Scientific and Technical Articles

Decision-Making for Centralized Forest Fire Management

by

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Abstract

Pressures brought about by severe fire loss, increasing fire control costs, and restricted budgets are causing some Canadian forest fire control agencies to consider new ways to improve efficiency. One attractive alternative, currently being pursued by several provinces, is the restructuring of their three-level, decentralized organizations to a provincial-regional, centralized fire management unit.

Under a centralized system relatively few people manage the necessary resources to handle a fire situation for a huge area. To attain this capability, they require the support of a computerized system designed to collect and process information on weather, fire occurrence and behaviour, and the status of detection and suppression resources.

Such a system has been developed and is undergoing operational trials at the centralized fire centres of both the Société de Conservation de l'Outaouais at Maniwaki, Quebec and the Ontario Ministry of Natural Resources at Timmins.

Résumé

Les pressions exercées sur les agences canadiennes de contrôle des feux de forêt par l'étendue des superficies forestières brûlées, l'augmentation des coûts de contrôle des feux et leurs propres restrictions budgétaires les amènent à considérer de nouvelles approches pour améliorer leur efficacité.

Une solution attrayante, considérée par plusieurs provinces, consiste à changer la structure actuelle, décentralisée, en une structure centralisée opérant à deux niveaux, provincial et régional. Sous un tel système, quelques personnes ont la responsabilité de la détection et de la suppression des feux à l'intérieur d'une vaste région. Ce même groupe a aussi la responsabilité de la gestion des ressources disponibles pour accomplir ces tâches. Ce type d'organisation a besoin d'être supporté par un système informatisé de collecte et de traitement des données. Ce système doit être capable d'intégrer des données sur la météo, la probabilité d'allumage, le comportement des feux ainsi que sur l'état des ressources disponibles pour la détection et la suppression.

Un tel système a été développé et subit actuellement des essais opérationnels aux centres des opérations de la Société de conservation de l'Outaouais à Maniwaki au Québec ainsi que de la Ministère des ressources naturelles de l'Ontario à Timmins.

The Canadian Forest Fire Problem

Forest fires in Canada during an average season are 9 100 in number, consume 1.3 million ha of productive forest, cost \$100 million in suppression costs, and cause at least \$50 million damage in lost timber, real estate and recreational values (Ramsey and Higgins 1982). Fire occurrence varies considerably from season to season. For example, in 1978 Canada experienced 7 900 fires that burned over 0.3 million ha for a suppression cost of \$100 million. However, during 1980, 9 147 fires burned over 4.8 million ha and cost \$225 million in suppression costs and a value loss of \$350 million (Ramsey and Higgins 1982). In the last five years the annual area burned has averaged three and one-half times the area harvested (Poliquin 1983).

The responsibility for protecting Canada's forests rests with each individual province and territory. Provincial forest fire control organizations have been in operation since the early decades of this century. Each organization has evolved over time in a manner that reflects the province's protection needs, fire problem, budget and operating philosophy. Until recently the common goal of each of these organizations has been the exclusion of fire from economically accessible forest land.

It is difficult to make conclusions about the effectiveness of these organizations from annual statistics. Clearly the goal of fire exclusion is a long way from being achieved. Analysis of individual fire reports indicate that current fire control organizations can readily cope with most fires if they are detected and attacked while still small. For example, during the past decade only 3% of all Canadian fires exceeded 200 ha. However, these relatively few fires burned 97% of the area. Statistics and experience indicate that we are not effective in com-

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bating large fires. Few large fires have been stopped by man's actions in spite of the huge amounts of money and effort spent in trying to do so. Large fires usually either run out of fuel or the weather changes, making the fuel too wet to support combustion.

Although the annual fire statistics indicate that increasing expenditure in fire control activities has not reduced fire loss, this must not be taken to mean that present fire control efforts are not essential. Statistics show that the number of forest fires has almost doubled since the 1940s (Ramsey and Higgins 1982). Much of this increase is associated with human intrusion into the forests for both industrial and recreational purposes. Most of our present losses are associated with relatively few large fires. We cannot say what would have happened without fire control. For certain, many of those fires successfully attacked and suppressed had the potential to become huge fires causing millions of dollars in losses.

Currently the annual cost of operating the provincial fire control organizations is about 70 million. This amount does not include the additional costs incurred in fighting fires, which varied during the past five seasons from about \$30 million to over \$150 million. Much of this additional money was spent fighting fires that were hopelessly out of control.

A New Approach

Traditionally, after a severe fire season, review of the organization's situation are made that most often recommend enhancing the existing system. Usually, most enhancing of the additional resources are directed toward improving capability to suppress large fires. The logic for this seems to centre around the idea that because large fires caused the losses, we must improve our ability to control them. This approach has inherent difficulties. First, the well has run dry; there is little additional money for fire control. Second, no amount of resources with today's technology have much chance of controlling a large active fire. The goal of fire exclusion should be abandoned in favour of a goal that recognizes our inability to cope adequately with large fires. We must be prepared to accept certain losses from large fires and at the same time concentrate our efforts in reducing the number of fires that become large. Redirecting a significant portion of the funds now spent for suppressing large fires to small-fire suppression activities should noticeably reduce fire losses.

This is not to say that all large fires should be allowed to run their course. Clearly we must maintain an effective capability to protect human lives, real estate and communities. We also must maintain and improve our ability to extinguish large fires when they become relatively dormant owing to improved weather conditions.

The improvement of fire control will not be achieved merely by augmenting existing components of the system. We must reexamine the total fire system in view of our expanded horizons, historical evolution, and the capabilities of new technologies in fire control, communications, transportation, and computing. Until now, the goal has been the suppression of each and every fire as dictated by the fire exclusion policy. Life will not be so simple in the future under a more realistic fire policy. Difficult decisions will have to be made on the degree of involvement with each fire and this involvement will vary over time. Moreover, fire is a recognized tool essential to wise management of Canada's boreal forests. Existing fire control organizations must expand their role to include the planned and deliberate use of fire to achieve forest management objectives. For example, in response to the disastrous fire seasons of 1980 and 1981, the Ontario Ministry of Natural Resources reviewed the provincial fire policy; the result was a new policy that permits flexibility both in suppression activities and in the use of fire as a management tool.

Over the past 60 years highly effective, decentralized organizations evolved based on relatively poor transportation, poor communications, and inexpensive labour. Until recently, these served us well and were able to handle most fire situations. However, constant or decreasing budgets and increasing costs of labour and air operations have steadily eroded the strength of fire organizations so that they are unable to cope efficiently with present and future situations. A fresh approach is required, centred around a new organizational structure. In designing this structure, consideration should be given to the variable nature of the fire problem, the greatly increased cost of personnel and equipment, the fact that total fire exclusion is an impractical goal, the present and future roles of fire as a management tool, and advances in supporting technologies.

Centralized Fire Management

The existing organization structure of most fire control organizations in Canada typically has three components: the provincial headquarters, regional service and coordinating centres, and district operations centres. The larger provinces have regions each spanning from 5 to 15 million ha. Each region may be divided into three to six districts. The role of the small headquarters group is to set general policy, planning, standards, budgeting, and servicing requests for additional resources. The role of the region is policy implementation, regional planning, and providing supporting services to the districts. Responsibility for the control and use of fire rests with the districts. To carry this out each district operates its own planning, suppression and fire control facility.

Centralized fire management is the phrase commonly used to describe the proposed alternative organization structure. It consists of just two levels, provincial and regional. A provincial fire centre, in addition to the role currently played by the headquarters group, now becomes an aggressive participant in the day-to-day fire management operations. It is responsible for anticipating and supplying the resource needs of the regional centres on a daily basis. The regional fire centre lies at the heart of the new organization and is responsible for meeting the complete fire management needs within the region. These needs obviously require district input during the annual planning stages; unlike the current structure, however, the district plays at most a support role in day-to-day fire control activities.

Key to the success of centralized fire control is the province-wide mobility of fire control staff, equipment and aircraft. Resources not currently in use can be moved to where they are most needed within a province or region. Fire crews, aircraft and equipment no longer are tied to specific locations, thus avoiding inefficient and expensive duplication. When a fire situation is anticipated, appropriate resources from the region and province can be quickly assembled. The system has lower manpower and training requirements, and these fewer resources should prove more effective.

Centralized fire management will encourage the creation of a more professional fire service, somewhat resembling a big city fire department. Fire control organizations now rely heavily on part-time employees, often students, who form the core of the fire control effort. High turnover rates and associated high training costs are common. Career paths for those wishing to remain in fire control are usually limited compared with other forestry career paths. Talented and highly motivated employees often have to leave the fire field because of lack of opportunities for promotion. Centralized fire control offers the opportunity for a smaller but more professional forest fire service with more permanent jobs, each with a better defined career path. More interesting and challenging work and a better work environment will lead to higher staff morale.

Figure 1. SCO decision support menu. With a light pen, the user positions the cursor in the appropriate box. Here the user is asking to see a map showing the current Fine Fuel Moisture Codes for the region (FFMC box lettering turns to red once the selection has been made).

Figure 2. A map of the SCO region showing four classes of drought codes. The red areas are the areas with very dry heavy fuels.

Figure 4. Lightning location for an 8-hour period on August 8, 1983. Each dot on the map represents a flash location. The colours indicate time periods with the red flashes occurring in the last hour.

Figure 5. A lightning fire occurrence prediction for August 8. The red areas have a high probability of lightning-caused fires.

Most government and industry forestry activities are now decentralized. One criticism of the new structure is that imposing a centralized fire management service upon a decentralized client structure can cause troublesome management and communications problems. Another criticism is that a centralized system cannot adequately meet the fire management needs of district or local levels. The fire problems unique to an area are well known to the local fire control personnel. A more mobile work force will lose this "local knowledge" and therefore will be less able to cope with the area's fire problems. This criticism is valid only if we are unable to transfer this knowledge to the regional decision-makers. An important goal of the decision support systems described later is to accomplish this task.

Resistance to centralized fire management will come from the district managers who will lose control of an important general purpose labour pool that had previously been provided by the fire organization. Middle fire control management may also perceive it as threatening their job security and, therefore, actively oppose it. Political sensitivity to the effects of reducing fire crew strength on local employment may generate resistance. Such maneuvers may be viewed as conflicting with government policy of providing employment, especially during difficult economic times.

There are counter arguments. A more efficient fire control organization is desirable because resources so released can be better used in other areas of forestry that are labour intensive, such as forest stand tending. Centralized fire management does not mean that staff and equipment must be physically centralized. These can remain based among the districts but must be free to move to problem areas within the region or province. Only the command, control, communication, and information systems must be centralized, leaving the implementation of decisions to personnel and equipment remotely situated.

Decision-making Framework

Centralized fire management must provide efficient fire services that meet various land management objectives and the district and regional standards for protecting life and property. A means must be established to enable public and private land and resource managers to review and have input into the regional fire management centre's operating guidelines. With these guidelines, a seasonal and daily operations plan for that year can be formulated that can best serve the needs of the centres "clients". Just as the old decentralized system responded to the needs of the local district, the new system will meet the needs of a much larger region.

The new approach combines features of a modern city fire department and a military command and control structure. Essential to the success of a centralized fire management are the following:

- A structured chain of **Command** and corresponding responsibility. Each person reports to only one superior and at the top of the hierarchy there is one active decision-maker responsible for the performance of the whole regional organization.
- The capability of the centre's decision-maker to **Control** the organization in its hour-by-hour activities. The regional decision-makers must have the necessary authority to oversee the implementation of their decisions and carry responsibility for the consequences of their decisions. Present decentralized systems lack this link. At present the person making the decisions does not have to pay the bills!
- State-of-the-art **Communications** to enable decisions and feedback to be transmitted to and from remote parts of the region and from the regional fire centre to the provincial fire centre.

* WEATHER contains tomorrow's forecast, today's current, current season, and past 10 seasons of weather and fire index values for each of the 24 weather stations.

LIGHTNING contains all flash locations for the current season up to the current second

FIRE contains details on each fire in the region from the present day back to 10 previous fire seasons

** Planned for the 1984 fire season

Figure 3. General structure of the SCO decision support software and databases.

- Timely **Information** flow into and through the centre to support the decision-making process, including the ability to anticipate response to the fire situation.
- Adequate and mobile resources to permit the most appropriate response to the fire situation.
- An active, appropriately staffed provincial fire centre with the necessary authority and responsibility, as well as communications, computer, and decision support systems to monitor the total fire situation and reallocate resources in anticipation of regional problems. It is the manager's responsibility in the provincial fire centre to ensure that each region has adequate daily resource levels.

There is an intimate connection between centralized fire management and new technology. New technology in transportation, communications, and information processing is essential for the operation of a centralized system. Conversely, without a centralized system, new technology cannot be efficiently utilized and probably is neither required nor wanted. This is particularly true in the area of computerized information processing. A decentralized system does not require elaborate information collection and summarizing systems. Managers' interests are specific to their relatively small forest area. Concerns focus on how to make the best use of existing, limited resources. Outside assistance is called for only after the local capabilities are exhausted . . . which can be too late in a severe fire situation.

District fire managers are supposed to know their area in terms of fuel types, occurrence patterns, weather patterns, detection requirements, and equipment and support availability. This type of knowledge traditionally resides, in unwritten form, only with the experienced local fire control personnel. Computerized information systems are neither needed nor wanted in this situation and most attempts to implement computer based technology in this situation have failed.

A centralized system must have a component dedicated to the collection and timely presentation of information on the state of the fire environment and resources. This component has been named the Decision Support System (Keen and Morton 1978). It relies on the use of computers to collect, store, and summarize data necessary to assist decision-makers. It must be emphasized that in no way is the computer

used to replace the decision-maker. Rather, output from the machine is used to help in making more effective decisions.

Present Use of a Decision Support System

Since 1970 the efforts of the Petawawa National Forestry Institute's fire management decision support project have been directed at researching and developing the concepts and information processing methods necessary for a centralized fire management system. A demonstration of this work has been carried out since 1975 in the area protected by the Société de Conservation de l'Outaouais (SCO). The SCO protects a 9-million ha area in southwestern Quebec and operates from a fire centre situated at Maniwaki. This region was chosen because it was the first in Canada to implement a truly centralized system.

Between 1973 and 1983 many Fortran computer programs were developed, tested and revised. About half of these programs are considered operational and used on a routine basis. The remaining programs are still in a developmental phase and undergo periodic simulated operational tests at the SCO. These tests identify the problems in the programs which lead to either corrections, redesigns or more research. This testing process can be as short as a few weeks or as long as 20 years. In one extreme case, for instance, periodic tests of the fire growth model have been carried out for the past 10 years and it is likely that another 10 years of work will be required before the model can be fully utilized.

Until 1981, the SCO used the Petawawa research project's Digital PDP11/34 minicomputer connected to the centre by two telephone lines. The centre had a remote computer terminal and a colour plotter for map output. By 1981 the workload at the centre increased to the point where the communications and computer processing capability were totally inadequate. Early in 1982 the SCO purchased its own computer, a Digital PDP11/44 with at least twice the processing power of the research computer. The existing computer programs were transferred to the SCO computer and new ones added. During the last year computer use has rapidly expanded. Currently the SCO employs one full time computer systems manager and one support person. For the 1984 season, the fire centre will have six conventional terminals (three for office support duties including personnel accounting and fire report records), two colour graphic terminals, two word processors, and one colour plotter. In addition, computer storage capability will be expanded to 400 megabytes. Up to 1980, the research computer at Petawawa supported the SCO with 2.5 megabytes of storage.

Most computer programs that are used on a daily or hourly basis have two modes. The first mode is used for updating, and usually involves the entry of new data into one or more of the databases. It is assumed that this process is carried out by a person with reasonable knowledge of the program and its requirements. This person must also have some knowledge of forest fire weather and behaviour, suppression methods, and the operational procedures of the centre. This updating activity is done without direct upper management input on a routine basis by the computer or fire centre support staff. It is this latter group's responsibility to keep the appropriate output files and databases current. The second mode of operation is used by the decision-makers, and involves only the display of output produced by the first mode. Here, a light pen-controlled menu and a series of sub-menus are used to identify the desired information quickly (Fig. 1). In most cases, the information is presented in the form of coloured maps either on a colour graphics screen or colour plotter (Fig. 2). This mode is designed for fast information retrieval by people unfamiliar with computers. Often not a single key needs to be typed!

Five major databases form the foundation of the SCO decision support system (Fig. 3). These include: a) equipment and personnel inventories current to the hour, b) fire history to the present hour, c) lightning location data to the present second, d) historical, current, and forecasted weather observations and corresponding fire weather indices, and, e) the forest fire fuel types (and, eventually, elevations) for each 50-metre square across the entire region. The weather and fire databases contain 10 years of historical data. Digital's "Data-trieve" database management system is used to manage all but the fuel-terrain database. This system permits fast and effective retrieval and display, easy updating, and simple command structure. Elementary knowledge of Datatrieve permits easy access by a decision-maker to the major databases, independent of all other decision support software. The more sophisticated Fortran programs access the same databases without the use of Datatrieve.

Three programs are used to keep track of equipment, personnel and aircraft. The equipment inventory program deals with 21 types of equipment at nine permanent locations and up to 150 temporary locations, e.g. fires. Reports can be produced at any time showing equipment status and audit trails. A personnel program is used by the SCO to keep track of those people available for fire fighting duties. Names, availability, skills, and experience are recorded for up to 400 persons. During the past two seasons, experiments have been carried out with a Datatrieve-based aircraft information system. The system provides aircraft usage accounting information and includes detailed information on each flight. In addition, the program can display the current location of each aircraft in map form.

A resource allocation program uses network theory to define efficient daily resource movements. Given the present locations of the item to be moved (crews, detection aircraft, airtankers, helicopters, etc.), the appropriate transfer costs, and estimated demand for the item at all potential locations, it determines the least expensive movement option that will meet the expected demand. The program has been set up to move aircraft around a large province but has not been used operationally.

Observed weather data from 24 SCO sites and Atmospheric Environment Service forecasts are manually entered into the weather database at least twice a day. The SCO region is divided into 150 cells and each cell is assumed to have the weather (forecasted or actual) of the nearest weather station. Based on these data, the current and forecast Fire Weather Indices are calculated and archived for each cell. Up to 15 different colour maps displaying weather observations and Fire Weather Indices can be viewed at any time.

Knowledge of the areal distribution of rainfall is inadequate even with the relatively dense network of rain gauges. The cost of adding to this network is prohibitive because of the cost of communications to remote areas and the expense of either manned observations or remote weather stations. Precipitation radar offers a potential alternative. During the 1979 and 1980 fire seasons, the McGill University radar computer transmitted via telephone lines to the SCO computer the average rainfall rate each hour, 24 hours a day, for each 5-by 7-km cell in the southern third of the region. Relative rainfall rates appeared quite reliable much of the time and probably would be very useful for improving fire occurrence and behaviour predictions. A study is now being conducted to determine the best design, costs, and operating problems of a forest fire precipitation radar system.

The SCO operates a full-time lightning location system consisting of three remotely located sensors directly linked to the SCO computer. When a flash occurs its estimated location is calculated and archived by the computer. A map showing the

colour-coded lightning locations for any time period can be quickly plotted on the graphic screen in the fire centre (Fig. 4).

Three programs are used at the SCO fire centre to predict daily fire occurrence. These programs are usually run in the afternoon to predict for the next day and in the early morning for the current day. Fire occurrence is separated by general cause, with one program dealing with man-caused fires and the other two programs dealing with lightning-caused fires. Those fires caused by lightning already in the database are handled by the one program and those fires expected to be started by future storms by the remaining program. These programs utilize the weather, fire and lightning databases (Fig. 5).

Each year the method of man-caused fire prediction is modified and consequently there is no lengthy test of the system's accuracy. Although there is a historical mode whereby the method can be tried each day for the past 10 years and compared with actual fire occurrence, this is not an independent test. Operational use of the 1983 version indicated that the system predicted within two fires on 70% of the days. This is not a good indicator of the robustness of the prediction system. It is easy to make a prediction system work during moderate fire weather. The true test is its performance during difficult times. A non linear scoring rule that gives most weight to prediction accuracy in difficult situations was used in a parallel test where both computer and manager made independent predictions. Results indicated that the program could predict at least as accurately as the most experienced person. It is probably safe to conclude that considerably more improvement can yet be made in predicting man-caused fires. It is also probable that future improvements will come from a model of the process rather than the relatively crude correlation methods now used. This model will deal with people's use of the forest: how many are in the cell that day, why they are there, the probability that they will leave behind one or more fires, and the smolder and arrival behaviour of the ignited fires.

Lightning fires are predicted on the basis of the number and location of the flashes and a model of the ignition, smoldering and arrival process. The ignition phase of the model is based on the work of the US Forest Service (Fuguay *et al.*, 1979) and predicts the probability that a fire will be ignited. It considers the rainfall pattern of the storm, the fuel moisture of the fuels in the dry and wet areas where the lightning may have struck, the density of the fuel, and the nature of the flash. Most of these factors have been estimated for the SCO conditions. Precipitation radar offers the potential for a big improvement in the use of this phase of the model.

The second phase deals with the ability of the ignited fire to maintain itself. In the SCO region lightning typically occurs late in the day or through the evening. A fire ignited by lightning must be able to smolder at least until the next burning period. Laboratory experiments are beginning to reveal the conditions necessary for this to take place. At the moment, this phase contains our best estimates of smoldering probability as a function of bulk density, duff moisture code, and time.

The final phase of the model deals with the development of an active fire capable of being visually detected, the arrival phase. Here, the probability of a fire arriving is assumed to be a function of the initial spread index which considers the fine fuel moisture and wind speed. The model permits a fire to arrive immediately or smolder into the next burning period. If the weather is too wet to support arrival, the fire has the potential to smolder through to the next burning period. The 1983 version of the model assumed the lightning fires started four days ago still had a finite chance of arriving the current day. Output from the lightning fire prediction was in coloured map form showing four classes of percent chance of one or more fires in each cell.

Use of these prediction systems by SCO during the past two seasons indicated that the model predicted quite well in easy to moderate situations (i.e. for storms with 0 to 10 fires). For more serious situations with many multiple starts, the model was unstable. Evidence is now building that holdover periods up to seven or eight days may be required. For certain, much more fundamental research is required to improve the relationships in the model. Such work is either being planned or is in progress both at the Petawawa National Forestry Institute and at the Northern Fire Laboratory of the US Forest Service.

A model to predict the perimeter location of a fire any time after ignition has been developed and is being tested by the SCO (Kourtz 1977). The model assumes that the forest consists of a grid of 50-metre squares as defined in the SCHO Landsat-terrain database. The rate of spread across a cell in eight radial directions is calculated according to fuel type, slope, fuel moisture based on fire weather indices at the nearest weather station, and the forecast wind speed and direction for that hour. A dynamic programming algorithm is used to ensure that the fire follows the shortest-time path between any two cell pairs. The fire can be stopped or forced to burn around groups of cells. This happens when the rate of spread is zero as is the case with cells containing fuel too wet to burn, or rock, water, or in the future, a fire control line.

To support this model, data from the Landsat satellite have been used to construct a 50-metre grid fuel database covering the entire SCO region. The database management system used in conjunction with these data can retrieve and display in several scales and in colour graphics the area surrounding any potential or actual fire location. The fire model can be activated once the hourly weather file is made current. Output is displayed in map form showing the fire growing over simulated time (Fig. 6 see cover).

The model was tested during the 1983 fire season by the SCO fire centre on two actual fires. The first test predicted a fire that was very similar in size, shape and behaviour to the fire that actually occurred. The model was run soon after the fire was reported and indicated a troublesome fire that would reach several hundred ha by the end of the first burning period. An energetic initial attack stopped the fire at 50 ha. The second test failed to adequately predict the size, shape and behaviour of the fire. An investigation of the situation revealed that the actual fire's characteristics were dominated by steep terrain. The fire model in its present form assumes flat terrain.

Work is proceeding to obtain and add to the database an elevation for every 50 metres across the SCO (Kourtz 1982). A modification to the method of rate of spread will be made to consider the slope relative to the direction of fire spread. It is hoped that tests can be carried out with the improved version in 1984. This model integrates much of our existing fire behaviour knowledge and use of it clearly points out areas where more fire behaviour research is required. In the future, once this model can reliably predict fire growth, modifications will be made to permit evaluation of various control strategies. Meanwhile considerable research is required to model the ground and aerial fireline construction process. Also, the model will play an important future role in the use of fire as a management tool. Prescribed burns will be easily simulated under differing fuel, moisture and wind conditions.

Each day a central manager must determine the regional detection requirements and formulate a plan that will meet these requirements. Two computer programs are in the development and early testing phases that should eventually assist in this planning process. The first program deals with the daily detection requirement in terms of the frequency and corresponding timing of flights over each cell in the SCO. The second program attempts to determine the number of aircraft

and actual patrol routes, each constrained by a minimum and maximum time duration, that will visit the required cells for the least total flight time.

Decision Support System in Ontario

Since the early 1970s, field trials of various components of a regional fire centre decision support system have been carried out through a cooperative program between the Ontario Ministry of Natural Resources (OMNR) and PNFI. These trials were carried out at the north-west and north-central region fire centres at Dryden and Thunder Bay. During this time the Ontario fire organization was a three-level, decentralized structure with the regional fire centers functioning as service centres to the districts.

Equipment inventory, fire weather, and fire prediction programs were tested at both centres using the PNFI computer and slow-speed communications lines. During this period the programs went through a rapid series of changes and redesigns as the many weaknesses were identified and corrected. Although these attempts cannot be considered successful, much was learned from them. The main concepts that underlie the present software were developed at this time. Valuable experience was gained on technology transfer to the field. Most importantly, the role of this technology as support for the decision-making process within a centralized organization structure was clearly identified.

The fire seasons of 1980 and 1981 were very costly in Ontario and the aftermath saw investigations of new ways to improve efficiency. In 1982 the process was started to create a two-level, centralized fire management system along with the necessary decision support systems. The northern regional fire centre at Timmins was selected as the demonstration site for developing and implementing a decision support system. Throughout the winter of 1982 PNFI and OMNR jointly prepared the necessary software and databases. During the 1983 fire season, the various computer programs were introduced to the fire centre staff. By late in the season most databases were current, lightning locations were being archived, and fire weather and fire occurrence prediction programs were functioning effectively. Plans are now being reviewed by OMNR to acquire the necessary computers and programmer support to permit the expansion of the Timmins system across the entire province.

Implementation of a Decision Support System in New Areas

The major prerequisite for a decision support system is the proper organizational environment. It is not enough for management to want such a system; it must be needed, and this need is only generated within a centralized structure. In addition, it must be recognized that the underlying technology is complex and expensive. At least one skilled computer analyst and access to a fairly large minicomputer are required on a continuous basis for each regional centre.

The decision support system is a highly integrated group of computer programs. Separate components cannot function independently. People insisting on obtaining only the fire prediction programs are disappointed to learn that before they can run these programs they require three large databases, an integrated fire weather and lightning location system, and, of course, access to a suitable computer. It requires approximately one person-year to prepare the databases and programs for a new area. This work and the day-to-day support and updating of the software must be carried out mainly by the

interested fire centre. Only limited assistance is available from other agencies.

The present software is designed for a Digital minicomputer. It is very expensive to convert this software to another manufacturer's computer even though all programs are written in Fortran. For example, many of the programs depend either on Datatrieve or on Digital's Record Management System direct keyed file access method and neither are available on other computers. Substantial rewrite of code would be required if another machine were used.

The feasibility of implementing the system on inexpensive micro computers is often asked. It is true that the latest micro computers are becoming large and powerful for a single user. However, experience indicates that a multi-user computing environment is essential. The SCO operate with over eight users accessing the computer, sometimes simultaneously. There are far too many data entry chores and display work for a single-station computer. Eventually the existing PNFI software will be converted to operate on a Digital Vax minicomputer. An adequately configured Vax costs about \$200,000 and should serve the needs of a regional fire centre for five to ten years.

Future Directions

The foundations for a regional decision support system have now been laid. Future work will centre around researching and developing more powerful decision assisting tools. Some of the new areas of the next 20 years include: resource allocation models to enable more efficient acquisition and pre-positioning of expensive resources; fire line construction modeling to assist in tactical planning; greatly improved fire modeling, utilizing digital timber inventory along with an integrated control strategy testing capability; integration of prescribed burn planning with the decision support system; the inclusion of fire effects into the models to assist in priority setting; and, the use of modern remote sensing for fire detection and fire growth monitoring.

Provincial fire centres must expand quickly to support properly their regional centres. Each such centre will require its own decision support system. Considerable work is required here to establish the role and operating procedures of such centres. New hardware and software concepts are required. It is envisaged that each regional computer will be tied to a provincial fire centre computer in a shared network. Information could flow freely between adjacent regions and between each region and the provincial fire centre. The provincial fire centre will operate databases containing summarized data for the province which could be presented in provincial map form enabling decision makers to see the "big picture". Provincial summaries of resource inventory, fire occurrence and behaviour predictions backed up with resource allocation models could assist in anticipating problems and moving appropriate resources.

New directions in forest fire research are required to meet the future demands of decision support systems. We now have computing and modeling tools that enable the pieces of fire-related knowledge to come together in a useful manner. What is required is a large research effort aimed at improving our crude perceptions of the real world that are embedded in our present models. Fundamental work is necessary to identify and quantify important factors that must be included in the next generation of models. Particular attention must be paid to the interactions of these factors with the total fire environment. Without these interactions, the models will not function properly. Fire research must be more integrated to permit multi-

disciplined teams to jointly work out the relationships necessary for the next generation of fire management models.

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