forestry report

No. 28 (September 1983) Northern Forest Research Centre Edmonton, Alberta

Flare-up of the 1981 Swan Hills Fire in central Alberta.

# A perspective on fire management

The past four fire seasons have been severe and unprecedented in recent history. Suppression expenditures in the prairie provinces and Northwest Territories escalated dramatically during 1979-82 to exceed $100 million annually, with economic losses from fire estimated to be a similar amount. Despite the money spent on suppression, about 4 million hectares have burned annually in Alberta, Manitoba, Saskatchewan, and the Northwest Territories.

These severe fire seasons have provided an opportunity for the rapid development and application of innovative operational approaches as fire management agencies have been challenged to improve their performances, incorporate new technologies, rationalize existing ones, and justify current and projected expenditures. Although these years cause considerable frustration for operational and research agencies alike, they nevertheless provide the feedback that enables us to assess recent technology, to evaluate the traditional approaches and basic tenets of fire management, and to reflect realistically on the place of fire management in overall resource management.

Forest management is often perceived as applied ecology, yet we choose to ignore simple ecological realities. Almost every stand we cut is of a post-fire origin. The boreal forest, being a fire-dependent ecosystem, owes much of its diversity, vigor, and character to the sometimes irregular but periodic occurrence of fire. In a fire-dependent ecosystem, fire is an in-

*Continued on next page*

In this issue:

## Fire

# An improved sprinkler system

A sprinkler system can be a useful piece of equipment for any fire operation. It is often used to wet down an area of vegetation to create a fire line during prescribed burns and to create a firebreak around villages or lodges when a wildfire is approaching. In both cases, once the sprinkler system is set up it can be tended by one man, thus relieving men for other duties.

A sprinkler system consists of a water source, pump, hose, and sprinklers. Although it is a simple system, there is still room for improvement. NoFRC in recent years has tested new materials as they became available and has developed a standardized sprinkler base that can accept a variety of heads.

The NoFRC sprinkler system has a pump, usually a Wajax Mark 3 or Mark 26, set up at the water source. From it runs the hose, with sprinklers at 15-m (50-ft) intervals. A new, lightweight, synthetic hose with a lining and lightweight alloy couplers is now being used, which is a great improvement over the old linen hoses with brass couplers that weighed about three times as much and were harder to handle and transport. The lining in the new hose decreases friction and therefore improves the water flow. In addition, the synthetic hose is mildew- and rot-proof and thus does not require the same level of maintenance as the linen hose.

The sprinkler consists of a base and a sprinkler head, as shown in the photo. The base is constructed from high-pressure, copper pipe 38 mm in diameter and 203 mm long. A 38-mm diameter threaded male adapter is brazed to each end of the pipe. A bronze bar, 13 x 203 x 6 mm, is brazed on the bottom of the pipe at a right angle, which stabilizes the base. The bar is drilled at each end to accept a 152-mm spike to further stabilize the base.

A sprinkler system is readily set up in the field.

Attachment of the sprinkler head to the base depends on the type of attachment point. Any size of riser necessary to accept the head can be brazed to the base. The NoFRC system has both a Buckner 195 sprinkler head, which attaches to a 25.4-mm male riser, and a Buckner 185 sprinkler head, which attaches to a 19-mm female riser.

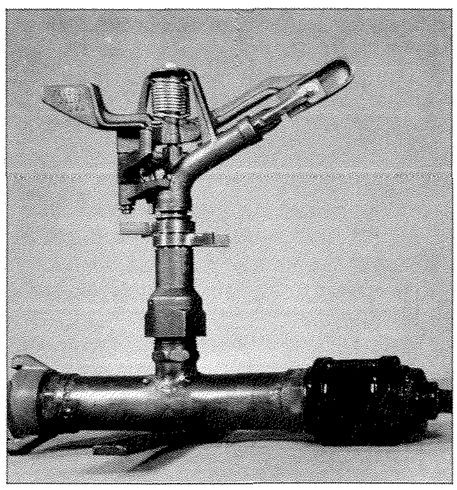
Future improvements will likely be made in sprinkler size and weight as stronger, lighter materials become available (possibly from plastic). More units could then be stored in a smaller space and would be easier to carry and transport due to their lighter weight.

One improvement that is on the market but has yet to be thoroughly tested is a rapid water additive that reduces friction in the hose so that a greater volume of water can be pumped over a greater distance. Tests performed at NoFRC showed an increase of 31% radius on the first sprinkler and 28% on the last sprinkler in an eight-sprinkler set powered by a Wajax Mark 3 pump. The major problem in using the rapid water additive is to get a reliable, simple injector system for it. The present injector system is too large and complicated to be portable and thus is not used.

*M.E. Maffey*

**SUGGESTED READING**

Quintilio, D.; Ponto, R.L.; Frew, I.B. 1971. A sprinkler system for use in prescribed burning. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent. Inf. Rep. A-X-41.



NoFRC sprinkler base with the head attached to a male riser.

## A perspective — continued from page 1

trinsic ingredient, acting as the primary cycling and rejuvenating mechanism. Although this is common knowledge, little attention is given to its implications at planning and operational levels.

Parts of the boreal forest will burn whenever Nature's recipe of fuels and weather with a dash of lightning are properly mixed. The existing fire environment and the relative inaccessibility of much of the boreal forest renders complete fire exclusion impractical either economically or ecologically. The demand for more resources for fire protection challenges traditional economic wisdom and ignores the oft-stated colloquialism that "Big bucks won't solve the fire problem."

The destructive potential of fire must not be understated. Fire can and does threaten human lives and competes with man for economically important resources. It is evident then that fire plays a dichotomous role, having both beneficial effects in terms of ecology and detrimental impacts in terms of socioeconomics. These influences are not mutually exclusive. Aggressive control must be improved in areas of high economic value, while fire management alternatives must be considered for areas that benefit from fire. This obviously raises the issues of determining values for forest-based resources and establishing land management objectives. It is also hoped that this will encourage a more equitable allocation of fire control resources when and where they are needed.

One compelling, overused reason given for sustained, expensive action on fires in remote areas of little current economic worth is that the public demands action. This is probably true and will continue to be true for some time, but why? We have over several decades successfully convinced the public that all fire is bad. We are, perhaps, simply reaping what we sow. Resource management agencies should now conduct public information programs aimed at clarifying the ecological and economical impacts of fire. Though the benefits of such a program may not be realized for years, without it fire management will remain a euphemism. A concerted, cohesive effort by managers and operations and research personnel will be required to develop and implement necessary policy and operational changes over the next decade. The approach is not without risk, but then progress is seldom made by playing it safe.

*D.E. Dubê*

A 3600-Litre water drop on black spruce.

# Short-term fire retardant effectiveness in a lowland black spruce fuel complex

Historically, forest fire retardant research has been conducted under closely regulated and monitored laboratory and field conditions. The combustion-inhibiting and flame-retardancy characteristics of retardants have been assessed under predetermined burning conditions using various types of mechanical spray systems and prepared fuel beds made up of particular forest fuels or cellulose materials. By conducting retardant effectiveness evaluations in the field, laboratory conditions can be exchanged for real-world applications and fuel conditions. Under such field conditions, the complexities of air tanker delivery procedures and forest fuel arrangements can create difficulties in assessing visual and measured observations.

Despite the inherent complexities and potential frustrations of field trials, the Northern Forest Research Centre (NoFRC) in cooperation with the Alberta Forest Service (AFS) initiated a forest fire retardant effectiveness study in 1978 to assess the relative merits of water, short-term retardant (Tenogum water thickener), and long-term retardant (Fire-Trol 100). Plots were established in lowland black spruce stands at a research site in the Slave Lake Forest in central Alberta. The PBY-5A Canso was chosen as typical of an aerial delivery system common to Alberta and elsewhere in Canada east of the Rockies.

Six 30 x 30 m experimental burning plots were laid out and sampled in 1976 to test a range of drying time intervals as a measure of relative retardancy effectiveness. Ony two of the plots, after undergoing Tenogum and water treatments, were eventually burned. This occurred during the afternoon of July 26, 1978, under high fire danger conditions.

Preburn fuel moisture and stand characteristics from plot data are shown in the first and second tables. Moisture content of samples of black spruce needles, Labrador tea twigs and stems, and Labrador tea foliage taken during the afternoon of July 26, 1978, averaged 109%, 94%, and 122%.

**Moisture content (% ovendry weight basis) of selected ground and ladder fuels**

| Fuel component | Plot treatment: Tenogum | Plot treatment: Water |
|---|---|---|
| *Sphagnum* spp. | 833 | 824 |
| Feather mosses | 18.1 | 12.3 |
| *Cladonia* spp. | 11.5 | 12.8 |
| Black spruce bark flakes | 10.3 | 11.2 |
| Dead twigs and branches[1] | | |
| 0-0.5 cm in diameter | 10.8 | 11.3 |
| 0.5-1.0 cm in diameter | 11.7 | 12.1 |

[1]Attached to the lower portion of black spruce tree boles.

**Overstory stand structure characteristics**

| Stand parameter | Plot treatment: Tenogum | Plot treatment: Water |
|---|---|---|
| Live tree density (stems/ha) | 6 500 | 10 322 |
| Basal area ($m^2$/ha) | 18.0 | 22.6 |
| Height (m) | 5.4 | 4.6 |
| Dbh (cm) | 5.3 | 4.2 |
| Live crown base height (m) | 1.9 | 1.4 |

The age of dominant trees in the study area was about 65 years. According to the AFS forest cover type classification, both plots would be mapped as B1Sb (i.e., medium stocked black spruce stand less than 10 m in height). The understory vegetation was dominated by Labrador tea, and the surface of the forest floor was covered principally by *Sphagnum*, feather mosses, and *Cladonia* species.

To test the relative effectiveness of the two treatments, moderately severe burning conditions were desirable in order to magnify the differences, if any, in the effectiveness of the treatments. The optimal environmental conditions prescribed to yield the desired fire behavior, in addition to fire weather and danger conditions recorded at 1300 Mountain Daylight Time (MDT) on July 26, 1978, are shown in the third table.

*Continued on next page*

# Short-term fire retardant — continued from page 3

The water treatment plot was ignited at 1420 MDT. One-half hour prior to ignition a 3650 L salvo water drop was placed on the downwind one-third (10 m) side of this plot from a drop height of approximately 25 m over the 5-m tree tops. During the half-hour interval prior to ignition, final fuel moisture, weather, and drop coverage information was recorded. Water penetration and recovery estimates were made on the basis of a low intensity sampling grid of collection cups and adjacent 30 x 30 cm cardboard placards placed throughout the drop zone. This grid extended across the width of the plot and 10 m on either side of the downwind end of the plot. These sample measurements combined with visual indications of canopy penetration and surface fuel wetting supported estimations of volume recovery.

The same procedure was to be applied to the next plot following the salvo drop of Tenogum-thickened water. Unfortunately, the majority of this load fell short of the plot, and only a portion of the plot and collection grid were hit. Since a follow-up drop would not be a feasible method of treatment, it was decided that the plot would be burned as treated and an ocular assessment of Tenogum performance would have to suffice. This plot was ignited at 1543 MDT.

Head fire ignition took place adjacent to the upwind side of each plot one-half hour following its treatment. The fire front progressed uniformly and rapidly through the untreated 20-m portion of each plot and appeared to achieve an equilibrium spread rate about 1 minute after crossing the plot boundary along the ignition line. Fire impact and behavior characteristics are summarized in the fourth table.

Posttreatment observations and calculations indicated that about 50% of the water drop that fell within the grid boundaries penetrated the canopy to fall within the recovery grid, while the remainder was retained in the crowns and was lost due to evaporation and drift. On the basis of open field drop tests it can be expected that from a drop height of 25 m over a forest canopy at least 20% of a salvo water drop would be lost because of evaporation and drift prior to coming in contact with the forest canopy. As a result, about 40% ([100–20] 0.5) of a potentially recoverable water salvo from a PBY-5A Canso would reach the surface fuels. Naturally, varying canopy heights and crown closure conditions along with the influences of drop height, speed, wind velocity, and relative humidity could considerably affect this recovery factor — probably downward.

Open field drop tests with the PBY-5A Canso and 0.25% Tenogum mixtures indicated that the percentage recovery does not exceed that of plain water. This being the case, it can be surmised that relative to the water drop there would be no better recovery or penetration for the Tenogum drop had it been successfully placed on the grid. Due to the slightly improved adhesive characteristics of Tenogum thickened water, it is conceivable that greater crown retention could even further reduce the amount reaching the surface fuels.

Following line ignition, the fire front progressed uniformly through the untreated portion of each plot. Once the advancing flame front came in contact with the water treatment zone, fire intensity and forward rate of spread were greatly reduced to the point of smouldering combustion. As a result, no more than 7.5 m of the width of the treatment zone was penetrated. Such was also the case where the fire front penetrated 7 m into the small portion of the plot that received the Tenogum treatment. For the remainder of this plot, the fire burned unhindered to the fire guard at the end of the plot.

Flames reached heights of 5 or more metres, and short-range spotting was prevalent. Propagation of the fire front in both burns was due almost solely to fine fuel moisture since there was little wind. All surface and aerial fuel components were simultaneously involved during each burn until the fire front advanced into the treatment zones. At the edge of the water treatment zone the active fire front died down very quickly because of the combined effects of increased fuel moisture and relative humidity. Once limited to surface spread, these fires advanced very little beyond the outer fringes of the wetted fuels and had failed to creep through the treatment area prior to extinguishment more than 1.5 hours later.

This very limited source of information suggests that water and Tenogum-thickened water, applied by a Canso water bomber, can be expected to equally retard the forward advance of a moderately vigorous fire in a lowland black spruce fuel complex following a half-hour drying period. Although fuel, weather, or time constraints beyond the scope of this investigation could preclude similar levels of success in wildland fire control, it is hoped that this information will contribute to increased effectiveness of water bombing operations.

Because of inclement fire weather conditions in 1979 and wildfire control commitments on the part of the AFS during 1980, the balance of this project was cancelled in 1981 in favor of evaluating the performance and effectiveness of fire retardants and aerial attack operations on actual fire situations in Alberta.

*R.G. Newstead*
*M.E. Alexander*

**Fire weather observations and fire danger ratings at 1300 MDT**

| Parameter | Proposed burning prescription | Actual conditions experienced |
|---|---|---|
| Dry-bulb temperature (°C) | 20-30 | 26.5 |
| Relative humidity (%) | 25-45 | 42 |
| Wind speed[1] (km/h) | 5-25 | 5 |
| Number of days since rain[2] | — | 6 |
| Fine Fuel Moisture Code (FFMC) | 88-92 | 90 |
| Duff Moisture Code (DMC) | 35-75 | 44 |
| Drought Code (DC) | — | 306 |
| Initial Spread Index (ISI) | 4-10 | 5.5 |
| Buildup Index (BUI) | 50-100 | 65 |
| Fire Weather Index (FWI) | 15-20 | 16 |

[1]Measured at 10 m in the open on level terrain.

[2]Amount greater than 0.6 mm.

**Fire impact on forest fuels and physical fire behavioral characteristics**

| Parameter | Plot treatment: Tenogum | Plot treatment: Water |
|---|---|---|
| Total consumption (t/ha): | | |
| Forest floor | 14.4 | 16.4 |
| Surface fuels | 2.3 | 6.5 |
| Tree foliage and branch wood | 12.7 | 12.0 |
| Depth of burn (cm) | 2.4 | 3.2 |
| Head fire rate of spread (m/min) | 6.43 | 7.53 |
| Frontal fire intensity (kW/m) | 3680 | 4230 |

# Overwinter adjustment to spring starting values of the Drought Code

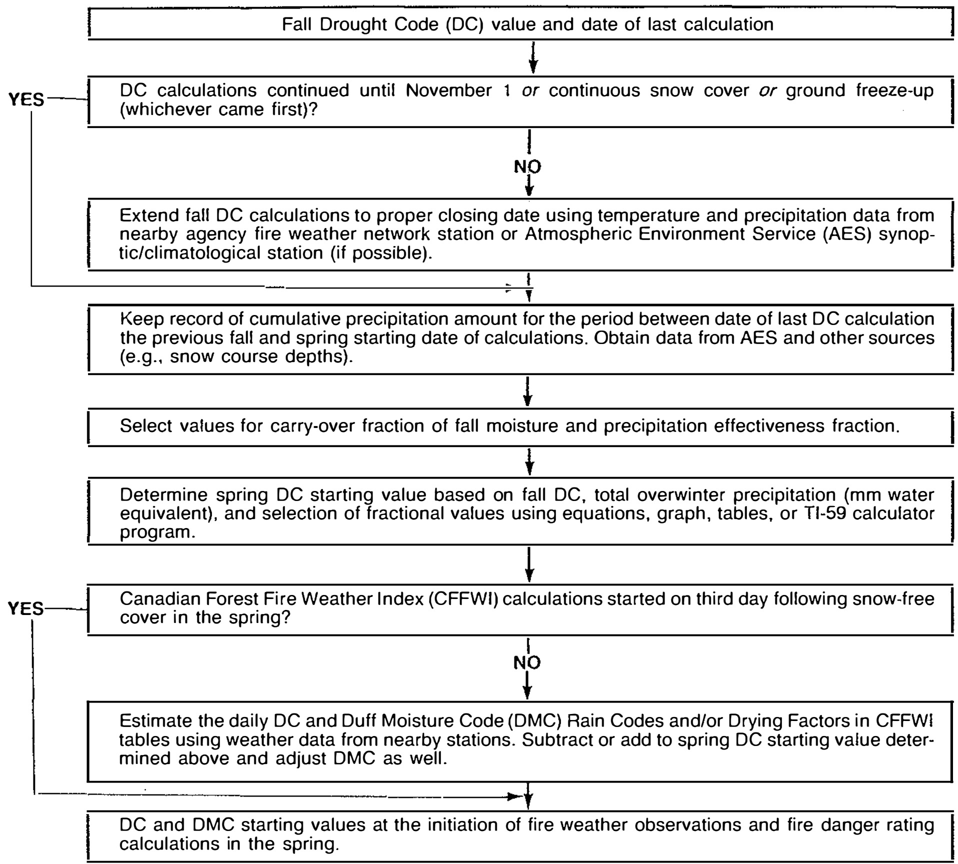
The impact of prolonged, cumulative drying on potential fire behavior is accounted for by the Drought Code (DC) of the Canadian system of forest fire danger rating. It cannot be automatically assumed that the DC starts at zero on the first day of fire weather observations and fire danger rating calculations in the spring. Occasionally, precipitation over the winter months is insufficient to recharge the deep, compact, organic fuels represented by the DC. Where saturation has not occurred, a higher DC starting value is warranted to compensate for this moisture deficiency. These revised spring DC starting values then become part of each agency's permanent fire danger record.

The methodology for overwinter adjustment to spring DC starting values is outlined in *Weather in the Canadian Forest Fire Danger Rating System: a user guide to national standards and practices,* Information Report BC-X-177, published in 1978 by the Pacific Forest Research Centre, Victoria, B.C. The procedure considers the last DC calculated the previous fall and the percentage of overwinter precipitation that actually percolates into the deep layers of organic matter as meltwater in the spring. For the 1981 fire season, the NoFRC fire research unit provided individual station DC starting value look-up tables to provincial and federal fire management agencies in west-central and northern Canada. Their use required simply an input of winter precipitation amount, since the 1980 fall DC value had been incorporated into construction of each table. Standard tables have now been prepared for situations typically encountered in the prairie provinces and NWT whereby spring DC starting values can be determined for any fall DC value and total overwinter precipitation amount.

The need for overwinter adjustments to spring DC starting values on a regular, yearly basis was discussed at the January 1982 meetings of the Central and Western Region Fire Weather Committees held in Winnipeg and Edmonton, respectively. The Atmospheric Environment Service will continue its role of providing precipitation data to fire management agencies. The NoFRC fire research unit will continue to monitor the relevance and performance of making calculations of overwinter deficits and spring DC adjustments to fire situations and user agency needs in the prairie provinces and NWT. Although the DC has definite meaning in terms of moisture deficiency, the significance of a particular stage of drought to fire control must be determined locally through experience. Field studies and computer analyses will be undertaken by NoFRC as required.

*M.E. Alexander*

**Flow chart of spring Drought Code starting value determination, including late starting provisions for the Duff Moisture Code.**




**Distribution of spring Drought Code (DC) starting values for selected network fire weather stations in the prairie provinces and Northwest Territories at the beginning of the 1982 and 1983 fire seasons**

| DC classes | Number of fire weather stations[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Alberta | | Saskatchewan | | Manitoba | | NW Territories | |
| | 1982 | 1983 | 1982 | 1983 | 1982 | 1983 | 1982 | 1983 |
| 15[2] | 36 | 25 | 1 | 7 | 1 | 22 | 0 | 7 |
| 16-65 | 28 | 15 | 13 | 18 | 3 | 8 | 2 | 2 |
| 66-115 | 25 | 36 | 13 | 7 | 9 | 4 | 1 | 4 |
| 116-165 | 25 | 33 | 6 | 2 | 8 | 1 | 0 | 5 |
| 166-215 | 40 | 37 | 5 | 0 | 6 | 0 | 4 | 2 |
| 216-265 | 13 | 24 | 0 | 0 | 3 | 0 | 3 | 4 |
| 266-315 | 0 | 9 | 0 | 0 | 0 | 1 | 0 | 0 |
| 316-365 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 2 |
| 365 + | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 |

[1] Includes national parks.
[2] Used as a standard value for starting the DC on the third day following snow-free cover in the spring. This assumes that following snowmelt there is complete saturation of the forest fuels represented by the DC.

**SUGGESTED READING**


Alexander, M.E. 1982. Calculating spring Drought Code starting values in the prairie provinces and Northwest Territories. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent. For. Manage. Note 12.

Alexander, M.E. 1983. Tables for determining spring Drought Code starting values in west-central and northern Canada. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent. For. Manage. Note 19.

# Evaluation of air tankers and fire retardants on wildfires

Laboratory and field testing of retardants and air tankers and their delivery systems have been conducted for many years. Operational assessment of their effectiveness on wildfires has received little attention, however. In 1981 NoFRC and the Alberta Forest Service began a study to evaluate air tanker performance and retardant effectiveness on wildfires during initial attack. A Hughes 500D helicopter quickly carried a two-man evaluation team to wherever in the province that air tanker action was anticipated.

As a result of the evaluation of air tanker and retardant performance on 12 fires in 1981, a number of operational problems were identified, and corrective measures were proposed.

B-26 air tanker dropping retardant on a small fire.

**Drop height in relation to tree height and stand density.** As a general rule, the lower the tree height (below 12 m) and the more open the stand (crown closure 0-40%), the higher the drop height should be; the opposite is true when tree heights are above 12 m and crown closure is greater than 40%. In the shorter, less dense fuels a drop height of 30-45 m over tree tops is recommended when using the B-26 bomber, and 40-50 m is recommended for the DC-6B. In taller, more dense stands, drop heights of 15-30 m and 20-30 m above the canopy are recommended for the B-26 and DC-6B, respectively.

Furthermore, the size of load dropped should vary proportionately with tree height and stand density. This should eliminate "logging" an area with the force of the drop. An increase in drop height also permits the load to elongate and disperse, resulting in more uniform and effective coverage of the fuels.

It was also noted that two-door string drops from a B-26 usually resulted in 10 m of minimal retardant coverage on both the aerial and surface fuels between the load increments. This may be attributed to pilot response time in triggering the door sequencing button in the B-26.

**Tactics on initial attack.** From ground observations it was apparent that the lee side of aerial and surface fuels and particularly slash fuels was not being adequately coated with retardant, which increased the likelihood that the fires would burn through the line.

Wise use of tank (load increment) options for the air tanker can result in the maximum effective line for the minimum amount of retardant dropped. For example, a single load increment can be used on the understanding that in most cases a B-26 or DC-6B can return to base half loaded. Unnecessary retardant application is wasteful.

Reinforcing a retardant line by approaching the target from the opposite direction with a second drop partially overlapping and adjacent to the first might be considered if the fire hazard and fuel conditions warrant.

**Viscosity of gum-thickened Fire-Trol 931.** Assessment of retardant drops consisting of unthickened Fire-Trol 931 and Fire-Trol 931 thickened to 500, 700, 1200, 1600, 1700, and 2200 mPa•s indicates that a viscosity range of 1200-1400 mPa•s provides the most effective uniform coverage of both aerial and ground fuels. This may vary somewhat in either direction depending on stand density and tree height.

**Retardant quality and air tanker problems over fires.** Because of problems with load placement and inconsistent viscosities at the fire sites, the use of long-term retardants is recommended for practice missions. This would allow bird-dog officers and air tanker pilots to better ascertain how the various retardants perform when dropped in different tactical modes at various drop heights and speeds under varying fuel conditions. A practice session could also serve to check retardant quality control and mixing equipment.

**Performance assessment.** It is important that air-attack personnel get on the ground periodically to assess what has happened when a load of retardant has been delivered to a given target. This provides some insight into canopy and surface fuel coverage, drop accuracy, and retardant effectiveness in relation to designated targets and the tactics used. Only through on-the-ground observations of fires can these personnel improve their knowledge of the performance of retardants in the initial-attack role.

During the 1982 fire season, continuation of this study provided insight into a number of problem areas not previously encountered. Six fires were documented in central Alberta during a 2-week period of intense fire activity. Although many of the foregoing problems had been overcome, several new situations emerged that adversely influenced the effectiveness of air-attack operations.

**Delayed follow-up action.** A combination of vigorous fire growth conditions and delayed follow-up action resulted in fire spread beyond retardant treatment zones (through, over, under, and/or around), often within the first hour following application. If ground control forces had been on the scene or prepared for support action, they could have benefited from aerial attack to

*Continued on next page*

contain these fires. Such an integrated suppression effort is extremely important (particularly as fire spread potential increases) and will contribute favorably toward an overall cost-effective operation.

**Assessment of fuel conditions.** Aerial-attack personnel and ground control forces must improve their assessment of surface fuel conditions in order to better interpret ongoing or anticipated fire behavior vis-a-vis the expected effectiveness of applied retardant. Of particular significance has been the persistent spread and vigor of fire in old growth and decadent coniferous fuel types, where surface fuel accumulation, arrangement, and moisture conditions in dead and downed woody and deep organic fuels augment fire growth and intensity.

In conjunction with overall stand conditions (e.g., height, closure, branching characteristics, and surface vegetation), these circumstances limit the penetration and coating performance of retardants and hence the effectiveness of aerial-attack operations. These factors may be partially overcome by committing additional retardant loads or altering the attack strategy to improve the coating of critical fuels.

It is particularly important that on-the-ground fuels and fire behavior information be communicated to aerial-attack personnel in order that tactical adjustments can be incorporated as soon as possible. This problem is further compounded when ground support capabilities are inadequate.

**Effective delivery of retardant.** There is a continuing commitment to overkill tactics in some target/fire behavior circumstances. Although many will argue that it is better to be safe than sorry, there have been situations where more discreet use of retardants and air tankers could have been as effective and would have cost less.

Some targets are difficult to identify when obscured by smoke, forest canopies, or topographic constraints or simply because of their small size. These conditions often require several runs by air tankers to satisfactorily place retardant loads where they will serve the greatest value. In such circumstances (which are often the case during multiple fire occurrence due to lightning), critical attention must be paid to whether the targets warrant aerial attack or may be handled by alternative resources and how much retardant can be devoted to each.

Load size and placement accuracy become all-important variables here, and the use of marker loads can result in reduced wastefulness and lowered costs associated with not committing full loads to indistinct targets. These loads can otherwise be delivered to alternative or higher priority targets or simply returned to base.

The preceding observations reflect preliminary results gathered during aerial-attack operations using air tankers and retardants in the initial-attack mode. This study will be continued during the 1983 fire season in an effort to document the specific hazard, fuels, and the fire-related parameters involved when a fire front comes in contact with retardant treated fuels.

*R.G. Newstead*
*R.J. Lieskovsky*

# AGA Thermovision scan extender

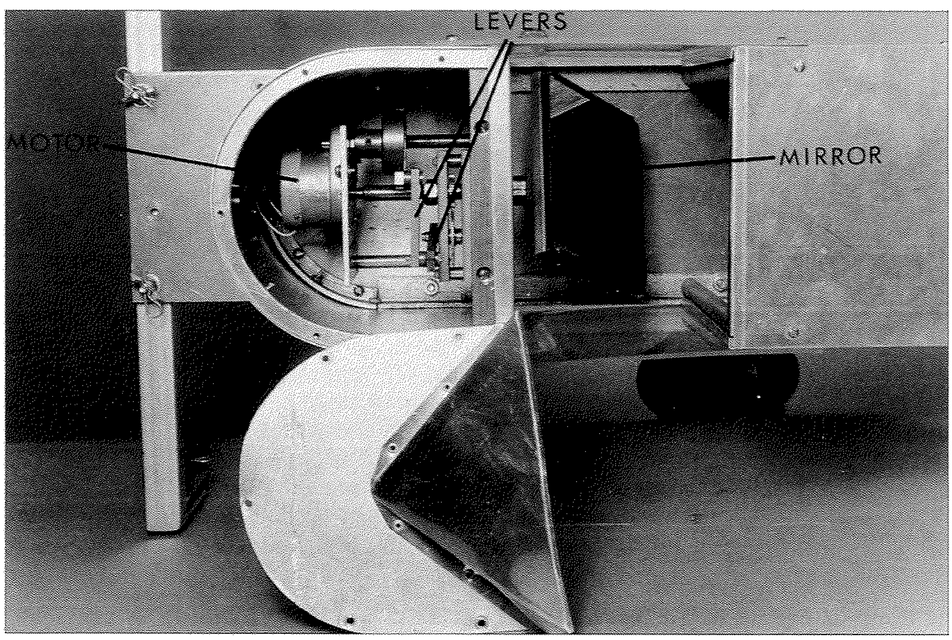
In an effort to get maximum use from the AGA Thermovision 750 infrared scanner, a device has been developed at NoFRC that allows the scanner to be used for systematic searches of large areas using either a fixed-wing aircraft or a helicopter.

The scan extender consists of an enclosed aluminum box that can be mounted outside the aircraft or inside facing out through a camera hatch. The infrared camera has a surface-coated mirror mounted at an angle in front of the lens. The mirror is connected to an electric motor through an eccentric gear that oscillates the mirror back and forth, reflecting into the camera a swath of ground up to 120° wide and 20° fore and aft. The angle of the mirror is adjustable but is usually kept in a slightly forward looking attitude to give the operator time to react to a target before the aircraft passes over it. The mirror can be stopped in any position and backed up, and its speed can be varied by using controls mounted on a small box that is kept at hand by the operator.

The device has been used with various aircraft: through the camera hatch of a Beech Baron, bolted to the wing of a Cessna Skymaster, bolted to the fuselage of a Piper Navaho, and attached to the cargo hook mount of a Bell 206B. The mounting position must provide a clear field of view and must be relatively free of vibration. Flying heights and speeds are varied according to the purpose of the search. Low and slow speeds are used for detailed searches of small areas, and higher and faster speeds are used for general searches of large areas. By flying a grid pattern and using the scan extender it is possible to do an infrared search of a fairly large area and to be confident that it has all been seen through the Thermovision.

The scan extender has been used successfully for mop-up on large fires. With the device fastened to the cargo hook mount of a Bell 206B helicopter operating at 300 m above ground level and 80 km/h it is possible to thermally scan the perimeter of a large fire in a fraction of the time it would take using the conventional hand-held method.

*C.J. Ogilvie*



Thermovision scan extender developed at NoFRC.

**SUGGESTED READING**

Ogilvie, C. 1981. Guidelines for use of the AGA Thermovision in forest fire mop-up operations. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent., For. Manage. Note 8.

Ogilvie, C. 1982. The Scan Extender — a device to enhance the capabilities of the AGA 750 Thermovision. USDA For. Serv. Fire Manage. Notes 43(3):22-24.

# Analysis of the Canadian Forest Fire Weather Index for the 1968 Lesser Slave Lake Fire

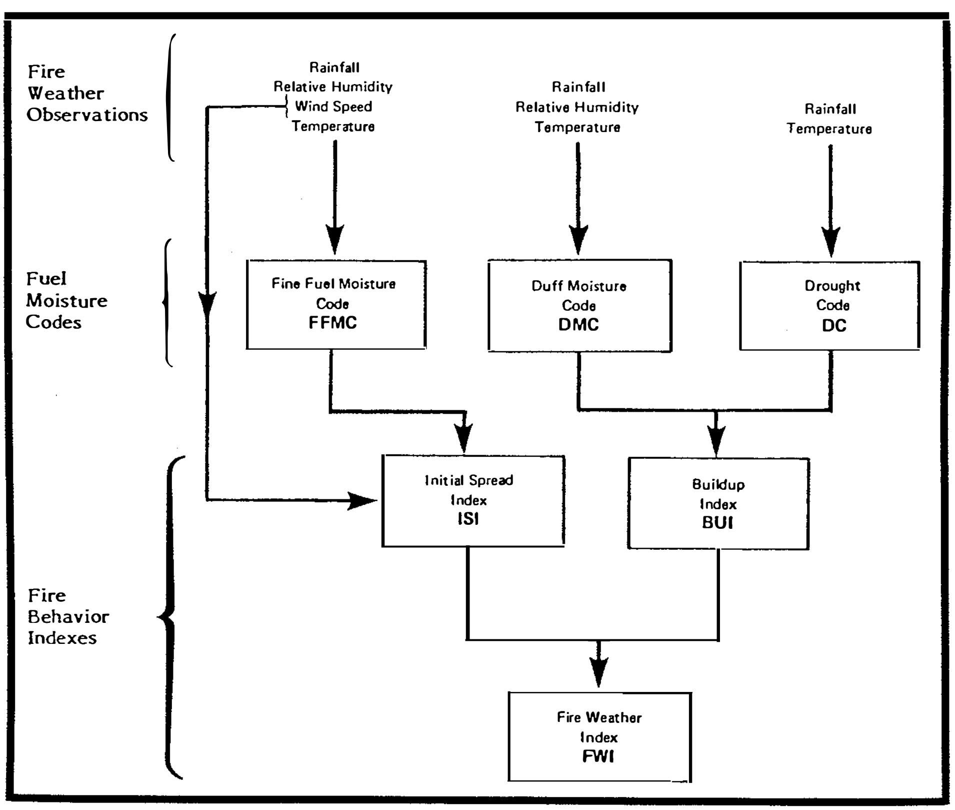
In central Alberta during the last half of May 1968, several man-caused fires occurred accompanied by a critical fire weather pattern that resulted in severe fire behavior and a correspondingly large burned-over forest area (McLean and Coulcher 1968). One such fire, commonly termed the Lesser Slave Lake Fire, started on May 19 and eventually covered an area of 133 550 ha. Nearly one-half of this area was burned over during the 10 hours between 1300 and 2300 Mountain Daylight Time (MDT) on May 23.

Advancing on a 16- to 24-km front, the fire on that day spread at an average rate of 6.5 km/h through a variety of coniferous and deciduous forest fuel complexes. The transport of firebrands far ahead of the main fire front (and the resulting spot fires) contributed greatly to this unusually high rate of spread. Peak frontal fire intensities were estimated to have exceeded 100 000 kW/m during the major run (Kiil and Grigel 1969). The fire storm released the energy equivalent to that of a 20 kt bomb exploding every 2 minutes (one such bomb devastated Hiroshima, Japan, in 1945).

## Well documented

The 1968 Lesser Slave Lake Fire remains the best known, well-documented example of extreme fire behavior in Canada. The fire-danger ratings that accompanied such a forest fire phenomenon are of interest and value to the fire management and research community. The Canadian Forest Fire Weather Index (CFFWI) system has provided a uniform and consistent scale of rating fire danger across Canada since it was introduced in 1970. The CFFWI system is composed of six modular components. The first three of these are moisture codes that follow from day to day the changes in moisture contents of three classes of fuel with different rates of drying. The three moisture codes plus wind are linked in pairs to form two intermediate subindexes, the Initial Spread Index (ISI) and the Buildup Index (BUI), which represent rate of spread and fuel available for combustion, respectively. Finally, there is the Fire Weather Index (FWI) itself, representing the flame front intensity of a spreading fire.

The CFFWI system depends solely on four weather variables recorded each day at 1300 Daylight Saving Time (noon local standard time): temperature, relative humidity, wind speed, and amount of rain (if any) during the previous 24 hours. The calendar date is introduced into the calculation of the Duff Moisture Code and Drought Code (DC) to allow for variations in day length throughout the fire season. The moisture content of fuels represented by the Fine Fuel Moisture Code (FFMC) is less dependent on day length.




Basic structure of the Canadian Forest Fire Weather Index system.

Had the CFFWI system been operating in 1968, what would the codes and indexes have been? To answer that question, the required daily observations were obtained from seven Alberta Forest Service fire weather stations adjacent to the fire area and the three closest Department of Transport (DOT), Meteorological Branch (now Atmospheric Environment Service), synoptic stations for the 1967 and 1968 fire seasons. From these historical data, the FWI and its associated components were computed for all of 1967 and for 1968 from the initiation of record keeping in the spring until the end of May. DC starting values in the spring of 1968 were adjusted for the very high DC values attained by the end of the 1967 fire season and for the subnormal precipitation experienced during the winter of 1967-68.

Hourly calculations of the FFMC, ISI, and FWI were made for each DOT station during the spectacular run of May 23, but only the standard 1300 MDT ratings and fire weather observations for that day and the spring rainfall are reported here. A file report detailing the entire CFFWI analysis of the 1968 Lesser Slave Lake Fire is available on request from the author.

The differences in fuel moisture code and fire behavior index values between stations as indicated in the summary table are attributable to elevation, site, geographical location, and precipitation history. An FWI $\geq 30$ is considered to be an *extreme* level of fire danger in Alberta based on the frequency of occurrence. Nine of the 10 weather stations were indicating an *extreme* level of fire danger on May 23. Fire weather and danger at the Wagner station are obviously influenced by its proximity to Lesser Slave Lake. The FWI of 86 reported at Vega Lookout undoubtedly reflects the true fire weather severity in the area.

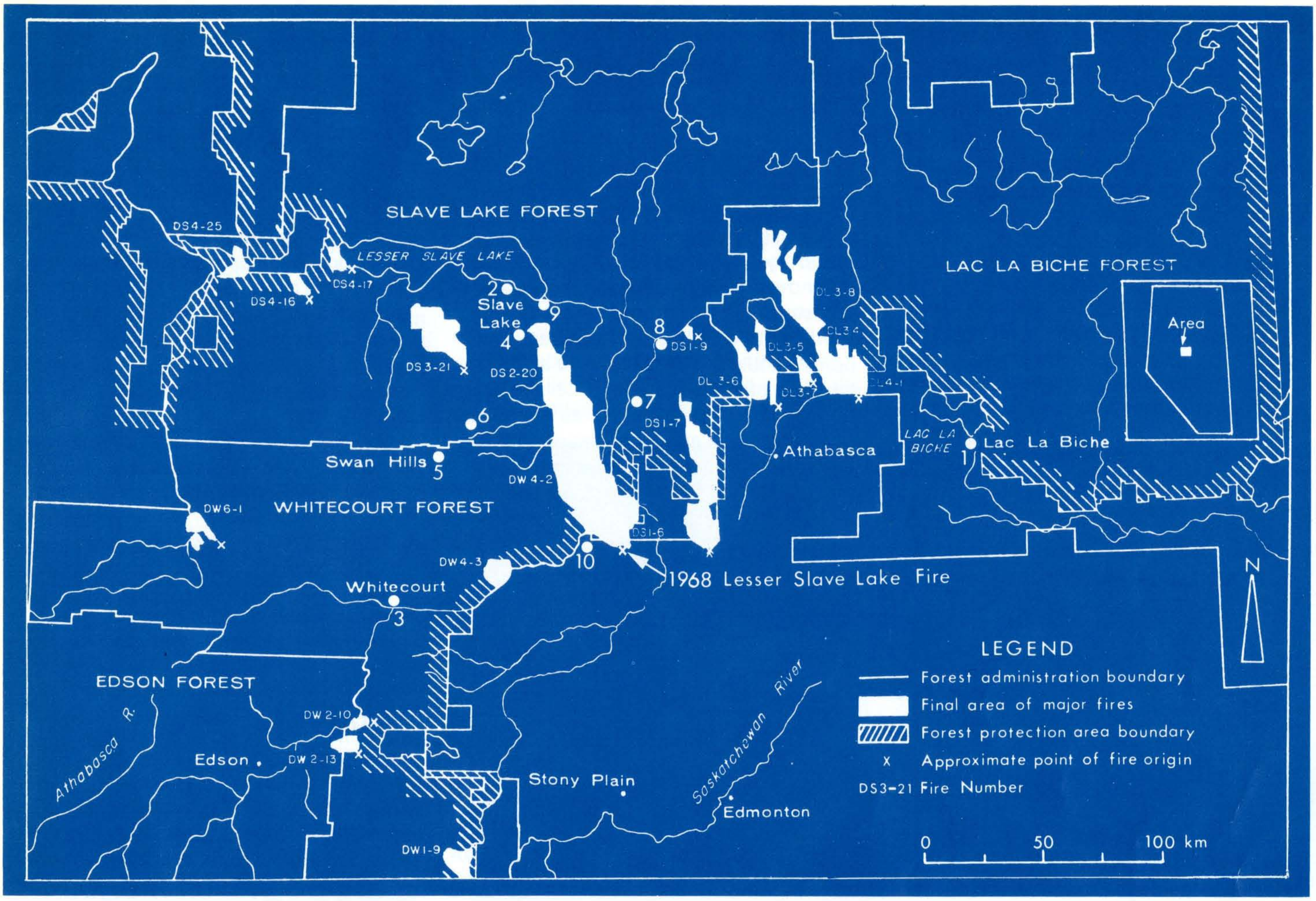
## Unusual conditions

The *extreme* FWI values resulted from a long run of dry spring weather (increasing BUI) and strong winds combined with low humidity on May 23 (extremely high ISI). How often would one expect to attain or exceed such burning conditions? According to a climatological study of the CFFWI in Alberta, the FWI is unlikely to exceed 80 more than about once every eight fire seasons.

When the CFFWI tables were first published in 1970, the fire behavior characteristics that were likely to occur at an *extreme* FWI were envisioned as follows:

> rate of spread will be extremely fast for extended periods; fire will be extremely hot and there may be extensive crowning and "long range" spotting ....

*Continued on page 10*




Location and final area of the Lesser Slave Lake Fire and of other major forest fires in central Alberta during May 1968. Federal and provincial weather stations are numbered from 1 to 10.

**Fire weather observations and fire danger conditions at 1300 MDT on May 23, 1968, from 10 surrounding weather stations prior to the major run of the Lesser Slave Lake Fire**

| Station No.[3] | Station Name | Elevation (m ASL) | Dry-bulb temperature (°C) | Relative Humidity (%) | Wind[1] Direction (from) | Wind[1] Speed (km/h) | Total rain[2] (mm) | Fine Fuel Moisture Code (FFMC) | Duff Moisture Code (DMC) | Drought Code (DC) | Initial Spread Index (ISI) | Buildup Index (BUI) | Fire Weather Index (FWI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Lac La Biche DOT | 559 | 22.8 | 21 | S | 32 (40)[4] | 9.0 (14) | 95 | 61 | 273 | 43 | 78 | 71 |
| 2 | Wagner DOT | 584 | 10.7 | 64 | N | 6 | 42.4 (8) | 87 | 35 | 184 | 4 | 47 | 11 |
| 3 | Whitecourt DOT | 741 | 20.0 | 29 | SE | 19 | 49.6 (17) | 93 | 58 | 161 | 17 | 61 | 35 |
| 4 | Flattop LO | 1030 | 15.6 | 19 | SE | 28 | 32.1 (9) | 93 | 41 | 116 | 27 | 43 | 40 |
| 5 | Swan Dive LO | 1272 | 15.6 | 39 | SE | 33 (52) | 25.2 (11) | 90 | 32 | 162 | 21 | 43 | 34 |
| 6 | Deer Mtn. LO | 1122 | 16.1 | 40 | SE | 28 (46) | 21.3 (10) | 90 | 32 | 155 | 18 | 42 | 30 |
| 7 | Chisholm LO | 677 | 21.1 | 28 | SE | 35 (54) | 7.1 (15) | 94 | 58 | 284 | 41 | 77 | 67 |
| 8 | Smith RS | 564 | 23.9 | 37 | SE | 2 | 11.4 (8) | 93 | 63 | 298 | 24 | 83 | 49 |
| 9 | Slave Lake HQ | 585 | 21.1 | 32 | SW | 18 | 32.0 (8) | 92 | 45 | 254 | 14 | 62 | 31 |
| 10 | Vega LO | 701 | 21.1 | 30 | SE | 46 (65) | 16.0 (16) | 93 | 53 | 245 | 68 | 69 | 86 |

[1] As measured at a height of 10 m in the open on level terrain.
[2] Measured between spring starting date and May 23. All stations began observations on May 1 except Lac La Biche (April 25), Wagner (April 29), Whitecourt (April 25), and Vega (May 2). The number of days since ≥0.6 mm of rain occurred is noted in parentheses.
[3] Refers to the numbered fire weather stations on the map.
[4] Reported gusts in parentheses.

# Forest ecosystems and fire hazard in central Saskatchewan

In the midseventies, 23 forest ecosystems within the Mixedwood Section (B.18a) of the Boreal Forest Region in central Saskatchewan were recognized and described in detail. The main purpose of this work (Kabzems *et al.* 1976) was "to introduce an ecological approach in forest management whereby short-term forest stand inventories would be replaced by permanent land-based ecological forest units, or ecosystems." The identification of such units was further intended "to provide a better understanding of the ecosystem concept ... and to relate consequences of various management alternatives regarding forest establishment, stand development and perpetuation."

Forest fires of the past have generally determined the type and composition of forest ecosystems, and a number of subclimax types, such as the pines and the aspen, have been effectively propagated by fire. Nevertheless, from the point of view of modern forestry, valuable natural timber stands, plantations, and areas under forest cultivation must be protected from such fires, as these can prove to be disastrous to wood-using industries. Only when fire is needed as a silvicultural treatment, perhaps to improve the seeding and planting conditions on nonproductive cutovers and other poorly regenerating areas, can strictly controlled prescribed burns be permitted.

Because susceptibility of various forest ecosystems to fire was unclear, the NoFRC fire research group was asked in 1978 by the Saskatchewan Forestry Branch to provide fire hazard ratings on the basis of available information about the individual ecosystems and knowledge of fire behavior.

The information considered in rating each ecosystem included composition of forest cover and minor vegetation, soil texture, soil drainage, site productivity, and inferred quantities of woody-ladder and ground-surface fuels that normally occur in undisturbed, mature, fully stocked stands. Variations in stand age, disturbance, and density could not be considered at the time because of inadequate data. This resulted in a system of rating that was applicable to standardized stand conditions at maturity, barring all prior interference.

Each of the 23 ecosystems received four fire hazard ratings on a scale of 1 to 10, incorporating the following conditions:

(a) Cured Dormant State (CDS) in early spring and late fall,
(b) Active Growth State (AGS) in late spring to early fall,
(c) Crown Fires (CF) in both CDS and AGS, and
(d) Surface Fires (SF) in both CDS and AGS.

During a subsequent 1979 field inspection of the various ecosystems, the individual ratings were adjusted if necessary. Participants in this field review were provincial forestry officials and fire researchers from NoFRC. A summary of the revised ratings was forwarded in 1980 to the Saskatchewan Forestry Branch.

The highest ratings of fire hazard were associated with black spruce, first in pure stands and then in various combinations with jack pine and tamarack. Next in line of diminishing hazard were jack pine, white spruce, white spruce-aspen, and aspen. Cured grass in early spring contributed substantially to fire hazard, while the predominance of *Sphagnum* moss tended to retard it.

It is beyond the scope of this article to describe the rated ecosystems individually, and the foregoing few remarks are meant to provide just a brief outline of the type of work being done. Further developments in rating fire hazard will be reported as they occur. The resulting information will serve as a regional supplement to the Canadian Forest Fire Danger Rating System.

*Z. Chrosciewicz*


#### REFERENCE

Kabzems, A.; Kosowan, A.L.; Harris, W.C. 1976. Mixedwood Section in an ecological perspective, Saskatchewan. Sask. Dep. Tourism Renewable Resour., For. Branch Tech. Bull. 8.


Flying drip torch is used in the control of large wildfires.

# Analysis — continued from page 8

Such a description adequately describes the 1968 Lesser Slave Lake Fire. The CFFWI system would have correctly interpreted the effects of past and current weather on fuel flammability had it been in use then.

How can fire managers utilize the CFFWI system in determining the potential for extreme fire behavior? Since the system is dependent on weather only, the CFFWI components can be calculated from the required elements contained in surface fire weather forecasts to yield a forecast of impending fire danger.

Unfortunately, no provision can be made in fire danger forecasting to directly account for special atmospheric conditions that are known to have a profound effect on wildfire behavior (e.g., airmass instability, low-level jet winds, large-scale subsidence). Fire managers must still rely on the state-of-the-art ability of fire weather forecasters to recognize synoptic-scale weather patterns and upper air characteristics that are conducive to extreme fire behavior.

*M.E. Alexander*


#### REFERENCES

McLean, J.; Coulcher, B. 1968. "Seven Days in May" — meteorological conditions associated with the Alberta forest fires of May 18-25, 1968. Alberta For. Serv., Edmonton.

Kiil, A.D.; Grigel, J.E. 1969. The May 1968 forest conflagrations in central Alberta — a review of fire weather, fuels and fire behavior. Can. Dep. Fish. For., For. Branch, For. Res. Lab., Edmonton. Inf. Rep. A-X-24.

# Electronic markers for relocating small forest fires

Initial-attack crews dispatched to fight small forest fires often depend on electronic marker beacons to direct them quickly to the fire. Many of these fires in the early growth stage produce very little or intermittent smoke and cannot be found easily by the crews traveling on the ground or by helicopter.

In the past 10 years there have been significant advances in the development of electronic devices for relocating small fires. Miniaturization of components, new long-lasting lithium batteries, and solar power packs have enabled researchers to develop simple, efficient, and durable electronic marking systems for fire suppression purposes.

An electronic marker system consists simply of a radio beacon dropped by a spotting aircraft near the fire and a radio receiver carried by the initial-attack crew. The beacon emits a radio signal that can be picked up by the receiver held by a crew member on the ground or in an aircraft. The directional antenna, attached to the receiver, indicates the direction to the beacon. As the antenna is pointed toward the unknown location of the beacon, the pulsating signal becomes louder, so that the strongest signal is heard when the antenna is pointed directly at the beacon (fire). The crew simply moves in the direction that is pointed out by the antenna. With little practice a crew can become highly skilled at relocating a radio beacon hidden in the forest.

## NoFRC system

NoFRC in 1972 developed an electronic marking system for relocating smokes. The early system utilized the common fire-line radio frequency (26.920 MHz) that was used by the Alberta Forest Service at that time. Commercial systems patterned after the original are available in frequency and component configurations to suit any fire suppression operation. New equipment is available that utilizes VHF frequencies (147.000 - 174.000 MHz) with advantages of greater range and less battery drain. Both beacon and receiver antennas are more efficient in the VHF frequency range.

New antennas for the receiver are more directional, making it easier to detect the direction of peak signal input. Some antenna models fold-down, making them convenient to pack through dense forest. Others are mounted directly on the receiver, resulting in a single unit module for the convenience of the initial-attack crew on the ground.

## Solar power

The new solar-powered beacons never need battery replacements and last for years. One model is strictly solar powered and will last forever unless physically damaged. This unit emits its signal during daylight hours only. Another solar-powered beacon works in conjunction with rechargeable nickel-cadmium batteries and will function day or night. During daylight hours the solar panel provides power for the transmitter, while at the same time it recharges the battery for night-time use. This unit will last 5-8 years before the rechargeable battery must be replaced.

New lightweight, hermetically sealed lithium batteries provide long-life characteristics for battery-powered beacons. A beacon equipped with a single D size lithium battery will operate continuously for a year. With an average on time of 1 month per year, the unit will be good for 10 years before battery replacement is necessary. The shelf life of the lithium battery is 10 years. Some units contain a solar switch that turns the unit off at night. The result is a doubling of life expectancy from 1 to 2 months per year for 10 years. Another beacon operates on solar power during daylight hours and lithium power at night. This unit would last 10 years if operated 2 months per year.

If more power and range are needed, there is a 1-watt beacon that will transmit a signal approximately 160 km ground to air. The more-powerful long-range unit requires more-frequent battery replacement.

Early detection leads to successful containment.

## Smoke detected

A typical application of the electronic marker technique begins with detection of smoke by an aerial observer. The aircraft moves to the smoke and circles while the observer activates one of the beacons and drops it to the ground from the aircraft. The location of the smoke is noted on a map or aerial photograph.

The ground crew is alerted and sent to a drop-off point as close to the approximate location of the smoke as access permits. A member of the crew turns on the receiver and listens for the beeping sound that indicates contact with the beacon. Once the signal has been picked up, the operator moves the directional antenna in an arc with a sweeping motion. The strength of the received signal will increase as the antenna points toward the source (beacon). The crew simply moves in the direction that is pointed out by the directional antenna. This procedure is repeated until the crew is led to the transmitter beacon at the smoke site.

These types of telemetry devices have been used for over 22 years by researchers studying the movements of wild game. The new equipment has proven durable, dependable, and capable of improving our ability to relocate small forest fires.

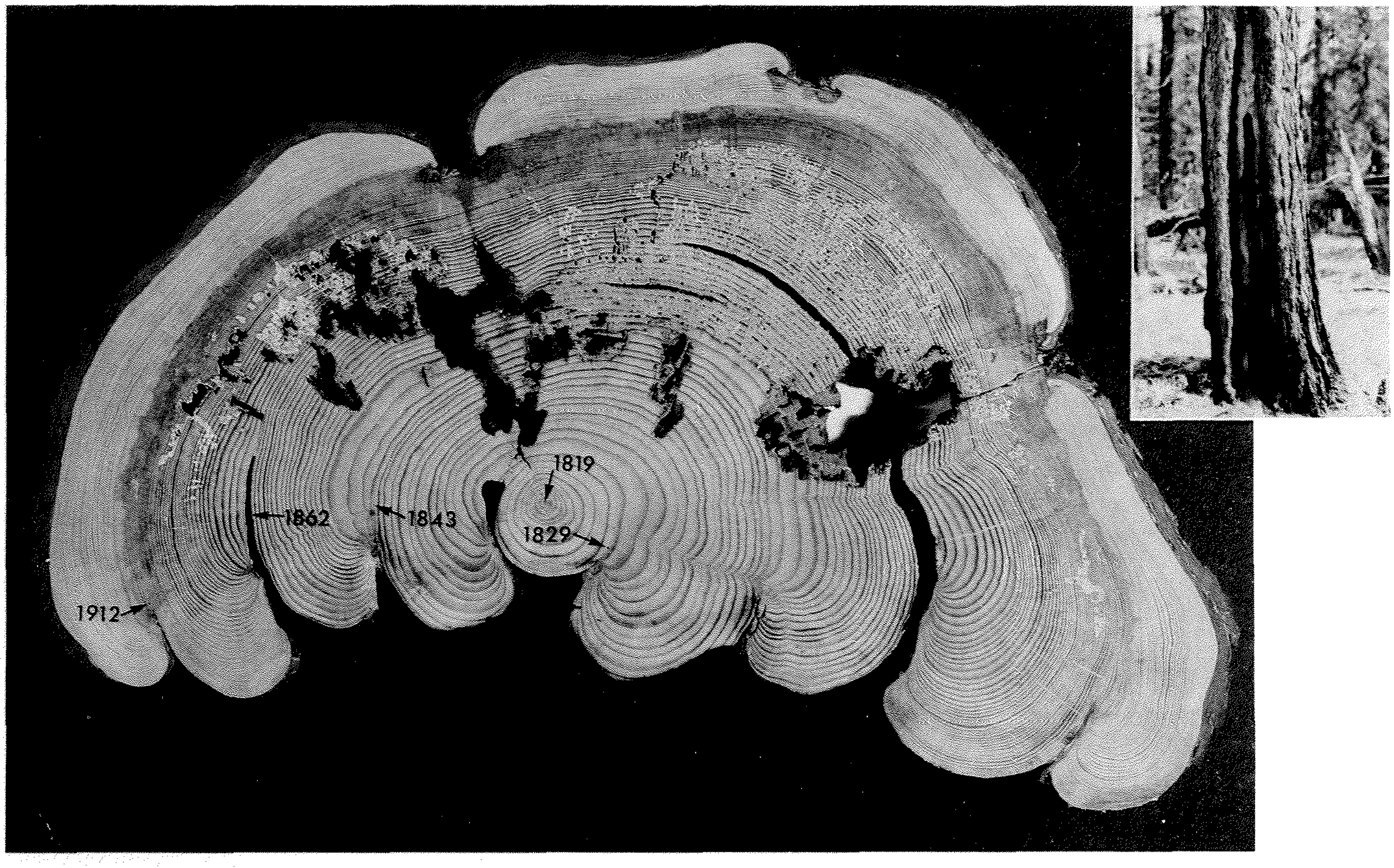
*G.M. Lynch*
*Alberta Energy and Natural Resources*

### SUGGESTED READING

Ponto, R.L. 1973. Electronics to replace toilet tissue as fire marker. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent. For. Rep. 4(4):4.

Ponto, R.L. 1974. Electronic fire marker being tested in Canada. USDA For. Serv. Fire Manage. Notes 35(2):14-15.

Ponto, R.L.; Lynch, G.M. 1973. Use of electronic markers to relocate small forest fires. Can. Dep. Environ., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-61.




Four fire scars in this jack pine cross-section provide evidence of fires in 1829, 1843, 1862, and 1912. Maximum width of this ground-level disk is 43 cm. The outside of the bole is shown in the insert.

The tree section was collected in 1979 from a park-like jack pine stand near the Parson Lake fire tower in Wood Buffalo National Park. Following its establishment in about 1817, the tree recorded fires at a mean interval of 28 years, with a range of 14-50 years, during the 96 years from 1817 to 1912. Some blue stain and carpenter ant activity can also be seen in the cross-section.

# One and one-half centuries of fire in Wood Buffalo National Park

Fire scar dating is one of the most reliable techniques used to decipher recent fire history. Just as tree rings are indicators of growth conditions, fire scars provide information on the frequency, areal extent, and to a certain degree the intensity of past forest fires.

A fire scar results when sufficient heat is applied to the surface of a woody plant long enough to kill a portion of the cambium layer. The fire-damaged tree then tries to heal itself by forming new wood (callus tissue) to cover the wound area. Jack pine will also exude resin to protect the newly exposed wood against insect and disease entrance. This process, however, is usually only partially successful, and because the resin is highly flammable, the tree's susceptibility to further fire scarring is enhanced.

Fire scars are dated by counting the number of annual rings from the cambium layer back to the callus tissue. Unfortunately, fire scars represent only some of the fires that have swept the surrounding area. Because of fuel discontinuity, fuel moisture variability, and fire residence time, the heat energy of a surface fire can miss an indiviual tree and therefore not leave any permanent record on it. That is why it is practically impossible to deduce the fire history of a certain area by studying a single fire-scarred tree.

Information collected from fire scar dating, even-aged stands of fire origin, charcoal and pollen analysis of lake bottom sediments, early cultural diaries and records, and historical fire statistics improves our ability to interpret and manage the existing vegetation mosaic in terms of past fire regimes.

*G.P. Delisle*
*D.E. Dubé*

Editors: J.K. Samoil and G.B. Turtle

This Forestry Report was coordinated by D.E. Dubé and was prepared by the Fire Research Group.

Northern Forest Research Centre
5320 - 122 Street
Edmonton, Alberta T6H 3S5
(403) 435-7210


Cat. No. Fo29-3/28-1983E
ISBN 0-662-12765-X
ISSN 0709-9959

Environment Canada / Environnement Canada
Canadian Forestry Service / Service canadien des forêts

Canada