Ninth Annual Symposium on Geographic Information Systems

GIS 95

Vancouver British Columbia Canada

The Canadian Wildland Fire Information System

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This paper describes a new GIS-based wildland management information system for Canada. The Canadian Wildland Fire Information System (CanFire) is a national level fire intelligence system currently under development by the Canadian Forest Service (CFS).

The purpose of the system is to provide a national overview of fire weather, fire behavior, and fire severity conditions. Currently, the system produces fire weather and fire behavior maps for use by fire management agencies, the research community, and the public. These products are produced daily and include forecasts out to six days into the future. The fire weather and fire behavior components of the system use the Canadian Forest Fire Weather Index (FWI) and the Canadian Forest Fire Behavior Prediction (FBP) Systems, respectively. The fire severity component represents new research that will predict the occurrence of large (200 hectares or greater) and multiple fire starts.

This paper provides an overview of the system as to its design, structure, and operation. This includes a description of system inputs, outputs, and the approaches used to model fire weather and fire behavior spatially. Spatial data layers used by the system are also described. Current research and development efforts are highlighted. Instructions on how to access these map products via the INTERNET using file transfer protocol (FTP) and the World Wide Web (WWW) are also presented.

Introduction

The Canadian Wildland Fire Information System (CanFire) is a national level intelligence system that is currently under development by the Canadian Forest Service. While computer-based fire management information systems have been in use in Canada for more than twenty years, there has never been a system specifically directed at the national level. Paul (1974) envisioned a national information system to calculate and display fire weather nationally for Canada. It was not until the implementation of CanFire in 1994, however, that national fire weather maps for all of Canada were available on an operational (daily) basis.

CanFire System Modules

The CanFire system was developed to provide a national wildland fire intelligence system for Canada. The system consists of a series of modules to access a range of national data automatically and determine the current state of the fire environment. Modules also exist to forecast this state up to one week in advance. These modules are as follows:

- Fire weather data acquisition
- Data storage and analysis
- Fire weather modeling and forecasting
- Fire behavior modeling and forecasting
- Distribution of maps, forecasts and other user information

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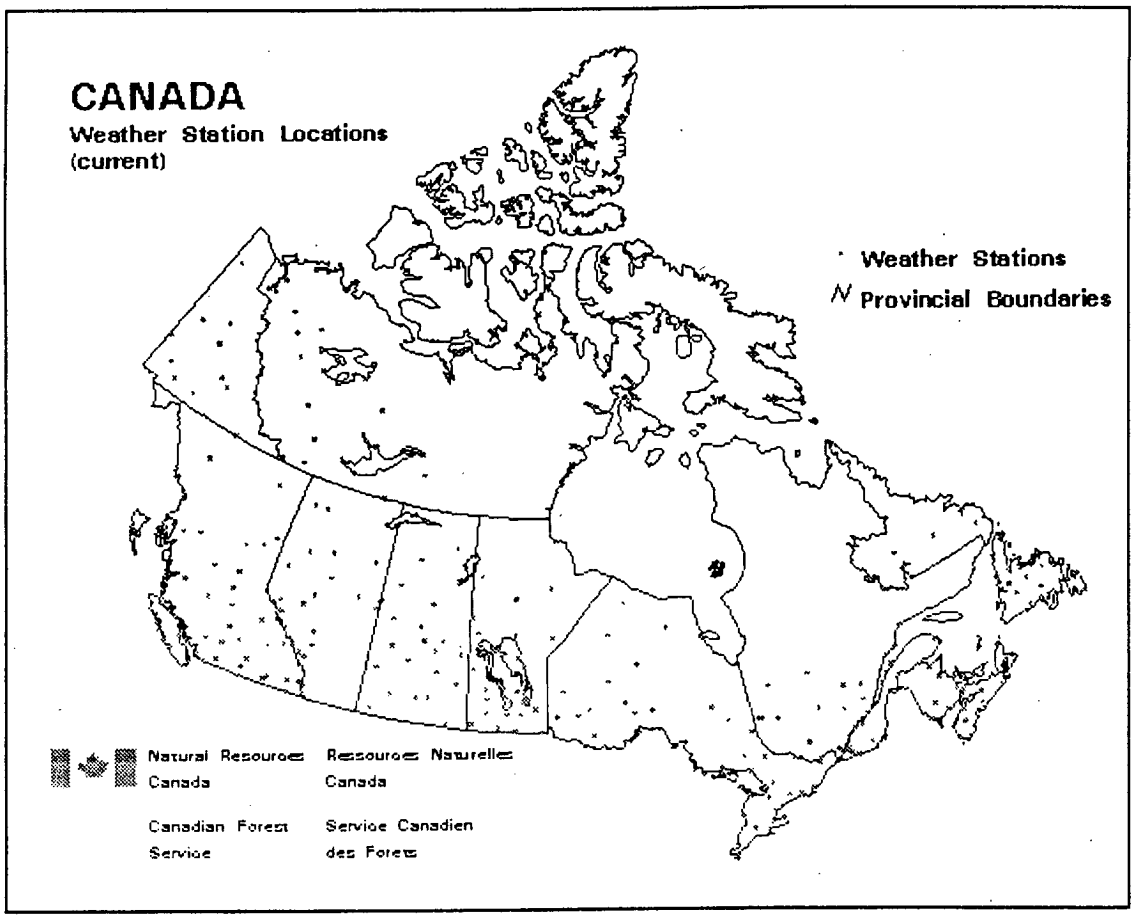


Figure 1: *Location map of Atmospheric Environment Service weather stations currently used by the CanFire system*

In its current design, CanFire uses weather observation and forecast data provided by the Department of Environment, Atmospheric Environment Service (AES). Hourly weather data from a network of manual and automatic weather stations is down linked from the ANIK-D satellite to the Northern Forestry Centre in Edmonton, Alberta.

Cartographic modeling of these data is done by a commercial geographic information system (ARC/INFO). Complex data models and modeling equations produce fire weather and fire behavior potential map products on a daily basis.

Observed and forecast maps of fire weather and fire behavior are produced and distributed in graphic interchange format (GIF) daily. Descriptive summaries of spatial statistics for each map coverage are also provided.

Data Storage and Analysis

The CanFire System operates in a work station environment under the UNIX operating system. The attribute data models used by CanFire have been implemented using the Oracle relational data base management system. Spatial data is stored in ARC/INFO in both raster and vector formats. The primary spatial data coverages include:

- Elevation : A raster coverage with a cell size of 860 metres.
- Fuels: A raster coverage of FBP system fuel types at a resolution of 1000 metres.
- Stations: A vector coverage representing the location of AES weather stations.
- Boundary: A vector coverage representing political boundaries.

The system operates in a fully automatic mode, 24 hours a day, seven days a week. Weather acquisition occurs year round, however, fire weather and fire behavior forecast maps are provided only during the Canadian fire season (April 1 to October 31). ARC/INFO is spawned when required to process fire weather and fire behavior maps and to produced graphic interchange files for distribution on the INTERNET. The system also has a graphical user interface for ad hoc queries and system maintenance.

Fire Weather Data Acquisition

CanFire relies on a network of approximately 250 fire weather stations located across Canada (Figure 1). This network consists of both manual and automated weather stations operated by AES. Fire weather data collection is a continuous process. A step by step description of this process follows and is diagrammed in Figure 2.

- AES Meteorological Information Service (AMIS) weather observations are continually received at the Northern Forestry Centre via Telesat Canada's ANIKOM-100 satellite service. This service uses a small diameter (.75 metres), receive only dish

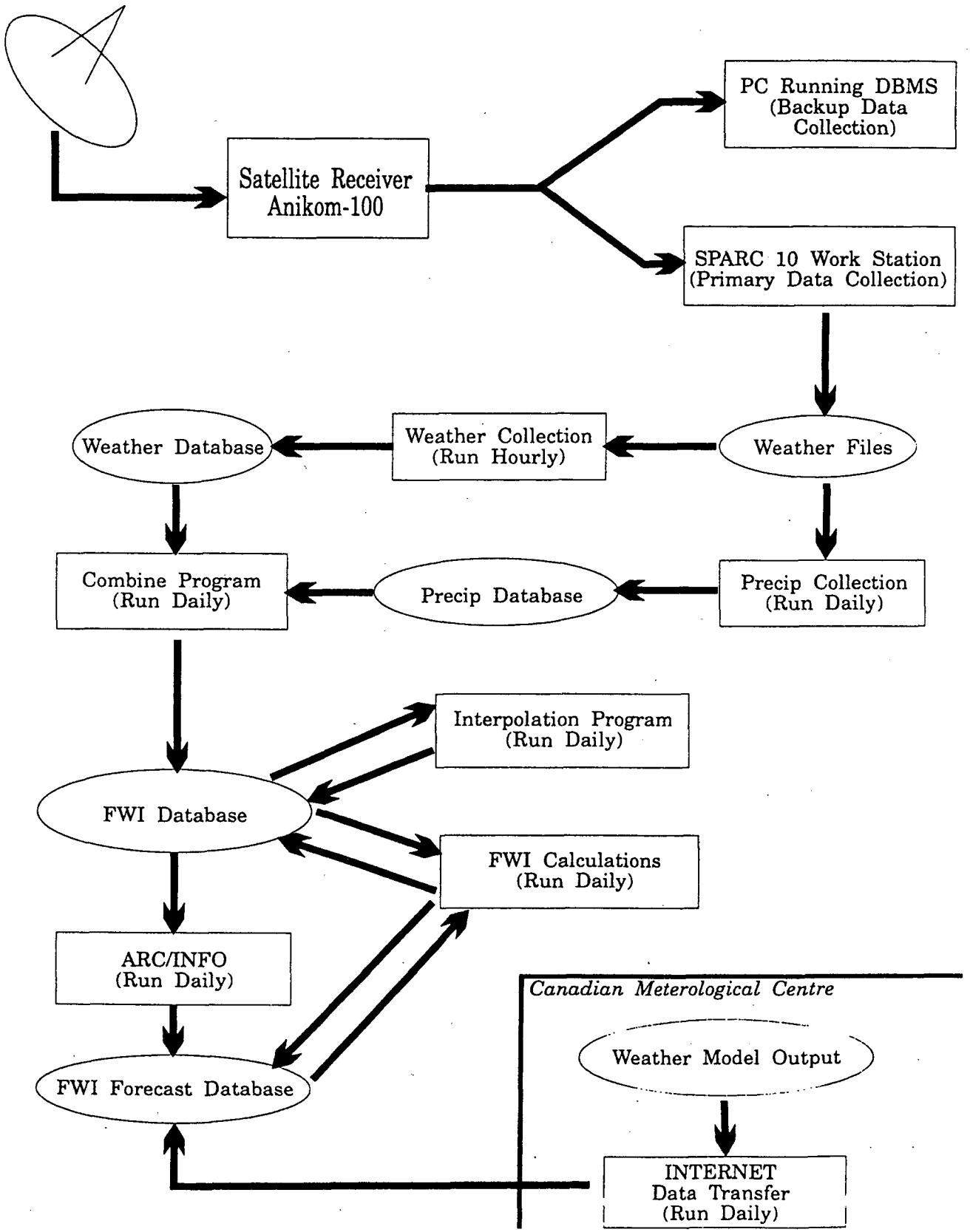


Figure 2: *Data flow diagram for the fire weather data acquisition module of the CanFire system*

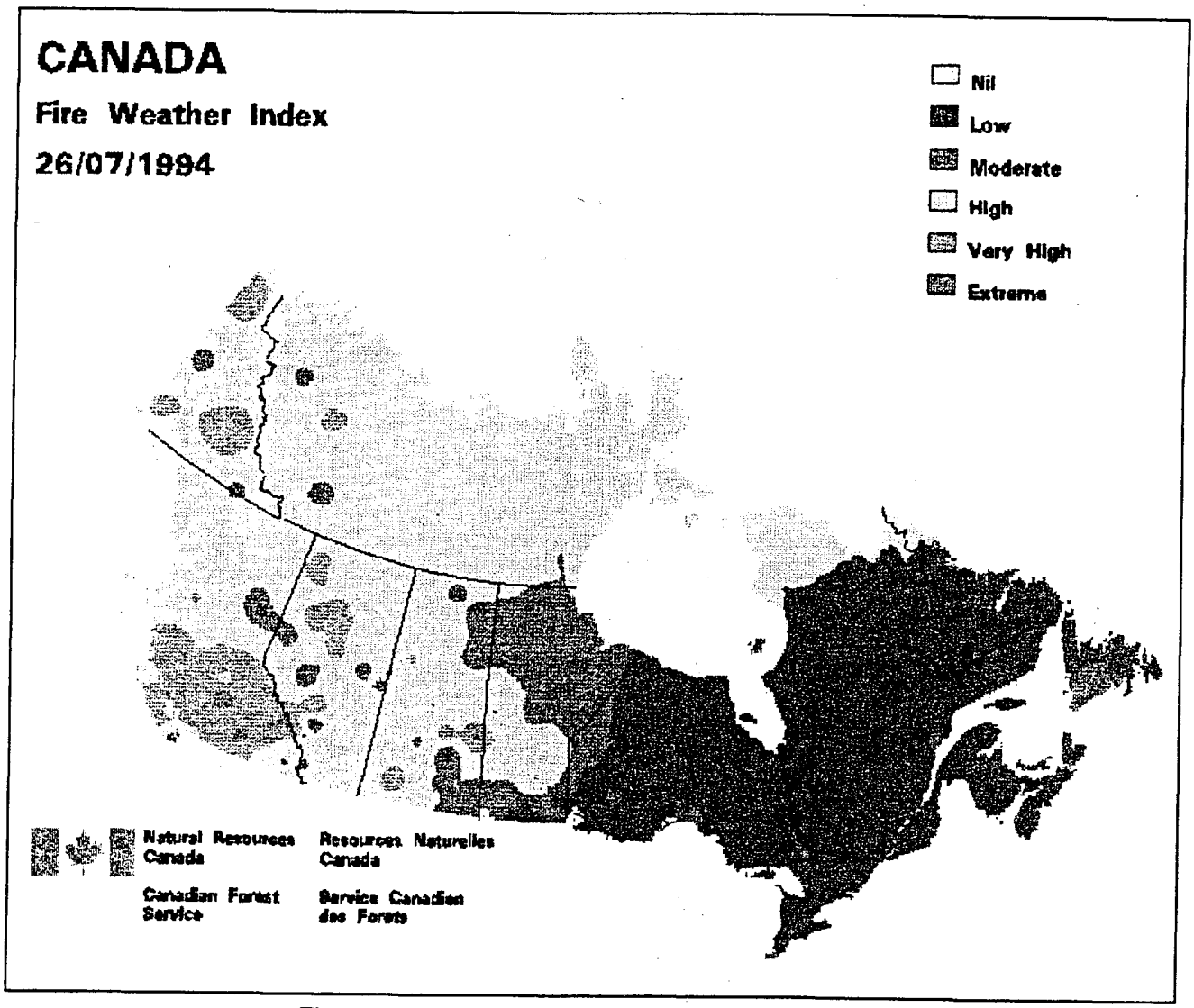


Figure 3: *Fire weather index map of Canada for July 27,1994*

antennae. This antenna is aimed at Telesat's ANIK-D satellite located 36 240 kilometres above the equator. The AMIS data originates at the AES offices in Downsview, Ontario and is up linked to ANIK-D by Telesat Canada in Toronto.

- The receiver for the ANIKOM-100 satellite dish is connected to two computers at the Northern Forestry Centre that constantly log the observations through programs monitoring the serial ports. The primary computer is a Sun SPARC 10/UNIX OS workstation. The second computer, an 80286 personal computer, serves as a backup data capture system if the Sun workstation or its network fails.
- A process (SATTERM) running on the Sun work station constantly logs selected weather station observations onto the UNIX file system in the AMIS file format.
- Once per hour a weather collection program (OraTRANS) on the Sun workstation collects weather observations in the AMIS file format and writes them to the WEATHER Oracle table.
- Once per day a process (OraPRECIP) accumulates precipitation amounts for the past 24 hours and writes this to the PRECIP Oracle table.
- Once the OraPRECIP process has run, another process (OraCOMBINE) combines the data from the WEATHER and PRECIP Oracle tables and inserts the data into the FWI table. FWI calculations are based on 1200 local standard time (LST) weather observations. It is necessary, therefore, to search the WEATHER table to retrieve data reported at 1200 LST for each station.
- The FWI system requires an unbroken daily weather record. To ensure this, a process (OraINTERP) is run to check for missing weather station values. If missing values exist, they are calculated from the surrounding stations using an inverse distance weighted squared interpolation scheme.
- The next process (OraFWICalc) calculates the FWI system outputs using the inputs in the FWI Oracle table.
- The final fire weather acquisition process (OraFORECAST) calculates forecast FWI values

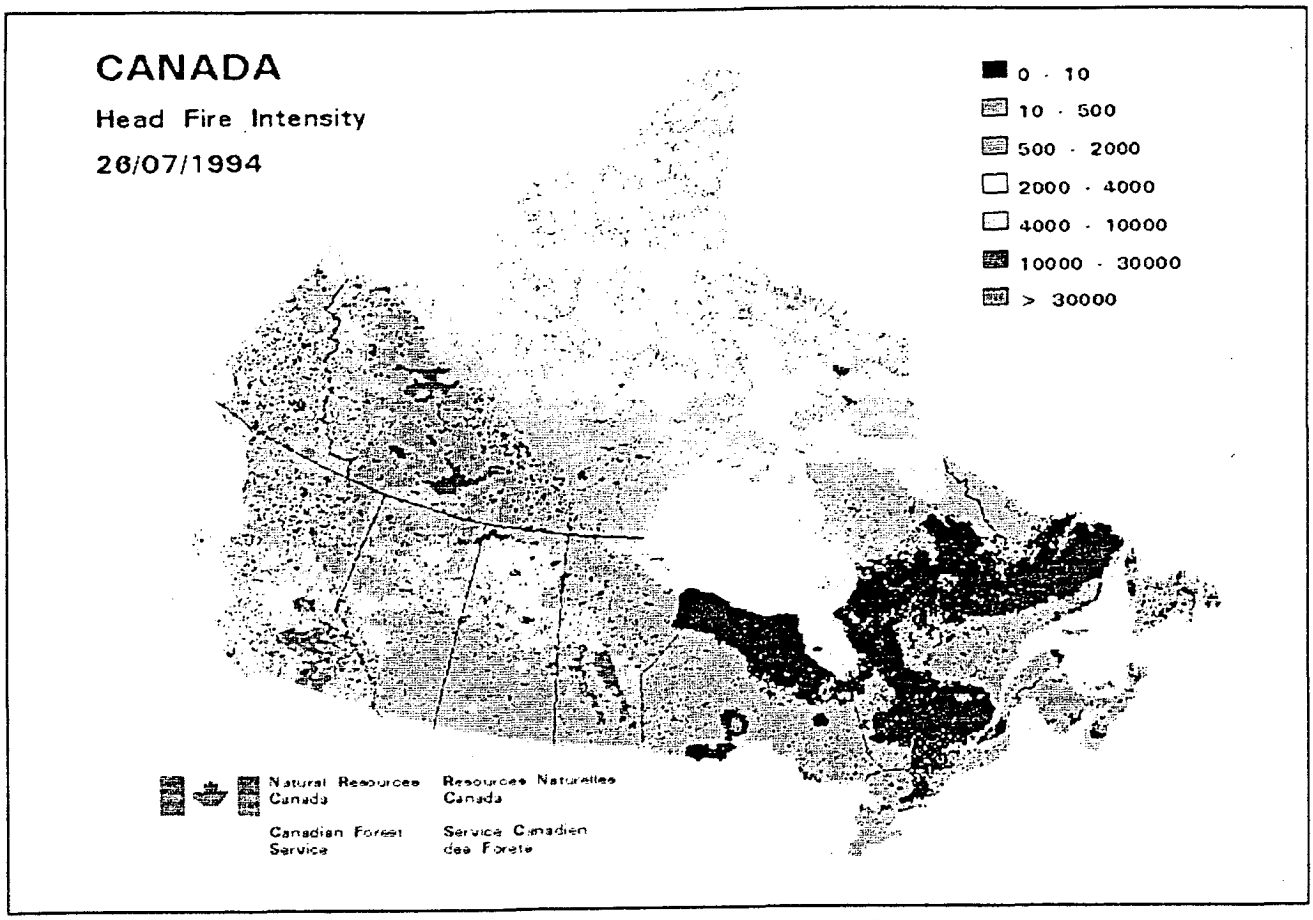


Figure 4: *Head fire intensity map of Canada for July 27, 1994*

using data from the FWI Oracle table and forecast weather values received from the Canadian Meteorological Centre (CMC) via the INTERNET. Up to six day forecasts of FWI system outputs are produced and saved in the FFWI Oracle table.

Fire Weather Modeling

CanFire uses the Canadian Forest Fire Weather Index (FWI) System (Van Wagner 1987) as a basis for modeling and interpreting fire weather. The FWI system estimates forest fuel moisture conditions using empirical models driven by daily 1200 local standard time (LST) weather readings. These weather readings include temperature, relative humidity, 10 metre wind speed, and precipitation. Outputs from the system include three fuel moisture codes and three fire behavior indices. A description of these outputs and their application in wildland fire management follows (Canadian Forestry Service 1984):

- Fine Fuel Moisture Code (FFMC): 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 the fine fuel.
- Duff Moisture Code (DMC): A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material.
- Drought Code (DC): A numerical rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and smouldering in deep duff layers and large logs.
- Initial Spread Index (ISI): A numerical rating of the expected rate of fire spread. It combines the effects of and the FFMC on the rate of spread without the influence of variable quantities of fuel.
- Buildup Index (BUI): A numerical rating of the total amount of fuel available for combustion that combines DMC and DC
- Fire Weather Index (FWI): A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger throughout the forested areas of Canada.

CanFire produces forecast maps for all six FWI system components by interpolating the values stored in the FWI and FFWI Oracle tables. The interpolation is done using the GRID module of weighting (IDW) function. The resulting surfaces are output at a cell size of 1000 metres for the wildland fire prone areas of Canada (Figure 3). The total number of cells produced for each coverage is approximately 35 million.

Fire Behavior Modeling

The Canadian Forest Fire Behavior Prediction (FBP) System has been in use in Canada since 1984 when an interim edition was released for operational use (Lawson *et al* 1985). The current version of the FBP system was released in 1992 (Forestry Canada 1992). The FBP system estimates the fire behavior potential for several defined fuel types.

The FBP system requires inputs from three major groups of variables that directly affect fire behavior. These groups are weather, fuels and topography. Information on elevation, latitude, longitude and date are also required to estimate foliar moisture conditions.

Using the fuels and topography inputs with interpolated FWI observations and forecast values, CanFire produces maps of potential fire behavior for the following FBP system components:

- Rate of Spread (ROS): A quantitative estimate of the forward rate of spread of the head of an advancing fire. Units are in metres per minute.
- Head Fire Intensity (HFI): A quantitative estimate of the fire intensity of the head of the fire. Units are in kilowatts per metre.
- Surface Fuel Consumption (SFC): A quantitative estimate of surface fuel consumption. Units are in kilograms per square metre.
- Total Fuel Consumption (TFC): A quantitative estimate of surface and crown fuel consumption. Units are in kilograms per square metre.
- Rate of Perimeter Growth (RPG): A quantitative estimate of the rate of perimeter growth. Units are in metres per minute.
- Fire Description: A qualitative estimate of the degree of crown fire involvement. Classes are surface fire, intermittent crown fire, and continuous crown fire.

This integration of interpolated weather with fuels and topography to produce quantitative estimates of potential fire behavior is carried out through a series of GRID programs that fully implement the 1992 version of the FBP system (Forestry Canada 1992). These map outputs are produced at final cell size of 1000 metres for the wildland fire prone areas of Canada (Figure 4).

Distribution of Maps and Forecasts

The INTERNET is a breakthrough in communications technology designed to enable global distribution of information. Map products produced by CanFire are available to users either via INTERNET file transfer protocol or via the World Wide Webb (WWW). In both cases the maps produced by CanFire have been transformed into GIF images that can be viewed on most hardware platforms that have a suitable viewer. Figure 5 shows sample output from the FWI link of the CanFire WWW server.

For users of the WWW, the uniform resource locator (URL) for CanFire is:

http://www.nofc.forestry.ca/fire/cwfis.html

For users wishing to access the map files via FTP, the address is: ftp.nofc.forestry.ca

Maps are located under the /pub/fire/maps directory.

Current CanFire Research

CanFire is still under development. Research efforts are currently underway to incorporate the Regional Atmospheric Modeling System (RAMS), the development of a fire severity index, and a large fire growth model.

RAMS is a simulation model developed by scientists at Colorado State University. RAMS is a limited area model but can be configured to cover all of North America at a coarse level of resolution. This model can predict wide range of meteorological phenomena. Some examples of these phenomena include wind fields, atmospheric stability, and hourly FWI system inputs. Such data could be used to predict blowup fire conditions and the passage of cold fronts. The prediction of blowup conditions is of extreme interest since it is in these situations where the FBP system may underestimate fire spread and energy release. Work to date has incorporated RAMS output into CanFire through the ARC/INFO GIS environment. Validation and demonstration of the application of the model to wildland fire management is the next phase of this research.

Another research initiative is the development of a national fire severity model. Using historical fire occurrence, fire weather, fire behavior, and upper air data, the model will predict the probabilistic occurrence of large fires (greater than 200 hectares in size). The model will be spatially-based and use artificial neural networks linked to ARC/INFO to produce fire severity maps for Canada. Implementation of the fire severity model is planned for the 1996 fire season.

A third research initiative is the integration of a large fire growth model within the framework of the CanFire system. This software module will simulate the growth of significant large fire events. The model will rely extensively on forecast fire weather outputs from RAMS.

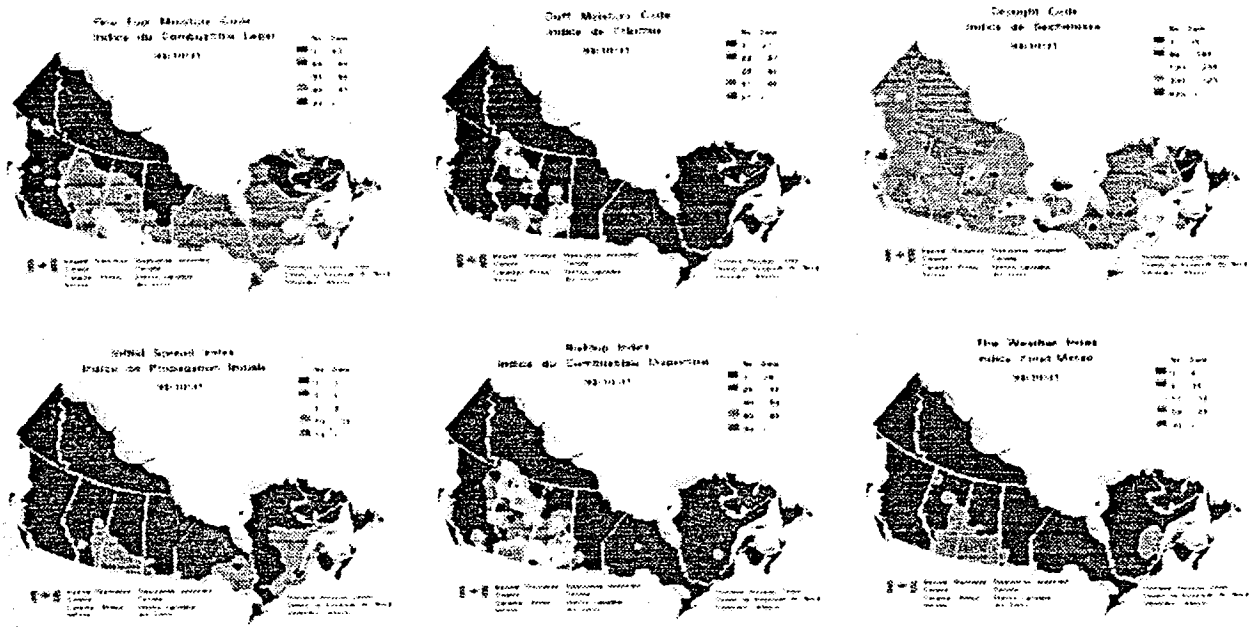
Conclusions

It is our belief that the information provided by the CanFire System will aid Canadian fire management agencies in developing more cost effective and environmentally-benign forest protection strategies. This national view of the current and forecast state of the fire environment has the potential to improve the ability of the fire manager to better respond to both daily and future fire management planning issues. It will benefit decision making concerning the interagency sharing of fire suppression resources in times of scarcity. The system will also benefit research, not only in fire science, but in climate change, forest ecosystem management and other disciplines. Finally, CanFire will provide information to the public both within Canada and globally.

Canadian Wildland Fire Information System

Canadian Forest Fire Weather Index System

The **Canadian Wildland Fire Information System** produces maps of Canada for the following Canadian Forest Fire Weather Index (FWI) System components. These maps are produced daily during the fire season (April 1 to October 31). Click on anyone of the following maps to retreive a full size image.



Weather Collection

Currently the raw weather data used to construct the Fire Weather Maps is being collected, via an ANIKOM 100 satellite dish, from over 200 Weather Stations located across Canada.

Go to the Canadian Wildland Fire Information System home page.

Figure 5: *Sample output for the Fire Weather Index module of the CanFire World Wide Webb server site*

Acknowledgments

The author would like to acknowledge the programming support provided by Rod Suddaby, Scott Powell, and Phil Blower. Technical support has also been provided by Richard Smith. Funding for this project has been provided, in part, by the Green Plan and the Canada/Saskatchewan Partnership Agreement in Forestry.

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