8.1 # FIRE BEHAVIOR KNOWLEDGE BASE (FBKB.CA)

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## 1. INTRODUCTION

Understanding potential fire behavior is an integral element of fire management and guides many fire management decisions daily. For this reason much effort has been placed on understanding fire behavior (e.g. Rothermel 1972), and developing fire behavior prediction systems (Andrews 1986, Andrews and Chase 1989, Forestry Canada Fire Danger Group 1992). Indeed there is a plethora of literature on the subject of fire behavior and fire behavior prediction in a variety of forest and fuel types. The Achilles heel of any fire behavior prediction system is the need to describe the forest in terms of a fuel model. Whatever the fire behavior prediction system, forest fuel complexes are described for use by fire managers, in terms of a fuel model. Unfortunately forests are infinite in their variability, and even if all the infinite number of wildland fuel complexes could be described in terms of fuel models, this would provide a near infinite number of fuel models for fire behavior analysts to select from. In Canada, the Canadian Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992) has 16 discreet fuel types and invariably the cry from the user community is the need for more fuel types. And while, with local knowledge, fire managers can develop an understanding of how fire behaves in local forest fuels, this knowledge is unavailable to fire managers moved across the continent to deal with an emergent fire situation.

Existing fire behavior prediction models were developed in the traditional way; a model form is conceived and tested, observational data is categorized and used to calibrate the model and then, depending on the form of the model, fuel models are preset or developed. Currently new trends in information management science challenge this standard approach. A key example of this is the advent of Wikipedia, the user contributed online encyclopedia. Tapscott and Williams (2006) document a number of tools like Wikipedia that allow users across the globe to collaborate and share knowledge tackling a variety of issues and technical problems.

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The Fire Behavior Knowledge Base (FBKB) seeks to redress the problem of infinite fuel models by providing users with information directly about wildland fuels and the fires that have burned within them. The concept draws upon the strength of a number of current information system theories to provide fire managers the ability to view and synthesize fire behavior information directly from observed data, and as they make observations of fire behavior – enter that into the data set for all to see. In this way the database is a growing thing, and as new fuel complexes emerge as problematic issues (e.g. insect or disease killed stands in some locale) information is made rapidly available to all who are interested.

## BACKGROUND TO THE CURRENT SITUATION

In Canada, the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992) provides fire managers the means to make quantitative predictions of fire behavior. The FBP System was developed from field observations of fire behavior. These observations of both experimental fires, and wildfires were categorized into one of 16 fuel types and then equation coefficients determined for each fuel type. The system has worked well since it's inception and has been exported to several other countries. However, a common problem fire managers quote is the restrictive nature of the fuel complexes – local fuel conditions never "match" FBP System standardized fuel complexes. The immediate solution jumped to is the need for more fuel types within the FBP System; however there are two problems with the development of more fuel models:

1. Experimental burning projects conducted to establish fire behavior models are expensive and can take up to a decade to complete.
2. There is an almost infinite number of natural fuel complexes, each with it's own subtleties and fire behavior issues. In addition to natural fuel models, increasingly there are engineered fuel complexes – natural forest fuels that have been thinned, or pruned, or treated in some other way to inhibit fire spread potential.

Clearly in a system such as the FBP System that was built on field observations and categorized fuel complexes, there is no easy answer to the problem of too few fuel types.

The other standard solution to is to utilize a fire behavior modelling system that allows users to define their own fuel models and thereby make predictions for any fuel complex situation. Such a system was facilitated by Rothermel (1972) with a standardized spread model and constructed by Andrews et al (19xx). This approach also has problems too; building fuel models can be a somewhat time consuming process, and fire managers, in the throws of dealing with a wildfire rarely have time to build a fuel model. Even when a large number of standardized fuel models are available, confusion amongst users can result; what fuel model is best for this complex?

Adding to the issues presented by these two approaches to fire behavior prediction is the mobile nature of fire behavior specialists. Over the past 20 years, fire fighters, fire behavior specialists and fire managers have become increasingly mobile, moving across the country and indeed exported to other countries. This is in response to a direct need for a fluid workforce to move to where fire activity requires them to be. Unfortunately this too can cause issues; fuel complexes common in one area and well understood by local fire managers, can be completely foreign to imported fire staff.

Finally fire models, for all their complexity and nuance, do not always paint a compelling picture of expected fire behavior. Simple numbers and verbal descriptions of expected fire behavior cannot compare with images and video depicting fuel complexes and fire behavior over a range of weather conditions.

## KNOWLEDGE MANAGEMENT

Knowledge Management techniques and practices have grown in popularity over the past few years (Garvin 1993, Senge 1990, Vicente 2003, Kirby 2004). Knowledge management can be considered as a series of structured and unstructured methods and tools for organizations and disciplines to retain and transfer knowledge and information between and amongst individuals. The range of tools can span the simple establishment of a user community of practice to share techniques to structured organizational policies and practices aimed at developing a "learning organization" (Garvin 1993). Within the fire behavior prediction community there have been limited efforts at developing tools to share knowledge among practitioners. Seemingly the major source of knowledge for fire behavior prediction specialists would seem to be the occasional publication of prediction models and case studies, and the opportunities afforded during the occasional meeting or conference. This provides a challenge and an opportunity; to provide a tool or environment where fire behavior prediction specialists can exchange knowledge and observations. Such an environment will allow these specialists to learn from others experiences in a wide variety of fuel complexes, and describe their own experiences for all to benefit from.

## THE FIRE BEHAVIOR KNOWLEDGE BASE

The Fire Behavior Knowledge Base utilizes knowledge management techniques and current tends in collaborative workspace to provide an environment for fire managers to:

- Search through existing fuel, weather and fire behavior observations;
- Compare local fuel complexes with field documented fuel complexes;
- Sort and assemble fire behavior data into groups based on factors defined by the user;
- View archived fuel complexes and resultant fire behavior not only as quantitative data but as qualitative pictures and videos;
- Compare fire behavior observations of a selected group with established fuel models
- Document observed fuel complex/fire behavior measurements in a growing database.

Originally available as a free downloadable standalone software package, the FBKB is now an online site, where users can explore fire behavior data, and record fire behavior observations.

The FBKB can be divided into two major activity streams; data search and analysis, and data entry/upload. The data search and analysis functionality is the heart of the software and allows users to search, sort through data, and analyse observations. A brief, generalized walkthrough of this portion of the software follows. The data entry and upload function allows the user to build a personal library of fire behavior observations, at a variety of data detail levels, and if desired, the data can be uploaded to the FBKB website for inclusion in the master database. One of the great strengths of the FBKB is the potential data richness that has not been possible in fire behavior prediction systems. Users can store images and/or videos of pre-fire conditions, fire behavior, post-fire conditions; as well as the standard numeric data and store entire PDF files (for example case studies or other documentation) recording background information to the fire.

## WALK THROUGH OF FBKB DATA REVIEW

There are essentially three stages to data selection and review within FBKB;

1. Initial search
2. Review and select
3. Analyse

In the initial search, the user defines the characteristics of the fuel complex of interest. This can be established as very general (e.g. coniferous overstory) or highly specific (jack pine overstory with a black spruce understory with a low stocking rate. Clearly the more general the search conditions the greater the number of successful "hits" in the database. This first stage sets some initial, general parameters to winnow out the database of observations into a manageable size for closer review

In the second stage the user reviews the fuel complex data returned in the first stage to see how it matches with the intended search the user had in mind. This is initially accomplished by reviewing the pre-burn fuel complex images, and those sites that seem suitable can be further reviewed for appropriateness (Figure 1).

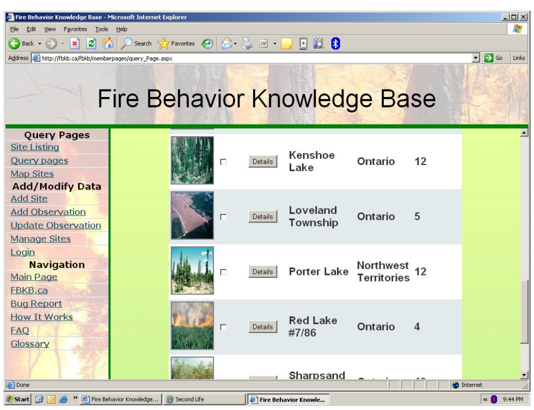


Figure 1. Screen shot of the second stage of data selection and review. Note the images of fuel complex that define overall fuel complex composition and structure.

Each site can have any number of fire behavior observations, some will have only a single observation, but many will have multiple observations indicating that while the fuel complex was constant over the observations, many observations of weather, and fire behavior were taken. From here the user selects those sites (or perhaps only some of the observations from a site) that are deemed suitable for further analysis. This selection can be based on whatever information the user feels is appropriate – all the data recorded about a fire is available for review at this stage including numeric fuels, weather, and fire behavior data; images recorded per, during and post burn; video data as well as reports. Selected data is then used in the final stage.

The third stage allows the user to begin to synthesize the selected data, albeit in a rudimentary manner (at this time). Select sites from the second stage can be mapped to see the spatial extent of the observations. Fire behavior data can be plotted and compared with existing fire behavior fuel models (Figure 2).

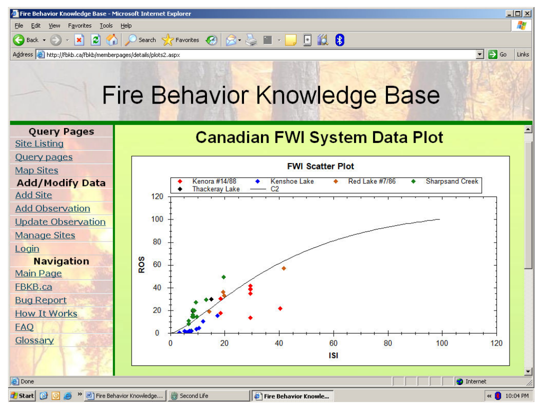


Figure 2. An example of a data plot created from selected data in FBKB and plotted with an C-2 fuel type rate of spread curve. Note that different observational sites, each with multiple observations, are represented with different colours.

A number of fire behavior parameters can be plotted against a variety of Fire Weather Index (FWI) System parameters as well as observed wind speed. Future enhancements would see a wider range of weather and fuel parameters that observational data could be plotted against (including other danger rating system elements) , a tool to print out formatted charts and tables of results, and a toolbox of statistical analysis tools including a curve fitting tool to build fuel models.

## CHALLENGES TO DATA QUALITY

Often the first concern of fire behavior experts, who learn of the plan to build a user managed database of fire behavior observations as an aid to fire behavior prediction, is data quality. Currently for experimental fires upon which fire behavior prediction systems are built, data collection and quality control standards are exceptionally high. Within a user managed data base how can users be sure that the data they are viewing is accurate? And given this how can they be comfortable in be guided by the data. There are several responses to these valid concerns. First, it is hoped that users take responsibility and pride in the data they are submitting to the database and ensure it is of the highest quality. The same arguments concerning quality, clarity and accuracy were voiced during the development and establishment of Wikipedia the online user managed encyclopedia. However Wikipedia has proved to be at least as accurate and of high quality as its more traditional counterparts (Tapscott, and Williams, 2006). Second, the documentation of fuel and fire behavior in the FBKB is not only numeric data. Users can view the pictographic evidence of fuels and resultant fire behavior thereby providing them with visual clues to the data quality. Finally, currently the authors provide a review and data quality assurance function, whereby all data that is uploaded to the main database is reviewed and checked.

## DEVELOPMENT PHILOSOPHY

While the FBKB was developed in Canada and currently has references to the Canadian Fire Danger Rating System, it was always intended that this development work was a starting point only. We consider the code and data to be “open source”, and thus are interested in sharing with other developers and interested parties who would add to the FBKB. There are several avenues for expansion as we see it:

- Adding conversion factors and additional data elements to allow other countries danger and behavior rating systems to be compatible. This would essentially add a “translator” so that fire managers and behavior prediction experts would be presented with terms and relative values that were familiar to them.
- Additional data analysis tools that would allow users to better explore the data and develop a better understanding of what to expect.
- An intelligent fuel complex analyser that would better screen data.

Of course the primary opportunity is to add to the data base of fuel and weather and fire behavior observations. While fuel complexes can be unique around the world, fire behavior is fire behavior, and how a fire behaves in grassland or savannah in Europe may b very similar to how it behaves in grassland or savannah in Africa, Australia, or North America. Collecting a global set of fire behavior data allowing fire managers and researchers to review, analyse, share and learn is the ultimate goal.

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