Position Paper on Fire Research in the Canadian Forestry Service

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POSITION PAPER ON FIRE RESEARCH IN THE CANADIAN FORESTRY SERVICE

by

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FOREWORD

This report was originally prepared as a background paper for discussion at the first meeting of the Canadian Forestry Service (CFS) Forest Fire Research Program Advisory Group in Ottawa in late 1973. Following review by Directors, Program Managers and senior fire researchers at various CFS establishments across Canada, the Advisory Group at its January, 1975 meeting in Ottawa recommended that the report be considered for publication.

The main purpose of the report is to outline the forest fire research program of the CFS, including the approach to program development, identification of work priorities and principles of operation. While it is intended primarily for use by the CFS and client fire management agencies, the information may be of value to other agencies interested in the fire research program of the Department. The author prepared the report while on a two-year term appointment as Technical Specialist – Fire at the Canadian Forestry Service Headquarters in Ottawa.

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INTRODUCTION

Annually in Canada, an average of 7,500 fires burn about one million hectares (2.5 million acres) of forested and non-forested lands. The agencies responsible for fire control spend about 25 million dollars on fire suppression and at least an equal amount in maintaining the fire control organization. The average annual loss by forest fires to the economy of Canada is probably equal to or in excess of the annual cost of maintaining the fire control organization plus direct suppression costs, and includes estimated adverse effects on water quality and quantity, vegetation, wildlife habitat, soils and aesthetics.

With the exception of federally-owned lands in Canada's North and within provincial boundaries, individual provinces are responsible for fire protection on 3.6 million square kilometres (1.4 million square miles) of land area. An additional 518,000 square kilometres (200,000 square miles) of federally-owned land is protected against excessive damage by wildfires. Fire control planning and operations are becoming increasingly complex, requiring expertise in such areas as organization, assessment of resource values, communications, public relations, fire-fighting strategy and tactics, understanding and application of modern fire control technology, and prediction of fire weather and fire behavior. The Canadian Forestry Service (CFS) through its traditional mandate[1] to conduct a fire research and development program in support of provincial and federal fire control activities has played a prominent role in furthering the art and science of fire control in Canada.

The CFS fire research program has evolved over the past 45 years and it has always been heavily mission-orientated towards providing useful solutions to the important operational problems facing the fire control agency. Current research, development and innovation activities include prediction of fire occurrence and behavior, prescribed fire applications, evaluation of fire control systems, development of techniques and procedures to optimize use of modern fire control technology, fuel appraisal, clarification of the historical role of fire in the forest, development of standards and operational guidelines to enable the user agency to effect savings in fire control expenditures, and development and testing of sophisticated fire management systems. The total staff and funds available to the program amount to about 65 research and support personnel and 1.5 million dollars in direct project and non-project functions, comprising about 5% of all CFS research and operational programs. Organizationally, the most far-reaching change occurred in the early 1960's when fire researchers were placed at some regional establishments to provide continuous, rather than occasional contact with the fire control agencies, to conduct research and to provide advice on programs of local significance. Today, fire research staff and funds are about equally divided between the centrally-located Forest Fire Research Institute (FFRI) and various regional establishments such as the Pacific, Northern and Great Lakes Forest Research Centres.

This paper is intended to document the rationale behind the fire research program and to outline an approach to program development. As such, it attempts to interpret the effects of both internal and external issues and influences on the fire research program as well as delineating, in general terms, the direction of the program so as to provide for the greatest savings in fire control costs and resource damage. The term "fire management" is used throughout this paper, with the connotation that it is essentially a dynamic process involving considerations of resource values, role of fire in the environment, what is an adequate level of fire protection, opportunities for prescribed use of fire, consideration of fire effects and, most importantly, optimization of the efficiency of the fire control operation. This concept is emphasized in the expectation that it will be widely accepted and that fire management will soon be operationally implemented in many parts of Canada. It is recognized that presently only a few fire control agencies in Canada openly practice fire management in the full sense of the term; however, nearly all agencies now consider resource values, fire ecology and prescribed fire to optimize the effectiveness of the fire control effort.

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[1] The legislative basis for federal forestry activity derives from the Forest Development and Research Act and was extended in the Government Reorganization Act, 1970, which established the Department of the Environment.

PROGRAM STATUS

GENERAL

The primary goal of the CFS fire research program can be stated as follows: through a program of research, development and innovation on fire management problems, to provide for the greatest reduction of forest fire losses and control costs to the minimal level consistent with the realities of economics and ecology. In recent years, this goal has been approached by development and maintenance of balanced research programs at the centrally-located Forest Fire Research Institute in Ottawa, the Petawawa Forest Experiment Station, and the Pacific, Northern and Great Lakes Forest Research Centres. Other research Centres do not presently have the staff and funding to pursue vigorous programs of fire research; and work is limited to technical and advisory services. Ongoing programs and the location of fire researchers to various establishments generally reflect expressed requirements by client agencies and the recognition that continuous rather than intermittent contact with these agencies is a basic prerequisite for meaningful research programming.

Identification of research problems and the assignment of work priorities have been the responsibility of each establishment. In general, work at the FFRI is concerned with providing solutions to problems of national significance as well as the conduct of background research, whereas regional programs reflect the relevant short-term planning and operational problems facing the fire management agency. It is evident that a wide range of problems are being tackled, presumably according to needs expressed by fire management agencies, the probability of the CFS being able to do the work and our own assessment of present and anticipated needs. Significantly, CFS fire researchers have developed generally effective and meaningful liaison and cooperative procedures with client agencies according to local attitudes, opportunities and requirements.

The nature and scope of the current CFS research program is reflected by the following listing and brief review of projects active during the 1974-75 fiscal year.

Forest Fire Research Institute (FFRI)

Statistics, Technical Information and Liaison
Forest Meteorology
Improvement of Forest Fire Control Systems
Development and Application of Complex Fire Management Systems
Forest Fire Detection

The collection, compilation and publishing of national forest fire statistics and related information has been a continuing function of the FFRI for many years. In addition, the Institute acts as a clearing house for technical information on fire control. Several meteorological studies have provided a better understanding of the complex relationships between weather and forest fire. The project entitled "Improvement of Forest Fire Control Systems" covers several studies concerned with fire weather forecasting, fire physics and chemistry, analysis of the use of aircraft, measurement of effectiveness of water and retardants, and testing of pumps.

The development and application of complex management systems to forest fire management utilizes the computational capabilities of computers and available expertise of fire research and management personnel. A prototype fire management centre has been demonstrated to officials of federal and provincial fire management agencies. A thunderstorm tracking instrument has been developed and field tested. Networks of lightning sensors have been established in several areas to predict the occurrence of lightning-caused fires.

Petawawa Forest Experiment Station (PFES)

Forest Fire Behavior
The Effects of Fire on the Forest Environment

A major contribution to improved fire control in Canada is represented by the development of the new Canadian Forest Fire Danger Rating System. This System, originally developed as a joint project involving the FFRI, the PFRC and to a lesser extent, most other regional establishments, is now in use throughout Canada, and

refinements are being incorporated to increase its reliability in different fuels. Fire effects on tree growth, biomass, tree regeneration, vegetation diversity and succession are also being studied.

Newfoundland Forest Research Centre (Nfld. FRC)

Public Awareness
Technical Services

An ongoing study attempts to develop and schedule a newspaper, radio and television fire protection publicity campaign for the Newfoundland Forest Protection Association. Another study provides for fire control technical services, including development and demonstration of training programs.

Maritimes Forest Research Centre (MFRC)

Liaison and Development
Forest Fire Research (contract)

Forecasting of the Forest Fire Weather Index for the Atlantic Provinces is an ongoing cooperative operational program involving the CFS, the Atmospheric Environment Service (AES) and the Fire Science Centre at the University of New Brunswick (UNB). In recent years, the CFS has provided contract funds to the Fire Science Centre at UNB in support of fire research of direct interest to the MFRC.

Great Lakes Forest Research Centre (GLFRC)

Forest Fire Research

Analysis of past fire and weather data has facilitated the establishment of correlations between indices of the Canadian Forest Fire Weather Index Tables and fire behavior. A prescribed burning program continues to provide empirical data required for the development of reliable fire behavior guides in major Ontario fuel types. A fuel classification system has been developed and is being field-tested. A study of wind patterns associated with major fuel complexes is continuing.

Northern Forest Research Centre (NFRC)

Reduction of Losses by Improved Fire Suppression Methods
Reduction of Losses by Improved Fire Danger Forecasting

The fire suppression methods program attempts to determine drop patterns of various airtanker/retardant combinations, to provide accurate fire line construction rates, to assist fire control agencies in raising the performance level of detection systems, to devise operational models for use in aid of suppression and to provide guidelines for improving suppression strategies and tactics. These and similar studies are developed in close cooperation with user agencies and results are often implemented when available. Work is continuing on development of fire behavior indices for major fuel types, appraisal of fuels, development of guidelines for prescribed burning, and assessment of fire effects on the environment.

Pacific Forest Research Centre (PFRC)

Improved Use of Prescribed Fire in Forestry
Improved Fire Danger Assessment
Improved Prediction of Wildfire Behavior

A major area of work involves the development of prescribed burning guidelines for hazard reduction and site preparation for planting. Field instrumentation and sampling techniques are being developed to obtain fire behavior data from wildfires and operational prescribed burns. The evaluation, interpretation and application of the Canadian Forest Fire Danger Rating System continue as important work areas.

IMPACT OF PAST AND CURRENT PROGRAMS

Nearly all fire research programs and studies have been initiated at the request of or in direct consultation with a user agency. While there is no guarantee that the results of a particular study will be applied, there is ample evidence to show that results of short term investigations, aimed at solving operational problems, are likely to be

implemented as soon as they become available. In recent years, increased emphasis has been placed on involving the client agencies in joint programs, including developmental work to promote application of relevant findings. Publications and other written material are of course necessary to complete the research function but continued emphasis on developing joint studies with direct involvement by a representative of the client agency appears to be paying dividends through early implementation of findings.

It is difficult to quantify the impact of CFS fire research on reduced fire losses and fire control costs, but the following contributions are indicative of the generally widespread acceptance of operationally useful information.

Various editions of the old Canadian Fire Danger Tables and the new Canadian Forest Fire Weather Index Tables have been or are being used by all provincial and federal fire management agencies. Supplementary tables have been developed and are being used for predicting behavior of prescribed burns and wildfires in major fuel types.

2. The CFS pioneered and implemented an operational procedure whereby computer-calculated actual and forecast fire danger indices, along with fire weather forecasts, are provided to several user agencies across Canada.

3. CFS fire researchers have pioneered the use of prescribed burning for hazard reduction and site preparation in many parts of Canada.

4. Various studies have contributed to improved detection and communications systems in many parts of Canada, including the development of a visual airborne forest fire detection patrol route planning system utilizing the computational capabilities of electronic computers.

5. Evaluation of the operational capabilities of airtankers, helicopters and other fire-fighting equipment has contributed to more effective aerial fire-fighting operations.

6. Development of decision models for detection scheduling, fire occurrence prediction, fire growth and related fire management activities represents an area with considerable potential for further improvement of fire management operations.

The CFS is responsible for the collection, tabulation and publication of national forest fire statistics and related information as well as the distribution of this information to interested user agencies.

8. Development of planning aids and procedures to assist fire control agencies in determining working objectives, including cost-benefit criteria and allowable burn areas.

9. Evaluation of the use and effectiveness of fire suppressants and retardants has contributed to the widespread use of fire-fighting chemicals across Canada.

10. Fire researchers continue to work closely with user agencies to develop operational guidelines for slash hazard evaluation, prescribed burning, use of fire danger rating indices, detection systems, training aids, etc.

PROGRAM DEVELOPMENT

GENERAL APPROACH

Within the framework of federal-provincial jurisdiction, opportunities and attitudes, a meaningful forest fire research program must reflect the rapidly-changing concepts, plans and operational capabilities of the fire management agency involved. The key to effective programming then lies in our ability to grasp and reconcile existing and potential differences in needs and priorities between the various client agencies and to mount the necessary programs to attain clearly-defined objectives. It is thus readily apparent that the CFS fire program must

be mission-oriented and needs to be sufficiently flexible to meet the urgent needs of our clients (provincial and federal fire control agencies, industry, the public, etc.) for information within a realistic time span. In the foreseeable future, we are therefore obliged to react to outside requests and stimuli for research and related fire management services, rather than having the freedom to develop a research program according to anticipated long-term needs. The success of this approach, i.e., emphasis on development and application of workable fire management guidelines, procedures and techniques, depends largely on the interest and willingness of user agencies to become fully committed to joint or cooperative programs.

Identification of research problems and assignment of work pirorities should be developed in close cooperation with user agencies by a review and assessment of programs carried out by other agencies, and by consideration of advice and recommendations made by various groups and committees. Generally useful informal and formal contacts and advisory groups exist to determine needs for fire research and services across Canada but additional dialogue and negotiation will be required to more clearly define real work priorities and to develop mechanisms for more effective conduct of joint interagency programs as well as for the early communication and application of relevant research findings.

It needs to be recognized that there is an underlying similarity in many of the important fire problems identified regionally; subsequently, active involvement by Headquarters in Ottawa appears desirable to help the coordination and integration of program components and resources according to Canada-wide priorities. It follows that coordination of the fire program requires continuous informal contact between researchers and frequent work meetings as well as more formal meetings to update work priorities. Greater cooperation and sharing of staff and resources between regions appears essential to make the best possible use of available expertise in satisfying the planning and operational needs of client agencies across Canada. The project or study will continue as the basic mechanism for joint action but Inter-establishment Projects (IEP's) appear particularly appropriate for formalizing joint programs with common and finite objectives in several regions.

For years, the primary aim of a fire control organization has been the early detection and suppression of wildfires according to availability of standby and emergency fire-fighting resources. Increasingly heavy reliance has been placed on various types of aircraft in all phases of detection, suppression and support services. Today, increased emphasis is placed on fire control in the broader context of fire management which involves consideration of fire ecology, fire use and fire control in a multiple-use framework. It appears that the CFS can play a useful role by monitoring and interpreting changes in fire management concepts and systems, and by developing techniques, systems and standard planning aids to assist fire management agencies attain the desired reduction in costs and damages. Examples of such developments include resource valuation and damage appraisal procedures, the fire management systems concept, computerized data storage and retrieval systems, application of systems modelling techniques in aid of decision-making, allocation of resources and clarification of fire effects on the environment. This work would include consideration of area burned, money spent, and effectiveness of operational procedures and techniques on a national scale, some of which need not, or cannot, be improved by producing more sophisticated scientific aids.

Internal constraints on staff and funding and expressed needs for fire research by client agencies tend to restrict the extent of CFS involvement in many work categories, but a prerequisite for effective cooperation with user agencies would include the establishment of an in-house liaison and interpretative capability at each regional Centre. At the same time, we should increasingly consolidate our strength in fire behavior systems, prescribed fire applications, suppression methods, fire management systems, etc. at a few Centres rather than trying to develop the necessary expertise at all establishments. This approach is predicated on the assumption that a workable mechanism can be developed and maintained to more effectively utilize the expertise at the FFRI and a few regional Centres to help solve operational problems in regions where the CFS does not have an in-house fire research program.

RESEARCH PHILOSOPHY

Fire research in Canada has followed the empiricial method, but theory has been linked with field results whenever possible. This emphasis on observation and measurement of real-life situations has paid off in terms of

immediately useable information of fire behavior and suppression methods, but even more importantly it has facilitated a close and credible working relationship between the researcher and user. Significant attempts have been made to theoretically model wildland fires, but results to date offer little promise that fire spread or energy release rates can be reliably predicted over the full range of fuel and weather conditions. Realistic critical characteristics of wildfires such as crowning, spotting, variability with time and fuel, etc., have not been incorporated into operational models. The observation and measurement of prescribed burns and wildfires in the field appears to represent the best approach to satisfy the present and immediate future requirements for fire behavior information by user agencies; in any event, it is difficult to conceive of a real-life situation with enough current descriptive data to satisfy the requirements of complex models and predictive systems that might be designed to utilize the computional capabilities of computers.

The inherent complexity of fuels, weather processes and terrain features place very real limitations on the fire researcher's ability to understand and describe fire behavior completely. By contrast, component parts of suppression activities such as aircraft, detection devices, fire-line construction and logistics of equipment use are somewhat easier to quantify and to control. Thus, modelling of the physical, rather than the biological, processes should be emphasized in support of maximum efficiency of fire control operations. The systems approach and simulation techniques appear to be increasingly useful for identifying the component parts and inter-relationships of the diverse activities involved in modern fire management decision-making and operations. Conceptual modelling should be concerned with all aspects of the fire management system – fire behavior, fire weather, fuels, fire-line productivity, resource allocation, etc. – including linkages between these components. By increasing our understanding of the system, models provide a framework or "blue-print" for structuring the research effort and for determining data needs. Furthermore, they should prove useful in providing an immediate "best" answer to a question based on presently available knowledge, rather than having the user wait for the final solution. In this context, the systems approach should be viewed as a joint activity involving scientists familiar with knowledge about fire behavior and fire control activities and scientists familiar with the structuring of this knowledge with the aid of simulation models and computers.

The nature and scope of the CFS fire research program is limited by available manpower, funding, logistics of data gathering and lack of in-house expertise in some work areas. Closely related, but outside the control of the CFS, is the important function of putting research findings into operational practice. Owing to the desirability and indeed the necessity to gear the research effort to meet the real needs of fire management agencies across Canada, more emphasis needs to be placed on ways and means of cultivating attitudes and procedures to facilitate the continuous flow of information from research to testing to final policy implementation. As present-day fire control evolves toward fire management, the CFS fire research effort will probably become more inter-disciplinary, with greater consideration being given to fire ecology, resource values, economics, fire weather forecasting and use of computers for information storage and retrieval. It is therefore essential that the program be developed in response to operational procedures and requirements with the greatest opportunities for improvement in efficiency and effectiveness, rather than become increasingly involved in devising elaborate predictive systems and in providing detailed descriptive data on forest fires, fire behavior, airdrop characteristics of individual aircraft and related activities. Better appreciation of the probabilistic nature of fire incidence, behavior and related processes would increasingly suggest that we need to answer such questions as: to what extent is additional work on a problem or system likely to contribute to a significant improvement in fire management?

DEGREE OF OPERATIONAL INVOLVEMENT

Fire researchers throughout Canada have enjoyed a greater degree of cooperation and direct operational involvement with user agencies than most other disciplines in the Canadian Forestry Service. This operational involvement has not developed by accident; rather, it has been considered a key element in the development of any fire-related work at the regional level. In fact, the user agencies have been invited to define problem areas, to establish work priorities and to get directly involved in project work by assigning a representative to at least monitor progress throughout the study period. Having established this level of cooperation and involvement, fire management agencies are likely to be more sympathetic to the needs of researchers to have access to operational

methods. The researchers on their part must respect the confidential nature of this information. Opportunities for active involvement in fire management operations by fire researchers depend largely on the needs and attitudes of the operational agencies. The ability of individual fire researchers to promote the implementation of new concepts and procedures is another important factor determining the impact of the CFS contribution in this area.

ADVISORY GROUPS

It is CFS policy to seek the counsel of advisory committees in identifying problems and in appraising programs. Advice on the CFS fire research program is received from the Canadian Committee on Forest Fire Control (CCFFC), which serves as a forum for all provincial and federal fire control agencies in Canada. At the regional level, advisory committees and groups have been established to advise on fire problem identification and program balance. Internally, a CFS Fire Research Program Advisory Group (FRPAG) composed of Directors or Program Managers from various establishments, has been formed to review and to propose an approach to improve coordination and integration of the fire research program. Working groups of fire researchers will continue to meet and to provide the in-depth technical expertise to facilitate program development in specific problem areas.

The advisory committees, workshops, seminars and other informal contacts with client agencies have served the purpose of program review and problem identification but they have generally not provided the mechanism to facilitate the early implementation of research findings. Inter-agency agreements, task forces and designation of project officers by client agencies represent possible approaches towards improved communication and early application of research results. Failure to initiate and maintain close communication between the researcher and the fire manager is likely to result in a lack of appreciation of what is available and delay the implementation of potentially useful findings.

PROGRAM AIMS AND PRIORITIES

To facilitate program planning and to provide a basis for discussion and clarification of objectives, the primary aims of the fire research program are stated as follows:

1. To develop methods for predicting occurrence of wildfires, and behavior of wild and prescribed fire.
2. To improve existing and to develop new methods and techniques so as to enable fire management agencies to assess and optimize effectiveness of fire suppression operations.
3. To understand the natural role of fire and fire effects on the environment and to develop concepts and procedures whereby this information can be integrated into fire management plans and operations.
4. To monitor, develop and standardize new fire management concepts, systems, planning aids, information sources and other background material so as to enable fire management agencies maximize net social and economic benefits from fire management across Canada.

A review of ongoing projects and studies indicates that much of CFS fire research has the primary aim of predicting fire occurrence and behavior. However, optimization of effectiveness of fire control operations and development of planning and decision-making aids are increasingly important program activities at some Centres. Several studies are concerned with fire ecology and effects, but CFS involvement in this work area remains relatively minor. Ongoing programs in fuels, fire behavior prediction, prescribed burning and fire effects should continue but the potential for significant pay-offs from greater CFS involvement in suppression and fire management systems research and development needs to be fully evaluated. Opportunities for initiating and developing such programs vary from region to region, but most user agencies appear willing to cooperate provided the study is likely to produce useful results in the foreseeable future.

Increasingly heavy demands are being placed on fire researchers to provide answers to a wide variety of research and operational problems. While some minimal increase in fire research staff and funding may be

expected at some establishments, significant shifts in program content and priorities must nevertheless be accommodated internally through termination of ongoing projects, resignations or retirements. Again, concentration of expertise at a few locations is essential, particularly in view of the trend towards fire management involving the role of fire and fire control in the broader context of resource management. These and related considerations point to the desirability of increased emphasis on the following activities:

1. Resource valuation and damage appraisal schemes to enable fire management agencies to establish priority zones for fire-fighting and to more realistically determine savings in suppression costs and resource damage that may be expected from a particular policy. It is recognized that this is necessarily an inter-disciplinary effort but fire researchers might well take the lead in defining the problem and in developing an approach to its solution to satisfy needs of fire management agencies.
2. Knowledge of natural fire incidence and effects is basic to further development of fire management. A national burned area inventory, assessment of detrimental and beneficial effects of fires and joint trials with users to promote application of prescribed fire are examples of possible studies. Some of this work can be handled by fire researchers on staff but considerable involvement by other technical specialists appears desirable.
3. Guidelines for determining the best allocation of funds between prevention, detection, pre-suppression and suppression activities.
4. Guidelines to integrate fire management into multiple-use resource plans.
5. Increased emphasis on determining the optimum strategies and tactics in use of aircraft and retardants.
6. Increased emphasis on fire research in Canada's north. Requests for increased CFS involvement in fire management planning and operations have been made by officials of the Yukon and Northwest Lands and Forest Services, and various National Parks.
7. Initiation of fire research programs, or an increase in CFS contributions in research and development in aid of fire control in Quebec and the Maritimes. Initially, contributions might be made primarily through liaison activities and contract work, by special assignments involving fire researchers at the FFRI and regional Centres, and by establishment of special provincial-federal task forces to resolve special problems.
8. Increased emphasis on development of operational procedures for aerial backfiring and construction of firelines by using explosives.
9. Guidelines for prescribed burning to meet specific forest management objectives, including smoke management.
10. Development of a comprehensive fire-management-related information gathering, storage and retrieval system to satisfy requirements of both client agencies and fire researchers.

STAFF

The existing CFS fire research group consists of about 25 fire research officers plus support staff of about 40. Staff and funds are about equally divided between the Forest Fire Research Institute in Ottawa and regional Centres. More than 80% of the regional staff is found at the Pacific, Northern, and Great Lakes Forest Research Centres. Nearly 50% of the staff is engaged in work related to predicting the occurrence and behavior of wildfires and prescribed burns. Another 25% of the staff time is taken up by studies on suppression methods. Ten percent of the staff is occupied with studies of fire ecology and effects, whereas the remaining 15% contributes to development and maintenance of sophisticated fire management systems, fire control planning aids and systems for storing and retrieving fire-related information.

LABORATORY FACILITIES

The Northern and Pacific Forest Research Centres, the Petawawa Forest Experiment Station and the Forest Fire Research Institute have indoor laboratory facilities to conduct fire-related experiments under controlled conditions. A similar facility will be available at the new Great Lakes Forest Research Centre in 1975. In addition, combustion laboratories are found at several Canadian universities including New Brunswick, Queen's, and Waterloo. It appears that essential laboratory work on fire physics, fire propagation, fire behavior, retardants and associated projects can adequately be handled with existing in-house laboratory facilities or through research agreements with universities. There appears to be little reason for duplicating the facilities at the three major forest fire research laboratories in the U.S.A.

FIRE RESEARCH OUTSIDE THE CFS

Fire-related research outside the CFS is mainly carried out by several universities and other federal government agencies. For the most part, university research is sponsored by the CFS and the Arctic Land Use Research (ALUR) Program of the Department of Indian and Northern Affairs whereas the Atmospheric Environment and the Canadian Wildlife Services of the Department of the Environment and the Department of Energy, Mines and Resources conduct some research and operational programs. Work at universities is concerned with basic fire chemistry and physics, thermo-dynamics and fire modelling. Government-sponsored research and operations are directed mainly toward studies of fire weather forecasting and fire ecology and effects, particularly in relation to wildfire and terrain sensitivity in Canada's north. Some provincial and federal fire management agencies support limited programs of applied research, including testing and evaluation of aircraft, retardants, explosives for fire-line construction, analysis of fire statistics and development of fire-fighting equipment to improve the operational efficiency of fire control. Several ecologists with the Northern Engineering Services Ltd., are involved in fire-related studies along the proposed gas pipeline route adjacent to the Mackenzie River in the Northwest Territories. While each agency pursues its own aims and objectives, there appears to be a need to bring the participants together to discuss program status and to decide if a greater degree of coordination and integration is desirable.

CONTRACT WORK

Since the advent of the Make-or-Buy Policy of the federal government a few years ago, many fire researchers have utilized contract funds to buy information from outside sources. This policy will encourage the building of an expanding research and development competence outside the CFS but the attainment of these policy objectives will require considerable direct participation by fire researchers on staff, at least in the initial stages of such programs. Nevertheless, this approach enables the fire researcher to concentrate on those duties which can only be carried out by individuals with considerable awareness of and experience in fire research and management activities.

The CFS has, in the past, supported fire research at several universities. For example, the Fire Science Centre at the University of New Brunswick is involved with fire danger rating index calculation and forecasting. Studies at the University of Alberta are concerned with fireline construction rates and corrosion rates for chemical fire retardants. Contracts, grants and research agreements with universities should also be expected to provide the CFS with a supply of qualified fire researchers, although it is not at all clear what, if any, increases in funding and permanent staff are likely to materialize in the foreseeable future to provide the necessary incentive for students to consider fire research as a vocation.

INTER-ESTABLISHMENT COOPERATION

The development of a meaningful working relationship between a regional Centre and a provincial or territorial fire management agency should be considered as a cornerstone to facilitate the development and maintenance of an effective research and development program. Primarily as a result of continuous contact with user agencies, fire researchers at regional establishments appreciate and are aware of local needs and opportunities for fire research to solve operational problems. In many instances, short-term studies or interpretation of available information from other areas within the framework of local conditions will satisfy the users' requirements.

Solutions to other problems may require in-depth research or expertise from other Centres or the FFRI. The FFRI has the primary role to develop and conduct a program of research and development which is Canada-wide in scope and application. It might also be involved in programs best carried out at a central location, i.e., one-of-a-kind laboratory and computer facilities. In general, FFRI might be expected to emphasize work which is national in scope and has the potential for significant longer-term payoffs in terms of development and application of modern fire control technology, including computers and electronics.

Some studies and projects, although regional in origin and input, are of interest and value to all fire control agencies in Canada. Work in fuel description, fire danger rating, prescribed burning, airtanker and retardant evaluation, allocation of fire control funds, damage appraisal, fire control planning aids, fire management systems and development of modern detection techniques and systems are examples of this type of work. There appears little doubt that greater coordination and integration of some of these programs would result in better definition of objectives and earlier completion of a study but this must be balanced against regional priorities and existing limitations in staff and facilities. Aside from the need for greater integration of some studies within each of the four major categories shown in Appendix A, there is also a concomitant need for increased coordination of objectives and programs between categories. This is particularly important in the context of the recent emphasis on the role of fire management in the multiple-use framework.

APPENDIX A

MAJOR WORK CATEGORIES

1. PREDICTION OF FIRE OCCURRENCE AND BEHAVIOR

Covers research on fuels, weather, and fire behavior in support of improvements in predicting occurrence of wildfires and behavior of wildfires and prescribed burns.

a) Studies of forest fuels: spatial variations of fuel components; fuel classification; volatiles in fuels and in air space, fuel sampling techniques; prediction of fuel characteristics; fuel – moisture – weather relationships; fuel energy; guidelines for fuel inventories; seasonal variation in fuels;

b) Investigation of meteorological factors (temperature, relative humidity, wind, precipitation, etc.) and their effects on fire occurrence and behavior; methods of predicting lightning and other weather variables; cloud seeding; wind patterns in forested areas; transpiration and evaporation in forested areas; identification of blow-up conditions; wind-fire relationships; climatic classification;

c) Studies of fuel moisture changes and variations in forest fuels; prediction of moisture content in various fuels; processes in development of long-term drought; fire season periodicity;

d) Investigation of fire behavior interactions; energy production rates; modelling of fire behavior (speed, intensity, impact etc.); fire propagation; studies of factors affecting surface and crown fires; development of methods and techniques for predicting fire occurrence and behavior; procedures and techniques for collecting fire data in laboratory and in field; conditions required for development of "fire storms".

2. OPTIMIZATION OF FIRE CONTROL OPERATIONS

The aim of this work is the testing and optimization of effectiveness of fire control operations.

a) Prevention – determination of sources of fires; development of educational programs to reduce fire starts.

b) Detection – develop effective methods and techniques for fire detection; studies to determine optimum allocation of fire management funds to detection; comparison of effectiveness of tower vs. aerial detection systems; utilization of modern technology; allocation of detection resources.

c) Suppression – development of optimum operational and strategic uses of air tankers, helicopters and support aircraft. Allocation of funds between prevention, detection, pre-suppression and suppression; fire-line construction rates; use and effectiveness of water and retardants in fire control; fire suppression models; cost/benefit analyses; indices of aircraft effectiveness.

3. FIRE ECOLOGY AND ENVIRONMENTAL EFFECTS

Fire history effects and environmental protection (smoke pollution) are becoming increasingly important topics in fire management circles, particularly in Canada's north and near high-density population centres.

a) Fire history including frequency, size-distribution patterns and causes should be determined for broad regions.

b) Pollution indices, plant succession indices, changes in water quality and quantity, erosion, multiple fires in short time-span, wildlife populations and aesthetical considerations need to be clarified and incorporated into fire management planning.

c) Use of prescribed fire in aid of forest management.

d) Development of a rationale to integrate the natural role of fire and its effects on the environment into present and future fire management concepts and operations.

4. FIRE MANAGEMENT CONCEPTS AND PLANNING AIDS

Involves the integration of fire control, prescribed fire and fire ecology into fire management planning, decision-making and operations within a multiple-use framework.

a) To monitor and interpret changes in fire management concepts, systems and applications.

b) To develop plans, systems and guidelines for evaluating resource values in relation to extent and intensity of fire management required.

c) Consideration of jurisdictional aspects of federal-provincial cooperation in fire research and fire management.

d) Development of new methods and techniques to enable fire management agencies to attain desired reduction in costs and damages, i.e., fire management or command centre concept, systems analysis, damage appraisal procedures.

e) Development and innovation of fire management standards to facilitate more uniform fire planning, training and operations across Canada.

f) Development and operation of information acquisition, storage and dissemination systems; fire statistics; planning aids.