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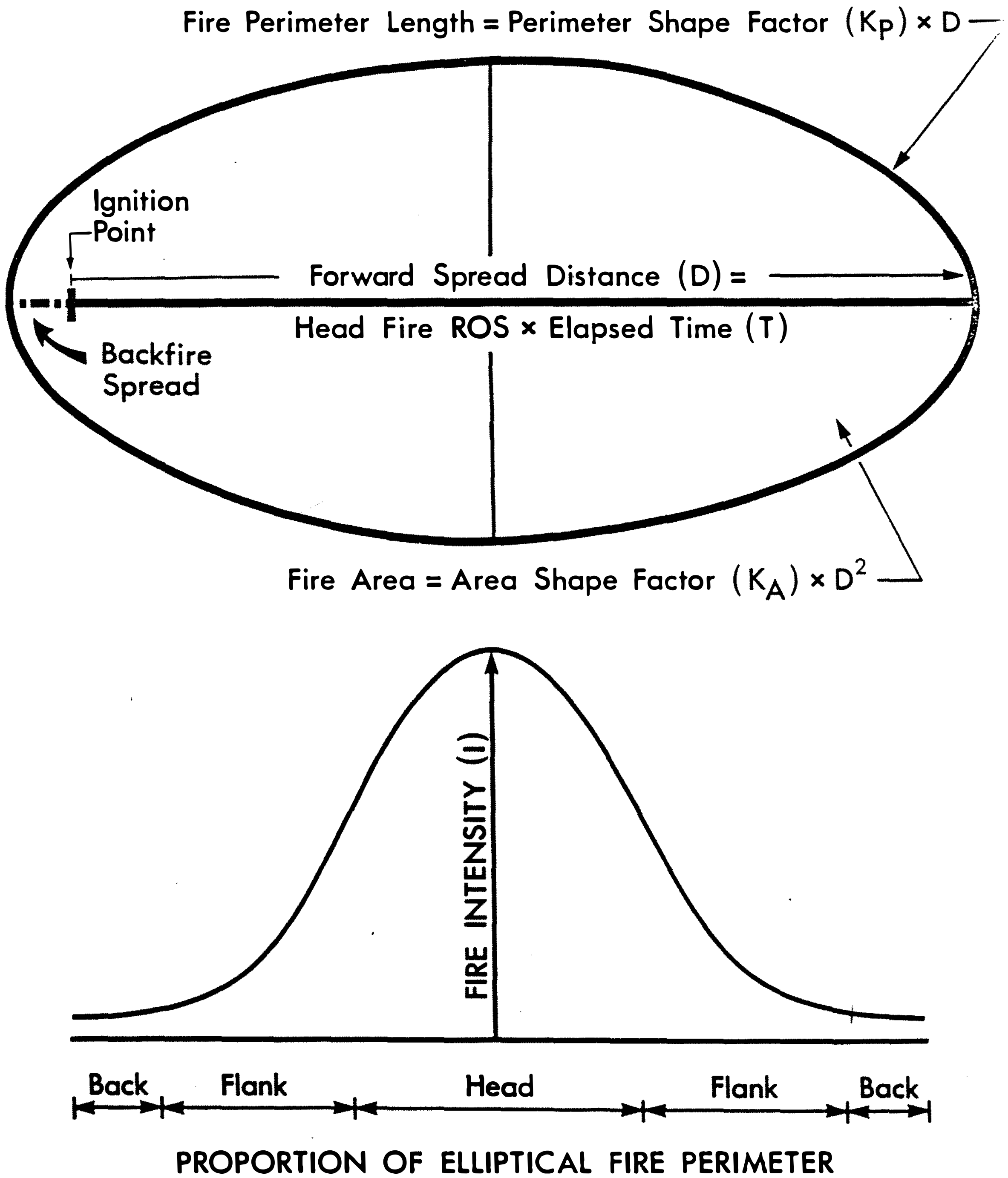
PROCEEDINGS OF THE THIRD WESTERN REGION FIRE WEATHER COMMITTEE SCIENTIFIC AND TECHNICAL SEMINAR - February 4, 1986, Edmonton, Alberta



PROCEEDINGS

OF THE THIRD WESTERN REGION FIRE WEATHER COMMITTEE

SCIENTIFIC AND TECHNICAL SEMINAR

February 4, 1986
Edmonton, Alberta

Compiled and Edited

by

Martin E. Alexander
Fire Research Officer

Study NOR-5-05 (NOR-5-191) File Report No. 15

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FOREWORD

The 1975 Federal Department of the Environment (DOE) Policy on Meteorological Services for Forest Fire Control sets out the responsibilities of the Atmospheric Environment Service (AES) and Canadian Forestry Service (CFS) in provision of fire weather forecasts, fire danger forecasts, and other weather-related services to the various fire control agencies. Briefly, this policy gives AES the responsibility of providing current and forecast fire weather and Fire Weather Indices in accordance with the needs of fire control agencies. The CFS role is that of research and development of improved Indices, research on fire behavior relationships with weather factors, and cooperation with AES in preparation of training aids and manuals. Both AES and CFS share the responsibility of improving meteorological services for forest fire control in Canada. Van Wagner (1984)[1] recently re-emphasized these specific obligations.

In 1976, six regional committees[2] were formed to facilitate the implementation of the DOE Policy on Meteorological Services for Forest Fire Control. The "charter" for these regional fire weather committees is as follows:

Membership: 1 or more AES representatives designated by AES Regional Director; 1 or more CFS representatives designated by CFS Regional Director; and 1 or more fire management agency representatives designated by the Provincial or territorial chief(s) of forest fire management.

Terms of Reference: Each Regional Committee will make recommendations to the Regional Directors of DOE Services (i.e., AES and CFS) for the development and implementation of a program of Meteorological Services for Forest Fire Control which is suited to the needs of the Region and is within the DOE Policy and Guidelines.

Guidelines: Regional Committees will be responsible for (a) identifying the needs of regional fire management agencies for meteorological services; (b) making recommendations of the services identified in sub-section (a); (c) monitoring the program and implementing changes, as required; (d) coordinating with the Development Committee; and (e) referring to the Development Committee those recommendations which the Regional Directors of DOE Services have been unable to implement.

The function of the Development Committee, referred to above, is to coordinate in consultation with the Regional Committees, the development of meteorological services for forest fire management through contacts, at the technical level, between research and development officers of AES and CFS, operations supervisors in the AES field establishments and technical representatives of fire management agencies.

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[1]Van Wagner, C.E. 1984. Forest fire research in the Canadian Forestry Service. Agriculture Canada, Canadian Forestry Service, Petawawa National Forestry Institute, Chalk River, Ont. Information Report PI-X-48. 45 p.

[2]These were aligned on the basis of the existing AES administrative boundaries: Pacific (British Columbia); Western (Yukon, Northwest Territories, and Alberta); Central (Saskatchewan, Manitoba, and northwestern Ontario); Ontario; Quebec; and Atlantic (Nova Scotia, New Brunswick, Newfoundland, and Prince Edward Island).

INTRODUCTION

The inaugural meeting of the Western Region Fire Weather Committee (WRFWC) was held at the Atmospheric Environment Service's (AES) Western Region office in Edmonton on January 8, 1976. WRFWC member agencies currently include Indian and Northern Affairs Canada - Northern Affairs Program - N.W.T. Region, Alberta Forest Service, Parks Canada - Prairie Region, Parks Canada - Western Region, and Canadian Forestry Service (CFS) - Western and Northern Region. The concept of holding scientific and technical seminars in conjunction with the annual business meetings of the WRFWC was begun in 1983. An analogous series was initiated by the Central Region Fire Weather Committee in 1984[1] with subsequent seminars in 1985[2] and 1986[3].

There have now been three half-day WRFWC scientific and technical seminars; these have all taken place at the AES's Western Region office in Edmonton. A list of the presentations from the first two seminars is given on the inside back cover of this document. This report constitutes a summary of the four presentations which took place at the third seminar. An attendance list is appended.

I sincerely hope that the WRFWC seminar series continues to provide a forum for the exchange of information, ideas, etc. on current and/or timely fire-weather related topics of direct interest to all WRFWC member agencies. In 1984, the WRFWC membership agreed to hold the seminars on a bi-annual basis. Therefore, the fourth WRFWC scientific and technical seminar is tentatively planned for the winter of 1987-8.

Finally, I would like to acknowledge the fine efforts of S. Ratansi and J. Simunkovic in the word processing associated with the production of this report.

Martin E. Alexander[4]
WRFWC Seminar Coordinator

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[1]Alexander, M.E. (compiler & editor). 1985a. Proceedings of the first Central Region Fire Weather Committee scientific and technical seminar (Apr. 17, 1984, Winnipeg, Man.). Environment Canada, Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alta. Study NOR-5-191 File Report No. 10. 26 p.

[2]Alexander, M.E. (compiler & editor). 1985b. Proceedings of the second Central Region Fire Weather Committee scientific and technical seminar (Apr. 17, Winnipeg, Man.). Agriculture Canada, Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alta. Study NOR-5-05 (NOR-5-191) No. 11. 31 p.

[3]Alexander, M.E. (compiler & editor). 1986. Proceedings of the third Central Region Fire Weather Committee scientific and technical seminar (Apr. 3, Winnipeg, Man.). Government of Canada, Canadian Forestry Service, Western and Northern Region, Northern Forestry Centre, Edmonton, Alta. Study NOR-5-05 (NOR-5-191) File Report No. 16. 62 p.

[4]Fire Research Officer, Northern Forestry Centre, Canadian Forestry Service, Western and Northern Region, 5320 - 122 Street, Edmonton, Alta., T6H 3S5.

ON THE EFFECT OF WIND SHEAR AND ATMOSPHERIC STABILITY ON FOREST FIRES[1,2]

by

E.R. Reinelt[3]

INTRODUCTION

Of all the elements normally considered to make up the weather, the wind is by far the most complex and capricious. It is usually the wind that figures large in severe weather events, and it is the vagary of the winds that can turn a smouldering ground fire into a major calamity, such as a so called "blow-up fire". One type of wind profile that may significantly alter forest fire behavior is that containing a layer of high-speed wind close to the surface, a feature commonly referred to as a low-level jet wind (LLJW). These winds are fairly common features of the lowest layers of the atmosphere, most often confined to the surface boundary layer, say the lowest 1000 m. Figure 1 schematically illustrates a typical LLJW associated with a cold front. These "jets" are also frequently subject to modification by the topography, such as wind gaps, valleys and ridges. However, most jets are probably independent of the structure of the underlying surface, but the result of dynamic causes such as convergence, strong thermal gradients and fronts, as depicted in Figure 2.

Theoretical studies by Buajitta and Blackadar (1957) have shown that the diurnal variability of jet intensification at night is due to air near the top of the boundary layer being decoupled from the air below by the formation of an inversion. Bonner (1961) presented evidence that the LLJW does also occur during the day. Wexler (1961) postulated that the primary cause of this jet is to be sought in the large-scale field of motion, in which a shallow layer of air flowing westward around the periphery of a high-pressure area is being deflected northward by the Rockies (Fig. 3). Findlater (1969) studying jets along the East African coast also noted that the curvature of the flow suggested orographic influence. He found jet cores centered near 1.5 km, attaining velocities of 25 m/s, and occasionally 50 m/s, with at most only minor diurnal variations. More recent investigations have essentially confirmed the earlier studies.

LOW-LEVEL JET WINDS IN THE CONTEXT OF BYRAM'S CLASSIFICATION

Byram (1954) distinguished and classified ten upper wind profiles, of which five contain jet points of different shape and core speeds. He recognized LLJWs as contributing to extreme fire behavior. Since Byram's classification is well represented in the literature, it will not be repeated here. It should be pointed out, however, that it is not the jet *per se* that is

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[1]A presentation made at the Third Western Region Fire Weather Committee Scientific and Technical Seminar, February 4, 1986, Edmonton, Alta.

[2]This paper is based in part on a Canadian Forestry Service sponsored PRUF (Program of Research by Universities in Forestry) Project entitled "climatology of Atmospheric Conditions Related to Extreme Forest Fire Behavior in West-Central and Northern Canada".

[3]Professor and Associate Chairman (i/c Meteorology Division), Department of Geography, University of Alberta, Edmonton, Alta. T6G 2H4.

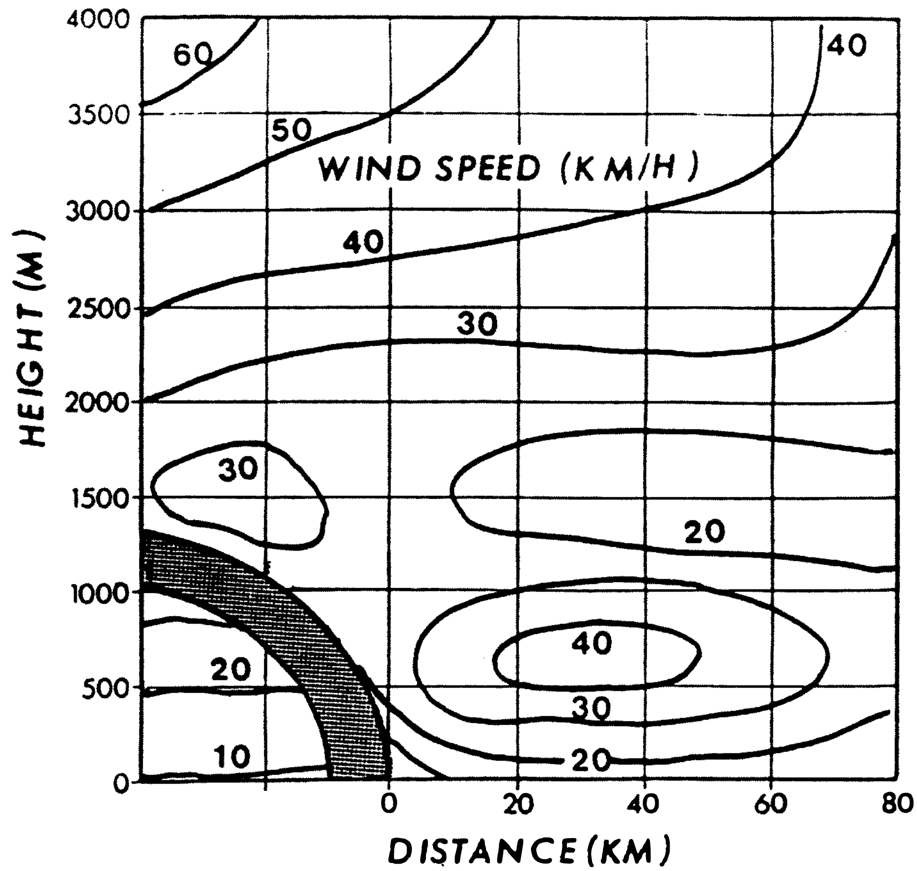

Figure 1. Schematic cross-section of a typical low-level jet wind structure in advance of a cold front.

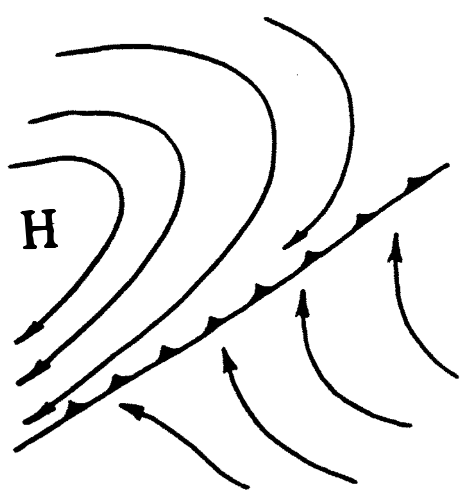

Figure 2. Convergence of two air masses leading to the formation of a low-level jet wind in advance of a cold front.

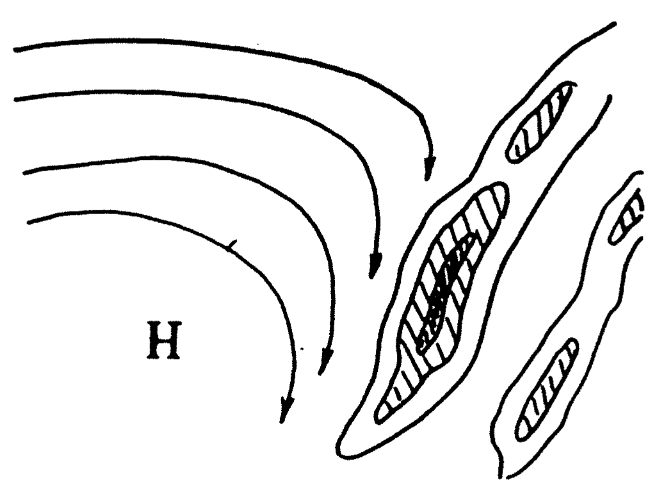

Figure 3. Low-level jet wind formed by convergence of anticyclonic flow along a mountain barrier.

responsible for influencing fire behavior, but rather that portion of the profile where the wind decreases with height. A wind decreasing with height is said to have a cyclonic (or negative) wind shear (i.e., $\partial V/\partial z < 0$). This is important in that a cyclonic shear has vorticity which tends to produce rotation of the air about a horizontal axis. The sense of rotation is such as to favor updrafts and hence the formation and maintenance of convection columns. The expression for the relative vorticity ξ pertinent to upper wind profiles is as follows:

[1] $\xi = V/R - \partial V/\partial z$

where, V is the wind speed at a given level, R is the (vertical) radius of curvature of the air-stream (by definition negative for anticyclonically curved flow) and z is the height above the terrain. Since over level terrain $R \to \infty$, the first term is usually small or zero, but it may be significant over rough and hilly terrain, where it may aid or hinder the spread of a fire, depending on the shape of the terrain and the location of the fire. Thus, when $R \to \infty$ and $\partial V/\partial z < 0$ results in $\xi > 0$. However, when R is small, say of the order of one km, then ξ may be positive, negative or even zero, depending on the sign and degree of curvature. This is one reason why fire behavior over rolling terrain is frequently erratic and very difficult to predict accurately.

The effect on two fires of an upper wind distribution containing a jet is shown in Figure 4. It will be noted that the fire below the jet core would be relatively safe, since it is burning in a region having anticyclonic or positive shear (i.e., the wind increases with height). The second fire on the higher ground, on the other hand is likely to burn out of control, since it is located in a zone of cyclonic wind shear, and thus subject to vortex motion favoring the generation of updrafts and the formation of a strong convection column. Hence, as can be seen on the sketch, fires burning on higher and exposed ground are more susceptible to being affected by jet winds than fires on low-lying and flat terrain. The single exception is the rare wind profile of Byram's (1954) Types 1-a and 1-b, where the decrease of wind with height begins within the lowest few metres of the surface.

"FALSE JET" PROFILES

What have come to be known as "false jets" are the result of inadequate upper wind measurement techniques. The commonly-used Single Theodolite Pilot Balloon (STPIBAL) observations may be misleading and should be treated with caution (see e.g., Ayer 1958), especially if taken under turbulent, unstable atmospheric conditions, such as may prevail on hot, thundery afternoons.

The errors result from the action of convection currents on the rising balloon. Thus, a strong downdraft in the lowest few hundred metres will prevent the balloon from rising at its normal rate, leading to a fictitiously high wind speed report as the balloon is carried downwind at a diminished rate of ascent. If subsequently, the balloon should enter an updraft, its now increased rate of ascent will be interpreted erroneously as a lower wind speed. Thus, a balloon ascending through consecutive layers of subsiding and rising air will be recorded as having encountered a jet wind (see e.g., Taylor 1962).

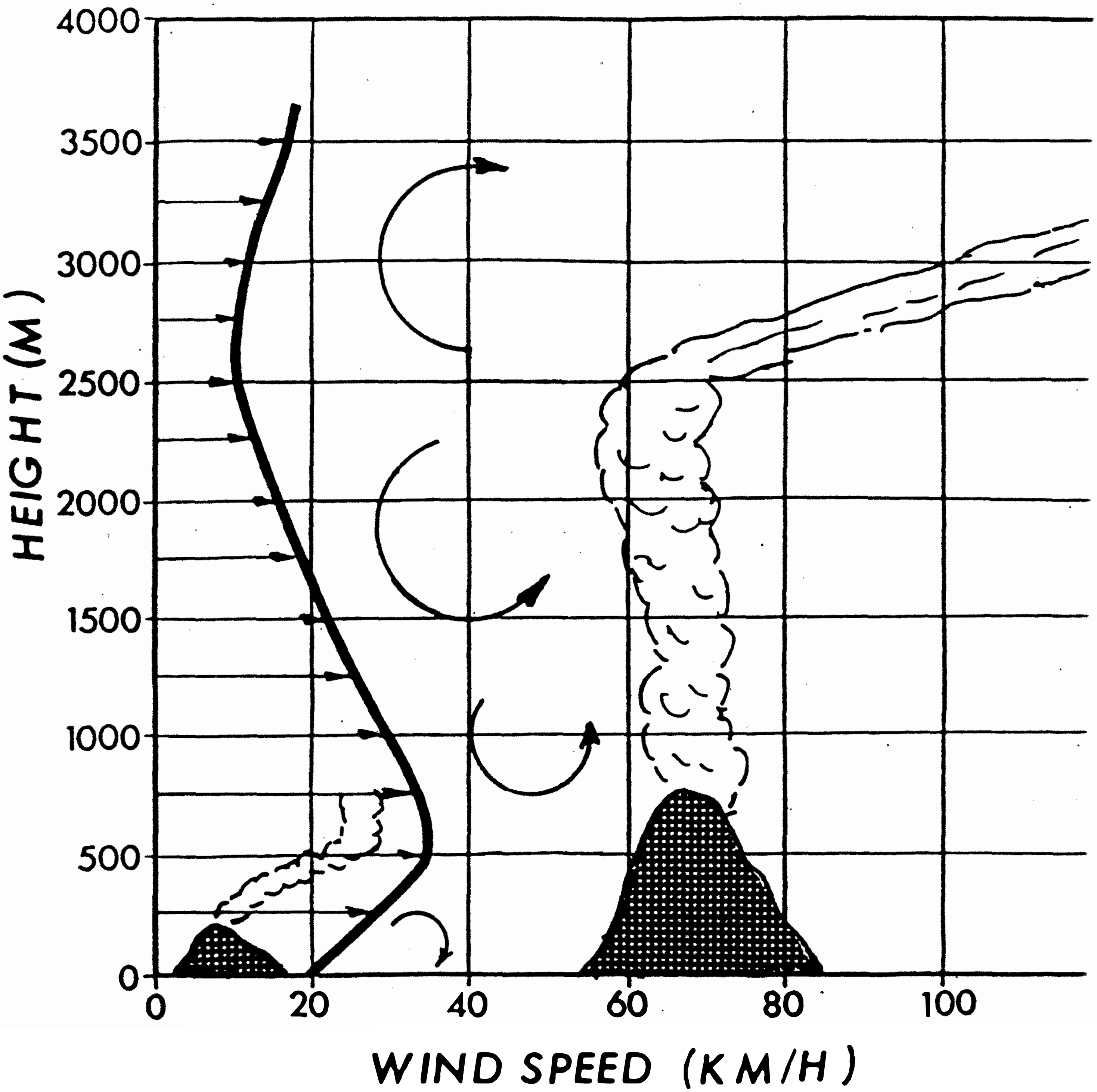

Figure 4. The effect of wind shear on forest fire behavior (refer to the text for a qualitative explanation).

The problem of "false jets" may be avoided by the use of Two- or Double-Theodolite balloon tracking, but this method is not currently employed in routine PIBAL observations. Of course, regular radio-sonde observation procedures are much less subject to such tracking errors.

DISTRIBUTION & FREQUENCY OF LOW-LEVEL JET WINDS

Analysis of some 20 years of radiosonde and PIBAL data pertinent to the west-central and northern region of Canada has revealed that about 10 percent of the wind profiles have shapes similar to Byram's ten principal types, but without matching them precisely level for level. If the selection is limited to profiles with surface winds equal to Byram's speeds, then the percentage drops to less than three percent. Considering the relative rarity of LLJWs and their narrow band structure, the chances of any one fire coming under the influence of a jet is estimated to be less than one-half of one percent for incipient fires that can be extinguished or controlled within three days. The odds increased for extended fire runs lasting a week to about two percent.

Locating LLJWs and similar problem profiles will require careful observation and judicious forecasting, especially of cold fronts and zones of air-mass convergence. These features can usually be detected and appreciated to best advantage on 850 mb contour charts and on stream-line charts, respectively. Fire-weather forecasters are urged to give special attention to the 850-mb level, especially when assessing the fire potential along Alberta's East Slopes, the Swan Hills, Birch Hills, etc., since the higher ground is at or close to the height of the 850-mb surface ($\simeq$ 1500 m). This circumstance makes these charts more representative of the actual fire potential at higher elevations than the conventional sea-level isobar chart.

ATMOSPHERIC STABILITY AND CONVECTION

It has long been known that air-mass stability may enhance or suppress convective activity and the vertical motion of the air, an important factor to be considered by the fire-weather forecaster. The stability condition of the air can be expressed in several ways by means of stability indices. A convenient recent summary is given by Sackiw (1986). Some indices such as the Showalter Index are very simple and easy to use, whereas others are quite complicated and not always soundly based on theory, but deduced empirically (e.g., Strong 1979, Johnson 1982, Strong and Wilson 1983), and frequently applicable only to local or highly restricted situations. Moreover, current stability indices available to forecasters and fire managers are those designed for assessing and predicting the development of convective cloud, thunderstorms and tornadoes. To date, no stability index has been designed specifically for use in forest fire management operations.

An index to be used in conjunction with fire-weather forecasting should be soundly based on thermodynamics, and yet be easy to calculate and use. Having considered many different indices described in the literature, it appears that none fully serves the needs of the fire manager. It is proposed, therefore, that a new index be introduced and tested under field conditions during the next fire season. The index, to be known as the THETA Index, is defined as the difference between the pseudo-adiabatic temperatures at the surface and the 700-mb level:

[2] THETA = $\Theta w_0 - \Theta w_7$

This index has the advantage that it is conservative, includes a measure of the temperature and the moisture content of the air, and provides a ready appreciation of the shape of the ascent curve as determined by a rawinsonde. Specific details, and other reasons for this choice will be given in a later paper.

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DEVELOPMENT OF A PREPAREDNESS SYSTEM FOR FOREST FIRE INITIAL ATTACK IN THE NORTHWEST TERRITORIES[1]

by

R.A. Lanoville[2]

INTRODUCTION

Development of the NWT Forest Fire Preparedness (FFP) System, which will hopefully be in full operation for the 1986 fire season, began about two years ago. The first year was spent examining a number of approaches in order to strike a reasonable balance between the collected managerial experience of northern fire managers and the latest development in fire science, particularly in quantitative fire behavior prediction and automated fire management systems. The method of determining fire preparedness that was in current use in the NWT was reviewed as well as plans and systems developed and used elsewhere. Two things became clear: (a) the procedures in use to determine fire preparedness had become outdated by advances in fire science and technology, and (b) the preparedness system developed by the Alberta Forest Service (1985) contained many desirable features that could be adapted for use in the NWT. This paper should be considered as a progress report on the status of the NWT FFP System. The specifics of the system as described here are not necessarily directly transferable to another fire management agency, although the development principles are deemed applicable. On a historical note, A.D. Kiil did, during his brief tenture as forest protection coordinator with INAC-HQ in 1973, develop a preliminary preparedness scheme for the NWT and Yukon (Anon. 1974) based on the Canadian Forest Fire Weather Index System.

BACKGROUND

In January 1985, fire managers from the INAC Districts and Regional Fire Centre (RFC) met in workshop sessions at Yellowknife to establish the objective of the FFP System and the guidelines upon which the system would be based:

> ***The objective of the NWT FFP System is to provide fire managers with a procedure, based on potential fire behavior (current and forecasted), to systematically build-up or build-down initial attack resources.***

The guidelines that were established at the Yellowknife workshop[3] are as follows:

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[1]A presentation made at the Third Western Region Fire Weather Committee Scientific and Technical Seminar, February 4, 1986, Edmonton, Alta.

[2]Fire Behavior Officer, Indian and Northern Affairs Canada (INAC), Northern Affairs Program - NWT Region, Regional Fire Centre, P.O. Box 7, Fort Smith, Northwest Territories, XOE OPO.

[3]Special thanks is extended to T.A. Van Nest (Fire Behavior Officer, Alberta Forest Service, Forest Protection Branch, Edmonton) and to M.E. Alexander (Fire Research Officer, Northern Forestry Centre, Canadian Forestry Service, Western and Northern Region, Edmonton, Alta.) for their assistance in the workshop.

- The levels of preparedness[4] will be determined by Perimeter Control Factors (PCF) which combine the effect of fire growth based on the Canadian Forest Fire Behavior Prediction (FBP) System and frontal fire intensity[5] based on the Canadian Forest Fire Weather Index (FWI) System with the suppression effort needed to control fires during the initial burning period following detection.

- In calculating the fire growth and frontal fire intensity aspects of the system, a constant 10-m open wind speed of 20 km/h will be used. When fuel moisture conditions are low, a 20 km/h value represents a pragmatic upper limit up to which initial attack efforts are likely to be successful[6].

- The initial attack[4] resources, in type and number, for each of the preparedness levels, will be assigned on a subdistrict basis. The amount of resourcing will depend upon historical fire load and the subdistrict's capacity to effectively manage and supervise the assigned resources.

Fire risk (i.e., potential number of ignition sources) is not considered in the FFP System *per se*. A traditional approach has been taken instead. Within the scope of the collected experience and "best" judgement of NWT fire managers, the resources assigned to each INAC subdistrict for each preparedness level should reasonably reflect the number and type of fires that could be attacked and controlled in one day. This usually means 3-4 fires but as many as 17 have been successfully actioned and contained in a single burning period.

The actual daily assignment of resources to the subdistricts by the RFC does not exclude the possibility to organize them in response to an anticipated increase in fire risk within a given area. For example, intercepting and tracking thunderstorms with "loaded patrols" is a common practice. Another

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[4]Basic definitions (from Merrill and Alexander 1987): Preparedness - Condition or degree of being able and ready to cope with an anticipated fire situation; Initial Attack - The action taken to halt the spread or potential spread of a fire by the first fire fighting force to arrive at the fire.

[5]Frontal fire intensity, which is synonymous with Byram's (1959) fireline intensity, represents the rate of heat energy release per unit time per unit length of fire front (I). Flame size is its main visual manifestation. Numerically, it is equal to the product of the net heat of combustion (H), quantity of fuel consumed in the flaming front (w), and linear rate of spread (r) ($I = Hwr$). See Alexander (1982) for further information.

[6]Crown fire spread is predicted to occur, if the fire is burning on level terrain, at an Initial Spread Index (ISI) of 12 or greater according to the 1984 interim edition of the FBP System (Alexander and others 1984, Lawson et. al. 1985). An ISI of ≥ 12 can be attained, with a 10-m open wind of 20 km/h, at a Fine Fuel Moisture Code of ≥ 90 (Canadian Forestry Service 1984, Van Wagner and Pickett 1985). Note also that a 10-m open wind of 20 km/h does coincidentally represent a typical average value for the daily burning period in the forested areas of NWT during the summer fire season (Atmospheric Environment Service 1982).

tactic is to open temporary base camps in areas of the greatest fire risk. In the same vein, but on a less regular basis, the RFC has "beefed-up" the resources in a subdistrict in preparation for greater than normal fire loads.

FFP SYSTEM STRUCTURE

The FFP System consists of four major modules: fire weather elements, the FWI System, the FWI System, the FBP System, and the Perimeter Control Factors (PCF). The 1200 h local standard time (LST) fire weather observations from the territorial fire weather station network and the forecasted weather are the primary inputs to the FFP System. The use of the FWI System and FBP System represent intermediary steps in calculating the PCFs. The FFP System assumes that the incipent stage of forest fire growth can be represented by an elliptical shape (Alexander 1985, McAlpine 1986).

Fire Weather Elements

The FFP System uses weather data from two sources in determining the preparedness levels. The synoptic preparedness levels are those determined from the daily 1200 h LST fire observations based on the territorial fire weather station network. Except for the 10-m open wind speed, which is held constant at 20 km/h, the 1200 h LST observations include dry-bulb temperature, relative humidity, and 24-h rain amounts. The synoptic preparedness levels apply to the day in which they are calculated and serve to verify the previously forecasted levels.

The fire weather forecasts supplied by Atmospheric Environment Service (AES) are used to forecast preparedness levels one and two days in advance. In forecasting the preparedness levels, the AES meteorologist assigned to the Regional Fire Centre would treat the fire forecasted 1200 h LST fire weather elements as follows:

Dry-bulb Temperature.--Select one of the following eight classes for each forecast area: ≤ 5°C, 5.5-10°C, 10.5-15°C, 15.5-20°C, 20.5-25°C, 25.5-30°C, 30.5-35°C, and ≥ 35.5°C.

Relative Humidity.--Select one of the following ten classes for each forecast area: < 10%, 15%, 20-25%, 30-35%, 40-45%, 50-60%, 65-70%, 75-80%, 85-90%, and 95-100%.

10-m Wind Speed.--Held constant at 20 km/h.

24-h Rain Amount (mm).--Rainfall is not considered in forecasting preparedness levels.

A number of critical synoptic-scale fire weather types occur in the Northwest Territories (e.g., Street and Birch 1986). In the FFP System, special consideration will be given to the breakdown period of a persistent upper ridge. According to Janz and Nimchuck (1985) the breakdown of an upper ridge is characterized at the surface by a period of strong winds, high temperatures and low humidities. The risk of thunderstorm activity is also greatly increased. Burning conditions may be 'explosive' over wide areas affected by the breakdown. Once an upper ridge becomes established, forecasting its impending breakdown becomes all important. In terms of fire preparedness, the levels attained while under the influence of a persistent ridge should be maintained through the breakdown period and sufficient time there after to evaluate the effect of the cooler, moister conditions that usually pervail. This means that, following an upper ridge breakdown, a higher level of preparedness may be maintained for a period of time longer than an evaluation of the surface weather conditions would indicate.

FWI System

The FWI System has been used as the basis for fire danger rating in the Northwest Territories since 1971 when it was first introduced to fire management agencies in Canada by the Canadian Forestry Service. Since its introduction in the NWT, the FWI System has been used with increasing confidence as a guide to planning and preparing for fire management activities such as detection, presuppression, and suppression. The FWI System consists of six components. Three of the components are fuel moisture codes whose values give, in turn, relative numerical ratings of the moisture content of fine fuels (needle litter), medium fuels (loosely compacted organic layers of moderate depth), and heavy fuels (deep, compact, organic matter). The three remaining components are fire behavior indexes, two of which are intermediary steps in calculation of the third, the Fire Weather Index itself. The NWT FFP System uses three of the six components of the FWI System: the Fine Fuel Moisture Code, the Initial Spread Index, and the Fire Weather Index.

The Fine Fuel Moisture Code (FFMC) component of the FWI System represents "A numerical rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel." (Canadian Forestry Service 1984). Fine fuels are abundant and widespread throughout the treed area of the NWT. Mosses, lichens, grasses, and small down and dead woody material are found in sufficient quantities either singly or in combination in all fuel complexes to carry fire. Except for wind, the fine fuel component of any forest fuel type is the single most important factor contributing to the development and spread of forest fires in the northern environment. The FFMC, which integrates the effects of wind speed, temperature, relative humidity and rainfall, over the past couple of days, is a good guide to ignition probability and general burning conditions. For this reason, the FFMC is used to determine the state of readiness for dispatch, or "get-away time" of the initial attack forces. This aspect of the FFP System still remains to be finalized.

The Initial Spread Index (ISI) component of the FWI System represents "A numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on rate of spread without the influence of variable quantities of fuel." (Canadian Forestry Service 1984). The ISI is an input to the FBP System and is used to predict the head fire rate of spread for specific fuel types.

The Fire Weather Index (FWI) represents "A numerical rating of fire intensity that combine ISI and BUI [Buildup Index]." (Canadian Forestry Service 1984). The proportion of an elliptical shaped fire perimeter (Fig. 1) that actually needs control action is scaled according to the frontal intensity of the fire (Fig. 2) as represented by the FWI. This amount of potential effort is expressed as a fraction and is called the Fire Control Factor (FCF). The FCF is presently deemed to be a function of the FWI and is given by the following equations (Fig. 3):

[1a] $FCF = 0.00023436(FWI)^{2.6301}$,if $FWI \leq 24$

[1b] $FCF = 1.0$,if $FWI > 24$

The value of the FCF varies between 0.0 when the FWI = 0 to 1.0 when the FWI = 24. For FWI values greater than 24, the FCF has been set constant to a value of 1.0. Expressed as a percent of the total perimeter, the FCF varies between 0 and 100 percent as the FWI varies between 0 and 24. Note that most elliptical fire growth/containment models assume that 100% of the perimeter must be controlled (e.g., Mees 1985) or some constant proportion such as 40% (e.g., Potter et al. 1981, Martell et al. 1984), regardless of the burning conditions.

FBP System

The FBP System, which produces quantitative outputs of selected fire behavior characteristics for major Canadian fuel types (Lawson et al. 1985), is an integral part of the FFP System. The FBP System is used in the FFP System to determine the potential growth of free-burning burning elliptical shaped fires (Fig. 1) in boreal spruce stands on near level topography. The FBP System Fuel Type C-2 was chosen as the most representative situation in the NWT for the following reasons:

(a) Spruce growing in singular stands or in combination with other tree species covers about 77% of the treed area of the Fire Attack Zone[7];

(b) Nearly all fires resulting from lightning ignitions develop and initially spread in this fuel type; and

(c) The vast majority of the fire control experience, upon which the requirements for suppression action are determined, has been in this fuel type.

When the FFP System eventually becomes automated, the fuel type which is most representative of each fire weather station will be used and the effects of slope and aspect will be included were appropriate.

Using the equation for the ISI component in the FWI System (Van Wagner and Pickett 1985), the head fire rate of spread (ROS) on level terrain for FBP Fuel Type C-2 (Boreal Spruce), expressed in m/min, is given by the following equation as taken from the 1984 FBP System interim user guide (from Alexander and others 1984):

[2] $ROS = 112.8 \left(1 - e^{-0.0323\ ISI}\right)^{1.863}$

[7]J. Gilmour, Staff Forester, Indian and Affairs Canada, Northern Affairs Program - NWT Region, Fort Smith, Northwest Territories (pers. comm. October, 1985).

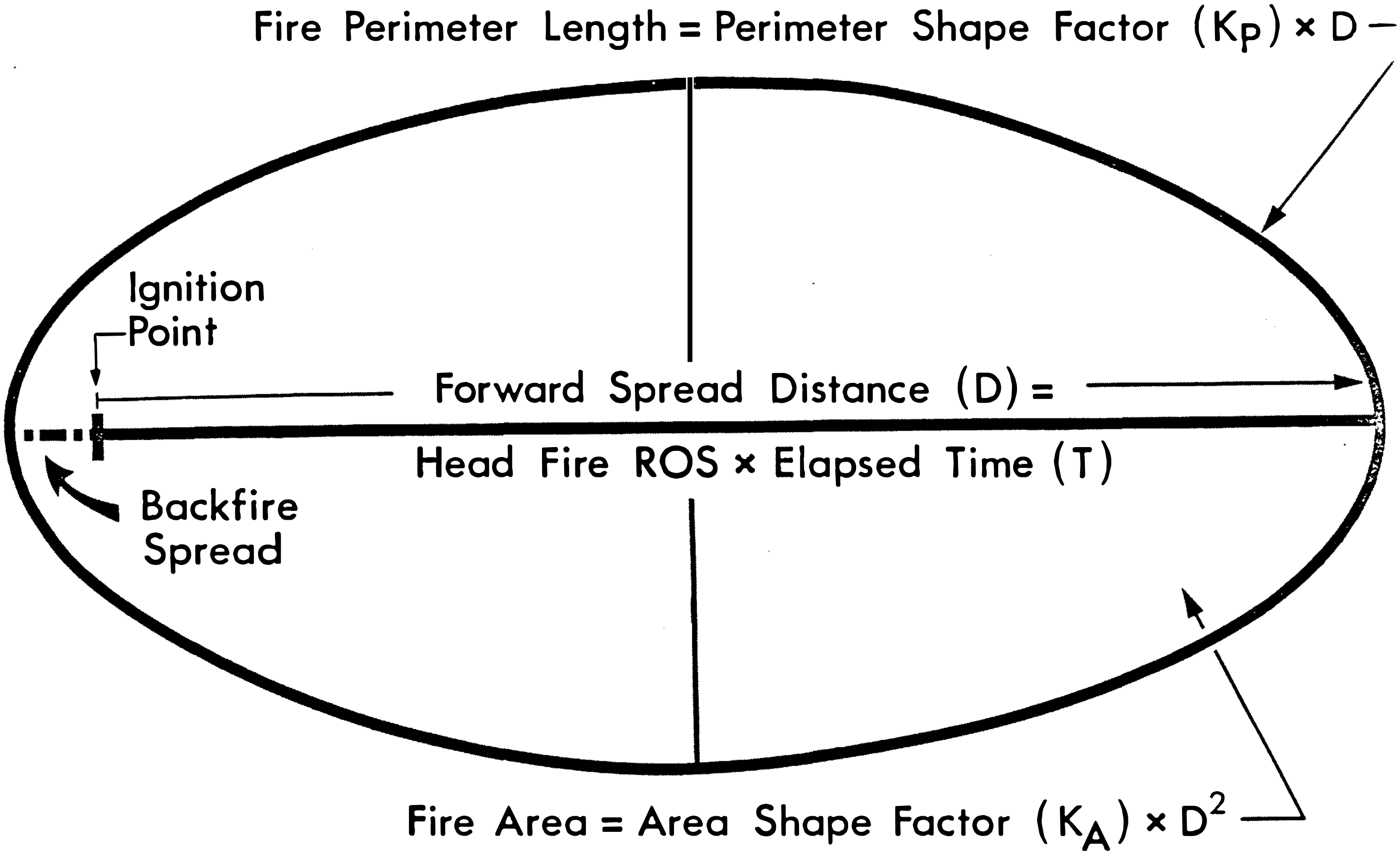

Figure 1. The free-burning elliptical shaped wind-driven fire on level terrain with a length-to-breadth ratio (L/B) of 2.0:1 (from Alexander 1986). The shape factors for calculating fire area and perimeter length would be based on the "focus approach" which indirectly accounts for backfire spread (see Alexander 1985).

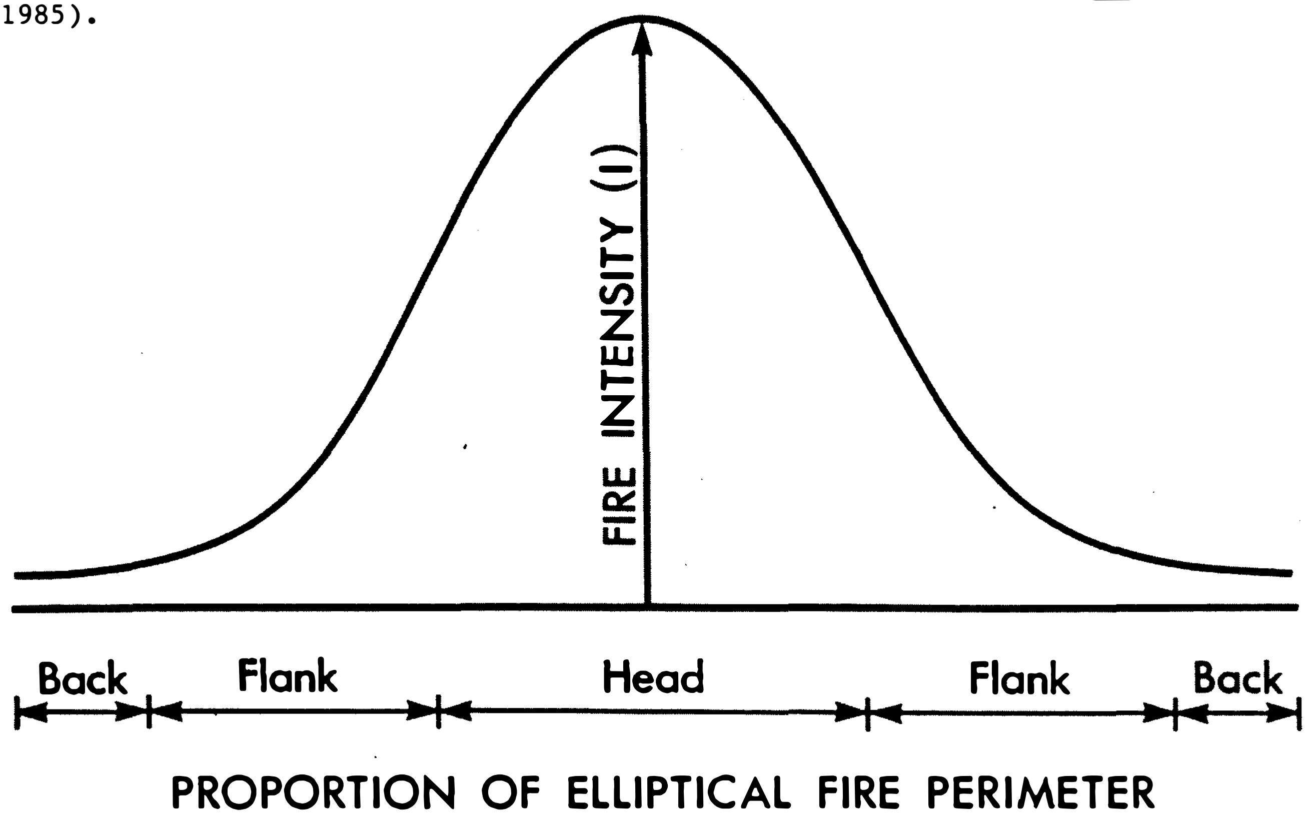

Figure 2. Variation in frontal intensity around an elliptical shaped fire front (after Catchpole et al. 1982). The proportion varies according to the L/B which is in turn a function of wind speed for a given fuel type.

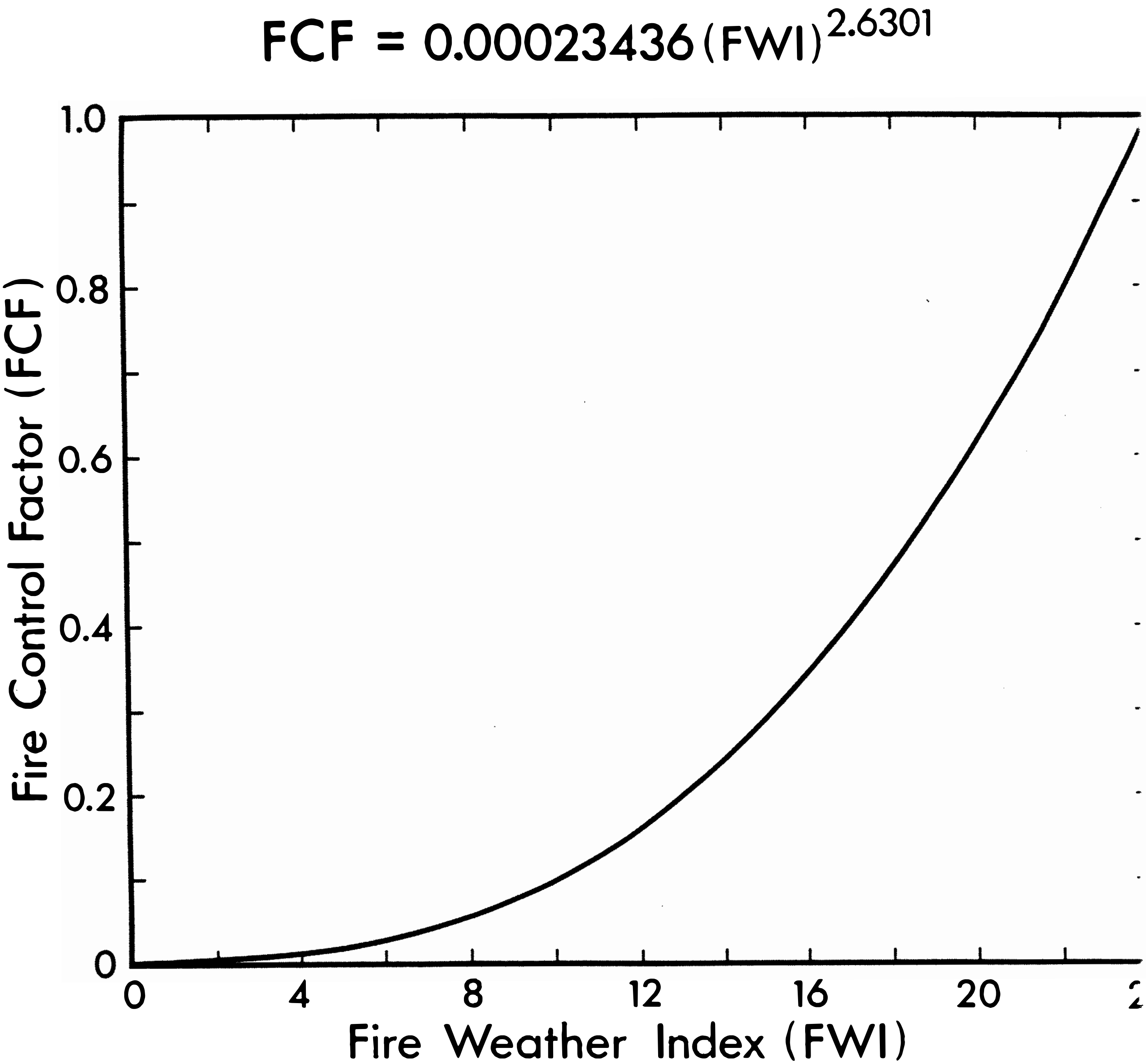

Figure 3. Fire Control Factor (FCF) as a function of the Fire Weather Index (FWI). This relation is presently based in part on the experiences of fire control personnel in the Northwest Territories supplemented by documented cases of fire behavior in FBP System Fuel Type C-2 (e.g., Kiil 1975, Newstead and Alexander 1983, Lanoville and Schmidt 1985). There were, however, two key data points: (i) the FCF should equate to 0.1 when the FWI = 10 and (ii) when the FWI is equal or greater than 24, currently the "extreme" fire danger class threshold value in the Northwest Territorties, the FCF should equate to 1.0.

The rate of perimeter increase (P_i), which is needed to calculate the Perimeter Control Factors in the FFP System, is determined as follows (from Alexander and others 1984):

[3] $P_i = K_p$ (ROS)

where, the ROS is determined from Eq. [2] and K_p is the Perimeter Shape Factor which is equal to 2.75 for a 10-m open wind speed of 20 km/h (Alexander 1985). This corresponds to an ellipical shaped fire with a length-to-breadth ratio (L/B) of about 1.8:1 (Alexander 1985). The rate of perimeter increase is expressed in m/min.

Perimeter Control Factors

The Perimeter Control Factor (PCF) represents the combined effect of fire growth (specifically, the rate of perimeter increase) and the frontal fire intensity (represented by the FWI) on the suppression effort needed to control detected forest fires during their initial burning period. The PCF, expressed in m/min, is calculated as follows:

[4] PCF = FCF (P_i)

where, the FCF is the Fire Control Factor determined form Eq. [1a] or [1b] and P_i is the rate of perimeter increase determined from Eq. [3].

In the manual look-up version of the FFP System, the PCF is determined from Table 1 by intersecting the FFMC (columns) with the FWI (rows). For example, a FFMC value of 87 and a FWI value of 13 gives a PCF value of 4. In constructing Table 1, the FFMC was chosen over the ISI or P_i as a matter of convenience to field staff. Similarly, FWI was used instead of the BUI in order to retain the frontal fire intensity concept in the FFP System.

To illustrate how the PCF value integrates fire suppression requirements with fire behavior characteristics, consider an FFMC of 86 and FWI of 18. From Table 1, the PCF value is 7. Question: what does a PCF of 7 actually mean in terms of fire suppression? The answer to this question can be found by examining the components which make up the PCF. From Eqs. [2] and [3], the rate of perimeter increase or P_i is calculated to be 14.6 m/min. Remember that the FCF, which is a function of the FWI, represents that fraction of the fire perimeter which requires suppression action to effect containment. By multiplying the P_i by the FCF given by Eq. [4], the resultant value is 7 or 7 m/min. The FCF has the effect of adjusting the rate of perimeter increase to the fire guard construction rate that is needed to control the fire. In other words, the PCF is the minimum fire guard construction capability required of initial attack forces for successful containment. In general, the fire suppression requirement is based on a combination of men and equipment which can construct fire guard at the rate given by the PCF values found in Table 1 or by Eq. [4] if computer calculation is employed.

The PCF can be used to group fires that have similar fire suppression requirements but different fire behavior characteristics. Consider two fires, one burning with a relatively low rate of spread but high intensity (Fire A) and another burning with a relatively higher rate of spread but lower intensity (Fire B):

Table 1. Perimeter Control Factor (**PCF**) as a function of the Fire Weather Index (**FWI**) and Fine Fuel Moisture Code (**FFMC**).
Note: Tabulation is only valid for a 10-m Open Wind Speed of 20 km/h.

FWI	**FFMC**[1] 78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
	PCF (m/min)[2]																	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1
5	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	2
6	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	2	2	3
7	*	*	*	*	*	*	*	*	1	1	1	1	1	2	2	3	3	4
8	*	*	*	*	*	*	1	1	1	1	1	2	2	2	3	4	5	5
9	*	*	*	*	*	1	1	1	1	1	2	2	3	3	4	5	6	7
10	*	*	1	1	1	1	1	1	1	2	2	3	4	4	6	7	8	10
11	*	*	1	1	1	1	1	1	2	2	3	4	5	6	7	9	10	12
12	*	1	1	1	1	1	1	2	2	3	4	5	6	7	9	11	13	16
13	1	1	1	1	1	1	2	2	3	4	5	6	7	9	11	13	16	19
14	1	1	1	1	1	2	2	3	4	4	6	7	9	11	13	16	20	23
15	1	1	1	1	2	2	3	3	4	5	7	8	11	13	16	20	24	28
16	1	1	1	2	2	2	3	4	5	6	8	10	12	15	19	23	28	33
17	1	1	2	2	2	3	4	5	6	7	9	12	15	18	22	27	33	39
18	1	2	2	2	3	3	4	5	7	9	11	14	17	21	26	32	38	45
19	2	2	2	3	3	4	5	6	8	10	12	16	20	24	30	36	44	52
20	2	2	2	3	4	4	6	7	9	11	14	18	22	28	34	42	50	60
21	2	2	3	3	4	5	6	8	10	13	16	20	25	32	39	47	57	68
22	2	3	3	4	5	6	7	9	12	15	18	23	29	36	44	54	65	77
23	3	3	4	4	5	6	8	10	13	16	21	26	32	40	49	60	73	87
≥24	3	3	4	5	6	7	9	11	14	18	23	29	36	45	55	67	81	97

[1]An **FFMC** ≤77 equates to a **PCF** value of <2, regardless of the **FWI** level.

[2]An asterisk indicates a **PCF** value greater than zero but less than 0.05 m/min.

Descriptor	Fire A	Fire B
FFMC	86	91
FWI	20	13
PCF	9	9

The similarity between the two fires is found in the common PCF value. From a fire suppression point of view, the same fireline building capacity is required to control the growth of both fires, although the type of resources would likely be different in view of the probable differences in flame size.

By averaging the PCF value calculated from either the 1200 h LST fire weather observations or the forecasted weather, the initial attack resource requirements can be determined for an area such as a subdistrict. The PCF value calculated for each representitive fire weather station in the subdistrict would dictate the distribution of initial attack resources and the average PCF value would indicate the total resource requirements for the subdistrict. In a similar manner, the distribution and amount of resources for an entire region can be determined and allocated accordingly.

The four preparedness levels of the NWT FFP System, which were assigned on the basis of the author's review of all available information, are given in Table 2. At a forthcoming INAC meeting this spring, fire managers in the NWT will collectively assign the initial attack resources to each preparedness level on a subdistrict basis. Once this has been done, the FFP System will be implemented, first on a manual look-up basis and then later as a computerized procedure.

Table 2. The NWT Forest Fire Preparedness (FFP) System levels and corresponding Perimeter Control Factor (PCF) classes.

FFP System Level	PCF Class (m/min)
1	0 - 2
2	3 - 14
3	15 - 29
4	30+

SUMMARY AND CONCLUDING REMARKS

The NWT Forest Fire Preparedness (FFP) System is a decision support system which integrates current and predicted fire behavior with the fire suppression effort needed to effect successful initial attack on incipient forest fires. The FFP System relies on fire weather observations from a network of stations and from forecasted weather elements supplied by the Atmospheric Environment Service. The system uses the FWI System and the FBP System of the Canadian Forest Fire Danger Rating System (CFFDRS) to compute Perimeter Control Factors which are in turn used to determine four levels of preparedness for each INAC administrative subdistrict in the NWT. By using the FFP System, initial attack resources in the NWT are allocated and deployed in a systematic and consistent manner.

The proposed system as described in this paper represents a modern approach to the problem of defining preparedness requirements for initial attack on forest fires. Those involved in the development of the FFP System believe that the system's structure is on a reasonably sound foundation. The relationships utilized in constructing the system are based on the best available information. Changes can be made, with a minimal of impact to field personnel, as operational experience with the system increases and new knowledge from fire research becomes available. For example, a reliable CFFDRS fire occurrence prediction system would undoubtedly improve the FFP System.

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THE 1950 CHINCHAGA RIVER FIRE IN THE PEACE RIVER REGION OF BRITISH COLUMBIA/ALBERTA: PRELIMINARY RESULTS OF SIMULATING FORWARD SPREAD DISTANCES[1]

by

Peter J. Murphy[2] and Cordy Tymstra[3]

INTRODUCTION

On June 1, 1950 a forest fire started approximately 30 km north-northwest of Fort St. John, British Columbia (Fig. 1). The fire was reported to the Fort St. John Ranger Station on June 2 at 1135 h -- estimated size: 40 ha. By the time the local ranger arrived at the fire later that day, it had doubled in size. The B.C. Forest Service ranger observed that the fire was burning out of control in slash on the abandoned operations of the Fort St. John Lumber Company and it was suspected as being man-caused. At the time, the fire was located within a zone in which burning permits were not required and was in a area judged to be future agricultural land. In view of these factors and the demands created by other ongoing fires within the Peace River Forest district, it was decided not to initiate suppression action (B.C. Forest Service 1950). The fire's general direction of major spread was northeasterly, and during the 1950 fire season it burned across the British Columbia-Alberta boundary. At the time, the fire control policy in northern Alberta stipulated that no suppression action be taken on fires further than 16 km (10 mi) from roads, railways, or communities (Murphy 1985a). The fire was therefore a free-burning event, not subject to control action.

Written and oral reports by local observers (LaFoy 1977, Philip 1983) indicated that although the fire was recurrently active during the entire fire season of 1950, it exhibited major activity during three days in the middle to latter part of September (Murphy 1978). Smoke from this and other nearby fires drifted over eastern Canada, the northeastern United States, Britain and Holland (Smith 1950, Wexler 1950, Winston 1950, Bull 1951, Elsey 1951, Downing 1951, McWhirter 1984). This wildfire situation had recently come to the attention of Dr. Carl Sagan and others, who expressed interest in connection with their studies of the "nuclear winter" theory[4].

The final size of the 1950 Chinchaga River Fire, as measured from aerial photographs, is about 1.4 million ha. This includes the area of a second fire which burned into its northwestern edge. The area burned by the Chinchaga River Fire is slightly larger than previously-documented major fires in North America such as the Miramichi-Maine Fire of 1825 (1.2 million ha), Michigan and Peshtigo fires of 1871 (1.0 and 0.5 million ha, respectively), and the Great Idaho fires of 1910 (1.2 million ha) (Brown and Davis 1973).

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[1]A presentation made at the Third Western Region Fire Weather Committee Scientific and Technical Seminar, February 4, 1986, Edmonton, Alta.

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[4]Craig C. Chandler, Arlington, Virginia, personal written communication.

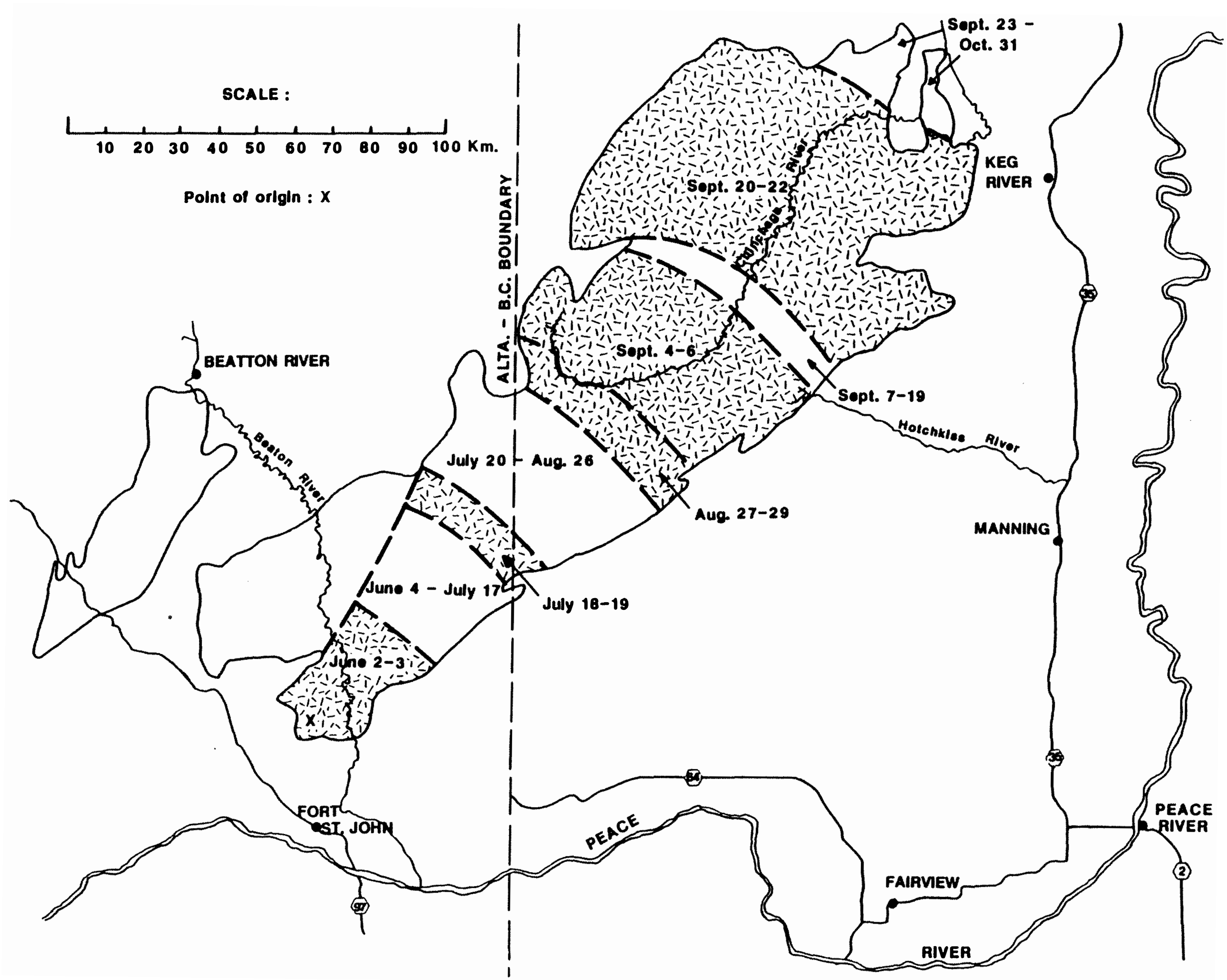

Figure 1. Fire progress map for the 1950 Chinchaga River 'conflagration' based on computer simulation modelling. The fire's final perimeter is based on an examination of aerial photographs.

Since the fire was in a remote area there are no records of its daily growth or distance travelled. The individual forest fire report prepared for the British Columbia side (B.C. Forest Service 1950) did not show it crossing the border into Alberta, and there was no report prepared by the Alberta Forest Service. The objective of the present study was to derive estimates of the daily linear spread and to calculate from these approximations, the possible area burned during major burning periods. The fire growth modelling relies heavily on the use of the Canadian Forest Fire Danger Rating System (CFFDRS).

The fire area is located within the boreal forest region of Canada (Rowe 1972). The topography is level to rolling with low ridges to the northwest and southeast of the Chinchaga River valley which may have constrained lateral fire spread. There were no topographic features to impede progress in the major north-easterly direction. Fuel types were largely coniferous interspersed with muskeg and some mixedwood stands of white spruce (Picea glauca var. albertiana) and trembling aspen (Populus tremuloides). There were reports (LaFoy 1977) of excellent spruce timber estimated at 100 cm or greater in diameter. Some lodgepole pine (Pinus contorta var. latifolia) was also present. For purposes of selecting an appropriate fuel type it was assumed that the conifer stands predominated.

Weather data were obtained from several stations operated by the Canada Department of Transport in northwestern Alberta (Fairview, Peace River and Keg River) and northeastern British Columbia (Fort St. John and Beatton River) (Fig. 1). The data from Fort St. John (elevation: 695 m MSL) were selected for this initial analysis since that station was closest to the fire area and upwind of the major direction(s) of strong surface winds. Component values of the Canadian Forest Fire Weather Index (FWI) System (Van Wagner 1974; Turner and Lawson 1978, Canadian Forestry Service 1984) were calculated using the program described by Van agner and Pickett (1985). The system is dependent on fire weather observations taken at 1200 h local standard time. Since the Fort St. John weather observations were recorded hourly on the half hour, the 1230 h Mountain Standard Time (MST) observations were used for the present study.

The distance of linear fire spread was calculated on a daily basis using the technique described by Murphy (1985b). Daily spread distances were computed using the head fire rate of spread (ROS)/Initial Spread Index (ISI) equation for Fuel Type C-3 (Mature Jack or Lodgepole Pine) in the Canadian Forest Fire Behavior Prediction System (Alexander et al. 1984, Lawson et al. 1985):

$$[1] \quad \text{ROS (m/min)} = 100.3 \left(1-e^{-0.0509\ \text{ISI}}\right)^{3.53}$$

This was converted to daily spread assuming a diurnal burning period of 12 hours as described by Murphy (1985b).

Initial results indicated daily spread distances during the three major days in September to be less than anticipated. Examination of the hourly readings showed strong winds developing in the afternoon on two of those days, which were not reflected in the 1230 h MST observations. The initial results indicated 20 different days within eight periods of 1-6 days in length, during which the fire made major advances. For those 20 days the daily spread was recalcuated using the hourly weather data from Fort St. John (Van Wagner 1977; Alexander et al. 1984), and the recalculated values were substituted in the summary. The long axis estimate was 256.9 km in contrast to the 245 km measured on the map. All daily spread values were then adjusted proportionately by a scale factor of 0.9537 so that the final total came to 245 km. From these adjusted values, 15 days in seven distinct periods were identified during which the forward spread distance exceeded 7.0 km either on individual days or during the 1-3 day interval.

Table 1 summarizes the seven suspected periods of major fire spread, and the five greatest periods are illustrated in Figure 1. Probable fire behavior and difficulty of control characteristics, based on the daily fire danger rating calculations at Fort St. John (Table 1) on days during which the Chinchaga River Fire made major runs is displayed in Figure 2[5]. The longest

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[5]Editor's Note: The chart and accompanying table were prepared initially for distribution at the 1986 Annual Meeting of the Canadian Forest Fire Management held January 21-23 in Ottawa, Ontario, in order to solicit comments, etc. on the concept. The prototype example, which was prepared for illustration purposes only, is in this case deemed applicable to upland jack pine stands on level ground. The key conceptual basis incorporated into the chart/table is that the frontal fire intensity, expressed in kilowatts per metre (kW/m) (see Alexander 1982), determines the difficulty of controlling a fire (i.e.,, what kind(s) of fire suppression resources would or would not be effective). What is not considered is the "containment capability" required (i.e., the forces required for constructing fireguard in order to exceed the rate of perimeter growth and/or resistance to fireguard construction due to fuel and site characteristics). The assumption is made that the fire has reached a 'steady-state condition'. The Initial Spread Index (ISI) and Buildup Index (BUI) inputs can be determined on the basis of the standard daily FWI System calculations at 1200 h LST or an updated Fine Fuel Mositure Code and 10-m open wind speed. How do you use the chart/table? Given the ISI and BUI, determine the Intensity Rank (e.g., ISI = 10 and BUI = 40, then Rank = 3) and then refer to the table for a descriptive explanation based on the numerical rating between 1 and 6 (e.g., Rank 3: Moderately vigorous surface fire. Hand constructed ...). Note the corresponding intensities and approximate flame sizes, as well as the associated Fire Weather Index values for upland jack pine. Several possible applications of the Intensity Rank chart are foreseen. For example, actual or forecasted ISI and BUI values from an agency's fire weather station network could be plotted on a daily basis to assist in presuppression planning. The chart could also be used to evaluate the potential fire behavior of a going campaign fire. The proposed chart format is considered a convenient way of portraying the frontal fire intensity component of the FBP System for the generalist and would also serve as a quick reference for the fire behavior specialist as well. The approach does avoid the mathematical necessity of calculating frontal fire intensity using the $I = Hwr$ formula. User agencies may wish to replace or supplement the numerical ratings of 1 to 6 with generalized symbols (e.g., back-pack pump, fire shovel/Pulaski, helicopter with bucket, airtanker, flying drip torch, towering or wind-driven convection column) or agency specific symbols (e.g., rappel crews, CL-215), color codes (e.g., Brown and Davis 1973, p. 245 -- green, blue, yellow, orange, and red) and/or typical fire behavior illustrated with representative photographs. When the first complete edition of the FBP System is issued, there will be a "customized" chart for each fuel type, included in the system, and/or fuel type/ground slope class (e.g., Fuel Type C-3/10-20% Ground Slope). The present example of the chart/table is based on readily available information (e.g., intensive review of world literature).

Table 1. Summary of burning conditions on selected days and the corresponding projected advance of the 1950 Chinchaga River Fire.

Time Period (day(s))	Fire weather elements[1] Maximum air temperature (°C)	Minimum RH (%)	Maximum 10-m wind (km/h)	Days since rain[4]	Fire danger ratings[2] Initial Spread Index (ISI)	Buildup Index (BUI)	Forward spread distance Period interval (km)	Cumulative total[3] (km)
June 2	22.0	21	48	1	27	47	21	21
3	21.0	44	42	2	30	51	13	34
June 4-9	-	-	-	-	-	-	1	35
June 10	26.8	27	35	3	15	73	8	43
June 11-July 17	-	-	-	-	-	-	20	63
July 18	25.0	40	45	3	29	30	7	70
July 19	18.9	47	40	4	20	33	3	74
July 20-29	-	-	-	-	-	-	6	80
July 30	19.1	37	48	3	15	51	9	89
July 31-Aug. 26	-	-	-	-	-	-	19	108
Aug. 27	19.4	37	39	12	17	64	6	114
28	17.2	53	45	13	10	66	5	119
29	16.8	47	37	14	14	68	3	122
Aug. 30-Sep. 3	-	-	-	-	-	-	1	123
Sep. 4	18.7	37	58	3	21	71	18	141
5	19.3	40	52	4	18	74	13	154
6	15.6	43	48	5	15	76	5	159
Sep. 7-19	-	-	-	-	-	-	7	166
Sep. 20	22.1	47	64	19	44	104	35	201
21	24.1	45	29	20	11	107	2	203
22	26.1	26	55	21	15	111	26	229
Sep. 23-Oct. 31	-	-	-	-	-	-	16	245

[1]As recorded at the Department of Transport-Meteorological Division weather station at Fort St. John, B.C.
[2]Based on the 1230 h MST observations at Fort St. John.
[3]Since the June 1 date of origin.
[4]Greater than or equal to 0.6 mm.

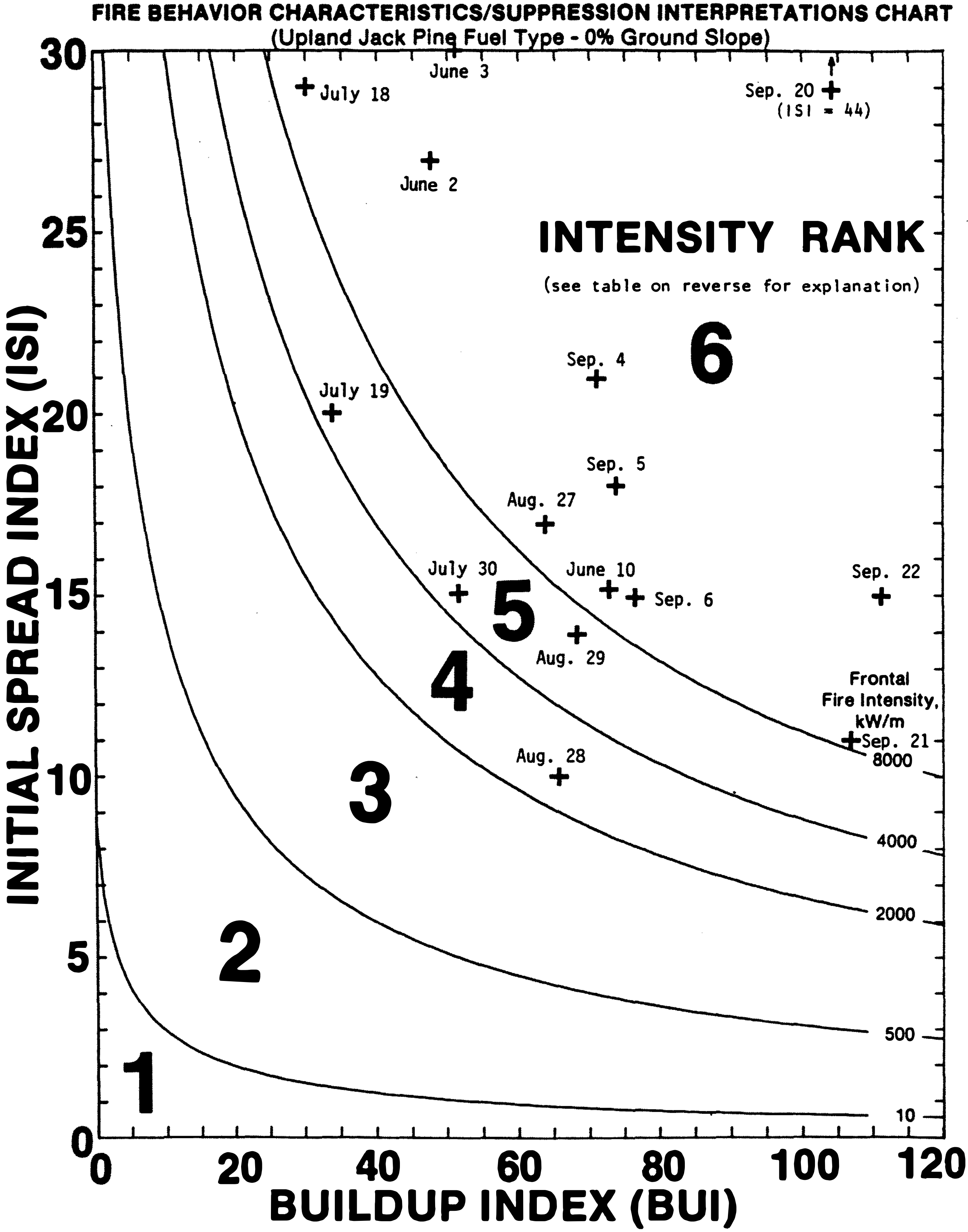

Figure 2a. Example of proposed fire behavior characteristics/suppression interpretations chart associated with the frontal fire intensity component in the Canadian Forest Fire Behavior Prediction (FBP) System illustrating its use in the case history analysis of the 1950 Chinchaga River Fire based on the daily calculations of the Canadian Forest Fire Weather Index (FWI) System components at Fort St. John, B.C.

Chart Rank	Frontal Fire Intensity (kW/m)	Head Fire[1] Flame Length (m)	Head Fire[1] Flame Height (m)	Description of Fire Behavior Characteristics and Fire Suppression Interpretations	Fire Weather Index[2] (FWI)
1	<10	<0.2	<0.1	Smouldering ground or creeping surface fire. Firebrands and going fires tend to be virtually self-extinguishing unless high Drought Code (DC) and/or Buildup Index (BUI) values[3] pervail, in which case extensive mop-up is generally required.	0-3
2	10-500	0.2-1.4	0.1-1.0	Low vigour surface fire. Direct manual attack at fire's head or flanks by fire-fighters with hand tools and water possible. Constructed fire guard should hold.	4-13
3	500-2000	1.4-2.6	1.0-1.9	Moderately vigorous surface fire. Hand-constructed fire guards likely to be challenged. Heavy equipment (bulldozers, pumpers, retardant air-craft, skimmers, helicopter w/bucket) generally successful in controlling fire.	14-23
4	2000-4000	2.6-3.5	1.9-2.5	Highly vigorous surface fire or passive crown fire (torching). Control efforts at fire's head may fail.	24-28
5	4000-8000	3.5-4.8	2.5-3.4	Extremely vigorous surface fire or active crown fire. Very difficult to control. Suppression action must be restricted to fire's flanks. Indirect attack with aerial ignition (i.e., helitorch and/or AID dispenser) may be effective.	29-33
6	>8000	>4.8	>3.4	"Blow-up" or "conflagration" type fire run; violent physical behavior probable. Suppression actions should not be attempted until burning condi-tions ameliorate.	>34

[1]Applicable to surface fire only; flame height based on flame length and a 45° flame angl

[2]Applicable to mature jack pine stands on level ground.

[3]DC >300 and/or BUI >40.

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Figure 2b. Example of proposed fire behavior characteristics/fire suppression interpretations table associated with the frontal fire intensity component in the Canadian Forest Fire Behavior Prediction (FBP) System.

daily spread was 35 km on 20 September, and the greatest cumulative spread of 63 km occurred during the 3-day period 20-22 September. The summary indicates that 71% of the total linear fire spread occurred during these 15 days which comprised 8% of the estimated 153 days of duration of the fire. The fire covered substantial distances during the two days after ignition -- 34 km in total. It made a run of similar length during the three-day period from September 4-6. Of the 15 individual days identified in Table 1, there was only one instance (Aug. 28) in which an "extreme" level of fire intensity (i.e., Rank $\geq$ 5) was not indicated based on the daily "noon" calculations of the ISI and Buildup Index (BUI) components of the FWI System (Fig. 2a).

Fort St. John recorded a six-month overwinter (Nov. 1949-Apr. 1950) precipitation total of 153.9 mm. The 1951-80 normal for the same monthly interval is 181.4 mm (Anon. 1982). Examination of the adiabatic charts for late September revealed that the atmosphere over western Canada to be conditionally unstable to 2000 m and at times as high as 5000 m (Smith 1950). Nimchuk (1983) and Janz and Nimchuk (1985) have described in general terms the wildfire behavior associated with times of upper ridge breakdown. For this study, Janz[6] kindly reconstructed the 500 mb height/maximum surface temperature anomalies chart using upper air maps. The resulting graphs are presented in Figure 3. They also depict the date and distance of major fire spread on the 15 days described previously. There is an interesting relationship between these, except for the major "blow-up" period in mid-September, which bears further investigation.

Four major points are brought out in this case study of wildfire behavior:

1. There is a potential for large fires in the western region of Canada's boreal forest with areas of continuous fuel and few natural barriers to fire growth.

2. There is a potential for major fire spread in these fuel types during periods exhibiting high ISIs reflecting high winds and low fuel moisture levels.

3. The relatively quiet intervals between periods of major fire activity suggest possibilities for control action, although the fire perimeter became very long.

4. The relationship between major fire spread and breakdown of the upper ridge substantiates the possible relationship between the two, but suggests the probable influence of other factors deserving of further study.

Continued study of the 1950 Chinchaga River Fire is tentatively planned in order to refine the estimates of fire spread and comprehensively summarize the attendant climatological and meteorological conditions. Finally, we are proposing to estimate fuel consumption during the major periods of fire spread and then describe the post-fire vegetative recovery, as influenced by estimates of frontal fire intensity, through comparison of fuel/vegetation types on vertical aerial photographs taken before and after the fire.

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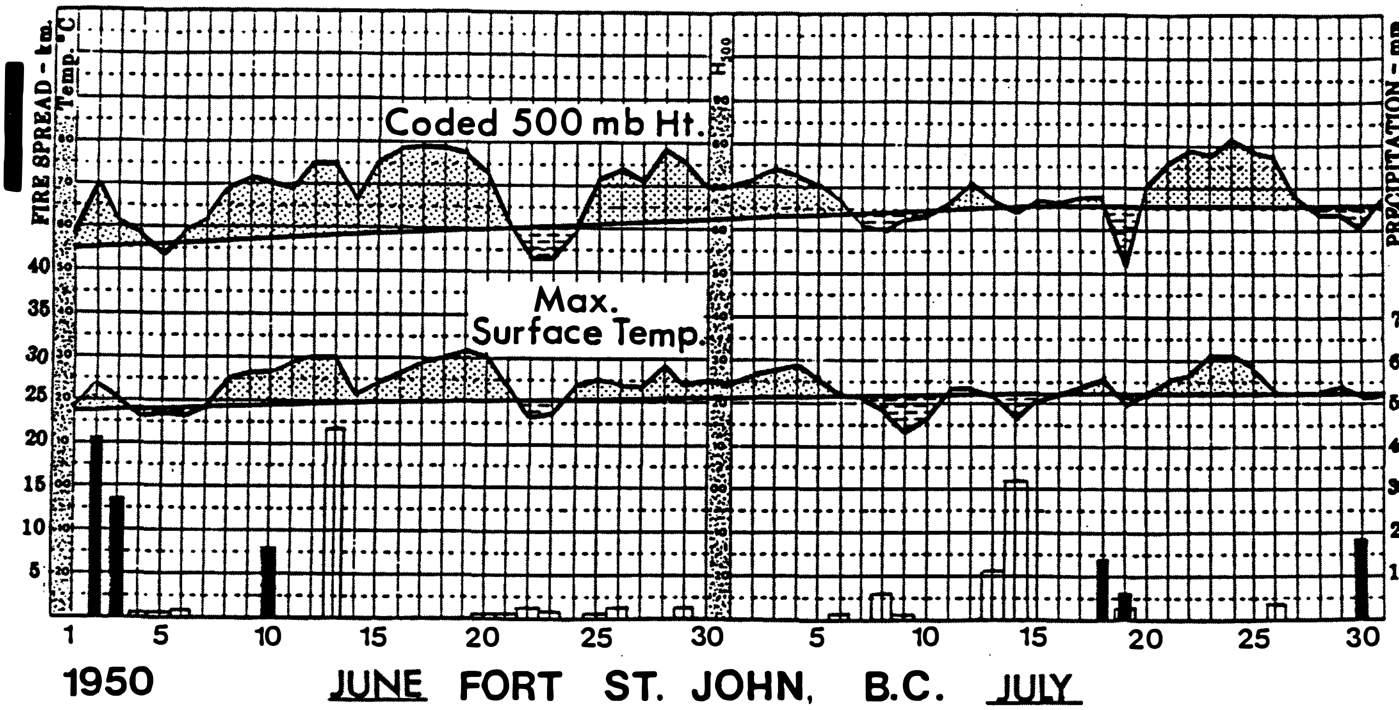
[6]Ben Janz, Fire Weather Supervisor, Forest Protection Branch, Alberta Forest Service, Edmonton, Alta.



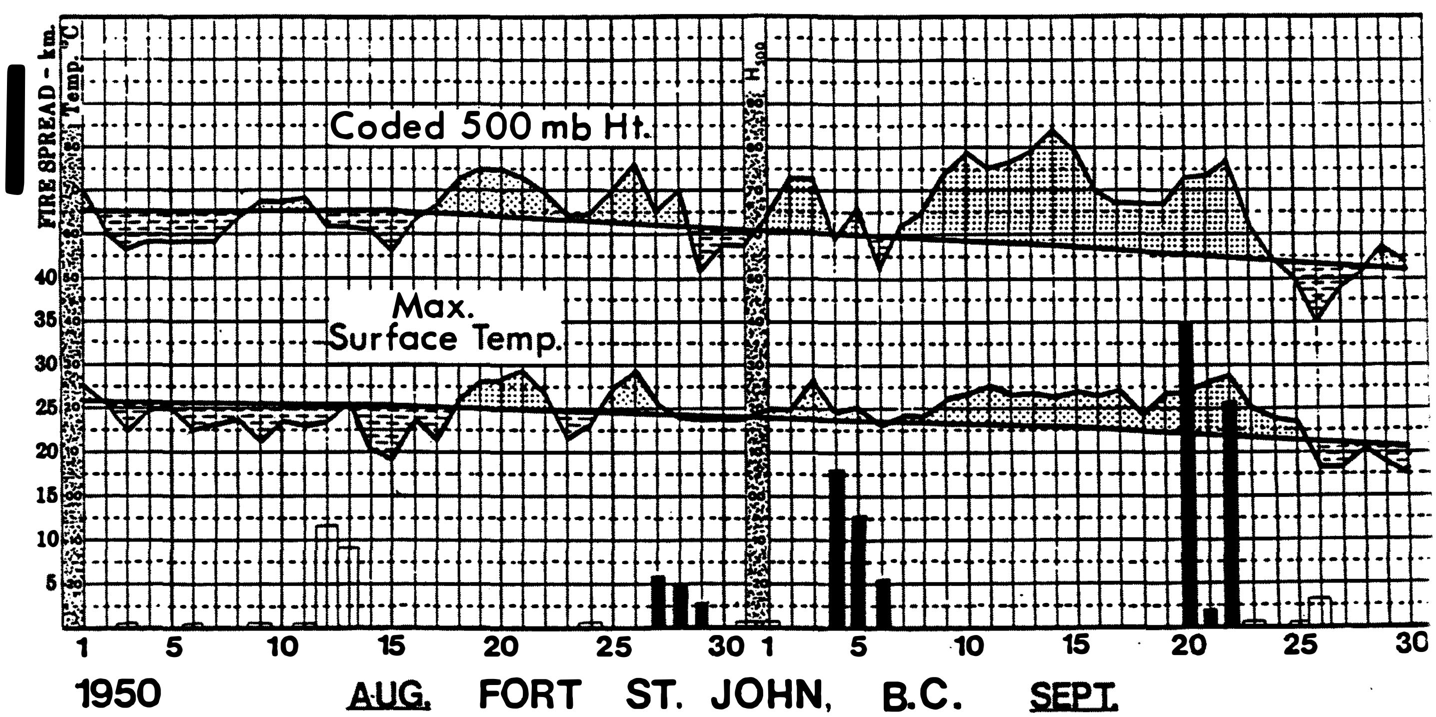


Figure 3. Chart of 500 mb height/maximum temperature anomalies with daily precipitation amounts at Fort St. John, British Columbia, June - September 1950 (courtesy of B. Janz). The suspected days of major fire runs and corresponding distances given in Table 1 are also noted.

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