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An Overview of the Canadian Fire Weather Index System

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INTRODUCTION

The subject of the Canadian Fire Weather Index is often not too well understood by those not directly involved with the Fire Weather Program. This short paper contains a summary of the various concepts involved in the formulation of the fire weather index system. It is intended to serve as a source of background information for any further Pacific Region Technical Notes on this subject.

FUELS

The term "fuel" is used to denote any forest material that is combustible. It includes growing trees and other plant material, the dead litter on the forest floor, and any organic material embedded in the soil.

The combustibility of a fuel is directly related to its moisture content. This moisture is a variable quantity. Moisture is lost through evaporation and it is gained through absorption from the atmosphere as well as directly from precipitation.

MOISTURE

Water is a vital ingredient for all plant growth. It transports nutrients from the soil to maintain the growing process. When the plant dies, this transport of water ceases. The plant material dries at a rate dependent on its physical structure, until it reaches the "air-dry" state. At this point, the amount of water remaining in the cell structure of the plant becomes a function of the moisture content of its immediate environment.

COMBUSTION

When heat is applied to a fuel, the first response is a loss of water from the fuel. Thus the initial effect is one of drying. If a sufficient source of heat continues to be present, a chemical reaction takes place, such that inflammable gasses are expelled from the fuel. The ignition of these gasses results in a visible flame. At this point, if the oxygen supply is adequate, the process becomes essentially self-supporting. The fire now provides the heat to ignite the adjacent unburned fuels.

RATING THE FIRE DANGER

The traditional method of rating forest fire danger has been through the use of "sticks". These sticks consist of a set of hardwood dowels of known dry weight. They are placed just off the forest floor to reach equilibrium with the existing litter. A subsequent weighing will reveal the moisture content of the sticks as well as that of the surrounding fuels. This is a reliable indicator, but it deals only with the top layer of forest-floor fuels. The current fire weather indices were devised to use various meteorological parameters for determination of the state of the fuels down to the deeper levels. At the same time, it provides an indication of expected fire behaviour.

THE FIRE WEATHER INDICES

Figure 1 is a block diagram showing the various components of the Fire Weather Index. Also indicated are the meteorological parameters which directly influence the numerical values of these components. With each, a low value indicates a high fuel moisture content. Conversely, high values are the result of dry fuels. Rising values therefore, correspond to an increasing fire danger.

THE MODEL FUEL COMPLEX

Figure 2 shows a cross-section of a typical coniferous forest complex. The fire weather index calculations for the ground fuels are based on the use of a simplified model fuel complex. This complex (Fig. 3) consists of a layer of fine fuels (about 1 cm deep), above a duff layer of loose organic material (up to 10 cm deep). The duff layer is, in turn, above a deep compact organic layer (about 50 cm deep) which lies on a base of mineral soils.

COMPONENTS OF THE FIRE WEATHER INDEX

The top three blocks in Figure 1 represent the moisture content of each of the organic layers of the model fuel complex. With no precipitation, each of the layers loses moisture at its own rate. The drying rate is exponential - falling fairly rapidly at first, but more slowly with time. The drying rate is described by the "timelag constant", which is the time required for loss of 2/3 of the available moisture.

We shall now look at each of the individual codes.

THE FIRE FUEL MOISTURE CODE (FFMC) is a rating of the moisture content of the loose litter and other cured fine fuels of the forest floor. It serves as the "ease of ignition" indicator. Under average drying conditions it has a timelag constant of two-thirds of a day.

THE DUFF MOISTURE CODE (DMC) is a rating of the moisture content of the loosely-packed duff layer. It has a 12 day timelag.

THE DROUGHT CODE (DC) is a rating of the moisture content of the deep organic layers which include the root systems. The timelag constant is 52 days. The DC gives an indication of long term buildup and is related to the ease or difficulty of controlling fires.

The remaining indices relate to potential fire behaviour.

THE INITIAL SPREAD INDEX (ISI) combines the FFMC with the wind speed. It is an indicator of the rate of fire spread just after ignition.

THE BUILDUP INDEX (BUI) combines the DMC and the DC. It can be thought of as a measure of the total amount of fuel which is available for combustion at any particular time.

THE FIRE WEATHER INDEX (FWI) combines the rate indicator (ISI) with the available fuel (BUI) to come up with a numerical assessment of potential fire behaviour.

CONCLUSION

The combustibility of a fuel is directly related to its moisture content. The first 3 components of the fire weather index utilize meteorological parameters to determine the moisture content of forest fuels. The severity of a forest fire is determined by the amount of available fuel and by the speed at which the fire spreads. The last 3 indices serve to give an indication of the existing fire hazard.

FURTHER READING

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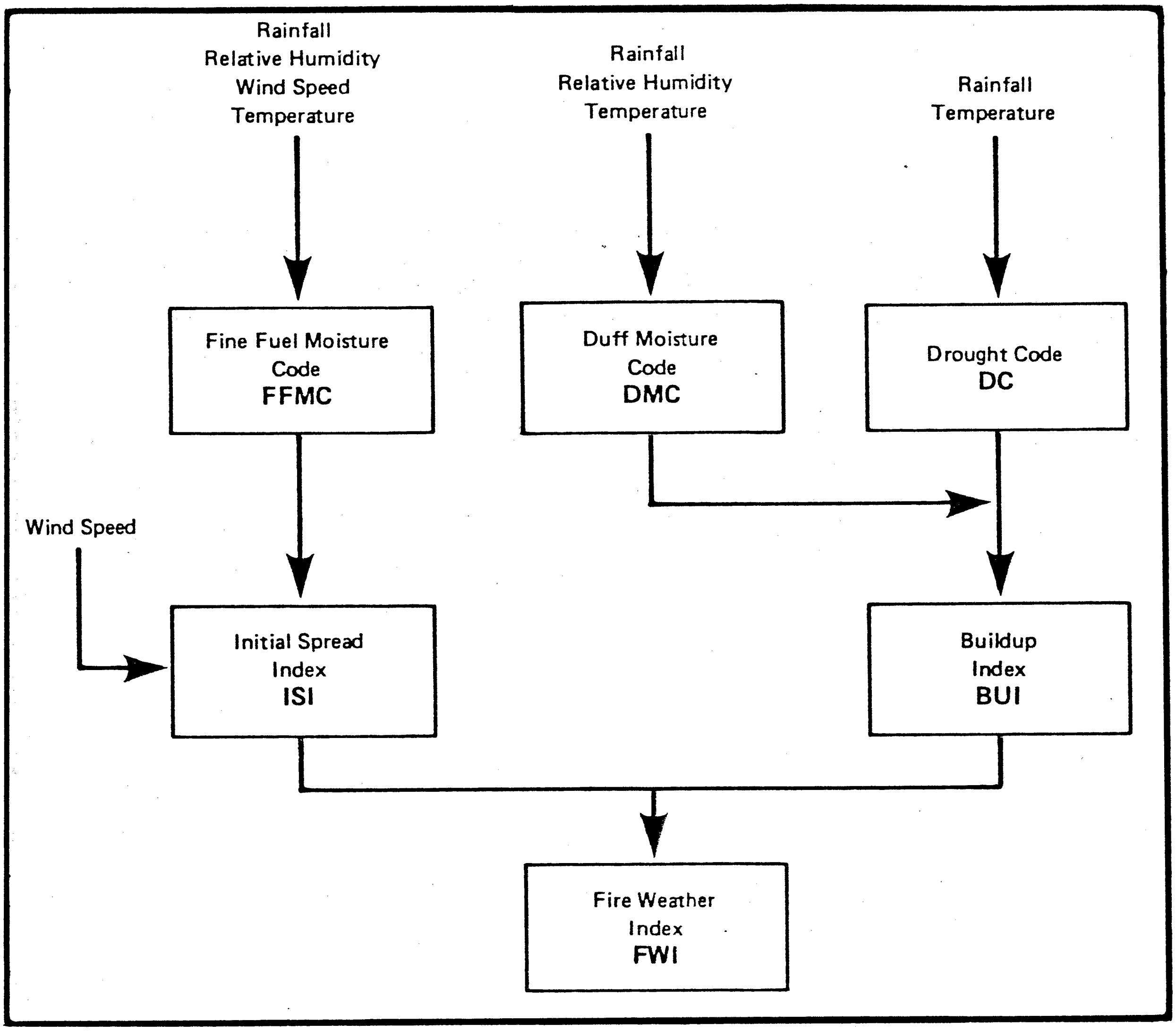

Fig. 1. Components of the Canadian Forest Fire Weather Index.

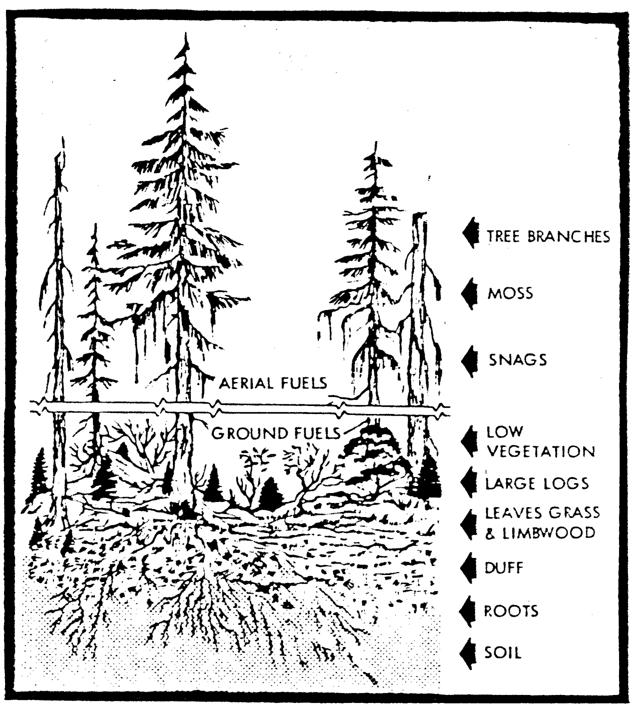

Fig 2. A cross-section of a coniferous forest complex.

Fig 3. The model fuel complex for ground fuels.