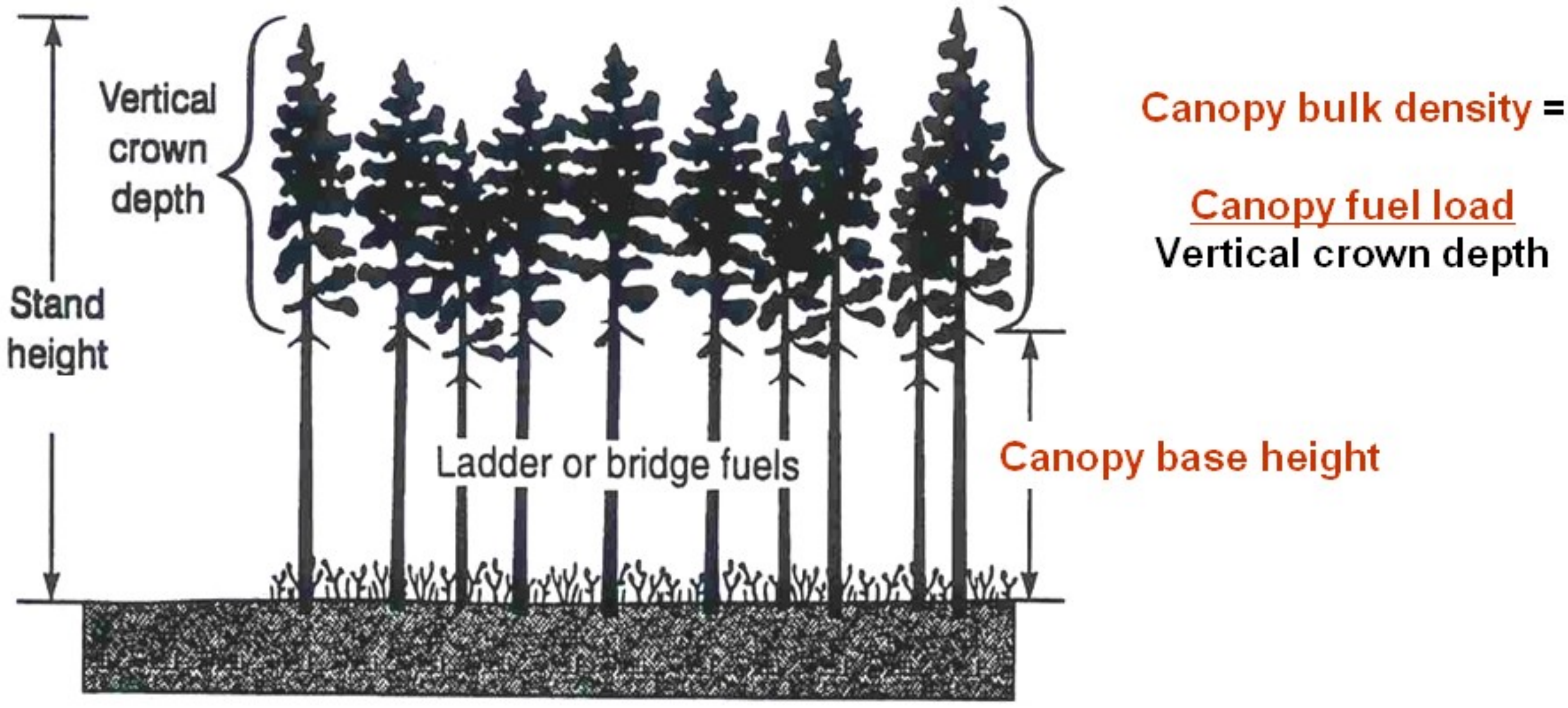
I	H	w	r
Fireline Intensity (kW/m)	Heat of Combustion (18 000 kJ/kg)	Fuel Consumed (kg/m^2)	Rate of Fire Spread (m/sec)

Fire intensity is the rate of energy release, or rate of heat release, per unit time per unit length of fire front



George M. Byram

Canopy Fuel Stratum & Stand Characteristics



Available Crown Fuel Load: needle foliage, lichens, small dead and live (a proportion) twigs < 1 cm in diameter

Ladder or bridge fuels: bark flakes, lichens, needle drape, boles branches (live & dead), understory conifers, tall shrubs

Types of Crown Fires

C.E. Van Wagner's (1977) three types of crown fires is the most widely recognized classification:

- Passive crown fire

- Active crown fire

- Independent crown fire

Torching does not constitute passive crowning as it generally does generate any kind of forward fire spread.

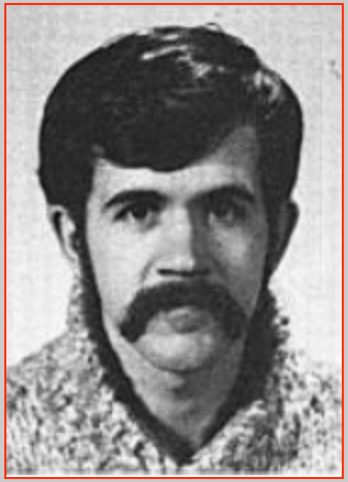
Understanding Crown Fire Behaviour based on Empirical Observations and Measurements in the Field

Observations and measurements of crown fire activity

- **Key to our understanding of crown fire dynamics**
- **Provides benchmark data for empirical-based model development and performance evaluation**
- **Serves as reality-checks for simulation studies**

Experimental fire, Ontario, Canada

Wildfire, Victoria, Australia



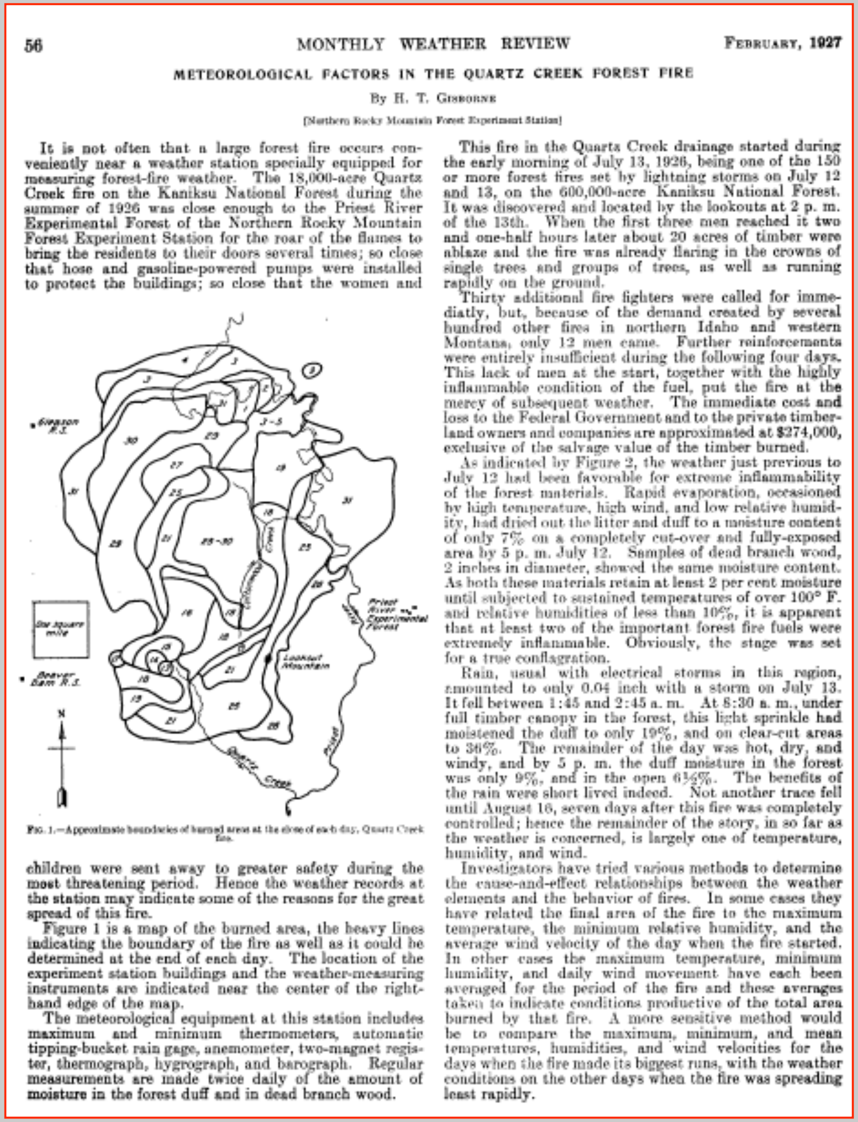
Marty Alexander

Porter Lake Project, Spruce-Lichen Woodland Stand, Northwest Territories, Canada

Big Fish Lake Project, Lowland Black Spruce Stand, North-central Alberta, Canada

A Historical Note: The First Wildfire Case Study?

1926 Quartz Creek Fire, Kaniksu National Forest – adjacent to the Priest River Experimental Forest, northern Idaho



56 MONTHLY WEATHER REVIEW FEBRUARY, 1927

METEOROLOGICAL FACTORS IN THE QUARTZ CREEK FOREST FIRE

By H. T. GISBORNE

[Northern Rocky Mountain Forest Experiment Station]

It is not often that a large forest fire occurs conveniently near a weather station specially equipped for measuring forest-fire weather. The 18,000-acre Quartz Creek fire on the Kaniksu National Forest during the summer of 1926 was close enough to the Priest River Experimental Forest of the Northern Rocky Mountain Forest Experiment Station for the roar of the flames to bring the residents to their doors several times; so close that hose and gasoline-powered pumps were installed to protect the buildings; so close that the women and children were sent away to greater safety during the most threatening period. Hence the weather records at the station may indicate some of the reasons for the great spread of this fire.

FIG. 1.—Approximate boundaries of burned areas at the close of each day, Quartz Creek fire.

Figure 1 is a map of the burned area, the heavy lines indicating the boundary of the fire as well as it could be determined at the end of each day. The location of the experiment station buildings and the weather-measuring instruments are indicated near the center of the right-hand edge of the map.

The meteorological equipment at this station includes maximum and minimum thermometers, automatic tipping-bucket rain gage, anemometer, two-magnet register, thermograph, hygrograph, and barograph. Regular measurements are made twice daily of the amount of moisture in the forest duff and in dead branch wood.

This fire in the Quartz Creek drainage started during the early morning of July 13, 1926, being one of the 150 or more forest fires set by lightning storms on July 12 and 13, on the 600,000-acre Kaniksu National Forest. It was discovered and located by the lookouts at 2 p. m. of the 13th. When the first three men reached it two and one-half hours later about 20 acres of timber were ablaze and the fire was already flaring in the crowns of single trees and groups of trees, as well as running rapidly on the ground.

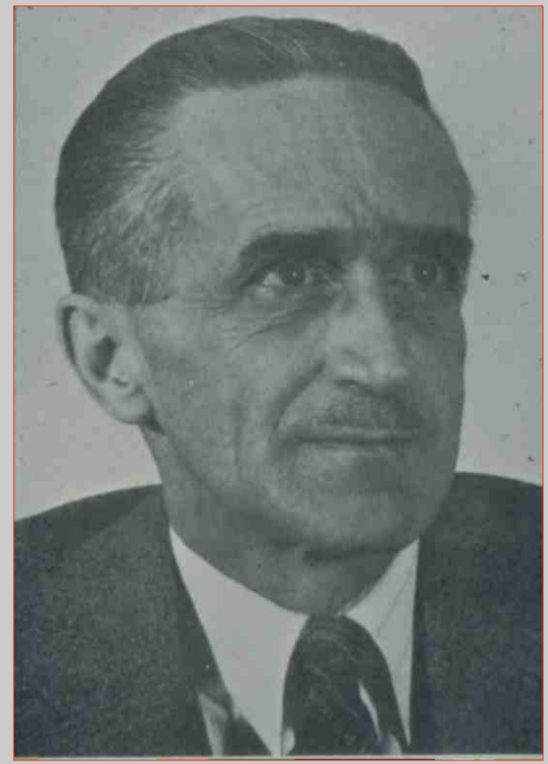
Thirty additional fire fighters were called for immediatly, but, because of the demand created by several hundred other fires in northern Idaho and western Montana, only 12 men came. Further reinforcements were entirely insufficient during the following four days. This lack of men at the start, together with the highly inflammable condition of the fuel, put the fire at the mercy of subsequent weather. The immediate cost and loss to the Federal Government and to the private timberland owners and companies are approximated at $274,000, exclusive of the salvage value of the timber burned.

As indicated by Figure 2, the weather just previous to July 12 had been favorable for extreme inflammability of the forest materials. Rapid evaporation, occasioned by high temperature, high wind, and low relative humidity, had dried out the litter and duff to a moisture content of only 7% on a completely cut-over and fully-exposed area by 5 p. m. July 12. Samples of dead branch wood, 2 inches in diameter, showed the same moisture content. As both these materials retain at least 2 per cent moisture until subjected to sustained temperatures of over 100° F. and relative humidities of less than 10%, it is apparent that at least two of the important forest fire fuels were extremely inflammable. Obviously, the stage was set for a true conflagration.

Rain, usual with electrical storms in this region, amounted to only 0.04 inch with a storm on July 13. It fell between 1:45 and 2:45 a. m. At 8:30 a. m., under full timber canopy in the forest, this light sprinkle had moistened the duff to only 19%, and on clear-cut areas to 36%. The remainder of the day was hot, dry, and windy, and by 5 p. m. the duff moisture in the forest was only 9%, and in the open 6½%. The benefits of the rain were short lived indeed. Not another trace fell until August 16, seven days after this fire was completely controlled; hence the remainder of the story, in so far as the weather is concerned, is largely one of temperature, humidity, and wind.

Investigators have tried various methods to determine the cause-and-effect relationships between the weather elements and the behavior of fires. In some cases they have related the final area of the fire to the maximum temperature, the minimum relative humidity, and the average wind velocity of the day when the fire started. In other cases the maximum temperature, minimum humidity, and daily wind movement have each been averaged for the period of the fire and these averages taken to indicate conditions productive of the total area burned by that fire. A more sensitive method would be to compare the maximum, minimum, and mean temperatures, humidities, and wind velocities for the days when the fire made its biggest runs, with the weather conditions on the other days when the fire was spreading least rapidly.

Gisborne, H.T. 1927. Meteorological Factors in the Quartz Creek Forest Fire. *Monthly Weather Review* 55: 56-60.

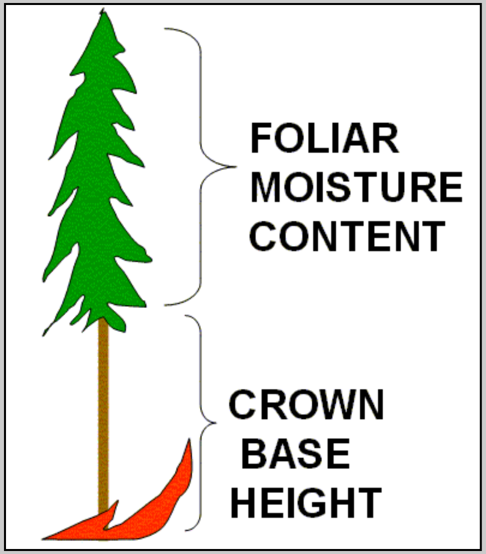


Harry T. Gisborne
Pioneer Forest Fire Researcher

Crown Fire Initiation

Van Wagner's (1977) Crown Fire Initiation Model

Vertical fire spread into the overstory canopy will occur when the surface fireline intensity (I_s) attains the critical value I_o as determined by ***z*** and ***m***.



$I_s < I_o$:

Surface Fire

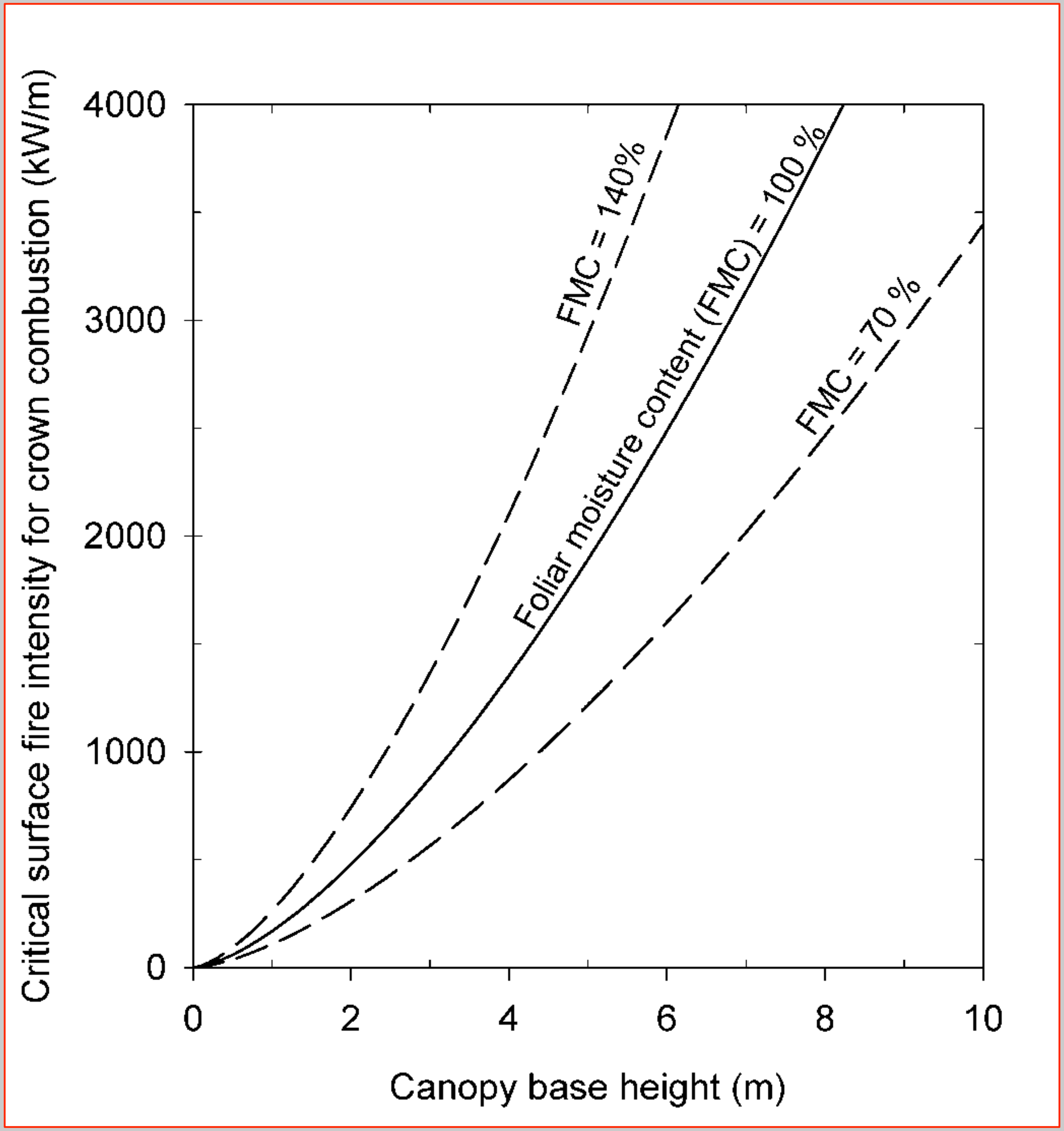
$I_s \sim I_o$:

Surface Fire - Crown Fire Transition

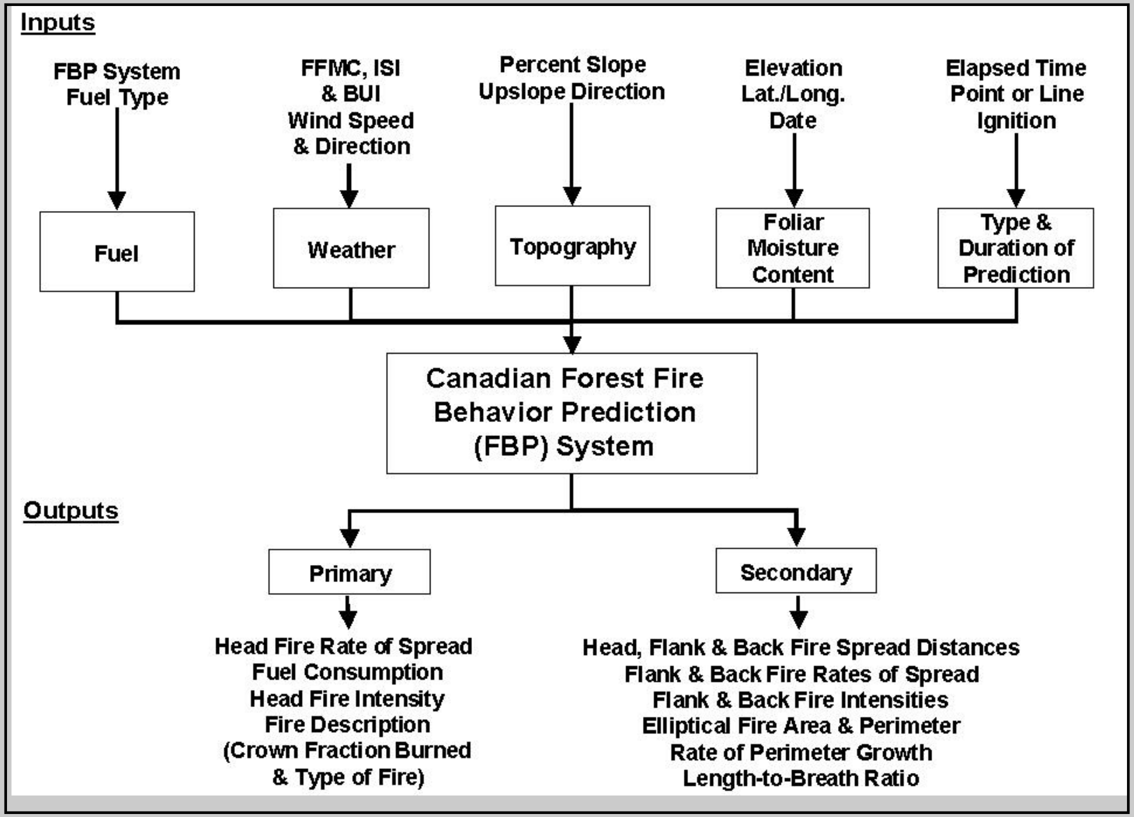
$I_s > I_o$:

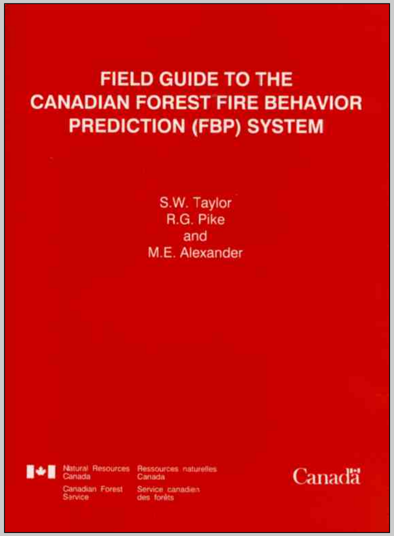
Crown Fire!

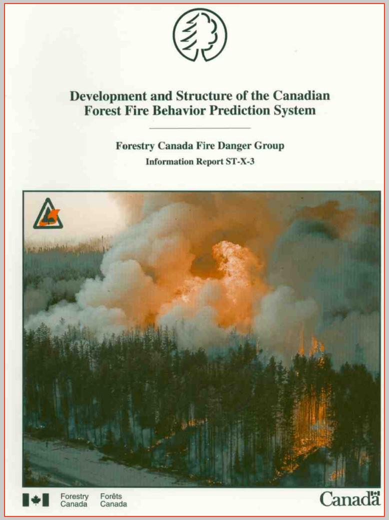
Van Wagner (1977) Crown Fire Initiation Model

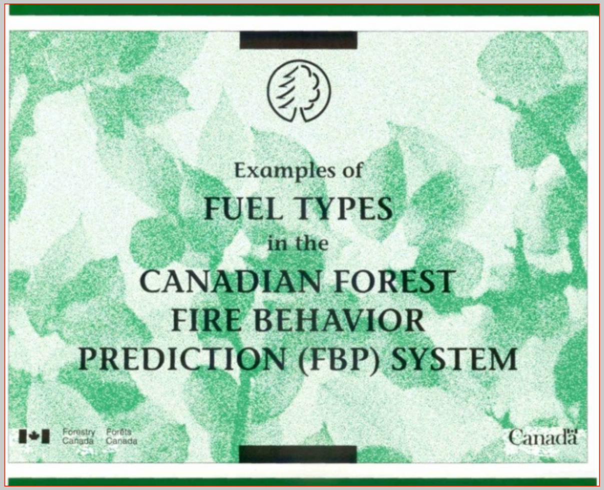


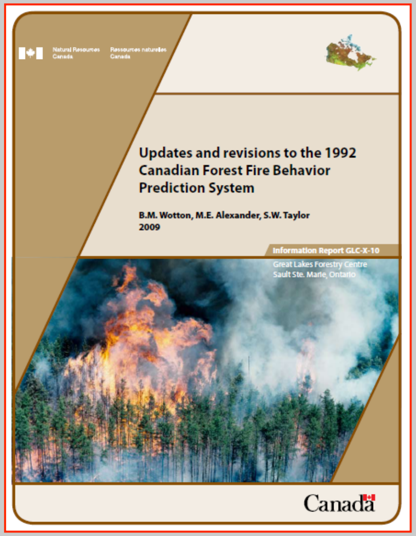
Canadian Forest Fire Behavior Prediction System



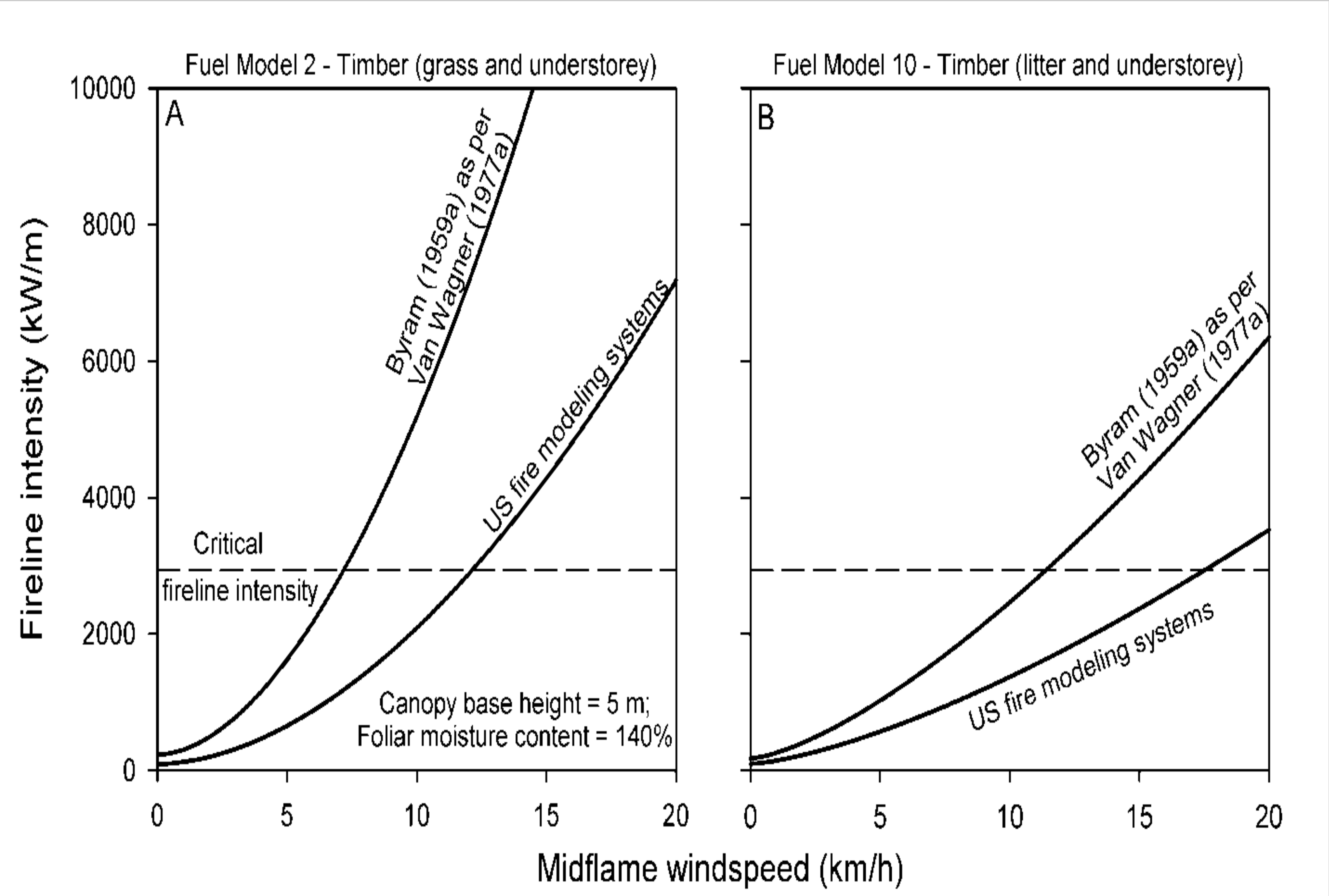








Under-prediction of crowning potential when Van Wagner (1977) model implemented in U.S. fire modeling **systems**

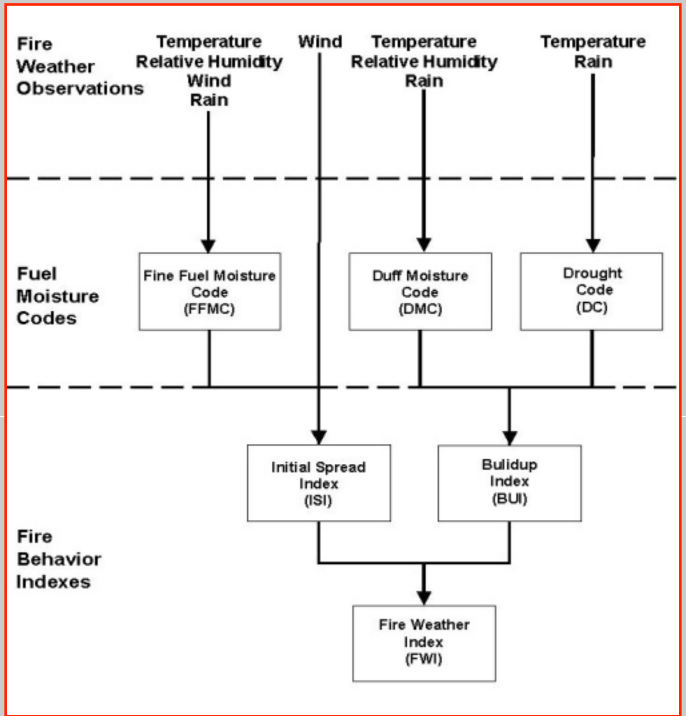


from Alexander and Cruz (2014)

Cruz, Alexander and Wakimoto (2003) Crown Fire Initiation Probability Models

Four different logistic regression models that use crown base height (***CBH***) and/or 10-m open wind speed (U_{10}) and components of the Canadian Forest Fire Weather Index System (***FFMC*** – Fine Fuel Moisture Code; ***DC*** – Drought Code; ***ISI*** – Initial Spread Index; ***BUI*** – Buildup Index):

LOGIT1: ***CBH***, ***FFMC***, U_{10}, ***DC***
LOGIT2: ***CBH***, ***ISI***, ***DC***
LOGIT3: ***CBH***, ***ISI***, ***BUI***
LOGIT4: ***ISI***, ***DC***



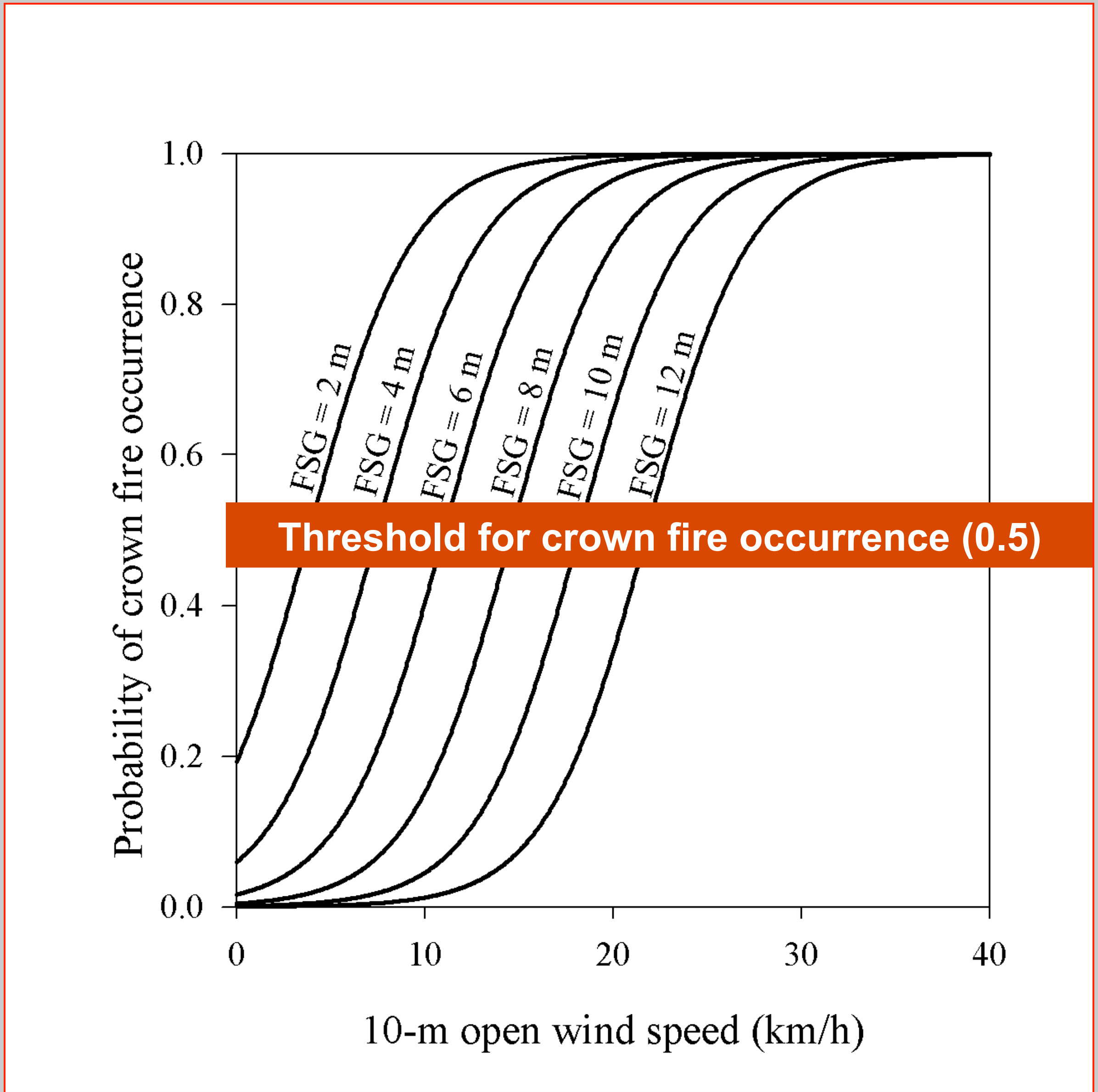
Cruz, Alexander and Wakimoto (2004) Crown Fire Occurrence Probability Model

Logistic regression model requires three environmental inputs and one fire behaviour descriptor:

- 10-m open wind speed (***U_{10}***)
- Canopy base height (CBH) or fuel strata gap (***FSG***)
- Estimated fine fuel moisture (***EFFM***); and one fire behavior
- Surface fuel consumption (***SFC***) class (<1, 1-2, >2 kg/m^2)

Threshold for crown fire occurrence judged to be 50% probability.

Cruz, Alexander and Wakimoto (2004) Crown Fire Occurrence Probability Model



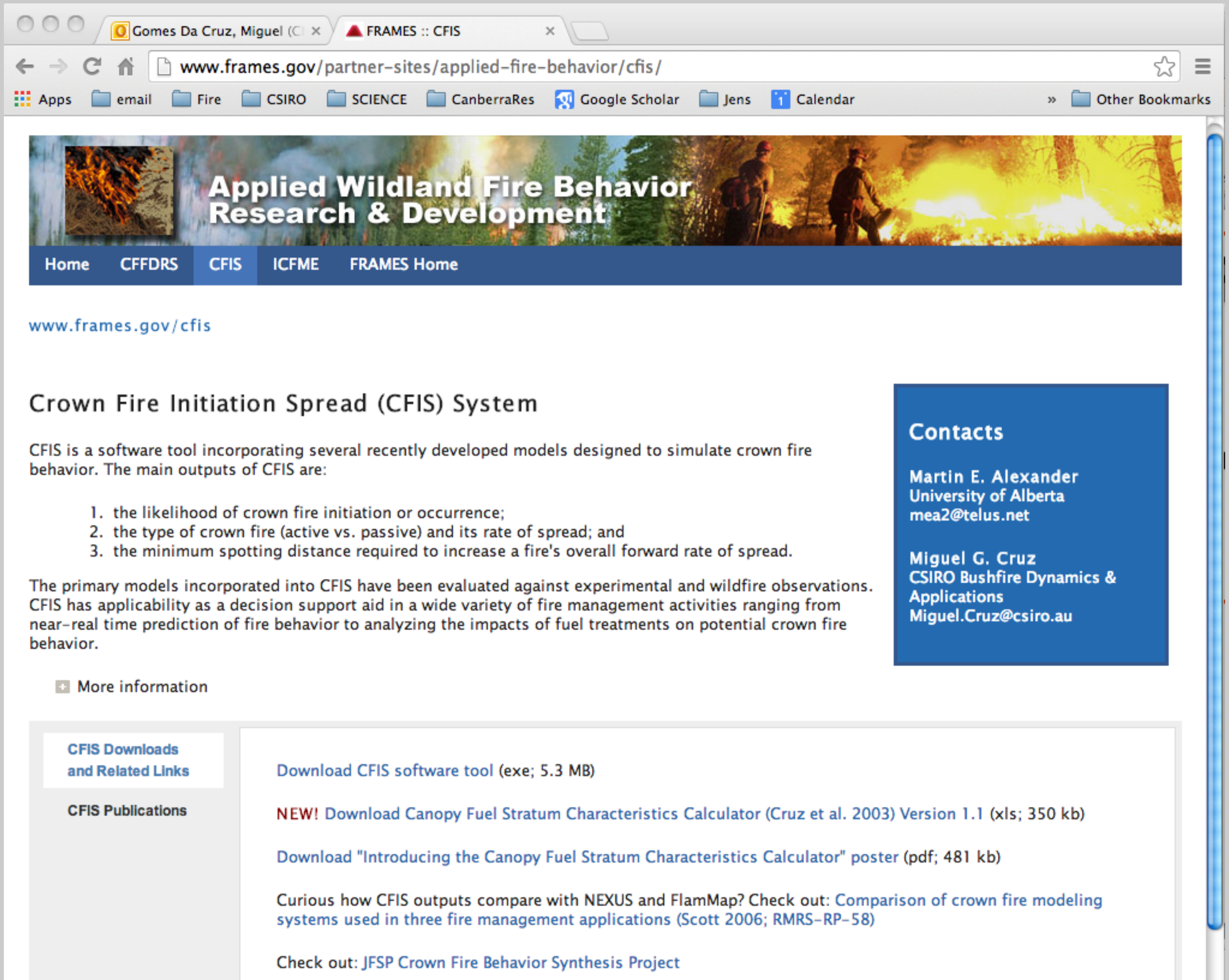
Effect of 10-m Open Wind Speed (*U_{10}*) under variable Fuel Strata Gap (*FSG*)

Assume:

EFFM = 6%

SFC = 1-2 kg/m^2

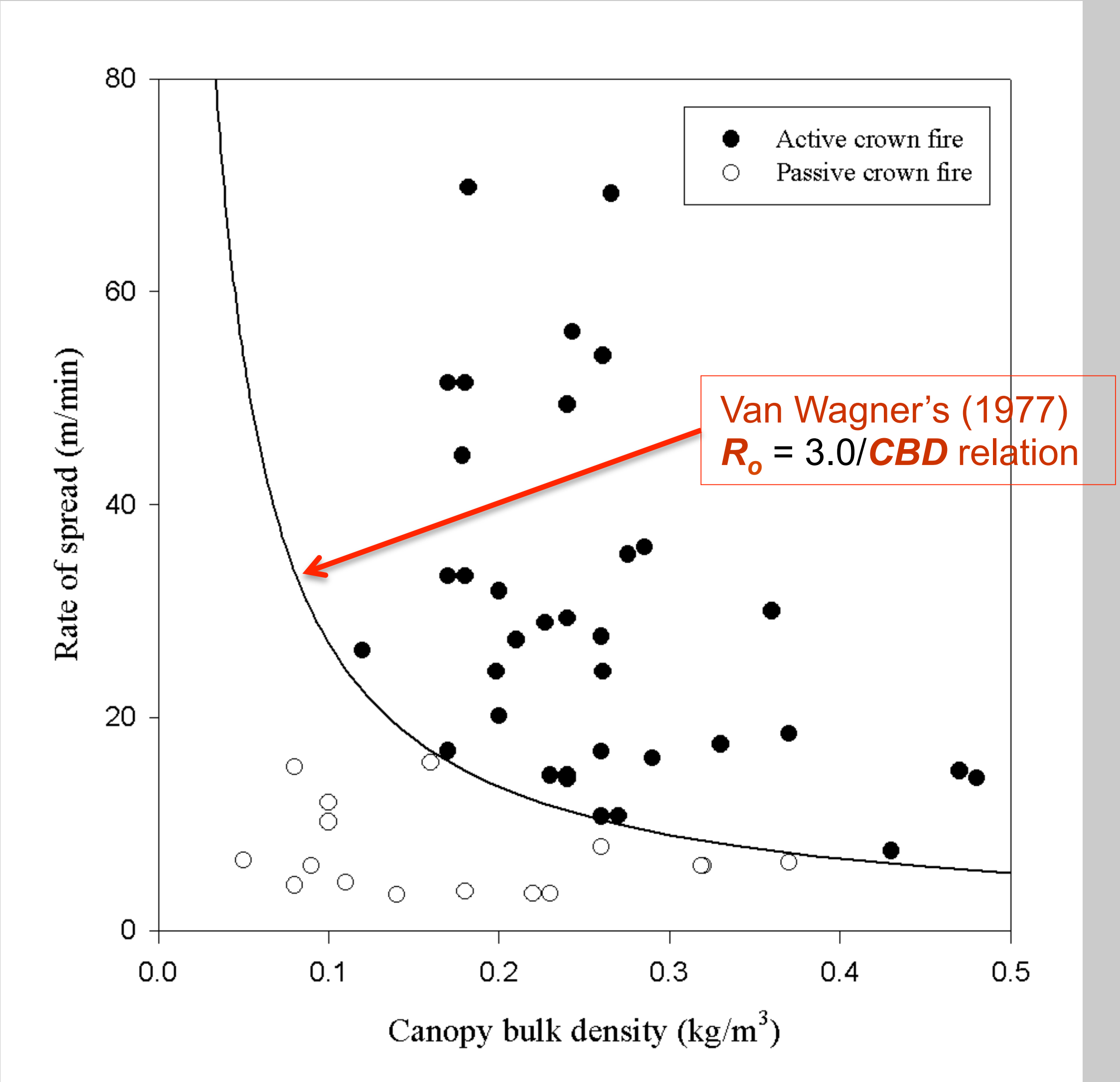
Download and install CFIS



http://www.frames.gov/partner-sites/applied-fire-behavior/cfis/

Crown Fire Rate of Spread and Intensity

Experimental crown fires used in the development of the Canadian FBP System plotted

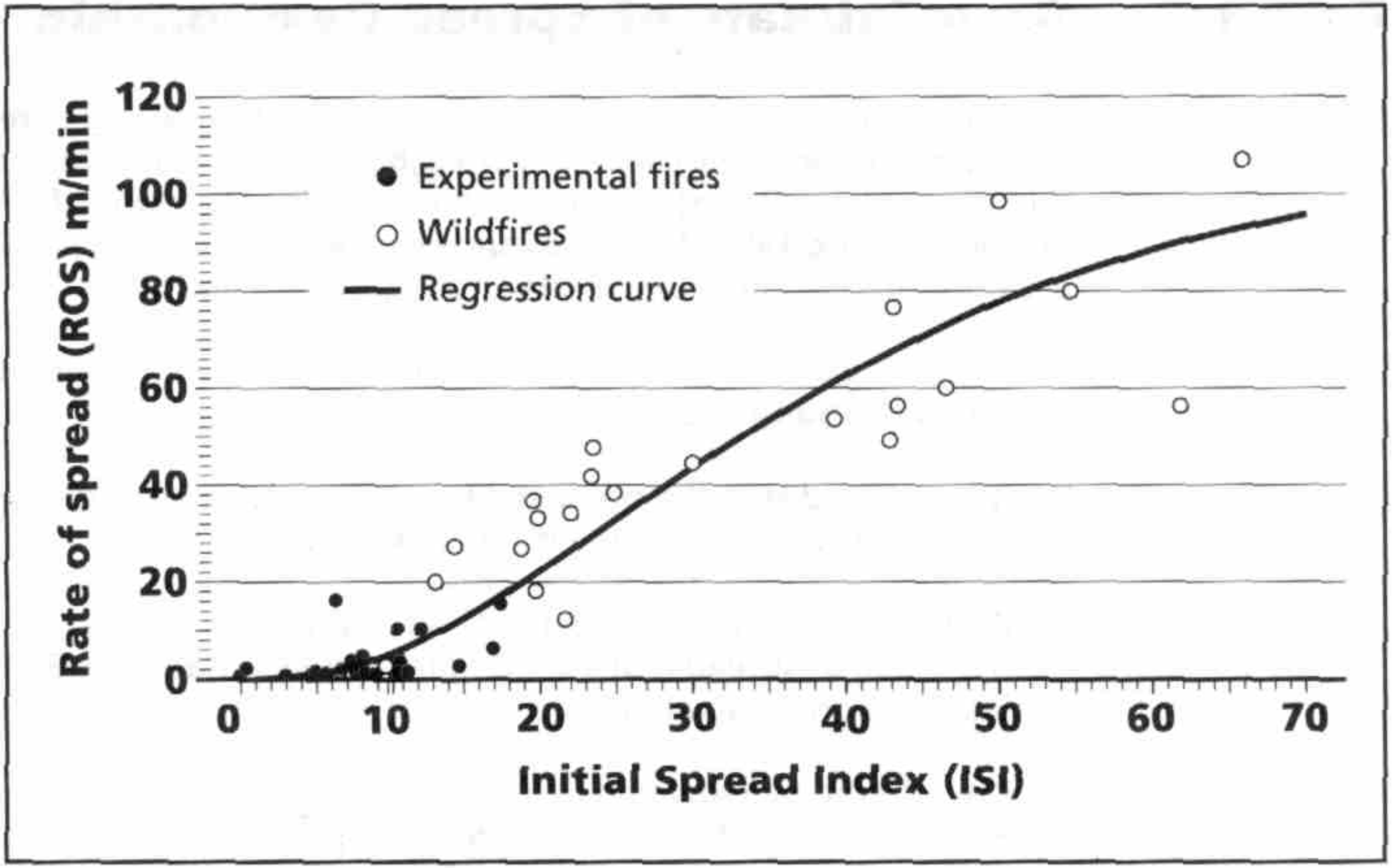


Points of note:

- No passive crown fires with ***CBD*** < 0.05 kg/m^3
- No active crown fires with ***CBD*** < 0.11 kg/m^3

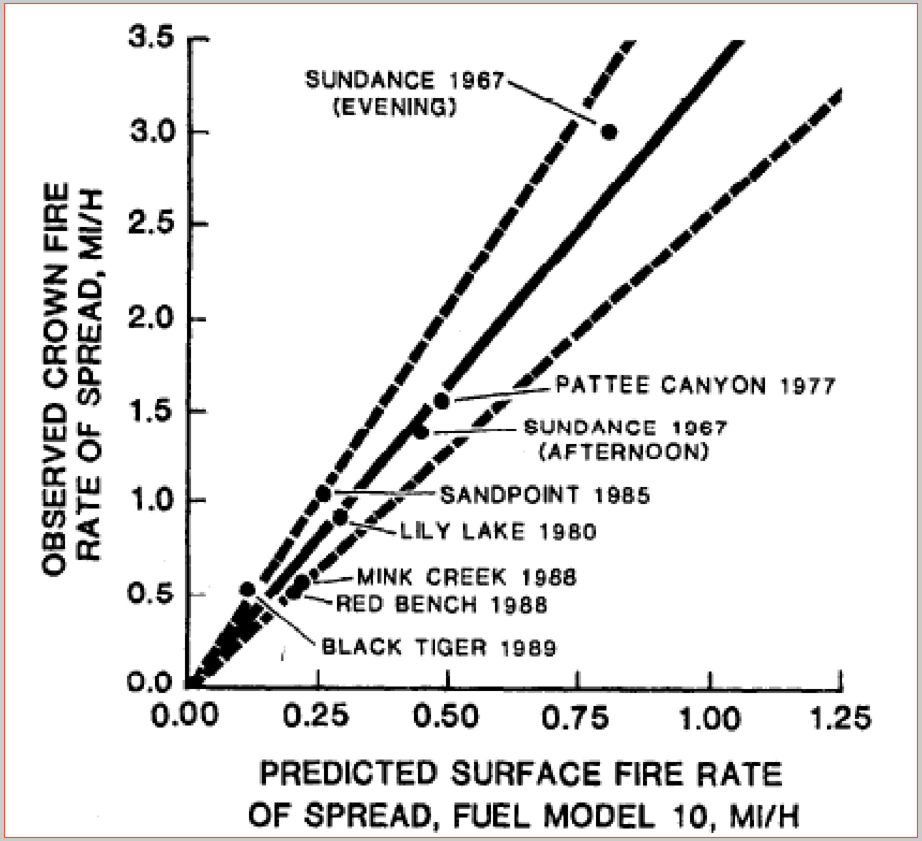
from Cruz, Alexander and Wakimoto (2005)

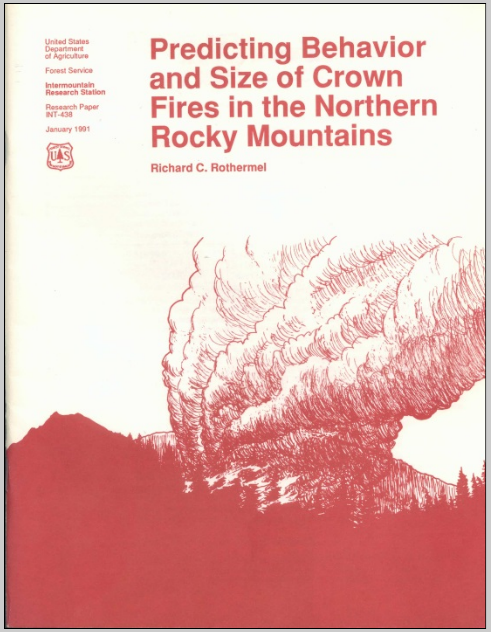
Canadian Forest Fire Behavior Prediction System: surface and crown fire rates of spread



Mature Jack or Lodgepole Pine (C-3) Fuel Type

Rothermel (1991) Rate of Spread "Model" for Wind-driven Crown Fires

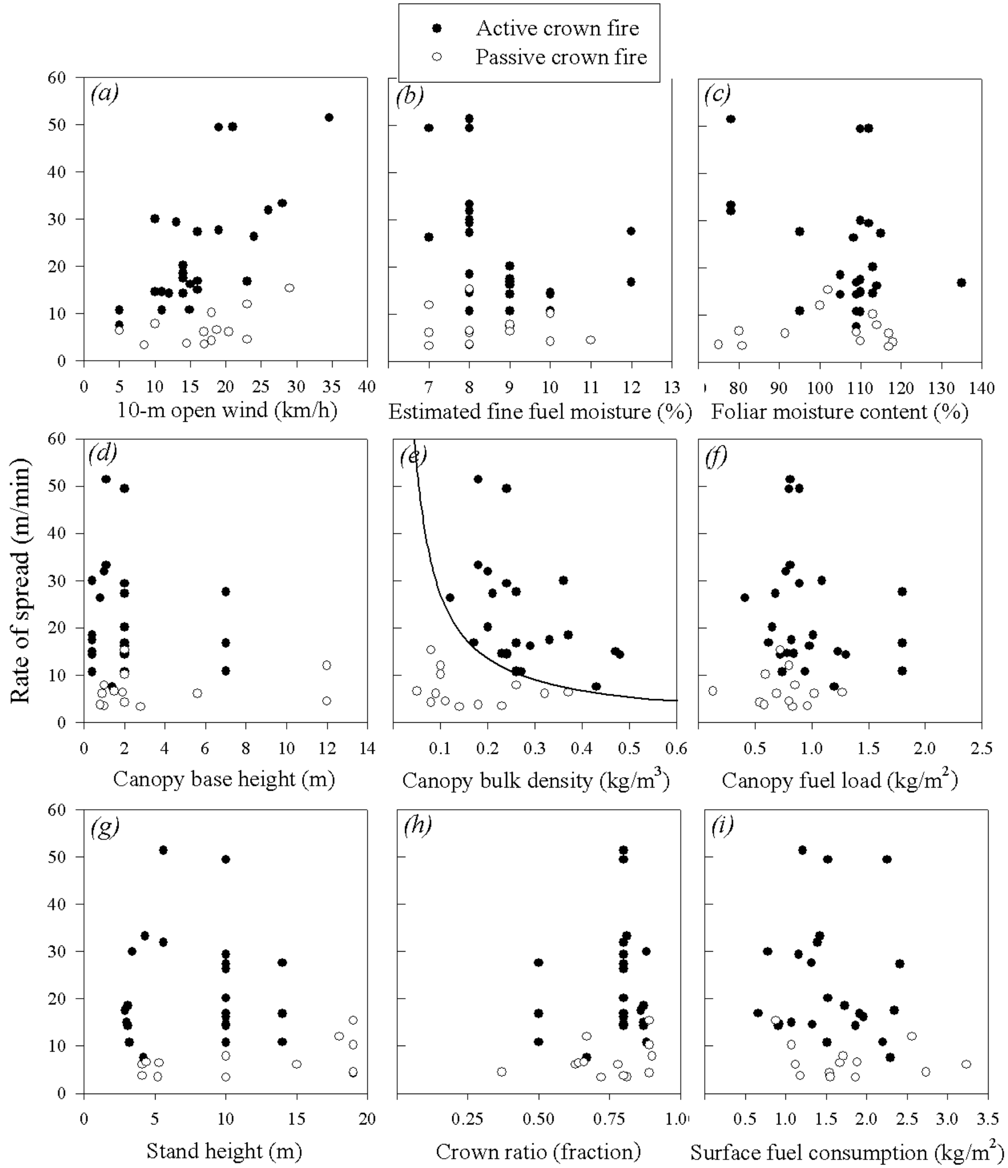




Ave. Crown Fire ROS = 3.34 x Surface Fire ROS

A statistical correlation between the predicted surface fire rate of spread for Fuel Model 10 (wind reduction factor 0.4) and 8 western U.S. wildfire observations

Cruz, Alexander and Wakimoto (2005)
Crown Fire Rate of Spread Models



- Data available 37 crown fires (24 active and 13 passive; all from Canada)
- Number of variables examined
- The criterion for active crowning (CAC) introduced:

$$\textbf{\textit{CAC}} = \frac{\text{Predicted Active Crown Fire ROS}}{3.0/\textbf{\textit{CBD}}}$$

Cruz, Alexander and Wakimoto (2005) Crown Fire Rate of Spread Models: The Equations

Active Crown Fires: $CAC \geq 1.0$

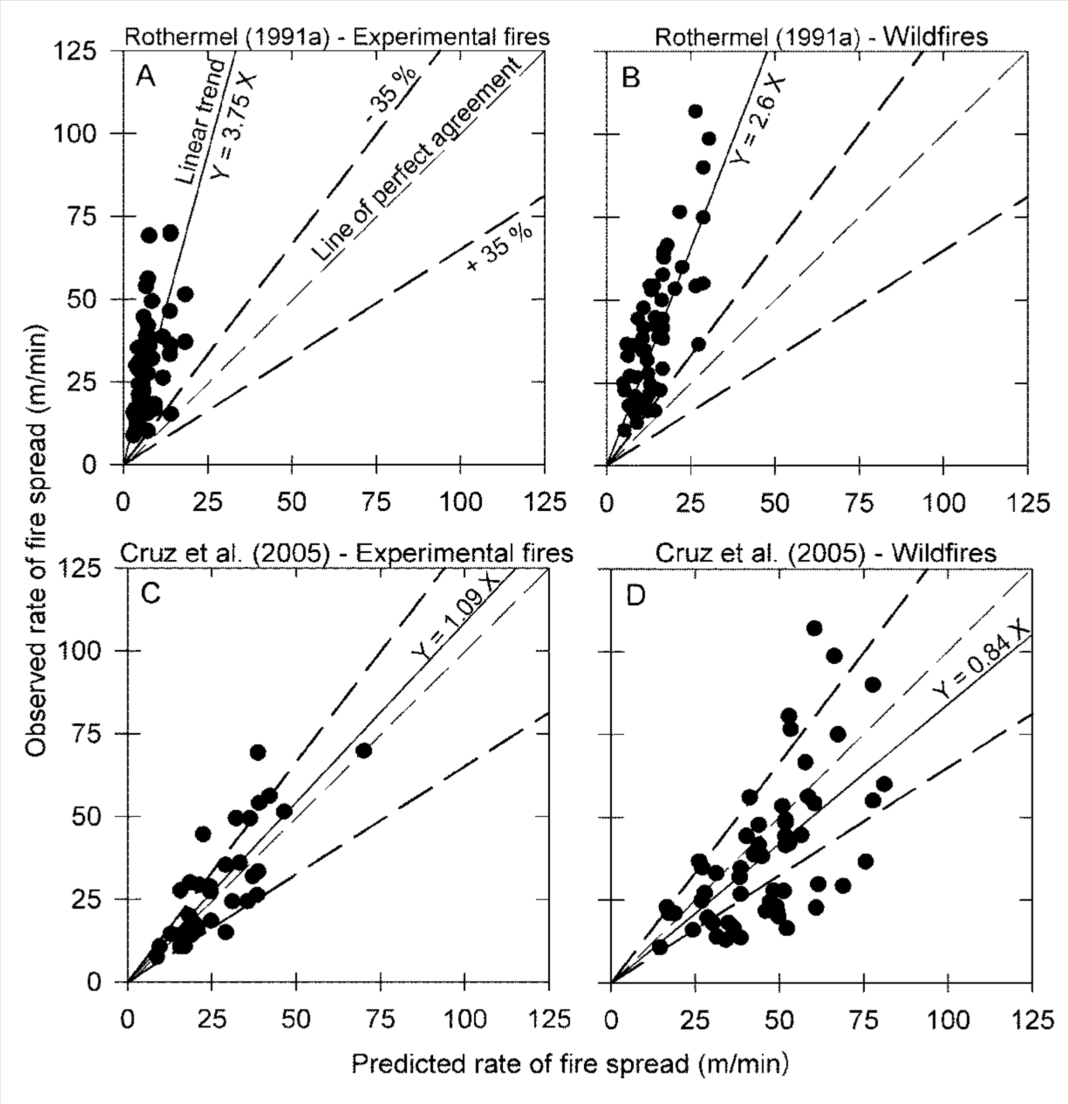
$$CROS_A = 11.02 \times (U_{10})^{0.9} \times CBD^{0.19} \times exp(-0.17 \times EFFM)$$

Passive Crown Fires: $CAC < 1.0$

$$CROS_P = CROS_A \times exp(-CAC)$$

where CAC is the criterion for active crowning dimensionless), CBD is the canopy bulk density (kg/m^3), U_{10} is the 10-m open wind speed km/h), $EFFM$ is the estimated fine fuel moisture (%), $CROS_A$ is the active crown fire rate of spread (m/min), and $CROS_P$ is the passive crown fire rate of spread (m/min).

Rothermel (1991) & Cruz, Alexander and Wakimoto (2005) Active Crown Fire Rate of Spread Model Evaluations



Rothermel model under-predicts by a factor of 2.6-3.8 and shows little sensitivity to burning conditions.

The Cruz *et al.* (2005) model slightly over-predicted.

after Cruz and Alexander (2010)

Byram (1959) indicated that his fire intensity-flame length equation would under-predict the flame length for "… *high intensity crown fires because much of the fuel is a considerable distance above the ground*."

He suggested, on the basis of personal visual estimates, that "… *this can be corrected for by adding one-half of the mean canopy height* …" to the flame length value obtained by his equation. Thus, the equation for crown fire flame lengths (L_c) taking into account stand height (***SH***) becomes :

$$L_c = 0.0775 \cdot (I)^{0.46} + (SH/2)$$

Rothermel (1991) suggested using Thomas' (1963) relation to estimate the flame lengths of crown fires from fire intensity:

$$L_c = 0.0266 \cdot (I)^{2/3}$$

Crown

Fire

Flame

Heights/Lengths

None of these methods seem to work consistently well based on comparisons against experimental crown fires undertaken in Canada. Take, for example, the following experimental crown fires in red pine plantations (***SH*** = 15 m) documented by Van Wagner (1977).

		------------- Predicted L_c (m) ---------		
Exp. Fire	**Obs. L_c (m)**	**Byram (1959)**	**Thomas (1963)**	**Butler *et al.* (2004)**
C4	**19.8**	**15.1**	**20.2**	**28.8**
C6	**30.5**	**15.3**	**21.2**	**29.4**

General Observation Based on Experimental Crown Fires:

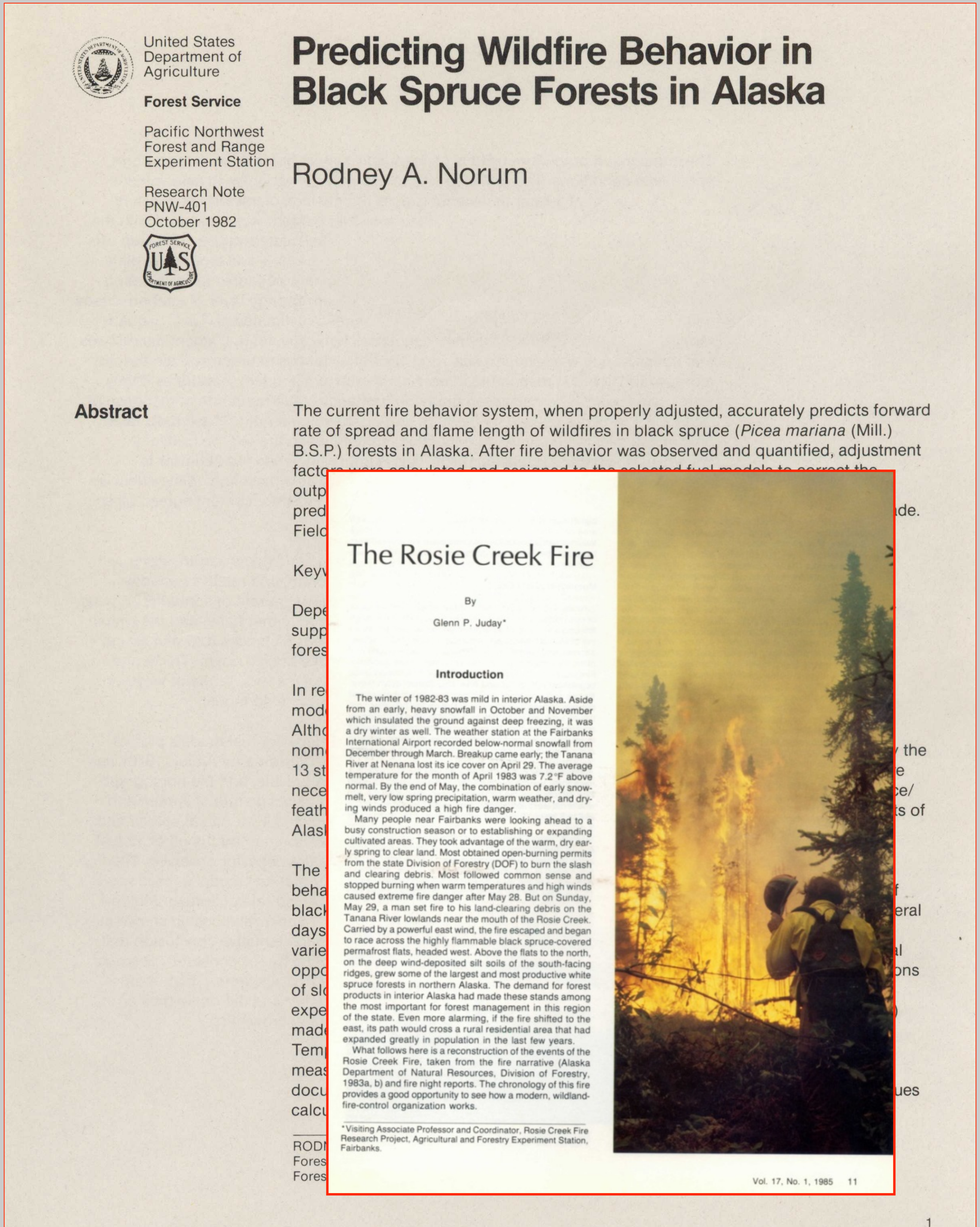
The flame front depth increases as fire intensity increases rather than a corresponding increase in the vertical flame length.

ICFME Plot 9 – Fireline Intensity ~93,000 kW/m

Alexander's Simple Rule of Thumb for Crown Fire Flame Heights: 2-3 x Stand Height for Active Crown Fires

Black Spruce

1983 Roise Creek "Case Study"



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.) B.S.P.) forests in Alaska. After fire behavior was observed and quantified, adjustment

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.

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

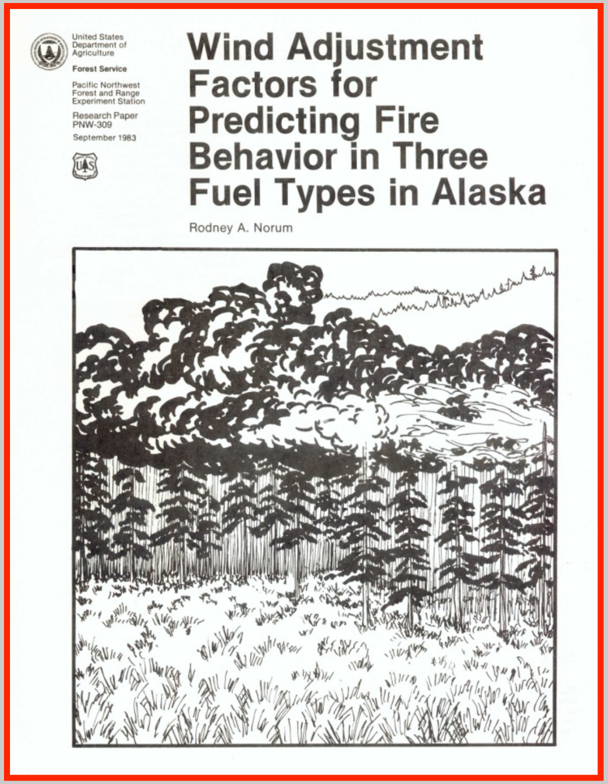
20-ft (6.1) Open Wind Speed: 13 mph (20.9 km/h)

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

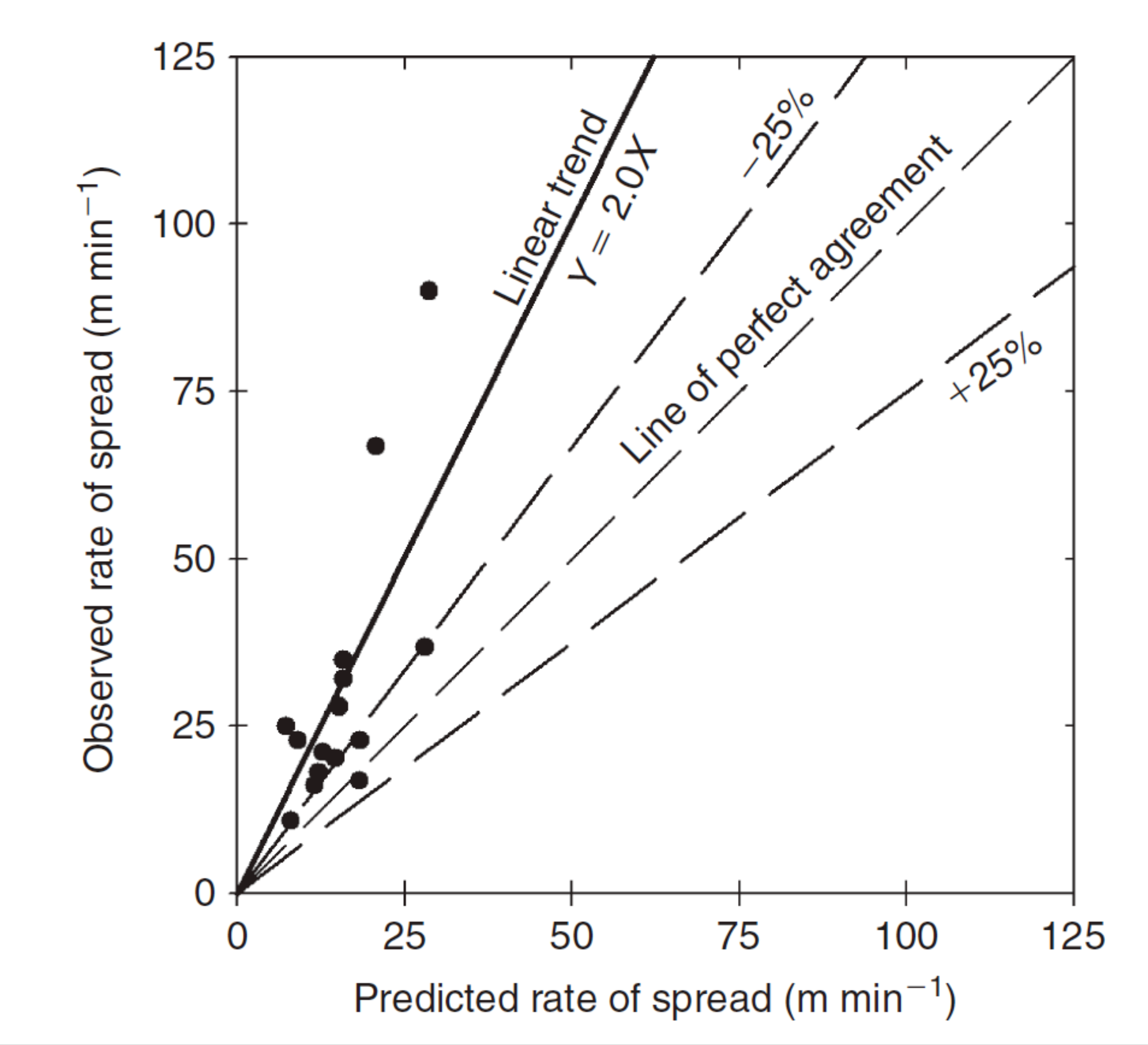


1983 Rosie Creek Fire, near Fairbanks, Alaska

Major run of Rosie Creek Fire: June 2, 1983

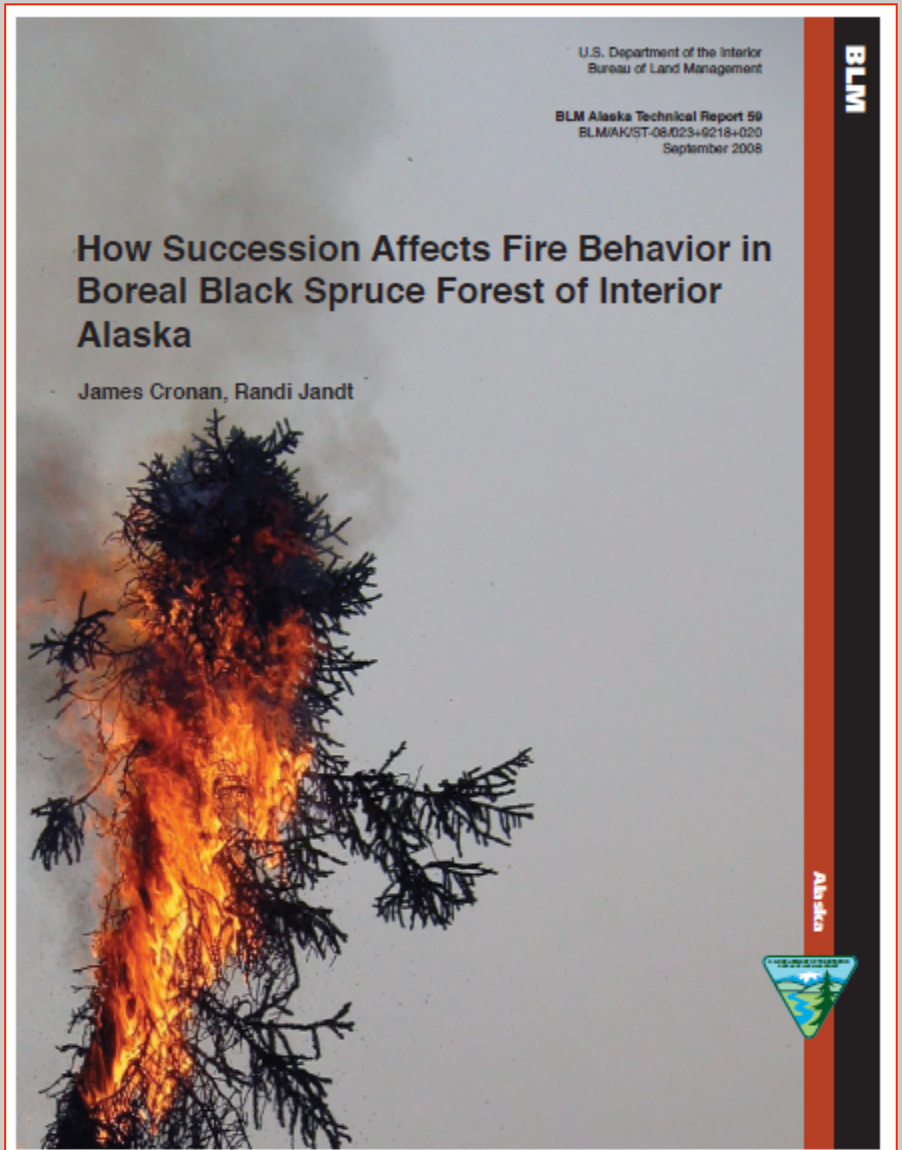
Fire Behavior Characteristic	BEHAVE System	CDN FBP System
Head Fire Rate of Spread (m/min)	1.2	31.4
Flame Length (m):	1.0	10+
Fire Intensity (kW/m) :	259	41 995

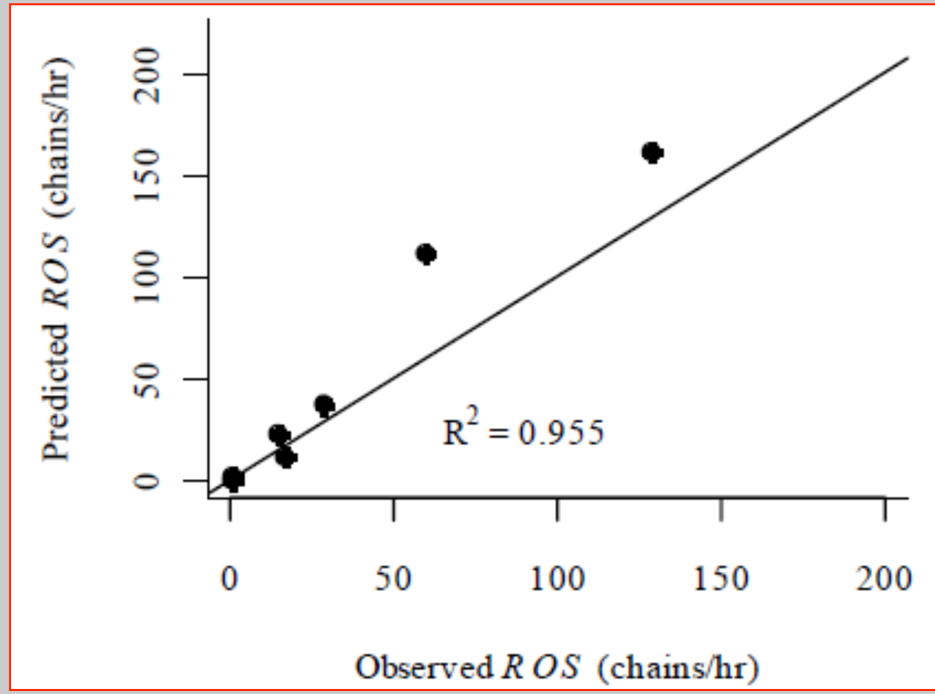
FCCS (Schaaf *et al.* 2007) Model Evaluation:
Comparison Against Wildfires in Black Spruce Forests (data from Alexander and Cruz 2006)



Model output showed under-prediction trend by a factor of 2.

Cronan and Jandt (2008) Study

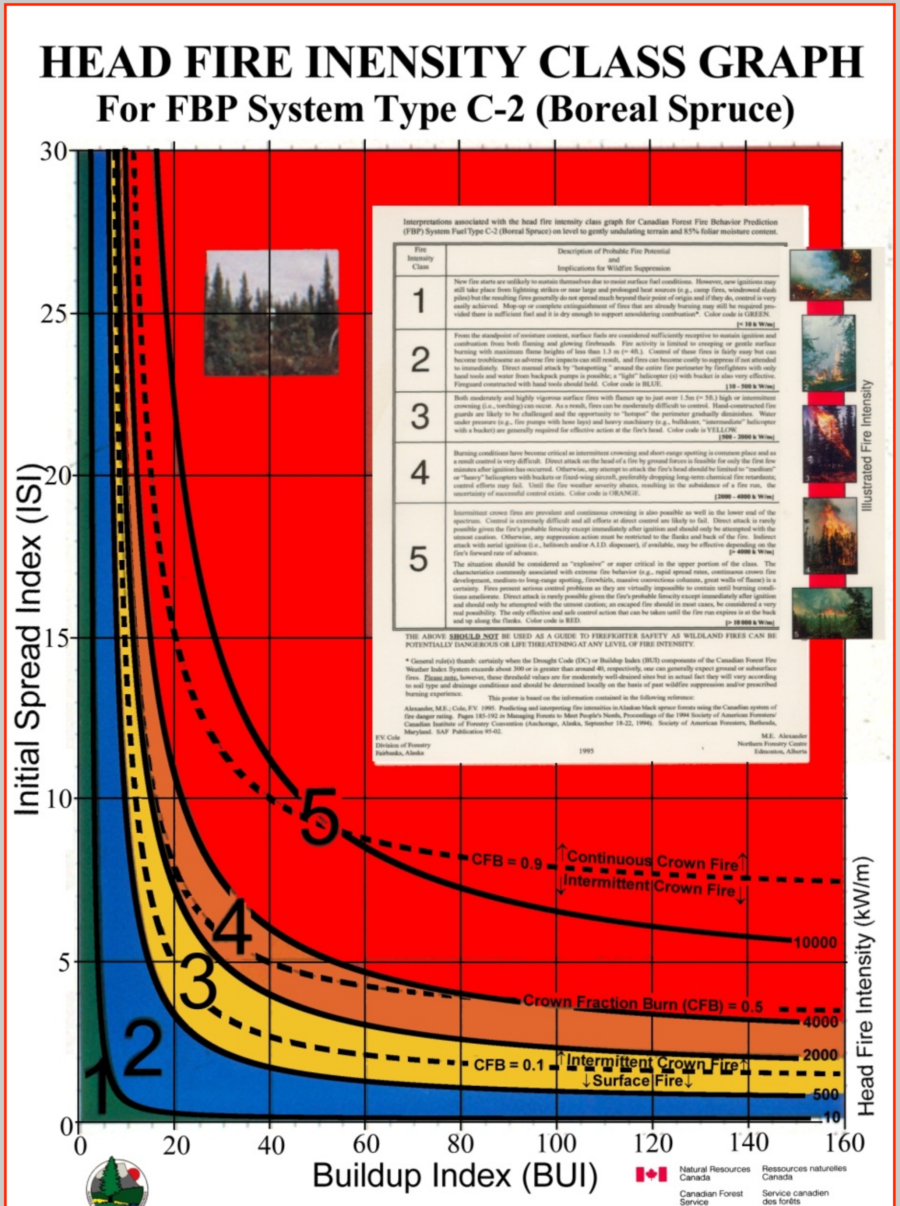




High fire spread predictions based on *CFIS*

Donnelly Dome Fire – June 13, 1999

Donnelly Dome Fire – June 13, 1999



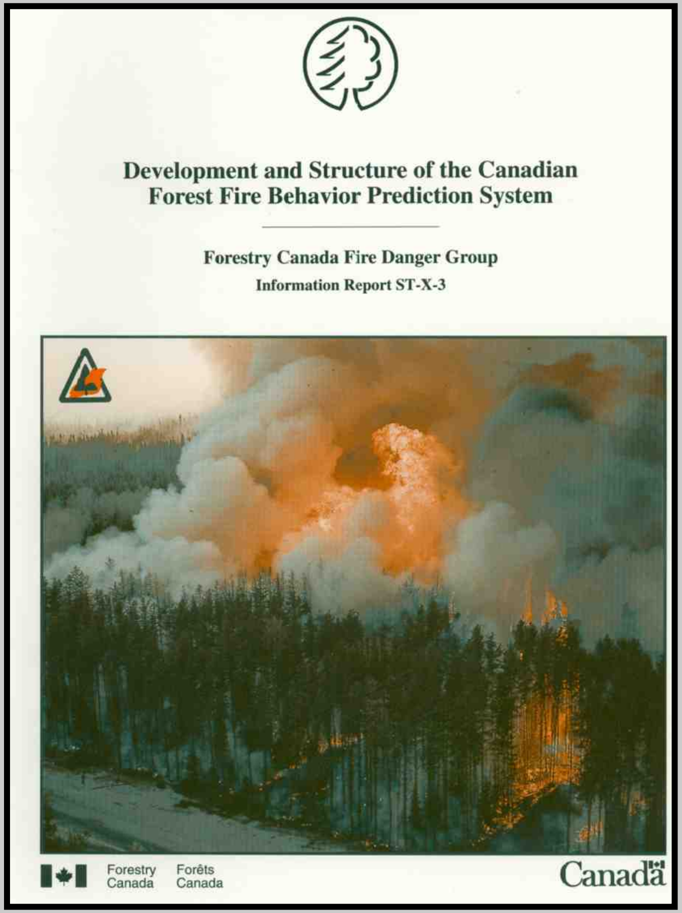
FFMC 94
DMC 59
DC 314
ISI 25
BUI 80
FWI 51

Description of Probable Fire Potential and Implications for Wildfire Suppression at Head Fire Intensity Class 5*

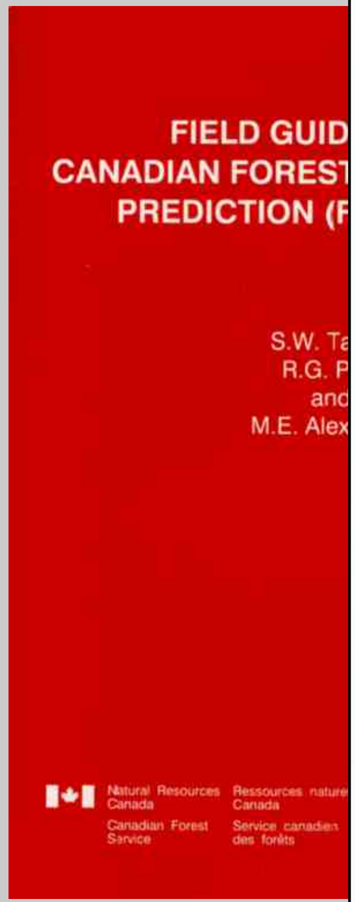
The situation should be considered as "explosive" or super critical in the upper portion of the class. The characteristics commonly associated with extreme fire behavior (e.g., rapid spread rates, continuous crown fire development, medium- to long-range spotting, firewhirls, massive convection columns, great walls of flame) is a certainty. Fires present serious control problems as they are virtually impossible to contain until burning conditions ameliorate. Direct attack is rarely possible given the fire's probable ferocity except immediately after ignition and should only be attempted with the utmost caution; an escaped fire should in most cases, be considered a very real possibility. The only effective and safe control action that can be taken until the fire run expires is at the back and up along the flanks.

***from Alexander and Cole (1995)**

“Operational Use” of the FBP System



Technical & Scientific Documentation



Operational
(FBP Syster

Table 4.2
Equilibrium rate of spread (m/min) and fire intensity class

C-2 boreal spruce

Intensity class

- 1 < 10 kW/m
- 2 10 – 500
- 3 500 – 2 000
- 4 2 000 – 4 000
- 5 4 000 – 10 000
- 6 > 10 000

ISI	BUI 0–20	21–30	31–40	41–60	61–80	81–120	121–160	161–200
1	0.1	0.3	0.4	0.5	(2) 0.5	0.6	0.6	0.6
2	0.3	0.9	1	1	(3) 1	2*	2*	2*
3	0.6	2	2	2*	3*	3*	3*	3*
4	0.9	3	3*	4*	(4) 4*	4*	4*	5*
5	1	3*	4*	5*	5*	6*	6*	6*
6	2	4*	5*	6*	(5) 7*	7*	8*	8*
7	2	5*	7*	8*	9*	9*	10*	10*
8	2	7*	8*	9*	10*	11	12	12
9	3	8*	9*	11*	12	13	14	14
10	3	9*	11*	12	14	15	16	16
11	4	10*	12	14	16	17	18	18
12	4	11*	14	16	17	19	20	20
13	4	12	15	17	19	21	22	22
14	5	13	16	19	21	23	24	25
15	5	15	18	21	(6) 23	25	26	27
16	6*	16	19	22	25	27	28	29
17	6*	17	21	24	27	29	30	31
18	6*	18	22	26	28	31	32	33
19	7*	19	23	27	30	33	34	35
20	7*	20	25	29	32	34	36	37
21–25	8*	24	29	34	37	40	42	43
26–30	10*	29	35	41	46	49	52	53
31–35	12*	34	41	48	53	57	60	62
36–40	14*	39	47	54	60	65	68	70
41–45	15	43	52	60	66	72	75	78
46–50	16	46	56	65	72	78	82	84
51–55	17	49	60	70	77	83	87	90
56–60	18	52	64	74	82	88	92	95
61–65	19	55	67	77	85	92	97	100
66–70	20	57	69	80	89	96	101	104

Constants: foliar moisture content = 97% ; crown base height = 3 m. ☐ = average BUI.
Type of fire: **surface, intermittent crown***, continuous crown. _ = CFB 50%.

Wildfire Monitoring and Case Study Documentation

U. S. FOREST SERVICE RESEARCH PAPER INT-5

1963

FOREST FIRES

IN ALASKA

CHARLES E. HARDY and JAMES W. FRANKS

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
OGDEN, UTAH

ERN FOREST EXPERIMENT STATION
JUNEAU, ALASKA
DEPARTMENT OF AGRICULTURE

U. S. FOREST SERVICE

RESEARCH NOTE NOR-8

July 1964

THE CHRONOLOGY AND ANALYSIS OF THE HUGHES FIRE, 1962 1/

Von J. Johnson, Research Forester (Fire)

Fire in the interior basin of Alaska is commonplace. Lightning- and man-caused fires have burned and reburned millions of acres. Despite their commonness and extensiveness, the specific history and characteristics of a fire as they relate to fuels and weather have not been systematically observed and recorded.

The Hughes fire in July 1962 did provide an opportunity to make systematic and detailed observations on fire behavior, weather, and fuels. The results of those observations and measurements are the basis of this report. The information and knowledge gained from this and similar opportunities as they arise will aid the fire control manager to more accurately predict fire behavior and, thereby, increase the effectiveness of the control techniques he uses.

The assistance and cooperation of the Bureau of Land Management is gratefully acknowledged and, in particular, that of George Kitson, fire boss for the Hughes fire.

FIRE CHRONOLOGY

At 11 a.m. on July 19 a fire 2/ was detected on the southwest-facing slope of Nutltoktalogi Mountain about 25 miles northeast of Hughes, an

1/ Research reported here was done at the Station's Forestry Sciences Laboratory maintained in cooperation with the University of Alaska at College.
2/ Designated as "Hughes NE 25, Number 48," in official records of the Bureau of Land Management.

Thank you for your attention?
Questions? Comments?