Forestry Canada Applies GIS Technology to Forest Fire Management

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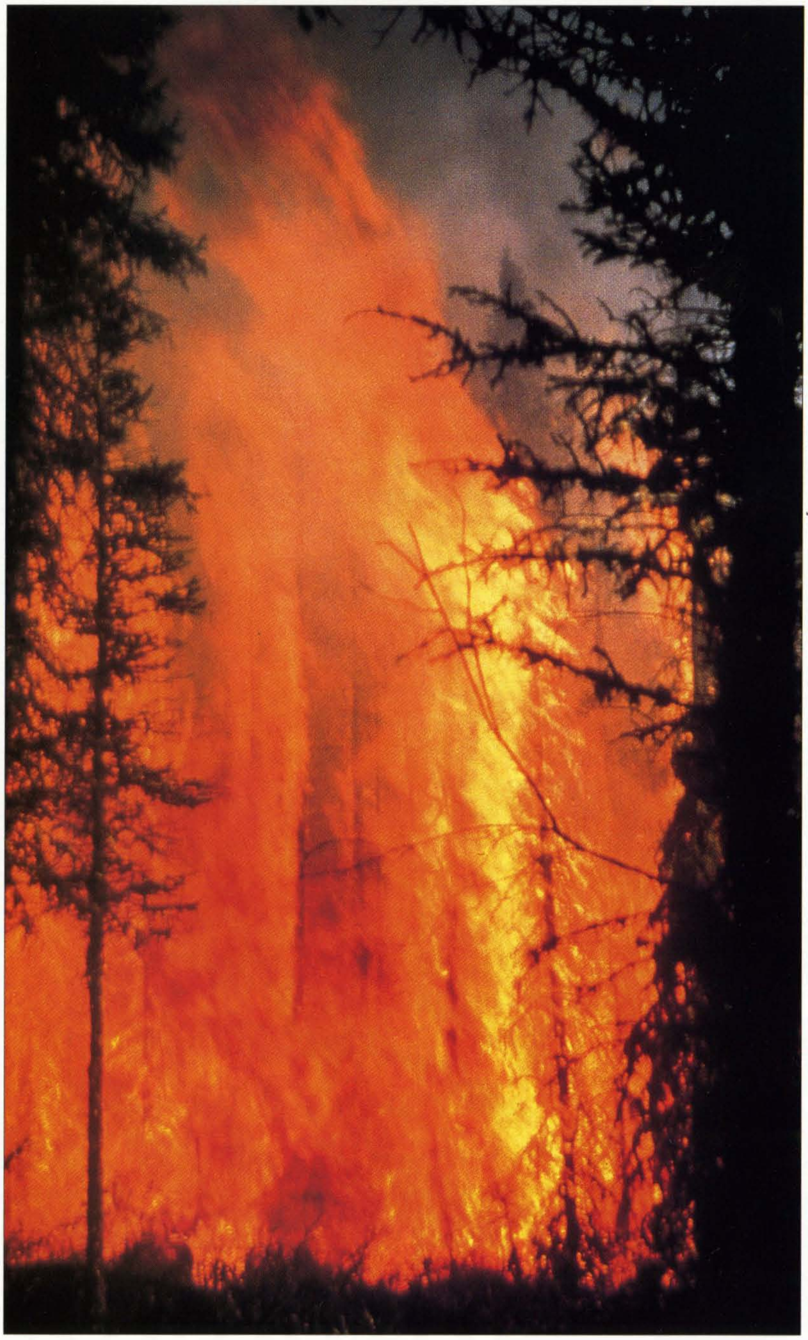


In recent years, Canadian forest fire management agencies have become more dependent on decision support systems for planning and real time decision making. In particular the integration of Geographic Information Systems (GIS) has become increasingly important for realistic modeling of forest fire danger and behavior prediction. However, to date few operational systems have been successfully implemented in an effective and cost efficient manner. The Intelligent Fire Management Information System (IFMIS), a personal computer based decision support system developed by Forestry Canada for operational forest fire management, is one exception. Following on the design and principles of IFMIS, Forestry Canada is currently designing and prototyping the next generation Fire Management Information System (FMIS). Using commercially available GIS technology, the FMIS prototype will be ready for operational field testing during the 1993 fire season.

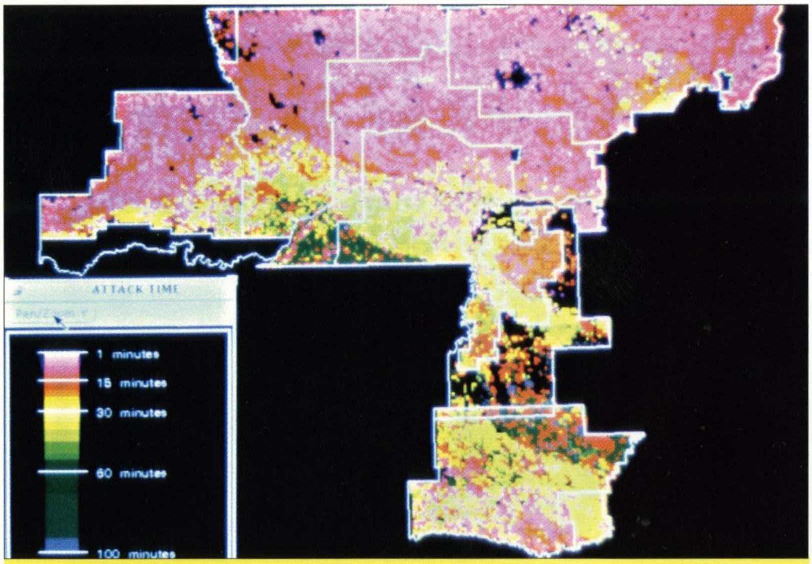
Vector and Raster Data Integration

Operational forest fire management and planning is a spatial problem. Fire Management data is both vector (point, line and polygon) and raster (lattice, grid) in nature. Spatial techniques that need to be employed by the forest fire manager include continuous surface interpolation, temporal sequencing, euclidian distance, and cost surface analysis.

Forest fire models developed through years of Forestry Canada research are being incorporated into the prototype using typical GIS tool kit functions and application programming interfaces (API) to address basic fire management concerns. These applications use base map, topographic, forest inventory, forest fuels, and weather data in real time integrative fashion. Application scenarios implemented to date have addressed a number of forest fire preparedness planning requirements including: fire weather modeling, fuel type modeling, fire behavior prediction, initial forest fire assessment, and the deployment of initial attack resources.

Modeling Fire Weather

The Canadian Forest Fire Weather Index (FWI) System, developed by Forestry Canada, is used across Canada, Alaska and other countries worldwide to model and predict fire weather conditions. The FWI system estimates forest

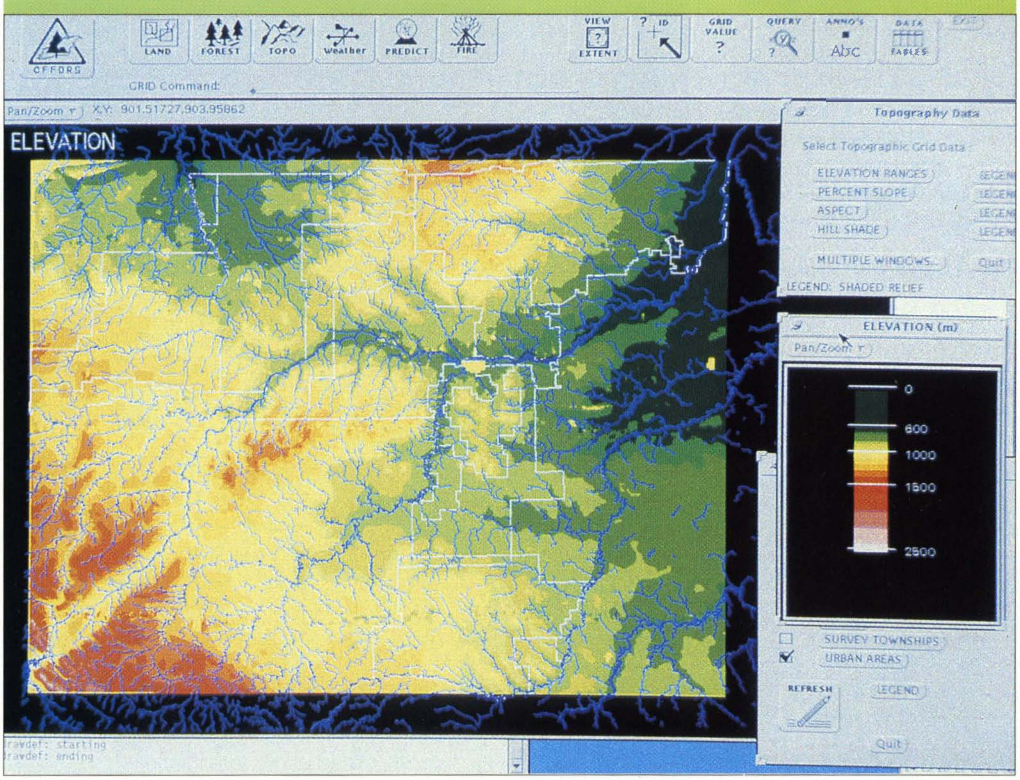


This slide represents initial attack times in terms of "get-a-way" time for a selected day at Whitecourt Forest. Attack times are based on calculated Rate of Spread for forest fires and critical fire size thresholds

fuel moisture conditions using empirically derived equations driven by either daily 1200 (noon) or hourly weather readings. These weather readings include temperature, relative humidity, 10 meter wind speed, and precipitation. Typically, the input data are collected from a network of fire weather stations using either manual or automated fire stations. This continuing monitoring of surface weather throughout the fire season results in large volume of data that must be spatially extrapolated across the forested landscape at either daily or hourly intervals.

Conceptually, the fire weather stations represent sample points (vectors) upon a continuous multilayered weather surface. Typically, weather stations are situated 50 kilometers apart. Using GIS modelling functionality, the input data layer's vector-sample points are extrapolated over a regular grid using the most appropriate interpolation techniques. Once the input data surface layers have been constructed by the GIS, fuel moisture and fire behavior indexes can be calculated by applying FWI models to each cell. The modeling is done by "drilling down" through each of the input surfaces, resulting in six new output layers which ascribed the fire danger state of the forest.

This slide represents the terrain information that is compiled from a DEM and utilized as input into the Fire Behavior prediction modelling.



Fire Behavior Prediction Modeling

Fire behavior prediction is quantitative, spatial and temporal. Using weather (FWI), fuels and terrain information as inputs, quantitative predictions of fire growth, fuel consumption, and crown fire potential can be derived. The prototype incorporates empirically developed equations from the Canadian Forest Fire Behavior Prediction (FBP) System. The FBP system estimates the forward rate of spread (ROS) of a fire for defined fuel classes using inputs from the weather, fuel type and terrain data. Additional FBP outputs include the head fire intensity (HFI), the crown fraction burned (CFB), and the total fuel consumed (TFC). The cartographic model shown demonstrates how each GIS data layer is processed to produce secondary and tertiary map products. Using the FBP system with the forest environment data base and interpolated FWI values, IFMIS can produce maps of potential fire behavior such as ROS, HFI, CFB and TFC.

This integration of interpolated weather with fuels and topography to produce quantitative estimates of potential fire behavior has greatly improved the ability of fire management agencies to respond to daily fire management planning issues.

Preparedness Planning

In western Canada, a number of forest fire management agencies have adopted forest fire preparedness planning approaches to determine daily fire suppression resource requirements. Forest fire preparedness planning is the process of ensuring that adequate suppression resources are available to cope with daily anticipated fire events. Preparedness planning is based upon the philosophy of early detection of forest fires and rapid initial attack. In order to meet this goal, all fires must receive initial attack before they reach a critical size. This criteria is called the initial attack size objective. Using such a policy, the prototype can assess the efficiency of prepositioned resources within a forest region on a daily or hourly basis.

For each cell, the prototype computes the time it would take a potential fire to reach the initial attack objective. This elapsed time criteria, referred to as the attack time, can be displayed in map form. With this type of information, the forest fire manager can determine how many resources can reach the cell within this time from predetermined bases. This elapsed time includes both the get-a-way time and travel time to a cell. The use of a raster data base, instead of vector, allows the GIS to compute travel time from initial attack bases to each cell in consistent fashion. The number of resources required and their optimal pre-attack location within the forest is determined by integrating the GIS spatial data base with linear programming algorithms developed by Forestry Canada. Using IFMIS and this approach, the Province of Alberta estimates that it has been able to save four million dollars annually in fire suppression costs.

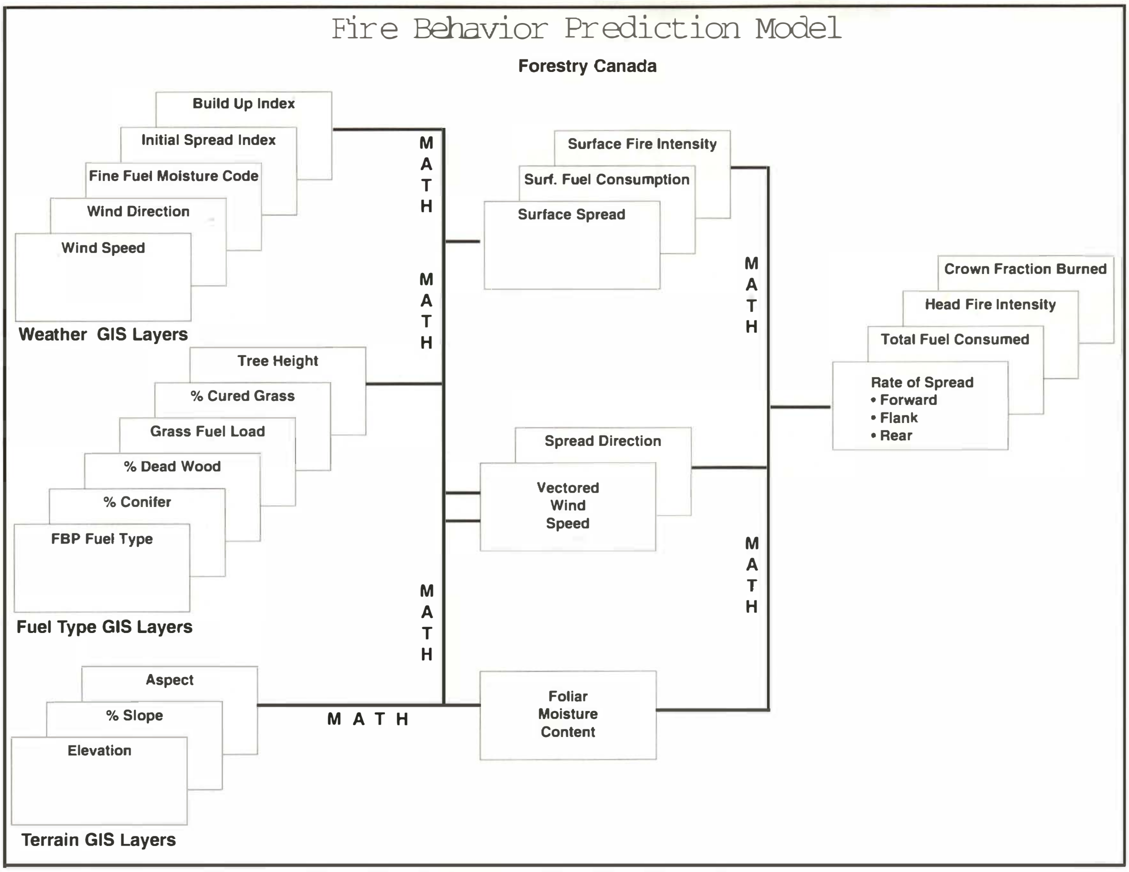
GIS is used to compute travel time from initial attack bases.

Fire Growth Modeling

Once a fire has been detected, the GIS can play another very important role. By using actual and forecasted weather data, fire growth projections can be made. This is only possible by using a raster data structure upon which a potential ROS cost surface can be derived. Using temporal sequencing, the projected growth and size of the fire can be estimated. This information can then be used by the field fire manager to determine optimal fire suppression strategies such as how many crews to send, how many air tankers are required, where to build fire breaks, and what values are threatened and need to be protected.

Conclusion

Forestry Canada has already made extensive use of GIS technology in the area of forest fire management and planning. In this respect, GIS has and will continue to play a major role in the protection of our forests, property, and human life. The recent availability of advanced commercial GIS tools now allow the fire researcher to use GIS to refine existing models and develop and test new models in spatial and temporal contexts. Parallel with this development has been the advent of GIS application programming interface environments and desktop mapping applications that make GIS



easier to use and cost effective to deploy in operational settings.

Over the next five years, Forestry Canada will be focusing its decision support research and development efforts upon the spatial data foundation that GIS can provide. These research and development efforts will not be restricted just to fire management but will be broadly based in the areas of forest insects and disease, silviculture and forest level planning. EOM