forestry report

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Integrating fire research into forest land management

In this issue:

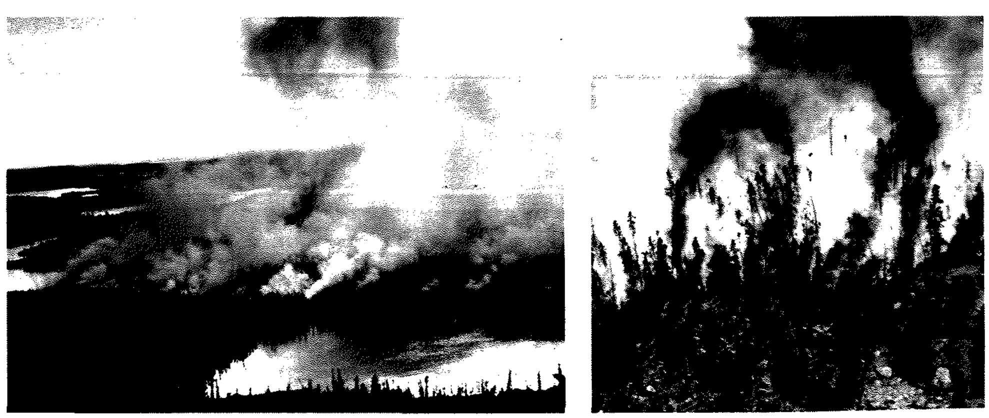
Fire

Fire is an important natural process that affects in many different ways the use and enjoyment of forest-land-based resources. Despite variable climatic cycles, an increase in man-caused fires, and a doubling in the area being protected (currently about 1 500 000 km² or 580 000 miles²) in Alberta, Saskatchewan, Manitoba, and the Northwest Territories, the three provincial fire control agencies have managed to reduce the size of the average fire to less than one-half of what it was about 30 years ago. In the Prairie Provinces and Northwest Territories this fire control effort costs more than $15 million annually. Losses of timber, wildlife, watershed, recreation, and other forest-land-based resources caused by fire are conservatively estimated to be at least equal to or in excess of fire control expenditures.

While traditional principles and practices of fire control are as valid today as they were 50 years ago, significant changes in forest management and forest land use by the general public are exerting greater pressure on fire control agencies to achieve sometimes apparently conflicting objectives. On the one hand, fire control is necessary to protect timber. On the other hand, the development of land use plans that encompass broader uses of forest lands than timber production implies that fire control should be incorporated into the integrated forest-land-use planning process. Human judgments about the damaging and beneficial effects of fire are central to the development of effective forest-land-use planning guidelines. In this sense, the term fire management describes all fire-related concerns — social, economic, political, and environmental — as viewed from the perspective of integrated forest-land-based resource management.

Fire-related factors of relevance in forest-land-use planning include justification of an appropriate level of fire protection according to the values at risk, preparation of cost/benefit analyses, the attainment of fuel management objectives through appropriate resource management, consideration of duration and intensity of climatic and other natural cycles, the preservation of the primeval or unimpaired condition of some areas (wilderness, national parks), and assessment of both short- and long-term consequences of a particular fire management policy. Fragmentation of forest, water, recreation, and wildlife resource management responsibilities among several agencies is sometimes a deterrent to meaningful integration of planning and operational activities. The far-reaching consequences of current resource management decisions lend weight to the importance of planning and operational guidelines as key ingredients of the process of forest land management. Undoubtedly, forest land management is going to get more complex, particularly the integration of forest protection and resource management activities.

In this region, fire management covers a wide range of activities from simple monitoring of wildfires in the far north to relatively sophisticated planning and operations in southern areas. With this diversity in mind and in response to ongoing and anticipated forest land management programs and needs, the fire research program at the Northern Forest Research Centre is increasing its emphasis on integration of research findings into a systems framework. We intend to emphasize the development of fire management alternatives in relation to integrated forest land management objectives. The products will be in the form of decision-making aids on cost/effectiveness, fire behavior, fire detection, suppression options, adverse and beneficial effects of fire on forest-land-based resources, and policy development. For best results, we will depend on regional fire and resource management agencies for their continued interest, cooperation, and support.



Wildfire in black spruce, Northwest Territories

Water-thickening compounds — how effective are they?

Canadian fire control agencies annually use about 7000 kL (1.5 MM gal) of thickened water, or so-called short-term retardants, for aerial wildfire suppression. The PBY-5A Canso, a water-skimming aircraft, continues to be the most commonly used airtanker for delivering these products to the fire.

Recent operational experience and research findings by the Canadian Forestry Service have raised some questions about the merits of water-thickening compounds. This report identifies and discusses some of the key factors influencing the cost/effectiveness of water thickeners in aerial fire control operations.

Compared to the combustion-inhibiting properties of long-term fire retardants, plain water and thickened water can truly be termed short-term retardants. They are generally applied directly onto fires to suppress them rather than being relied upon to retard combustion. In the past, several products displaying water-thickening characteristics were marketed, including bentonite clay, algin gel, and natural and synthetic polymers (e.g., Gelgard). Only Tenogum, a vegetable gum-based water-gelling agent, is currently available; however, a modified Gelgard can be obtained upon special request.

Originally water thickeners were used to provide a thick coating of water on the fuels that would resist ignition and fire spread over a longer period of time than plain water could. Early reports concluded that oxygen exclusion and reduced evaporation made these coatings more effective than plain water, at least in inhibiting low-intensity laboratory fires after short drying periods. However, recent studies at the Forest Fire Research Institute in Ottawa suggest that differences between Tenogum-thickened water, mixed to the manufacturer's specifications, and plain water as either a suppressant or a retardant are insignificant. These tests with slash fuels have shown that twice as much Tenogum-thickened water may be required to do the same job that plain water does. Increased surface tension and subsequently reduced penetration of slash fuels are cited as the primary reasons. These observations and measurements will be assessed under field conditions during forthcoming burning trials in Alberta designed to provide a sounder base for determining the merits of water-thickening compounds and long-term retardants.

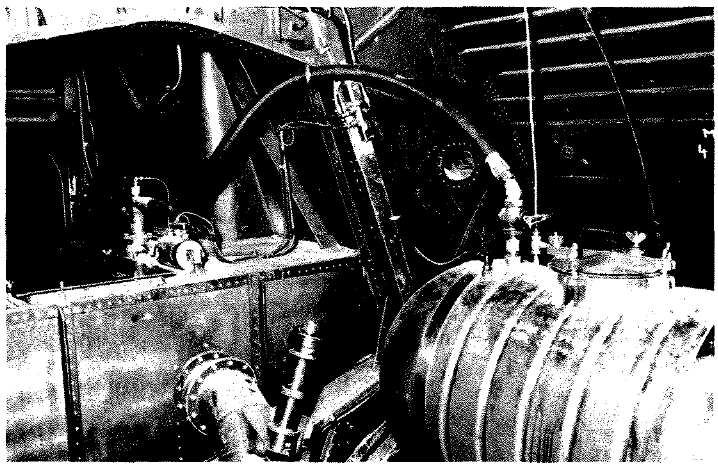
Another desirable attribute of thickened water would be increased load cohesion during air drops. Gum-thickened long-term retardants have been shown to provide much improved volume recovery and more uniform drop patterns from drop heights in excess of 30 m (100 ft). We must recognize, however, that relatively slow skimmer aircraft like the PBY-5A Canso rarely drop from heights of greater than 30 m (100 ft) over the forest canopy.

The effectiveness of thickened water depends to some extent on the quantity and arrangement of fuels between the base of the flames and the airtanker. For example, open drop tests conducted by the Northern Forest Research Centre in 1968 with Gelgard and water in dense vertical fuels indicated that canopy retention was 48% of the recoverable volume of water and 54% of the recoverable volume of Gelgard, based upon the average recovery of each. As a result, average ground patterns for water were superior at the more concentrated recovery levels of 0.18, 0.25, and 0.38 mm (0.07, 0.10, and 0.15 in.) because of the better drip-and-run or throughfall characteristics of water. These trade-offs between canopy retention and surface fuel wetting must be considered by user agencies in terms of local fuel and fire conditions.

The presumed ability of water-thickening compounds to effectively reduce the rate of evaporation of applied water would favor their use. However, limited laboratory tests by the Canadian Forestry Service have not shown marked differences between evaporation rates of Tenogum and water. We have therefore begun a series of field trials aimed at documenting the relative evaporation rates of water and Tenogum under actual fire conditions.

It is reasonable to expect that the water-retention properties of thickening agents should persist in the presence of fire-generated heat as well as under ambient conditions. However, this did not hold true for several Tenogum mixtures tested at the Northern Forest Research Centre. Under laboratory conditions, samples ranging from 300 to 1100 mPa. s (300 to 1100 cps) lost virtually all of their original viscosity almost instantly when exposed to flames in the 427 to 927°C range. Similar observations have been made during experimental burns involving slash fuels treated with Tenogum. On the positive side, the reduced surface tension should increase fuel surface penetration, provided that simultaneous evaporation losses are not excessive.

PBY-5A Canso bomber dropping 3650 L (800 gal) of Tenogum-thickened water



Pressurized storage hopper and Tenogum injection system on board a PBY-5A Canso bomber (Fairey conversion)

There appear to be several constraints associated with the operational use of Tenogum. The first concerns the amount of powder required to adequately thicken a volume of water to improve load cohesion and, most importantly, to reduce evaporation during free fall and at rest. For example, the present Canso injection systems (Field and Fairey conversions) have a relatively low upper limit on the amount of powder that can be pressure-fed into the tank(s) during the short 10- to 15-second water pickup time. Depending upon the hopper pressure, a time lag of between 10 and 19 seconds will be required to inject .35% by weight of Tenogum powder through these systems during water pickup. Such mixtures should yield viscosities in the order of 500-600 mPa.s (500-600 cps) at ground contact (Brookfield viscometer, spindle #2 or #4 @ 60 rpm). However, drop trials in Saskatchewan during the summer of 1977 did not yield such results, largely because of the effect of dissolved salts (magnesium, calcium, sodium, potassium), which drastically reduced measured viscosity. As a result, laboratory tests have been undertaken at the Northern Forest Research Centre to measure the tolerance of Tenogum mixtures to various levels of water hardness. Even when these effects are accounted for, it remains to be seen whether viscosity levels attained to date are useful under wildfire conditions.

A second operational concern is the manner and rate at which Tenogum hydrates and thickens. Both laboratory and field trials have demonstrated that the viscosity achieved by Tenogum during the first 20 minutes after water pickup is very low, almost waterlike. However, once released from a Canso, it will respond to shear forces and thicken during the release and free-fall stages, eventually achieving a viscosity of 500-600 mPa•s (500-600 cps) at ground contact. This phenomenon was demonstrated recently when a DC-6B airtanker was used to drop a 0.5% Tenogum mixture prepared with an in-line continuous induction mixer. Although a viscosity of only 100 mPa.s (100 cps) was recorded in the tank, 1 hour later the sample recovered immediately after the drop measured 1400 mPa•s (1400 cps) (Brookfield viscometer, spindle #4 @ 60 rpm). Laboratory trials, however, have shown that such mixtures do not respond to shear forces during the first 8 minutes after the powder has been added to the water; only after an 8- to 10-minute hydration period does drop height and/or drop speed contribute towards final viscosity at ground contact. A required minimum hydration period such as this limits the operational use of Tenogum where short turn-around times prevail, such as with skimmer aircraft.

The presence or absence of color seems to be of little significance to Canso pilots. Like drops with plain water, viscous water drops are repeated frequently enough during a suppression operation that pilots can generally rely on changes in the fire behavior or reflected light or wet patches to indicate where a previous load was placed. Moreover, Tenogum mixed according to manufacturer's specifications is not readily visible when applied to dark-colored fuels such as coniferous canopies.

It is questionable whether the benefits attributed to water-thickening compounds exceed their cost when they are used with water-skimming aircraft. Tenogum requires a minimum .35% mixing ratio before any appreciable viscosity can be demonstrated, and the cost of such a mixture is in the order of $80 per 3650-L (800-gal) load over and above the airtanker operating costs for dropping water alone. Depending on individual lease arrangements, the cost of delivering a load of Tenogum could possibly be double that of a similar load of water. However, researchers, users, and manufacturers are continuing their effort to better understand the role of water thickeners and develop products that are both effective and reasonably priced, particularly for water-skimming operations.

Coping with forest residues

Natural and man-made disturbances such as windthrow, forest fires, insect epidemics, logging, oil exploration, and land clearing operations contribute to the accumulation of forest residue. The resulting amount, distribution and condition of foliage, unmerchantable branches and stems, cull logs, or even entire trees may modify site physical characteristics and nutrient conditions, hinder planting crew efficiency, influence suitability of the habitat for wildlife, increase the fire hazard, or affect recreational opportunities. Management agencies are cognizant of residue problems and interested in appraisal methods and treatment guidelines to attain specific management objectives.

In the three Prairie Provinces alone, an estimated 40 000 ha (99 000 acres) are logged annually, resulting in slash accumulations from a few tonnes to well in excess of 240 t/ha (100 tons/acre). Other land-use activities, including land clearing by settlers, seismic line construction and road building, also create heavy loadings of dead vegetative matter on thousands of hectares annually. Debris problems are most acute following natural disturbances such as windthrow, red belt, and insect epidemics.

Full exposure of such fuels to the drying effects of the atmosphere increases their flammability — a condition that may warrant special measures to reduce hazard to an acceptable level. The final decision about the most appropriate debris treatment method should also consider the fire hazard in the surrounding area, the size and location of the area affected, the ability of the management agency to cope with the increased risk and fire hazard, and related multiple-use management objectives and activities. Intensification of forest land management activities — whether for timber, wildlife, water, or recreation — will increase the need for debris appraisal and treatment guidelines.

In Alberta, concern about the fire hazard of logging slash led to the initiation of research studies to characterize these fuels in order to develop a fire-hazard rating scheme. For the fuel characterization phase of the study, we felled, measured, and weighed the crowns and unmerchantable tops of nearly 400 individual lodgepole pine, white spruce, black spruce, and alpine fir covering the full range of diameter classes found in Alberta. Correlations between tree descriptors (dbh, crown width, tree height, crown length) and weight of various crown and stem components (needles, various sizes of branches, stem wood) provided fuel weight prediction equations and tables. The relatively high correlations between weights of crown components and individual tree parameters suggest that the prediction equations provide reliable estimates over a wide range of sites, stand types, and tree sizes.

This information, when used in conjunction with stand tables (number of trees per hectare by dbh class) or measurements of single-tree parameters (crown width, tree height) on large-scale aerial photographs, provide the basis for estimating the loading and related characteristics of fuels to be expected

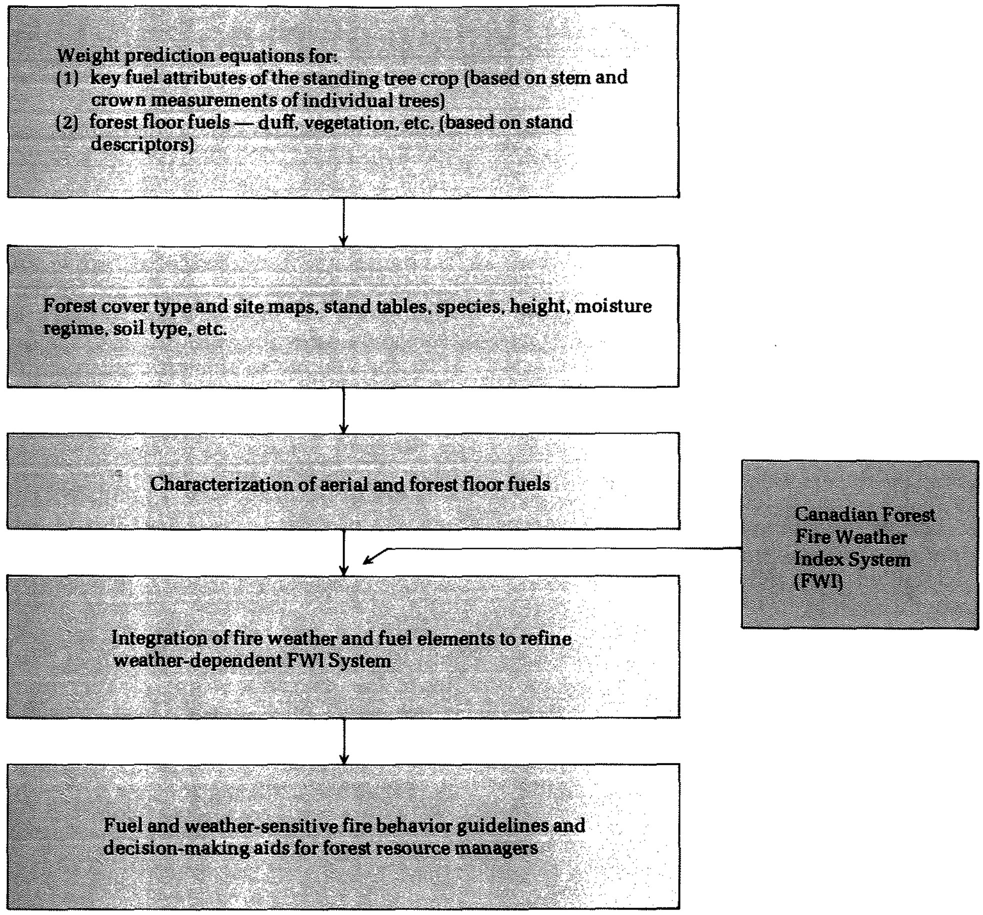
Logging residue

following harvesting. Since the method is based on single-tree measurements, it can also be used to estimate debris accumulations following any forest disturbance by using standard inventory information.

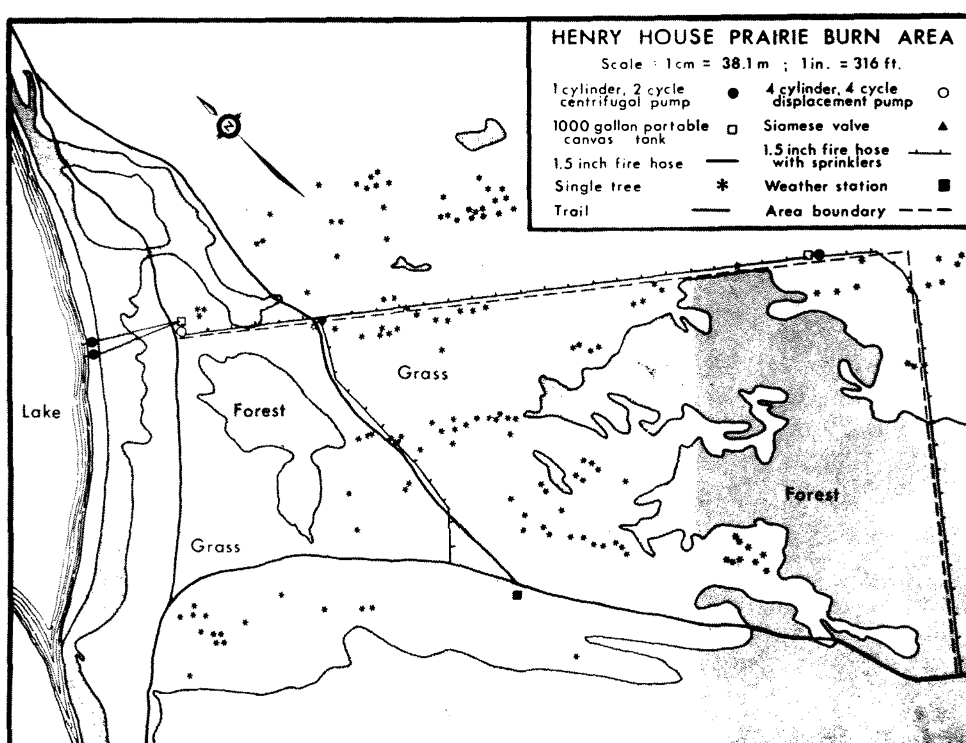
To test the reliability of the slash weight equations, we calculated weight for 23 forest stands for which stand tables were available. For purposes of comparison, a line intersect survey was run on 27 clear-cuts. The two methods were applied to a variety of cover types in different locations. Direct comparison between the two methods is particularly difficult in overmature decadent stands where preharvest debris is not easily distinguished from the material left by the harvesting operation; nevertheless, the test results are promising. Weight of slash less than 10 cm (4 in.) in diameter averaged 47 t/ha (21 tons/acre) for the indirect method, compared to 45 t/ha (20 tons/acre) for the line intersect method.

We have also completed a field sampling program to provide a basis for predicting the weight and depth of the forest floor from site and forest cover type descriptors such as moisture regime, stand age, density, and height. Work is now underway to develop a computerized system for characterizing fuel attributes of major forest cover types, including fuel loading, arrangement, and condition brought about by harvesting or other disturbances. This information, when combined with the components of the Canadian Forest Fire Weather Index system (FWI), helps define the interaction of fuel and weather factors on fire behavior.

This method of appraising fuel characteristics and fire behavior was used by an Alberta Forest Service task force charged with the responsibility of determining what the fire hazard is following logging and developing guidelines for treating forest residues. They developed a fire-hazard rating scheme that consists of numerical point ratings for each of: (1) risk (lightning, man), (2) rate of spread (slash weight, depth, continuity, and condition; snags; lesser vegetation; slope and aspect), and (3) resistance to control (depth of duff, log weight, slope and condition of terrain). The points assigned to each factor are totalled to yield indices for risk, rate of spread, and difficulty of control; the task force used combinations of these indices and FWI indices to prepare guidelines that will aid resource managers in deciding on the most appropriate slash treatment method to satisfy silvicultural and fire control objectives. It is conceivable that similar guidelines for planning an appropriate level of fire control in response to changes in risk and hazard caused by debris and assessing the optimum location, size, and shape of individual clear-cuts before logging to best satisfy broad resource management objectives will also be developed.



Information used in the forest fuel appraisal and fire behavior rating process.



Vegetation types and location of fire lines and equipment in prescribed burn area, Jasper National Park

Prescribed burning in Jasper National Park

Fire history studies in the Athabasca Valley of Jasper National Park have confirmed that fire has played an important role in the development and maintenance of the plant and animal life in the park. This information has encouraged park officials to seriously consider new approaches, alternatives, and strategies to complement present fire suppression policies. Prescribed fire is one useful management tool that may provide a means of simulating the natural fire regime in the valley without the high risks associated with wildfires. Obviously, wildfires cannot be tolerated in the more heavily developed valley corridors.

In the summer of 1976, Parks Canada and the Northern Forest Research Centre embarked on a prescribed fire program at Henry House Prairie, 13 km (8 miles) north of Jasper townsite. The objectives of the program are to examine the role of fire as an effective management tool in perpetuating natural systems in the valley corridors of Jasper National Park; to assess the effects of fire on vegetation, wildlife habitat, and other physical factors; to provide a basis for developing and formulating fire management plans; and to inform the public about the role of fire in the environment, including the development of interpretive programs. The Northern Forest Research Centre is responsible for all research functions; National Parks will supervise the operational aspects of the experimental program.

Approximately 14 ha (35 acres) of forest and grassland were selected and divided into two contiguous units of 3 ha (7 acres) and 11 ha (28 acres). The site is dry and well drained, resulting in sparse vegetation cover and fuel loading. June grass is a major component of the grassland; the forest is dominated by lodgepole pine, with buffalo berry and ground juniper the common understory shrubs.

A standard fire weather station was maintained on site several weeks prior to burning. Weather was monitored throughout the summer months, and the Canadian Forest Fire Weather Index (FWI) was calculated at 1:00 p.m. daily. Fuel weights and moisture contents of key fuels prior to burning are shown in Table 1; the burning prescription and actual weather conditions are given in Table 2. Throughout the afternoon, temperatures increased to 22°C and relative humidity dropped to approximately 34%, thereby improving burning conditions.

A water curtain with sprinklers spaced every 30 m (100 ft) was established on the east and south boundaries of both units. This system, operating 2-3 hours before ignition and during the actual fire, provided a continuous overlapping wall of water. The flanks opposite the water curtain ran parallel to an existing trail that served as an effective fire guard. Conventional firelines, such as bulldozer and handlines, were not employed because of the extreme sensitivity of the site to mechanical damage.

Unit 1 was burned at 2:30 p.m. on 23 September 1976. Headfire ignition proceeded along the south edge of the unit in the open grassland. Sparse fuels and low wind speed hindered fire spread and prevented a uniform burning pattern. As the fire moved under the forest canopy where ground fuels were heavier, fire intensity and rate of spread increased considerably. Juniper shrubs burned vigorously and sometimes acted as a ladder fuel, resulting in candling of individual pine trees. The burn pattern was uniform under the forest canopy, with depth of burn being greater at the base of trees where litter accumulations were heaviest.

The eastern half of Unit 2 was ignited at 3:40 p.m. on the south boundary. Although more wind was evident during the second burn, the lodgepole pine stand prevented it from having a marked effect on fire spread. Also, herbaceous fuels under the protecting canopy were not fully cured, resulting in spotty fire spread. When the fire moved out onto the open grassland at the north end of Unit 2, the influence of the wind was more pronounced, resulting in fairly rapid spread rate of about 10 m/min (35 ft/min) even though fuels were much lighter here than under the forest canopy.

Fire spread in grass at Henry House Prairie

Prescribed fire was safely and economically introduced into Jasper National Park by park personnel, who benefited from the field exposure to prescribed burning principles and procedures. Research and operational information obtained from this fire, together with that which will be collected in subsequent burnings, will assist park managers in developing a fire management plan consistent with resource management objectives.

Table 1. Loading and moisture content of fuels, Henry House Prairie

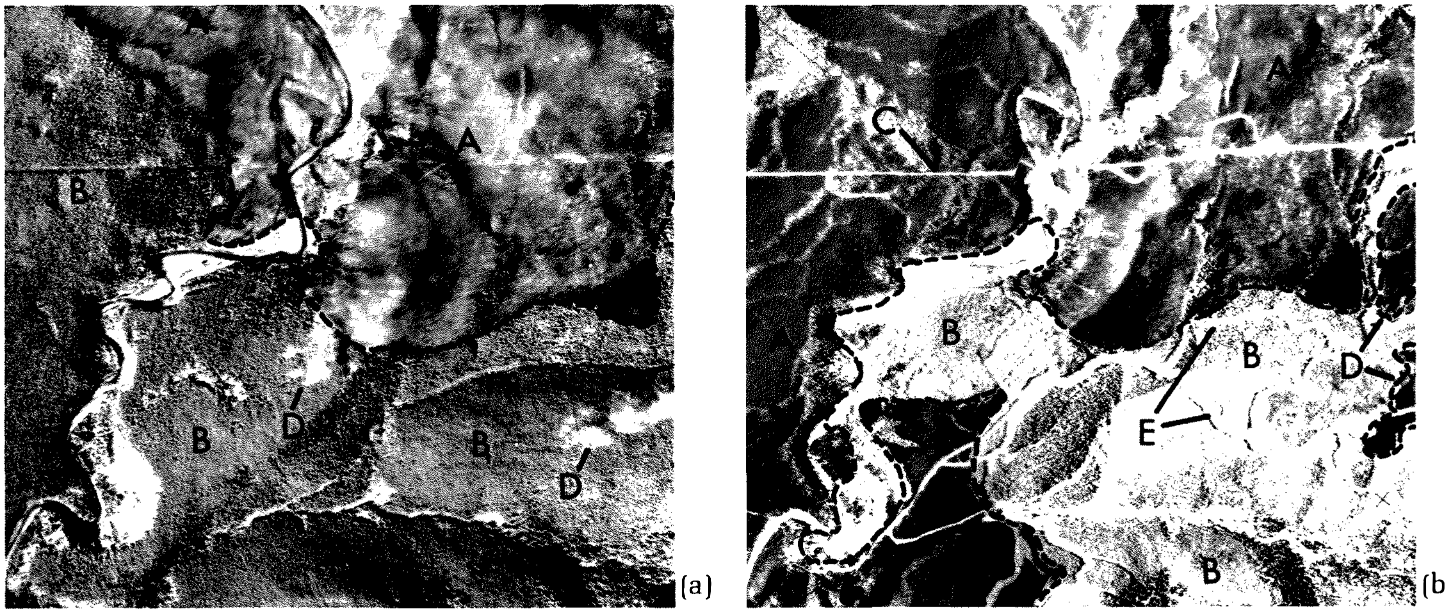
Vegetation type	Fuel Loading in t/ha			Moisture Content (%)				
	Herbs and shrubs	Duff	Dead Woody Surface Fuels	Herbs	Shrubs	Tree Bark	Tree Needles	Dead Tree Branches < 6 mm
Grassland	0.9	3.0	1.4	92	—	—	—	—
Pine stand	2.4	22.5	7.0	160	120	14	117	14

Table 2. Burning prescription and actual weather conditions, Henry House Prairie

Burning Prescription		Weather conditions at 1:00 p.m. 23 Sept. 1977
Temp. (°C)	16-23	17
Rel. Hum. (%)	25-40	43
Wind (km/h)	8-24	8
BUI[1]	> 20	75
ISI[1]	5-12	4
FWI[1]	10-12	14

[1]From Canadian Forest Fire Weather Index Tables
BUI = Buildup Index
ISI = Initial Spread Index
FWI = Fire Weather Index

A look at fire mapping



Sector of fire DB 7-4 photographed by the Alberta Forest Service on 24 August 1977 (a) and on 30 August (b).
A — burnt area, B — green coniferous forests, C — existing dozed mineral exploration lines, D — spot fires outside fire perimeter, and E — dozed fire guards

A good fire map is a valuable tool on any fire. Not only does it provide a general overview of the fire situation at a glance, it also serves as a common denominator in communicating fire intelligence. Depending on their purpose, fire maps come in many shapes and forms. All fire control agencies engage in some fire mapping according to the type and level of operation the map information is meant to support.

To the fire boss on a major fire, the map is a pictorial integration of information that tells him the relationships of various factors at the time of mapping, such as:

1. The location of the fire perimeter
2. The location, nature, and number of spot fires inside and outside the fire perimeter
3. The intensity of the fire along the fire perimeter
4. Unburned fuel inside the fire perimeter
5. The fuels ahead of the fire
6. Natural and man-made fuel breaks
7. Access routes to and within the fire, heliports and airstrips
8. Division, Sector, and Crew operational boundaries, their camp locations, and designation
9. Type, number, and location of equipment and working units
10. Location of tool and supply caches
11. Radio frequency allotments and radio call signs
12. Fire lines constructed and planned

Headquarters may prefer broader fire maps showing perhaps only the current fire perimeter with the changes of the most recent burning periods, combined with a list of resources at the fire and approximate expenditures to date.

Division, Sector, and Crew bosses may be interested only in details pertaining to the area under their jurisdiction. For the rest of the fire they may want nothing but the most basic information. Helicopter pilots may need to know only the location of the fire perimeter, camps, heliports, and fuel caches. If crews are to be placed and picked up during the mop-up phase of a large fire, they may insist on a good photo mosaic. Truck drivers and equipment operators may look only at the ground access routes on the map. Regardless of the user, the fire map facilitates the receiving or passing on of fire information.

The information shown on fire maps stems from many sources. Some of it is already on the base map which, depending on availability, is usually a forest cover type or topographic map at a scale ranging from 1:15 840 to 1:250 000. The base map may contain plotted intelligence gathered by visual observation or information transferred from photographs or infrared imagery.

The basic fire map is usually compiled at the main fire camp. It must be simple enough so that each user can add information as required. The map should be laid out to allow rapid copying on standard office copiers and telecopiers for dissemination to fire-line camps. The line camps send their information back to the main camp using the basic map as reference.

On a large fire no single source of information is sufficient to produce a good fire map. Photographs, thermal imagery, live (real time) thermography, and video or visual observation each furnish some of the information that goes onto a fire map. The use of filtered infrared black and white film (Kodak 2424) enables mapping crews to take advantage of reduced smoke density in the morning or shifts of the smoke column or to underfly clouds and smoke palls to record details of fire perimeter, access routes, dozed lines, campsites and heliports, fuels, and vegetation mosaics on both sides of the fire perimeter.

Depending on the size of the job, a trained and well-equipped fire mapping team operating from the airport nearest to the fire can produce a map within 2-4 hours. This type of operation requires competent personnel, usually four persons, who double as navigators, camera operators, photo processors, photo interpreters, draftsmen, and field scouts. Agencies may use fully equipped mobile field laboratories or U-2 reconnaissance aircraft; however, good results can also be obtained with public charter aircraft and improvised laboratory equipment operated out of motel rooms.

Some fires go through stages when the smoke is too heavy for photography. One method of obtaining pictorial information through most heavy smoke palls is by means of infrared line scanners. However, moisture in the smoke and low clouds can affect the quality of the imagery and may prevent the procurement of imagery when it is needed most.

Another approach to extracting information from smoked-in areas that is becoming operationally feasible is the use of mini FLIR (Forward Looking Infrared) systems. FLIR systems provide a two-dimensional live infrared view that can be recorded. Thus, the observer can monitor the fire's progress and sketch the perimeter or take a polaroid or video recording for later use. Since FLIR systems can be operated close to the ground, they can provide information about the intensity and location of hot spots too weak to be found in any other way. This makes it the ideal supplement for a photography-based fire mapping operation, particularly after the fire becomes stationary.

In the future, we can expect that visual sketching, supported by FLIR imagery, will continue to be the primary fire mapping technique in Canada, with reflected-light photography added on large fire operations. Line scanner imagery will be of importance on large smoked-in fires but it is unlikely to become the universal mapping tool.

An oblique photograph and corresponding fire map used in Alberta. A–burnt area. B–green coniferous forests

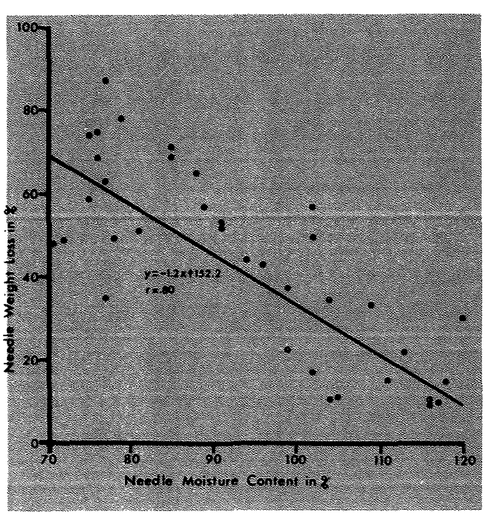
Lodgepole pine flammability

Recent studies at the Northern Forest Research Centre have thoroughly documented the seasonal variation in conifer foliage moisture content in Alberta. In 1-, 2-, and 3-year old pine needles, moisture content decreases from about 115% during the winter to about 85% in late spring, increasing gradually again during the summer. Crown fires occur in conifer stands throughout the entire fire season, regardless of needle moisture content; however, in Alberta spring fires seem to crown more readily. Prevalence of cured vegetation, persistent high-pressure systems, rapid drying of dead forest fuels, and lower foliage moisture content all interact and contribute to the severity of the spring fire season.

To better understand the influence of the spring moisture content "dip" on crowning and foliage flammability, we carried out small-scale laboratory burning experiments with young lodgepole pine trees collected in mid-January near Hinton, Alberta. Small trees 1 m (3 ft) high were preconditioned to needle moisture contents ranging between 120% and 70%. For the flammability tests, each tree was anchored on a burning platform in the Northern Forest Research Centre fire laboratory and weighed. Five grams of air-dry excelsior were placed at the base of each tree and ignited, and subsequent weight loss was recorded over the duration of the combustion period using a load cell and strip chart recorder.

Flammability of the young trees varied considerably over the moisture content range. At the high end, the small heat source created by the excelsior had little effect even on the foliage of lower branches. The same heat source under foliage conditioned to 80% moisture content ignited the entire crown and resulted in significant weight loss. Needle weight accounted for about 50% of the complete tree weight; during the short combustion period only the needles burned. At minimum moisture content of 70%, weight loss equalled 68% of the foliage weight. Sample trees with low moisture content lost weight at *four times* the rate of those with high moisture content.

Further observations are required to determine the relationship of the laboratory study to conifer foliage flammability in the natural state. Living trees exhibiting normal seasonal changes in moisture content will be studied under field conditions. The results will be used to refine the assessment of crowning potential of spring fires in Alberta.



Needle weight loss during combustion relative to moisture content


Ignition of sample tree using 5 g of air-dry excelsior

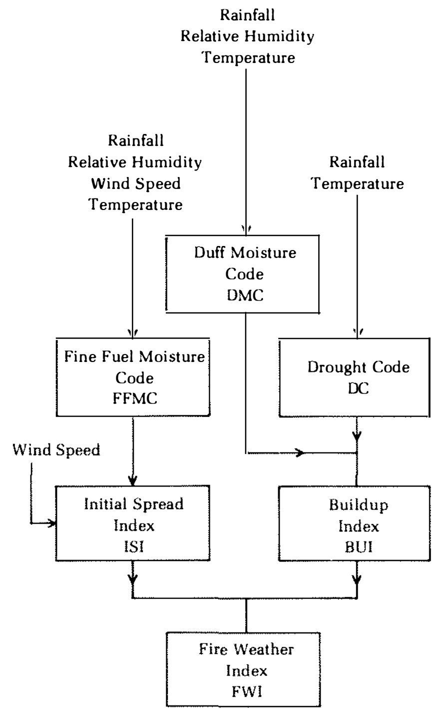

Range of needle loss by combustion as foliage moisture content decreased from 120% (far left) to 70% (far right)

Overwinter monitoring of the Drought Code is recommended

Resource management agencies responsible for fire control in Alberta, Manitoba, Saskatchewan, the Northwest Territories, and the National Parks adopted the Canadian Forest Fire Weather Index (FWI) in 1971. These weather-dependent codes and indices are calculated daily during the fire season at over 300 fire weather stations throughout the forested areas of the above regions and are commonly used in support of prevention, detection, suppression preparedness, and suppression activities at both the provincial and local levels. While the FWI system has provided a uniform and consistent scale for rating fire weather severity across Canada, user agencies are concerned about its performance in relation to specific fuel and operational situations. A study was carried out in Alberta to more closely examine correlations between FWI components and local fire occurrence, fire size, and suppression costs. Since release of the results of this study in March 1977 (*Calibration and performance of the Canadian Fire Weather Index in Alberta*, Information Report NOR-X-173), the opportunity arose to examine in more detail the importance of low overwinter precipitation (as measured by the Drought Code, one of the components of the FWI) on fire behavior during the following spring and summer.

While fast-spreading fires are a common occurrence shortly after snowmelt in the spring, historical records suggest that many of the severe conflagrations in summer occur after extended periods of subnormal precipitation. Parts of the three Prairie Provinces experienced abnormally low precipitation during the second half of the 1976 fire season and the winter of 1976-77. At the request of several regional fire control agencies, we monitored these moisture deficits with the help of the Drought Code (DC), which provides a numerical rating of the average moisture content of deep organic layers. Using data from about 40 weather stations in the Prairie Provinces and the Northwest Territories, we calculated the DC to the end of October 1976. Many stations also reported abnormally low precipitation totals during the winter of 1976-77. It was estimated that only 50% of overwinter precipitation would go into the ground to help saturate duff and soil layers; the remainder would be lost in evaporation and runoff prior to melting of ground frost. As a result of these adjustments, starting values of DC in the spring of 1977 ranged from about 50 in parts of Alberta to over 400 in southern and central parts of Saskatchewan and Manitoba. A DC value of 400 implies a 10-cm (4-in.) moisture deficit in deep organic layers.

This is nice to know, but what does it mean in terms of fire behavior? The events of the 1977 spring fire season in Saskatchewan and Manitoba have brought us a step closer to the answer. Central Saskatchewan, with DC values in the 300-500 range, experienced a particularly severe spring fire season, with widespread crowning, deep and persistent burning of duff layers, and difficult mop-up conditions. Field reports also suggest that DC values in excess of 500 or so may be responsible for severe moisture stress in trees growing on sandy, well-drained sites. Further calibration and assessment of DC performance will be required, but recent experience suggests that fire control agencies can benefit from year-round monitoring of the DC to indicate the effect of prolonged drought on fire severity. For best results, particular attention should be given to developing a reliable procedure for adjusting overwinter precipitation to adequately reflect its effect on soil moisture recharge in forested areas.



Components of the Canadian Forest Fire Weather Index

This and other study results suggest that the FWI system is a relatively well discriminating operational tool, provided that a meaningful calibration is carried out to optimize the use of system components as indicators of fire business. Work is underway to develop a practical fuel appraisal procedure whereby important differences in fire behavior attributable to major vegetation or fuel types and conditions can be rated. The user will then have at his disposal an operational tool markedly more sensitive to seasonal changes in forest flammability.

Can you use your AGA Thermovision 750 scanner in a fixed-wing aircraft?

Research staff at the Northern Forest Research Centre say "yes." In cooperation with the Alberta Forest Service they mounted a 750 camera in front of a surface-coated mirror tilted 45° looking down through the drop hatch of a Dornier DO 28 patrol plane.

By "toggling" the mirror along its axis, the scanner covers a swath of ground underneath the aircraft up to 120° wide. The mirror can be instantly stopped or the toggle speed and direction changed as required. Thus, lines can be kept in the field of view from low altitudes, while from higher altitudes the full 120° scan width can be utilized without missing scan line overlap.

An on-board videorecording system focused on the scanner's display screen allows instant on-board replay of detected targets. This assists in locating the targets on the ground and after landing gives fire control personnel in camp a thermal view of the target area. The complete system, which can also be mounted in a helicopter, is awaiting operational use in 1978.

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