ADAPTATION OF A NATIONAL SYSTEM OF FIRE DANGER RATING IN ALBERTA, CANADA: A CASE STUDY IN TECHNOLOGY TRANSFER[a]

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ABSTRACT

In 1969-70 a major research product was introduced to the Alberta Forest Service (AFS) and all other forest fire protection agencies throughout Canada by federal government fire researchers. The Canadian Forest Fire Weather Index (FWI) System, the first major phase of a national fire danger rating system, was accepted and implemented nation wide by 1971. The FWI System was subjected to intense scrutiny and suspicion during its initial years of use in Alberta. However, the gradual and conclusive acceptance of the FWI System eventually resulted. To day, the system's components are utilized in initial attack preparedness planning and other fire management activities (e.g., prescribed fire, escaped fire analysis). This paper describes the technology transfer events over nearly two decades, as user confidence in a major research and technology transfer program developed. The review and interpretation of key factors contributing to successful technology transfer suggest that the process is continuous and complex, requiring coordination and active involvement of both researcher and user.

Key Words: forest fires, technology transfer, fire danger rating, fire research, fire management, Alberta, Canada.

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INTRODUCTION

Wildfire continues to be a major drain on Canada's wood supply, accounting for an estimated 80 million m^3 of gross merchantable volume, or about 55% of the annual harvest (Honer and Bickerstaff 1985). A well-funded fire protection program is fundamental in insuring that investments in intensive forest management reach fruition. As a consequence, fire control remains a high priority forest management activity involving annual expenditures in excess of 250 million CAN$ (Van Wagner 1984). By comparison, annual silvicultural costs amount to an estimated 300 million CAN$ (Smyth et al. 1984).

Modern forest fire management resembles a military operation in its organization and operational implementation. Electronic lightning location systems, sophisticated communication networks, automatic weather stations, computer and satellite technology, and rotary and fixed-wing aircraft are now used routinely for information gathering and fire suppression activities. To control and use fire effectively and safely requires an understanding of the *fire environment*, -- i.e., the surrounding conditions, influences, and modifying forces of topography, fuel, and weather that determine fire behavior. As a result, nearly all fire-prone countries use some type of fire danger rating system as a guide to making fire control and fire use decisions which are cost-effective, environmentally sound, and cognizant of potential wildfire threats to life and property.

The primary purpose of this paper is to describe the technology transfer activities that led to the initial adoption and ongoing adaptation of a national system of fire danger rating, developed by Canadian federal government fire researchers, in Alberta during the 17-year period from 1969 to 1985. The term "technology transfer" as used in this paper refers to the process of providing beneficial new knowledge and technology directly to the user agency (Moeller and Heytze 1981). As participants in the process of moving new knowledge or technology from research to practice, we hope that our experiences will enhance the reader's understanding and appreciation of the events and factors contributing to successful innovation. The views and interpretations expressed here are those of the authors and may not necessarily be shared by others who were involved.

BACKGROUND

Fire Environment of Alberta

Alberta is located in western Canada between latitudes 49-60°N and longitudes 110-120°W. The Continental Divide of the Rocky Mountains forms its southwestern boundary. Two-thirds of Alberta's 644 400 km^2 is forested; the remainder consists of agricultural lands and prairie grasslands. The Boreal Forest Region of Alberta occupies roughly the northern two-thirds of the province and is characterized by level to gently rolling country, limited ground access in most places, and few natural barriers to large-scale fire growth. The subalpine and montane forests are concentrated in the complex terrain associated with the mountains and adjacent foothill areas. Alberta's forest cover consists of nearly equal amounts of coniferous and deciduous types. The fire season normally lasts from April to October, with three more or less distinct periods (i.e., spring, summer, and fall) with respect to potential fuel flammability. Lightning is most prevalent during the summer; a record 125 lightning fire starts occurred in just one evening in 1982. A number of critical synoptic-scale fire weather types, including 'lee cyclogenesis', occur with some regularity and contribute to extreme fire behavior (Gray and Janz 1985). A sustained fire run

run of 65 km in 10 hours occurred in 1968 and 325 000 ha was burnt over during a single day in 1981.

Modern Fire Record in Alberta

The magnitude of the forest fire control problem in Alberta is illustrated in Figure 1. The record for the early years is no doubt somewhat incomplete owing to changes in area protected, detection efficency, and method of cause determination. The following selected measures of fire business in Alberta are therefore based on the 30-year "normal", covering the period from 1956 to 1985:

- Number of fires per year - 694 (42% caused by lightning)
- Area burned per year - 141 818 ha (72% by lightning fires)
- Average fire size - 204 ha (lightning fires - 354 ha)
- Area burned per year as a proportion of protected land - 0.37%
- Annual fire control expenditure-35.4 million CAN$ (constant 1985 $)

These simple averages tend to mask the large year-to-year variations that can be attributed largely to the pattern of fire weather severity and to a lesser extent, fire fighting efficiency and fire management policy. The boreal forest has sustained the greatest fire activity. The largest area burned in a single year was 1.3 million ha (1981), the least was 1 824 ha (1962). If we arbitrarily define a "severe" or "major" year as one in which more than 1% of the current protected area was burned, then at least seven years qualify (1938, 1941, 1949, 1968, 1980, 1981, and 1982). 'Class E' fires (i.e., >200 ha) represent less than 3% of all fires but account for about 95% of the total area burned.

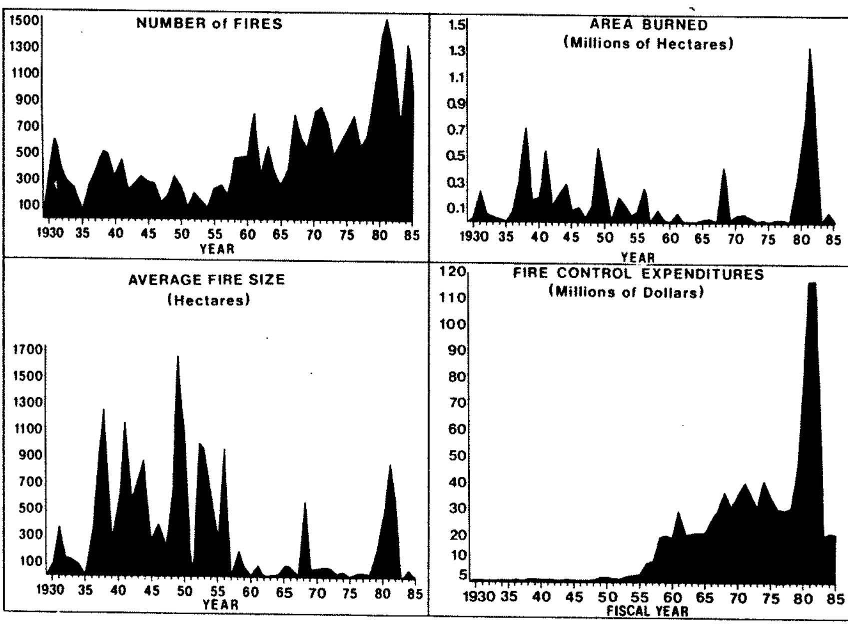


Figure 1. Forest fire statistics for Alberta Canada, excluding National Parks, covering the 56-year period between 1930-85 (data source: annual reports for the Alberta Forest Service). Fire control expenditures for 1930-84 were adjusted to constant 1985 CAN$.

Fire Management and Research in Alberta

Prior to 1930, the federal government was responsible for the development and protection of forest resources in western Canada, including Alberta. In 1930, this responsibility was transferred to the Alberta government, leaving the federal government with a mandate to conduct forest research and to manage federal lands such as National Parks. Virtually all of Alberta's forests are on provincial crown lands. The Alberta Forest Service (AFS) is responsible for forest administration and has become a recognized leader in the development of enlightened policies. Provision of improved fire control capability to protect other forestry-related programs and investments has been a central feature of its ongoing commitment to forestry. Modern fire control efforts in Alberta began in the late 1950s and have continued at an accelerated pace to the present time (Murphy 1985). AFS has operated under virtually a complete fire protection policy since the late 1950s, with an annual allowable area burned objective of one-tenth of 1%. The current strength of the AFS approaches about 700 employees, many of whom are involved in fire operations.

The federal role in fire research can be traced to the mid 1920s. The primary emphasis for more than three decades was on fire danger rating. Until the early 1960s, field research at various locations in Canada, including Alberta, was conducted out of the Ottawa headquarters. The Canadian Forestry Service (CFS) initiated a modest year-round fire research program within Alberta in 1962. In 1967, the unit was transferred from its regional office in Calgary to Edmonton, the site of AFS headquarters. By the early 1970s about 5 university-trained researchers plus support staff were involved in studies pertaining to fire behavior, prescribed fire, fire ecology, fire suppression, and fire management systems. The ratio of effort in research (i.e., systematic search and discovery of new facts) versus development (i.e., modification and adaptation of available technology) has been maintained at the 50:50 level, although the relative allocation of resources has fluctuated between work areas and over time. Owing to provincial priorities and rapid developments in areas of detection and suppression technology, CFS fire research has generally been guided by the need to provide practical answers to pressing operational problems (Kiil 1975, Van Wagner 1984). Nevertheless, the split mandates covering federal responsibility for research and provincial jurisdiction of forest resource management are key considerations impacting on the approach taken to applying research findings.

The increasing sophistication of fire management activities in the early 1960s brought to light the sometimes inadequate training of fire control personnel in relation to their responsibilities and technological innovations. This problem was eventually addressed by the establishment of a 2-year diploma course for forest technicians to supplement ongoing training courses for AFS staff.

Fire Danger Rating Research and Use

The CFS produced the first set of forest fire danger rating tables directly applicable to Alberta in 1948. New improved tables specific to Alberta East Slopes and the Boreal Forest Region of the province were published in 1957 and 1959, respectively. A "Cladonia Fire Hazard Table - Alberta" supplement to the 1959 tables was issued in 1963. The biggest complaint with the 1957 and 1959 tables was that the 16-point index scale was much too restrictive in its evaluation of fire danger. The 1959 tables were used up to and including the 1965 fire season. In 1966, the AFS Forest Protection Branch modified the 1964 version of the

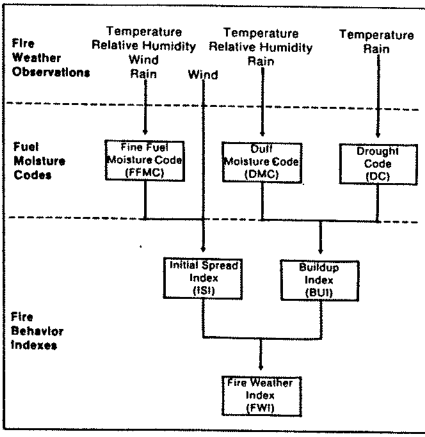
U.S. National Fire Danger Rating System (USDA Forest Service 1964) to suit their specific needs for separate fire danger classes in spring, summer and fall. This method of fire danger assessment was used until the 1971 fire season.

The need for a new, improved national system of fire danger rating was recognized at a CFS fire research staff meeting in 1965. Work on what is now referred to as the Canadian Forest Fire Danger Rating System (CFFDRS) began soon afterwards and has more or less continued uninterrupted to the present day. A modular approach to the CFFDRS was adopted in the late 1960s and the first major subsystem, the Canadian Forest Fire Weather Index (FWI) System (Fig. 2), was initially published in 1970. Technical documentation can be found in Van Wagner (1974). The scientific basis for the system represents a combination of accumulated empirical field data plus experience coupled with simple theory. The FWI System components each represent guides to various aspects of fire potential in a standard fuel type (i.e., mature jack or lodgepole pine) on level terrain, based on four weather observations recorded at noon local standard time (LST). Table and computer computations are both possible. Except for the Fine Fuel Moisture Code (FFMC), which has a maximum possible value of 99, all component scales are "open-ended" (i.e., a higher value, and hence greater flammability, is always possible if the fire weather worsens).

CHRONOLOGY OF EVENTS LEADING TO ADAPTATION

The purpose of this section is to outline the significant events and researcher-user linkages that contributed to the acceptance and refinement of the FWI System in Alberta (Table 1):

1969.— A milestone in the lengthy and involved process of developing a new national system of fire danger rating. Provisional tables for calculation of the FWI System were issued for field trials and a truly national product was scheduled for introduction across Canada. Acceptance of the FWI System by operational agencies, however, was another matter. The system had been developed by researchers in relative



FFMC - A numerical rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel.

DMC - A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material.

DC - A numerical rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and amount of smouldering in deep duff layers and large logs.

ISI - A numerical rating of the expected rate of fire spread. It combines the effects of wind and **FFMC** on rate of spread without the influence of variable quantities of fuel.

BUI - A numerical rating of the total amount of fuel available for combustion that combines **DMC** and **DC**.

FWI - A numerical rating of fire intensity that combines **ISI** and **BUI**. It is suitable as a general index of fire danger throughout the forested areas of Canada.

Figure 2. Structure of the Canadian Forest Fire Weather Index System and definitions of its six components (after Canadian Forestry Service 1984).

Table 1. Highlights of the major innovative activities leading to the adaptation of the Canadian Forest Fire Weather Index (FWI) System in Alberta.

Year	Innovation	Key factors contributing to successful adoption and/or adaptation	Other considerations influencing the adaptation of innovations by user agency
1970	1st edition of FWI System Tables published.	Regional research unit initiates technology transfer effort to promote adoption of FWI System.	New system produced by a national working group involving CFS fire researchers from several locations across Canada.
1971	AFS adopts FWI System phase of CFFDRS.	CFS & AFS agree to adapt FWI System to satisfy provincial needs.	AFS formally agrees to establish experimental burning areas in forest stands. *Forestry Report* series introduced by CFS to facilitate technology transfer.
1972	CFS produces specific fire danger classes for AFS.	CFS provides positive confirmation of FWI System's reliability in Alberta.	AFS develops an index to reflect unique crown fuel flammability conditions in spring. AFS/CFS/university initiated initial attack model linked to FWI System.
1973	FBI calculated at all 150 provincial fire weather stations.	AFS-produced FBI index and FWI System components jointly calculated to test reliability of both.	National meeting to discuss fire danger rating philosophy and application in Alberta. Consensus that cooperation must be voluntary and aimed at producing best product to meet Alberta's needs.
1974	AFS & CFS jointly host major experimental burning project.	National /regional/provincial cooperation involving CFS researcher/AFS user teams.	Experimental burning trials confirmed reliability of FWI System and enhanced credibility of CFS fire researchers.
1975	AFS introduces preliminary 'man-up tables'.	Acceptance of need for more refined decision making aids and guidelines.	CFS and AFS cooperate to develop first generation guide for initial attack man-up.
1977	CFS introduces new spring Drought Code adjustment procedure.	Need to reflect importance of overwinter precipitation on spring burning conditions. Formal regional request to adjust national system.	CFS publishes reports on FWI System calibration & performance in Alberta (co-authored with AFS research liaison officer) & Darwin Lake experimental burning project.
1982	AFS introduces presuppression preparedness system.	Credibility of FWI System and need to link presuppression expenditures and fire danger rating.	AFS experiences severe fire activity during 1980, 1981, and 1982 fire seasons.
1984	1st interim edition of CFFBP System published by CFS.	Need to quantify fire behavior and impact in major forest types.	This major sub-system of the CFFDRS incorporates results of major experimental burning programs carried out in Alberta.

isolation and initial reactions in Alberta were predictable. Table calculations were not overly complex but unfamiliarity with the new terminology and the lack of seasonal adjustments (which were already in place) created some resistance on the part of operational staff.

1970-71.-- The first published version of the FWI System was made available for distribution across Canada, and AFS adopted the system in 1971 (Kiil and Quintilio 1971). Preliminary fire danger classes were provided. Alberta's major concern was the lack of seasonal adjustment for vegetation condition; hence, the CFS designed a spring modification to differentiate between cured and green vegetation. The AFS concurrently agreed to establish a research study area in central Alberta to gauge the FWI system against actual fire behavior in local forest types. National Parks requested only a stylized hazard classification based on relative fuel type differences (Grigel et al. 1971) and both projects were implemented by the CFS. A AFS-CFS task force was established to develop slash fire hazard rating guidelines.

1972.-- Fire danger classes suited to Alberta climatic conditions and fire control needs were implemented. The reaction from the AFS was positive since this initiative recognized regional variations in fire conditions. The first guide to quantitative fire behavior and impact prediction for Alberta was issued, relating fire spread, intensity, and depth of burn in lodgepole pine logging slash to the standard FWI System components (Quintilio 1972). Additional experimental fires were documented in the black spruce and aspen forest types. However, the perceived spring fire problem in Alberta precipitated a provincial initiative in the fire danger rating business. The AFS issued a Foliar Buildup Index (FBI), which was intended to address the problem of early springtime flammability developing as a result of moisture changes in foliage of conifers. The implementation of the FBI was considered a direct challenge to the utility of the FWI System and was viewed with great interest by CFS fire researchers. Calibration of the FWI System against 5 years of actual fire business in Alberta proceeded and results were very beneficial to the continued assessment of the merits of the system. Of particular note in 1972 was the implementation of an initial attack computer simulation model based on 10 years of fire occurrence and weather data from central Alberta (McDonald 1976; Quintilio and Anderson 1976). The intent of the model was to provide the information necessary to man-up initial attack resources based on the FWI System components and risk of ignition. Eventually, over 30 workshop sessions attended by AFS district and headquarters operations staff, CFS researchers, and university consultants were held during a 3-year period to define and construct the model. This initative was to have a significant influence on events in 1973.

1973.-- The logistics of calculating both the FBI and FWI System components at all 150 provincial fire weather network stations precipitated much discussion and comparison and eventually a major national review of the FWI System. AFS protection staff and regional and national CFS fire researchers met in Edmonton to decide the fate of the FWI System in Alberta. The fire weather forecasting unit within the AFS was pushing for rejection of the CFFDRS and additions to the FBI to account for summer and fall seasons. The CFS countered that the calibration projects (e.g., Fahnestock 1975) and familiarity with the new system would demonstrate the reliability potential of the FWI System. The decision reached, after a very stimulating day of discussion, was to continue evaluating both methods. The results of the computer simulation workshops, initiated in 1972, influenced the decision in favor of the CFS recommendations to carry both procedures in spite of the additional workload on field staff.

1974.-- Another milestone, this time combining the expertise of CFS and AFS staff, occurred during the summer. A national project designed to produce a quantitative guide to fire behavior in the jack pine forest type in one field season was conducted in northeastern Alberta. Seven experimental fires were conducted over a range of burning conditions. Results of these trials demonstrated the strong association between fire spread, crowning tendency, etc. and the FWI System components. Researchers and operational AFS staff headquartered at the burning site for the summer developed a strong working relationship under field conditions, and the credibility of the FWI System was enhanced.

1975.-- Initial efforts to hire and allocate initial attack resources based on specific FWI System components began in 1975. Manning tables were designed jointly by AFS and CFS, and then implemented as guide lines (see Kiil and Quintilio 1975); however, major presuppression expenditures were not fully sanctioned.

1976.-- The spring fire problem in Alberta was now being related to winter carry-over moisture deficiency in heavy fuels, rather than the desiccation of conifer needle moisture content supposedly represented by the FBI. The CFS began to adjust the start-up Drought Code (DC) values in the spring to account for variation in the fall, winter, and spring precipitation trends (Kiil 1977). This adjustment proved valuable and formally became an integral part of AFS's annual calculation of the FWI System in 1981.

1977.-- Two major reports dealing with the FWI System in Alberta were published by CFS (Kiil et al. 1977; Quintilio et al. 1977).

1978-79.-- Further experimental fires were conducted and airtanker effectiveness was tested against documented fire behavior on test fire plots. A CFS fire researcher involved with implementation of FWI System (second author of present paper) resigns to take position as provincial fire training coordinator at Forest Technology School (FTS) in Hinton.

1980.-- This was the first of three consecutive record fire seasons in Alberta, and the unusually early season demonstrated the importance of an overwinter adjustment to the spring DC starting value.

1981-82.-- The second and third record fire seasons resulted in major adjustments to the fire protection program in Alberta. Annual 3-day advanced fire behavior course delivered jointly by FTS, AFS, and CFS, began in April 1982 and continued until 1986. A presuppression preparedness (PPRS) or man-up system, linking the FWI System to initial attack (IA) strategy and expenditures, was officially implemented in 1982 to augment a province-wide airtanker program already in place (Gray and Janz 1985) This procedure provides a forecasted preparedness level based on three components of the FWI System (Fig. 3). Once the daily level has been determined, forest protection officers have about 18-20 hours lead time to assemble and deploy resources prior to the peak of the next burning period. Each level has a minimum resource requirement designed to meet predicted fire incidence and severity potential. Elapsed time standard are also set (i.e., acceptable attack time from point of dispatch to first suppression action on fire).

1983-85.-- These 3 fire seasons provided the opportunity to test the PPRS and confirm the merit of the FWI System/man-up link during periods of normal to extremely high fire incidence. Analysis of selected aspects of 1980-82 fire seasons was undertaken jointly and separately by AFS and CFS. An interim edition of the Canadian Forest Fire

Behavior Prediction (CFFBP) System--the second major subsystem of the CFFDRS--was released in July 1984 (Lawson et al. 1985). Joint AFS/CFS experimental burning project in black spruce was undertaken during 1984-85.

SOME LESSONS FOR TECHNOLOGY TRANSFER

As participants in the technology transfer process over a 17-year period, our impressions generally fall within the framework and findings others (e.g., Moeller and Heytze 1981; Moeller and Seal 1983; Callaham 1984). This is not surprising considering the ongoing nature in of the process, the problem-oriented approach to research, and the orientation of both research and operational organizations toward relatively rapid change and technological innovation. In a broad sense, the early 1970s can be characterized by a researcher "push" for application of research findings, followed by a user "pull" for new knowledge and products in the late 1970s and early 1980s. In the context of the present study, the following observations and lessons are judged to be especially critical for successful technology transfer:

1. Technology transfer opportunities and goals should be identified at early planning stages of a research project, followed by ongoing review and modification. A degree of flexibility is particularly significant in fire research because fire incidence and severity are cyclic phenomena and tend to generate unexpected opportunities and demands for technological innovation.

2. Formal and informal channels of communication are crucial for successful technology transfer. Advisory committees, task forces, semnars, training sessions, assignments for researcher-user teams on wildfires and prescribed burns, and field demonstrations are effective communication methods to develop awareness and interest in applications. At the personal level, a willingness to respond to requests for information and to deliver the intended product will establish the

MAN-UP TABLE

Fine Fuel Moisture Code (FFMC)	Buildup Index (BUI) 0 - 25	26 - 60	61 - 85	86+
	PPRS Preparedness Level			
0 - 84	I	I	II	II
85 - 88	I	II	III	III
89+	II	III	IV	V*

*Level VI is in effect when the **Drought Code (DC)** is 300+.

RESOURCE BUILDUP GUIDELINES

PPRS Preparedness Level	Seasonal I.A. Crews	Initial Attack (I.A.) Committments: Eight-man squad	25-man crew	Rotary-wing: Light	Rotary-wing: Medium	Cost Per Day (1985 $)
VI	X*	8	3	8	5	53 976
V	X	5	2	8	2	34 068
IV	X	3	2	6	1	23 446
III	X	3	1	6	0	16 062
II	X	3	0	4	0	9 960
I	X	0	0	0	0	—

* Regular complement of resources assigned for the entire fire season. Therefore, no additional costs are incurred.

Figure 3. The major features of the Presuppression Preparedness System (PPRS) used by the Alberta Forest Service during the 1985 fire season.

credibility and profile of the researcher. The maintenance of an effective working relationship will enable the researcher to influence the user's attitude about research products and selected aspects of operational fire management when requested.

3. Results of problem-oriented research should be disseminated to users as soon as possible. Scientific publications are essential for the researcher and for his peers, but of limited value to most users. Coauthorship with users is recommended, but increasingly, many innovative activities can best be served by other information dissemination methods. Outlets for applications may be in the form of computer programs, operational manuals, technical guidelines and field aids, or staff secondments.

4. Confrontations between researchers and users about new contributions to existing programs can, if addressed properly, lead to more rapid and optimum solutions to problems.

5. Cooperative arrangements involving researchers and users are often effective and sometimes essential for attainment of research goals and operational targets. In fire research, field studies and demonstrations of fire behavior on provincial lands can only be carried out with the support of the fire control agency. Study teams involving researchers, users, and modellers, as in the case of the initial attack simulation referred to earlier, can work harmoniously to achieve common objectives, as well as ensuring immediate acceptance of results. This is not surprising since both researcher and user will consider the product as their own.

6. Technology transfer is ongoing. The publication and application of a national fire danger rating system was a major research product in 1970, but the systematic use of its component parts in support of different fire management activities required further research, evaluation, and adaptation to more sophisticated uses.

7. The hierarchies of the research and client-agency organization determine the likelihood that innovations are encouraged or discouraged. Policies and attitudes change over time, and the participants in the technology transfer process must be cognizant of and sensitive to the attitudes and perceptions of senior managers as well as technical and field staff. Formal reporting relationships and communications channels may impede technology transfer.

8. The research agency must pay special attention to the interaction of units responsible for national and regional research and technology transfer. The development of a national fire danger rating system in 1970 was the product of joint planning and research by researchers at both the national institute and at regional establishments. A CFS national working group coordinated the research and development work leading to the publication of the tables and maintained an ongoing lead role in producing new knowledge while preserving the integrity of the national system. This relatively informal arrangement has been instrumental in facilitating the refinement of system components and in improving the linkages between researchers and users.

9. Technology transfer is concerned with a complex set of activities from research to development to acceptance of some product by the user agency. Ideally, the researcher is in the best position to couple his creativity and knowledge with the operational needs of the user. Unfortunately, current award systems for research scientists give less than adequate recognition for technology transfer activities.

10. The research and development activities that resulted in specific adaptations of the national danger rating system required from one-half

to 6 years of effort. Application usually occurred within weeks or months of work completion. The ensuing scientific or technical papers were published from 1 to 4 years later, although implementation guidelines were prepared much earlier.

11. The effectiveness of technology transfer in fire management can be improved by combining the skills of several research fields. Applications of simulation modelling principles and procedures, operations research, and related systems-based approaches have proven themselves during the course of this case study.

CONCLUDING REMARKS

The introduction of the FWI System in 1969-70 precipitated a chain of events that eventually bridged the gap between a problem-oriented research unit and a progressive user agency. The ultimate result demonstrates that research needs a responsive and motivated user, and that a user needs new and innovative ideas developed from systematic research. Technology transfer is the process that maintains the relationship. Optimization of the process requires a mix of planned approaches and initiatives, but flexibility to pursue promising new leads or to respond to urgent requests for new products is sometimes essential and should not be neglected. Given the different mandates, responsibilities, and program requirements of researchers and users, it is absolutely essential that priority be given to the fostering of mutual understanding and appreciation of each other's perspectives and concerns. While each situation needs to be judged on its own merits, the willingness of the research agency to consider a part of its program as being "client-driven" will likely enhance early application of research results. Similarly, the user agency can priorize the need to adopt new knowledge and technology by actively supporting and acknowledging research productivity. Notwithstanding the importance of the contributions made by policy-makers and senior managers, mutual involvement by researchers and actual users of new products is also of utmost importance. Collaboration at all levels is considered to be a cornerstone for successful technology transfer and must be a recognized responsibility of all participants.

While research organizations appear to be increasingly mission-oriented in their program activities, this does not ensure that they are organized for technology transfer or likely to produce operationally useful products. Research station publications and journal articles remain as the primary products for the evaluation of a research er's productivity, but they are often unsuitable or untimely for satisfying technology transfer needs. Research organizations can enhance their effectiveness by identifying an organizational focus for technology transfer activities, followed by emphasis on planning of innovative activities, development of a positive attitude toward the need for applications of research products, and training of staff to carry out their duties as effectively as possible. The latter activity appears to have special merit in the case of "entry-level" researchers and for well-established scientists who are interested in gaining wider recognition for their research efforts.

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