Backburning in Wildfire Suppression: A Comparative Suppression Cost Analysis of Backburning and Direct Attack on Five Northern Manitoba Wildfires

By

Chris Kuzenko

A Practicum Submitted in Partial Fulfilment
of the Requirements of the Degree,
Master of Natural Resources Management

The Natural Resources Institute
The University of Manitoba
70 Dysart Road
Winnipeg, Manitoba
R3T 2N2

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0-612-51736-5

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ABSTRACT

An analysis of backburning on five fires in northern Manitoba has revealed that the cost of conventional wildfire suppression, or direct attack, can exceed the cost of backburning to secure fireline by a ratio of over 100 to 1. The fires analyzed occurred during the 1995 fire season and all were large fires that had exceeded initial attack capabilities. Due to the severity of the fire season, suppression resources were stretched thin and backburning with a helitorch became a strategy that comprised a major portion of each fire's suppression effort. Documentation of the fires was adequate to permit an analysis of backburning costs for comparison with direct attack.

On four of the five fires, it was demonstrated that backburning comprised less than 4% of the total suppression cost while at the same time was responsible for securing an equivalent amount of fireline as direct attack. When related to the cost to secure one kilometre of fireline, backburning costs ranged from $81.00 to $783.00 per kilometre as compared to $20,056.00 to $98,757.00 per kilometre for direct attack. One of the fires in the study was secured using backburning as the only suppression technique. A total of 6.8 kilometres of fireline was secured at a cost of $783.00 per kilometre, a relatively low expenditure when compared to direct attack suppression.

The cost effectiveness of backburning can be attributed to three primary factors: 1) a relatively small amount of aircraft, equipment, and personnel are required to conduct a burn operation regardless of its size; 2) a large amount of fireline can be secured in a very short period of time thereby speeding up the suppression effort; and 3) the costs of backburning are a function of time required to complete a burn and do not rise appreciably as the size of a backburn operation or fire increases.

ACKNOWLEDGMENTS

The author would like to express his gratitude to the Manitoba Department of Conservation Fire Program for providing the sponsorship and opportunity to complete this project. Had it not been for the technical and logistical assistance in compiling and analyzing data and the time allowed during "working hours" for re-writes, GIS analysis, and revisions; this study could not have been completed. Numerous individuals provided valuable information and assistance and all are thanked for their support. It is hoped that the information within will be of interest to the province's fire managers and the study results will be of value and utility to the provincial Forest Fire Program.

Members of the author's research advisory committee at the Natural Resources Institute, including Thomas Henley (University of Manitoba), Rick Riewe (University of Manitoba), Pierce Roberts (Manitoba Department of Conservation), and Bill Medd (Manitoba Department of Conservation Fire Program)(retired) are thanked for their input and comments on drafts of this report.

A special thanks is extended to Pierce Roberts who, as a co-worker and leading expert in the field of backburning, provided valuable technical input and was responsible for getting me involved in the Manitoba Backburn Program.

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Finally, I would like to thank my family and friends who provided the motivation required to complete this project by constantly telling me to "*get your practicum done!*"

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF TABLES

Chapter 1

INTRODUCTION

1.1 Background

Forest fire managers have a number of suppression tools available to assist in containing and extinguishing forest fires. Sophisticated lightning detection systems, helicopters, air tankers, and a variety of other suppression equipment have permitted fire managers to detect and attack fires rapidly and effectively. Many of these tools are responsible for significant leaps forward in fire suppression efficiency which as a result has reduced the number of fires that historically would have burned out-of-control causing widespread destruction of forest and property values (Wein & MacLean 1983). Notwithstanding the improvements to suppression efficiency, large fires are still phenomena that fire managers are faced with (Bailey 1985; Hurd & McBride 1985; Doerkson 1985; Kincaid 1985; Pyne 1984).

A recent advance in suppression technology has been the development of the helitorch (Photo 1). Initially developed in the 1970s for the ignition of coastal slash burns in British Columbia (Quintilio et al.,1985), the helitorch is a specialized drip torch that is slung and remotely activated from a helicopter using gelled fuel to achieve ignition (Merrill & Alexander 1987). Although the helitorch has been available since the seventies, it has recently opened new possibilities for large-scale backburning[1], a technique that is gaining popularity in the forest fire suppression field. By allowing a large volume of fire to be rapidly set from the air, the helitorch has expanded backburning to a scale that at one time was impossible and unsafe to achieve using conventional hand-ignition techniques.

[1] Backburning, in the context of this paper, is a collective term used for all suppression strategies that use intentionally set fire to remove unburned fuels from the path of an advancing fire. This includes backfiring, burning out, and burning off. These strategies are covered in Chapter 2.

Photo 1. The Manitoba Helitorch being used on a burnout.

Fire managers are now able to combat forest fires in ways that were at one time difficult to conceive. With favorable conditions, a helitorch can be used to knock down the head of a crown fire or steer it from its direction of spread. Convection columns can be "stood up" to improve visibility for air tankers and fires can be contained within the confines of inter-linked networks of natural fuel breaks (Photo 2). By using natural fuel breaks as a barrier to fire spread, suppression costs can be significantly decreased by reducing the fire perimeter requiring traditional suppression action involving ground crews, air support, heavy equipment, etc. (Quintilio et al. 1985; ETC 1995). This benefit has been recognized by many forest protection agencies and some have undertaken steps to incorporate the helitorch into their suppression programs (SFFMB 1995). Manitoba's Forest Fire Program has been no exception.

The Manitoba Conservation Forest Fire Program introduced a Backburn Program into the provincial forest protection program in the spring of 1991. The objective of the program was to place experienced personnel in charge of provincial helitorch backburning operations. Prior to the Backburn Program, the helitorch had been used to combat forest fires in the province;

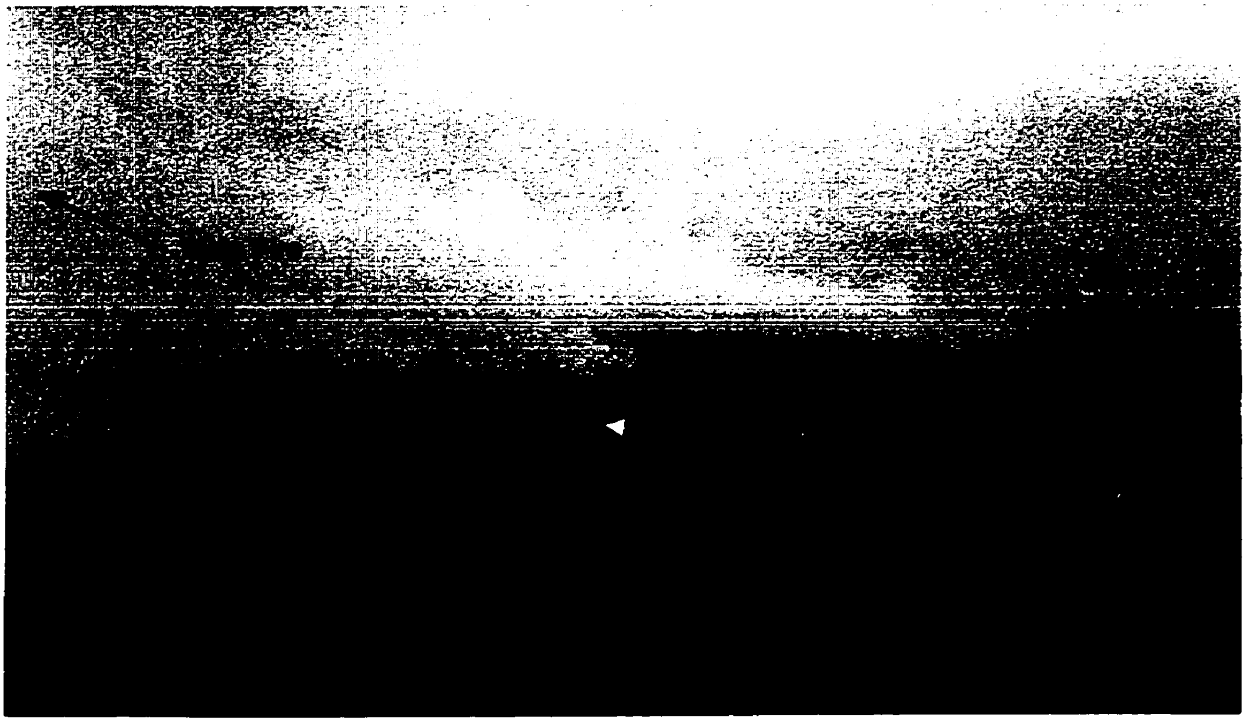

Photo 2. A creek is used as a natural fuel break for a burnout operation. The main fire was located out of the picture to the left. A helitorch was used to ignite and burn out the unburned forest fuels between the creek and the fire. The objective of the burnout was to use the creek as a control line to prevent the fire from spreading into merchantable timber located out of the picture to the right.

however, this was infrequent and often had limited success. This was due, in large part, to a lack of reliable equipment, a poor understanding of backburning as a suppression technique, and a lack of personnel experienced in applying prescribed fire (Roberts pers. comm. 1999). If the helitorch was to be used effectively in the provincial forest fire program, a change in operating procedures was required. In response to this need, the Backburn Program was formed. A new reliable helitorch was developed, and the responsibility for all provincial backburning operations was appointed to specialized Backburn Teams.

Since the Backburn Program's inception, Manitoba burn teams have been deployed on approximately 100 burn operations with in excess of 50 deployments occurring in the 1995 fire season. The high rate of use in 1995 can be attributed to the severity of the fire season which saw fire managers, faced with a shortage of suppression resources to fight multiple fires, frequently relying on backburn strategies as a means of fire control. The season provided a valuable learning experience for provincial helitorch personnel, as there were several opportunities to test the helitorch in a variety of different fire situations. The suppression results that were achieved on several fires exceeded fire managers' expectations, and only recently have many begun to realize the utility of the helitorch as a fire suppression tool. Backburning with a helitorch is still a field in its formative stages, and there is still much that can be learned.

1.2 Problem Statement

Although the Manitoba Backburn Program has been a part of the provincial forest fire program since 1991, its introduction was low-key and was initially on a trial basis. In fact, until the 1995 fire season, very few fire suppression personnel in Manitoba were even aware that a provincial Backburn Program existed. Consequently, acceptance and utilization of backburning was slow.

Due to the relatively quiet entry of the Backburn Program into the provincial forest fire program, there has been somewhat of a subsequent need to "prove" to both provincial forest fire managers and suppression personnel that backburning on a large-scale with a helitorch has its place in provincial forest fire suppression. Initially many personnel were skeptics who felt backburning only burned more forest than it saved. This was an attitude borne from previous bad experiences with backburning conducted by inexperienced personnel prior to the development of the Backburn Program (Roberts pers. comm. 1999). However, since the program has been in place there have been an increasing number of occasions where backburning has been used on different fires. The value of this strategy is slowly becoming realized and its use has been on the increase.

In today's environment of fiscal restraint, there is more pressure on fire managers to make decisions on the basis of economic justification. In many instances, if the economic values of the forest and/or property threatened by fire are not worth the money to put the fire out, the fire may be left to burn and run its course. This is particularly evident in Manitoba's Observation Zone where fires are generally left to burn unless a significant value is threatened. When developing a suppression plan, provincial fire managers must weigh a number of variables to develop the most suitable plan that will help bring the fire under control; one of the most important variables being the cost.

One of the main claims made by proponents of backburning is how a properly executed backburn strategy, under the right conditions, can reduce the amount of fire perimeter requiring direct attack suppression thereby decreasing total suppression costs. Although this is a relatively straightforward concept, there is very little documented evidence to support this claim. In Manitoba, the only evidence is through word-of-mouth and various individual eyewitness accounts of successful backburn operations.

To date, an attempt to quantify and document the cost-saving potential of backburning on fires in Manitoba has not been completed. At present, provincial fire managers do not know the costs of backburning in relation to direct attack[2], nor is there a method of making a comparison. This type of information is important when evaluating suppression options, in particular where there may be an opportunity to utilize backburning to reduce suppression costs. Although cost is not the only variable that must be considered when choosing suppression alternatives, it is one of the most significant, and it stands to reason that fire managers should be familiar with its cost-saving potential.

[2] Direct Attack is defined as a fire suppression method where the fire is attacked immediately adjacent to the burning fuel. Direct attack involves the use of ground suppression crews, aerial attack, and heavy equipment to extinguish the fire perimeter.

1.3 Objectives

The purpose of this study was to evaluate the cost-saving potential of backburning as compared to the method of direct attack suppression. Five case-study fires involving backburn strategies were evaluated to achieve the following specific objectives:

- to document the objectives of the backburn strategy on each fire and discuss if the objectives of the burn plans were met;
- to determine the amount of fire perimeter secured on each fire by both backburning and direct attack suppression establishing each in relation to the total fire perimeter;
- to calculate backburn and direct attack costs on each fire establishing the proportion of each in relation to total costs;
- to calculate a comparative measure for direct attack and backburning costs; and,
- to make recommendations regarding the use of backburning on the basis of suppression cost.

1.4 Limitations to the Study

Although there have been upwards of 100 separate backburn operations conducted in Manitoba since the Backburn Program began, this study only researched five fires for the analysis. The reason for only using five fires can be attributed to a lack of documentation of fires that have included a backburn and direct attack strategy. The primary goal of the study was to make a comparison of backburning vs. direct attack; thus fires that had received both suppression strategies were required. To accurately do a comparison, it was necessary to know exactly where each strategy was used on the fire, what the suppression objectives of each strategy were, if the objectives were achieved, how much fireline was secured by backburning and direct attack, what were the costs, and numerous other bits of information.

The five fires that were chosen were the only fires with records that were documented well enough to contain enough information to permit the analysis. Formal documentation of backburn operations and recording of day-to-day suppression action are not a regular part of fire record keeping in Manitoba. Generally this information is documented in the personal notes of suppression staff but does not form a part of the final fire record or file. Most records contain no more than a final point-form fire report, payroll journal records and a final map of the fire, which in some cases is incomplete. A certain amount of information was obtained from the Manitoba Conservation National Fire Information System (NFIS) database such as fire weather observations and costs; however, detailed records of the suppression activity were generally only available from field staff notes and their personal recollection. This was necessary information that was required to separate the backburning from direct attack suppression in order to make a comparison.

Fortunately the five fires chosen had enough information to permit the analysis. Although the records were not entirely ideal, the author was a member of the Backburn Team that conducted the backburning on each fire, which aided in recounting the events that took place as well as the names and positions of field staff that also worked the fire. These other individuals provided valuable information to fill the gaps where information and documentation was lacking.

A second limitation of the study is that it only focuses on fires on which backburn operations were successful in meeting the suppression objectives that were set out prior to execution of the burn plan. It does not attempt to evaluate backburn operations that were unsuccessful or did not achieve their suppression objectives. There is no question that backburning may not always be successful and there is a risk that a set fire may escape and result in more damage than if the burn was attempted. There have been instances where this has occurred in Manitoba but these happened in the "early years" prior to the development of the Backburn Program when large-scale backburning with a helitorch was not well understood (Roberts, pers. comm. 1999). The main goal of the study was not to prove whether backburning or direct attack was a better suppression option but rather to compare two effective suppression techniques in achieving a common objective; bringing a fire under control. It is recognized and must be stressed that backburn strategies are not possible on all fires and require a special set of burning conditions and weather that must be present for a burn to succeed. Backburning is not a replacement for direct attack but rather another tool available to today's fire manager that may be used in conjunction with other suppression techniques.

As a final note, one of the primary objectives was to compare backburning to direct attack costs, there was no attempt made to compare the economic value of "values" (timber, property, habitat, etc.) that were protected or may have been lost as a result of either suppression technique. The study focused only on suppression costs.

Chapter 2

AN OVERVIEW OF FIRE MANAGEMENT IN MANITOBA AND THE APPLICATION OF BACKBURNING IN FOREST FIRE SUPPRESSION

2.1 Introduction

Chapter 2 provides a brief overview of forest fire management in Manitoba, followed by a discussion of backburning and its application in forest fire suppression. To assist in placing the helitorch and backburning into the context of provincial fire suppression, the chapter begins with a review of Manitoba's fire management policy and objectives, a description of provincial forest protection zones, and a brief discussion of initial attack, direct attack, and escaped fire suppression objectives. A discussion of backburning objectives is provided in the latter part of the chapter, followed by a discussion focusing on specific applications of the technique which are presented through a review of the three primary backburning strategies that are presently used.

2.2 Manitoba Forest Fire Management Policy

Provincial forest fire management activities are the responsibility of the Operations Division of Manitoba Conservation. Forest fire suppression is conducted at the district level under the direction of a Regional Duty Officer who is responsible for resource allocation and preparedness planning activities in the region. The duty officer receives direction from the Fire Program, the administrative body responsible for fire management, located at the provincial headquarters in Winnipeg, Manitoba.

Provincial fire management activities are directed by the following mandate:

> *As the primary forest fire protection agency in the province, the department has a mandate under the Wildfires Act to directly provide and/or support fire protection within the Burning Permit Area and unorganized territory and to assist in fire control outside of these areas when necessary and/or requested - subject to availability of resources and values at risk.*
>
> Policy Directive, PO 15 / 02, Manitoba Natural Resources, revised, January 1, 1998. (Manitoba Natural Resources 1999)

Under direction of the policy mandate, Manitoba Conservation Fire Program tries to meet three specific forest fire management objectives:

1. *to protect life, property and other resources from wildfires;*
2. to provide levels of protection consistent with the values at risk; and
3. to minimize total costs plus losses.

The main priority is the protection of life. The majority of forest fires do not directly pose an immediate threat to people; therefore, Manitoba's fire suppression activities primarily involve protecting timber, property, and resource values.

2.3 Provincial Fire Protection Zones and Initial Attack Objectives

Manitoba is divided into three fire protection zones that were established as part of the criteria used for decision-making in determining the nature of suppression response that the Fire Program may take on fires within the province. They include the Observation Zone, the Primary Protection Zone, and the Agricultural Zone (Figure 1). Fires in the Observation Zone are generally left to burn unless a threat to life or property values warrants a suppression response. Agricultural Zone fires are the responsibility of a Rural Municipality or Local Government District and suppression action is only conducted upon request. The most significant portion of provincial forest fire suppression takes place in the Primary Protection Zone which makes up much of the wooded area of the province, and it is here where most of the province's commercially valuable timber can be found.

The Primary Protection Zone is further subdivided into priority zones that have been established on the forestry values at risk (Figure 1). The Department's response to a fire will largely depend on within which zone the fire is located; "red" zone fires are highest priority receiving an immediate initial attack. "Green" zone fires are lower priority, but initial attack may still be undertaken based on the values at risk and the availability of fire suppression resources. "Yellow" zone fires are considered intermediate in priority.

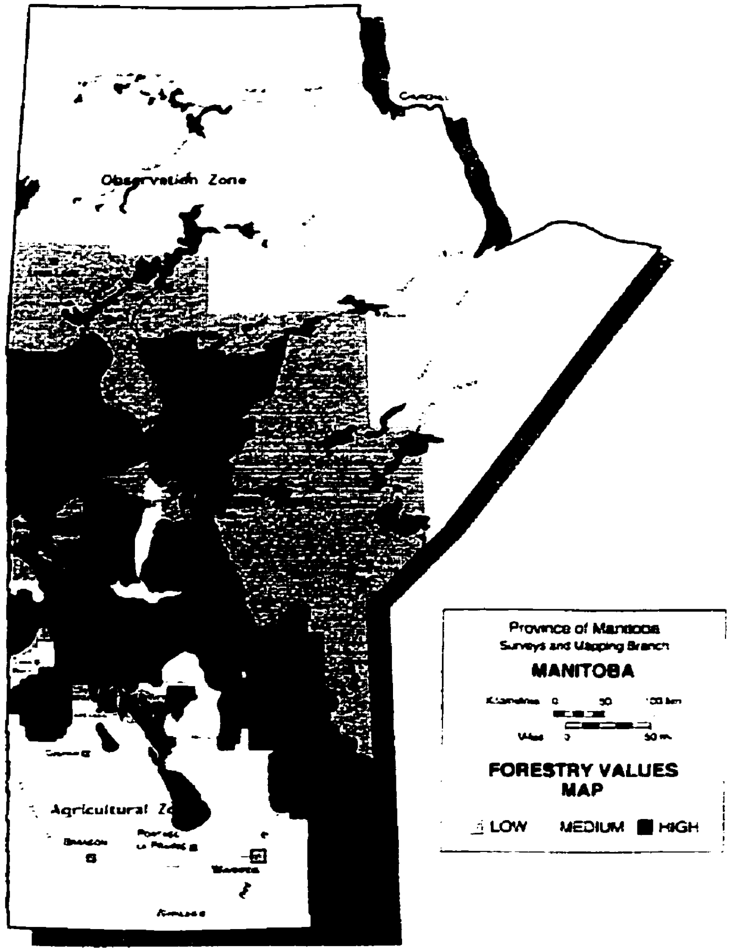

***Figure 1.** Manitoba's provincial fire protection zones and fire priority zones. The fire priority zones are based entirely on forestry values. The current map was last revised in 1994 and is currently under revision.*

Every fire season, Manitoba Conservation establishes a minimum base level of suppression resources throughout the primary protection area. This permits the Fire Program to be prepared for initial attack in the event a new fire is reported. The provincial base level for an initial attack response time is 60 minutes from when a fire is reported. This is applicable when fire alert levels are low, and the time is reduced accordingly to 30 minutes or 15 minutes as the fire danger becomes more severe (Manitoba Natural Resources 1990). The shorter response time requires that more initial attack crews and resources be placed in those areas where fire danger is the highest and where values at risk warrant an immediate response. This is to ensure all newly reported fires are "hit hard and hit fast" and quickly brought under control. The objective is to achieve this goal by the time a new fire reaches 1.2 hectares in size (Manitoba Natural Resources 1999).

2.4 Direct Attack Objectives

Direct Attack is the primary method of wildfire suppression. It involves the placement of ground crews on the fireline to physically extinguish the fire perimeter using pumps, hose, hand tools and other suppression equipment, which can include waterbombers, a helicopter and bucket, and heavy equipment.

In the initial attack stages of a fire, the first suppression action will either be placement of an initial attack crew with suppression equipment on the fireline and/or an aerial attack on the burning fire perimeter with waterbombers. Depending on the fire location, the initial attack crew will arrive at the fire by helicopter, fixed wing, boat, or vehicle. Once at the fire, an assessment of the fire is conducted and an initial attack plan is formulated. A water source close to the fire will be chosen which could include a lake, pond, stream, swamp, or other source with a sufficient water supply. Hose is laid out and water is pumped from the source to the fire perimeter where the crew will undertake to extinguish the fire by surrounding it with hose while putting out the burning perimeter. Once the fire has been surrounded and the perimeter has been secured, the fire crew will work their way into the centre of the fire to extinguish, or mop up, the remaining hotspots until the fire is out. Generally, an initial attack crew will be replaced with an Emergency Fire Fighter (EFF) crew to complete the mop up, but if the fire is relatively small and can be extinguished rapidly, the initial attack crew will remain on the fire until it is out.

When a fire is of a low to moderate intensity it can usually be extinguished relatively easily with ground suppression forces alone (Hirsch & Martell 1996). However, if the fire intensity is such that there is a potential for a fire to escape before a fire crew can surround it, an aerial attack with waterbombers and/or a helibucket may be used to "cool down" the fire perimeter to assist the ground crews. The decision to use an aerial attack is generally made during the initial fire assessment prior to placing the ground crew on the fire. However, in some cases when a fire poses a control problem, an aerial attack is called in after initial attack has commenced.

The primary objective of initial attack is to contain and extinguish fires while they are small and easily handled with a relatively small suppression effort. However, if the fire weather and fuel conditions are such that a fire cannot be contained with initial attack, or if a fire is simply too large to contain with one or two crews, the fire suppression effort grows. Additional ground crews will be required and will be placed along the fire perimeter at different water sources or intervals in an attempt to contain the fire. Containment is achieved when the crews "tie in" with each other around the fire perimeter which is simply when a crew meets up with the next and extinguishes the fireline in between. More crews are required as the length of the fire perimeter that needs to be extinguished increases. On very large fires, it is not unreasonable to have hundreds of personnel, numerous helicopters, air attack, and heavy equipment involved in the direct attack effort. When a suppression effort reaches such a large scale, a fire is considered a project and a project team overtakes the suppression effort. A project, or overhead team, is a group of specialists trained in large fire suppression who take over the coordination of the suppression effort.

The logistics of a project fire suppression effort are complex and require the coordination of two large operations, the suppression function and service and supply function. The suppression function is a group of individuals concerned primarily with the planning and execution of the suppression plan while the service and supply function serves as a support role to suppression. Service and supply includes, but is not limited to, the set up and operation of the base camp; administration and accounting; and coordinating the procurement and distribution of food, supplies, fire equipment, accommodation, transportation, fuel, personnel, heavy equipment, first aid, commissary and anything else required to keep the suppression effort functioning for a period of days or weeks. Direct attack on a project scale, or smaller, is labor-intensive and is an expensive operation particularly if a fire is located in a remote location accessible only by air, as aircraft can account for over 50% of the total costs of suppression

(ETC 1998; Manitoba Natural Resources 1995). Placing ground crews on a fire and providing support with aircraft is the primary reason why direct attack costs are high.

2.5 Escaped Fire Suppression Objectives

Fortunately, Manitoba's Initial Attack System is successful in extinguishing most new fires at a small size and the objectives of the provincial fire management policy are frequently met. However, if weather conditions cause extreme fire behavior, a fire can escape initial attack and the task of extinguishing fires becomes more difficult. Fires that escape initial attack undergo an escaped fire/financial control analysis which is a process that outlines alternative plans for suppression, their estimated costs, the probability of success of each suppression plan, and an estimate of the values at risk. The Regional Director approves a plan before additional funds are committed to the fire. Once approved, a copy of the analysis is sent to the Provincial Duty Officer who in turn ensures the Assistant Deputy Minister of Operations Division and the Director of Headquarters Operations are kept informed of the situation (Manitoba Natural Resources 1996b).

In an escaped fire analysis, several alternative suppression strategies are considered based on the situation at hand. These could include abandonment of a fire, limited action, or a full-scale suppression attack. Abandonment usually occurs where the values at risk do not warrant a response, and consequently suppression action will not be taken. However, if a fire requires a limited or "all out" attack, many options are considered. Limited action is where only portions of a fire's perimeter are attacked to protect values that may be threatened, whereas a full-scale attack is a commitment to suppress an entire fire perimeter.

Expenditures on suppression can be considerable particularly when weather conditions favoring extreme fire behavior persist for several days and a fire grows to be very large. Therefore, the costs of the alternative strategies play a major role in which alternative will be chosen. Strategies that appear to have the most potential to keep a fire from spreading while minimizing suppression costs are generally the favored choice. In Manitoba, backburning is one such strategy. However, there remains hesitancy on the part of some fire managers to consider a backburn operation as a suppression option. This is due to an incomplete understanding of the technique and how it can be applied to a suppression effort. This has resulted in missed opportunities to backburn when it would have been the most feasible suppression alternative (Roberts, pers. comm. 1999). In many cases, backburning is viewed as a last resort and the request for a Burn Team is made after the point where a backburn operation would have been most effective.

2.6 Backburning Defined

Fire managers have always pondered the difficulties associated with the task of containing a large fire. Containing such a fire involves a large expense due to the number of suppression resources that are required (Brown & Davis 1973). With reductions in fire suppression budgets, using backburn strategies has become a viable option to keep these costs to a minimum (ETC 1995).

Backburning, also known as an indirect attack or *fighting fire with fire*, refers to a collective term used to describe three forest fire suppression strategies: burning out, backfiring, and burning off. Although backburning techniques have been defined and described by various authors (Van Nest 1989; ETC 1995; SFFMB 1995; AFS 1998; Merril & Alexander 1987; BCMF 1984) backburning in this report is described in the context of it's application in Manitoba (Manitoba Natural Resources 1996a). The objective of backburning is to use fire to consume fuel in the path of a fire thereby reducing or eliminating its spread potential.

In forest fire suppression, the helitorch is used to ignite another fire, which subsequently competes with the main fire for fuel. In the context of this paper, backburning will refer only to those operations that utilize the helitorch as the means of ignition. As previously mentioned, the helitorch is slung beneath, and remotely operated from within a helicopter, and when activated emits a flaming stream of a gelled gasoline or turbine fuel (Jet B) mixture that falls to the forest floor. Globs of the burning mixture hang in branches as it passes through the treetops thereby igniting the fuels from the canopy to the ground surface within minutes developing a high intensity wall of flame.

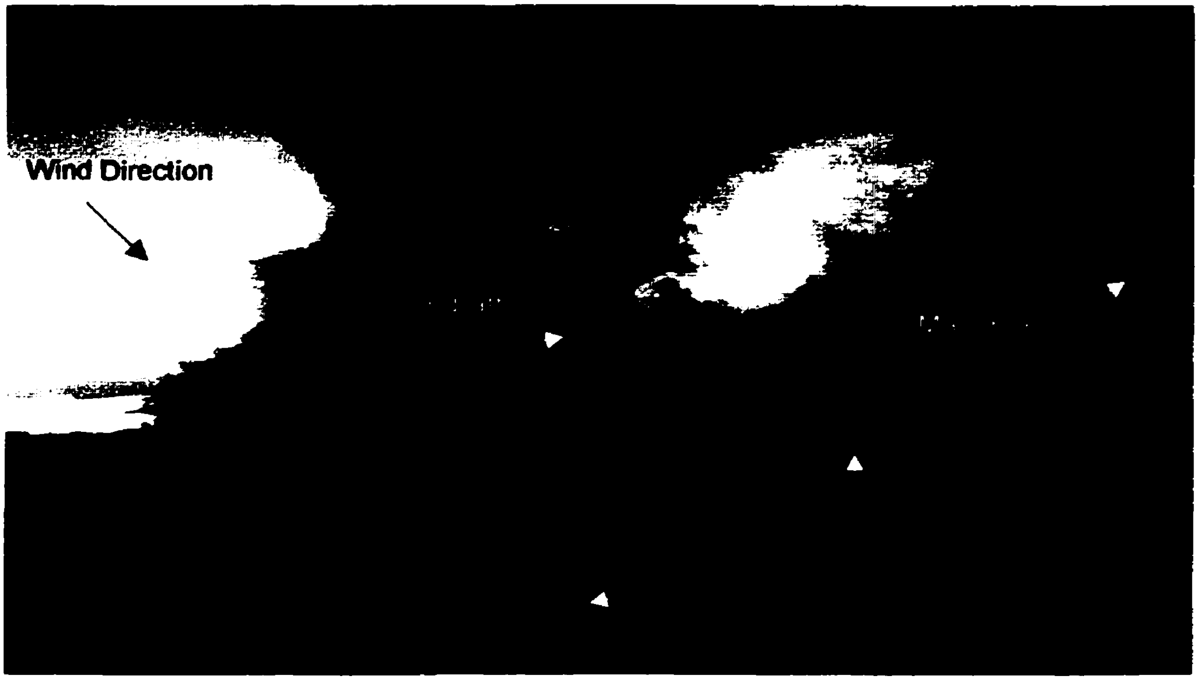

Photo 3. An example of a fire's convection indraft. The main fire is located to the right of the picture. The effect of the indraft is evident as demonstrated by the tilt of the smoke columns. As hot air rises in the main convection column (to the right out of the picture), it is replaced from all sides with the indraft of cooler air. The above was a burnout operation. The indraft was used to draw the parallel ignition lines into the main fire. The heat from the main fire generated a sufficiently strong indraft that enabled the backburn to be conducted against the effect of the prevailing wind.

One of the most important facets of successful backburning is the utilization of a forest fire's convection indraft (Photo 3). When a fire burns and gathers momentum its intensity increases and heated air and smoke rises building a convection column. As the column develops, the hot, rising air is replaced by an indraft of cooler air drawn into the fire near the ground surface. The more intense the fire and larger the convection column, the stronger the indraft of cooler air. This indraft effect can be dramatic on large forest fires, so much so that it has been observed to crest waves on lakes in a fire's vicinity (Walker pers. comm. 1995). Fire suppression personnel, in effect, take advantage of this natural indraft phenomenon when using backburning strategies. Fires set inside the influence of the indraft are pulled toward, and burn into, the main fire eliminating an intervening area of fuel. Alternatively, fires can be set and made of such intensity that their indrafts can be used to influence a fire's spread direction. Several options are available. However, regardless of the strategy chosen, fire personnel must be familiar with the principles of fire behavior and how the interaction of an aerially lit fire can alter the character of a forest fire (Rothermal 1985). The secret to a successful backburn strategy is not completely in understanding the scientific principles controlling how it works, but rather in how it is applied.

2.7 Backburning (Indirect Attack) Objectives

The justification for using a backburn strategy is related to its cost-effectiveness and capability in helping to bring a fire under control when other suppression options may not be feasible. In the only documented evidence found by the author at the time of this writing on the cost-efficiency of backburning, Quintilio et al. (1985) have suggested a rough estimate of backburning costs of $375/km. This is a significantly low figure when compared to direct attack costs of about $18,750/km for the same length of fireline. Whether a cost saving of this degree will be achieved depends entirely on the success of a backburn and if the objectives of a backburn strategy are met. These objectives include: the utilization of natural fuel breaks for containing the fire, slowing the head fire spread rate, reducing the spotting potential, altering the direction of head fire spread, improving visibility for airtankers on the fire front, and creating a sufficiently wide fuel break where necessary (Van Nest 1989).

Indirect attack using a backburn strategy is not required on all forest fires. In general, most fires are surface types of low to moderate intensity and can be direct attacked and extinguished using ground crews, water bombers, helibucketing, and heavy equipment (Pyne 1984). However, one of the most common reasons for a fire's escape is the high fire intensity brought on by winds and crown fire activity (Alexander & Cole 1994). In these situations, a direct attack is often not a feasible option from both an economic and safety standpoint, and backburning becomes a viable alternative. Backburning is possible and best accomplished under extreme burning conditions where a complete removal of fuel can be achieved (Photo 4).

In general, the specific objectives a fire manager will want to achieve on a large fire will dictate the type of backburn strategy that will be used. These could include burning out, backfiring, or burning off.

Photo 4. Ideal conditions for backburning. The extreme burning conditions were excellent to ensure complete removal of both aerial and surface fuels.

2.7a Burning Out

By far, the majority of backburning strategies that are conducted can be referred to as burnouts. Burning out is defined as: "*A fire suppression operation where fire is set along the inside edge of a control line or natural barrier to consume unburned fuel between the line and the fire perimeter, thereby reinforcing the existing line and speeding up the control effort* " (Merrill & Alexander 1987, p.4). A burn out strategy is generally used when unburned fuel exists between a fire's edge and a natural barrier (Photo 5) or an established control line. The objective of burning out is to remove both the surface and aerial fuels and with it, the potential for the fire's edge to flare up, build momentum, and jump the control line.

In theory, the ideal place to conduct a burnout is on the upwind side of a fire where the prevailing wind blows away from a control line and toward the fire. A backburn fire can be lit along the inside edge of a control line, which in turn spreads into the main fire under the influence of the prevailing wind. By burning out the fuel, the risk of a potential flare up can be prevented should the wind shift and blow in the opposite direction at a later time.

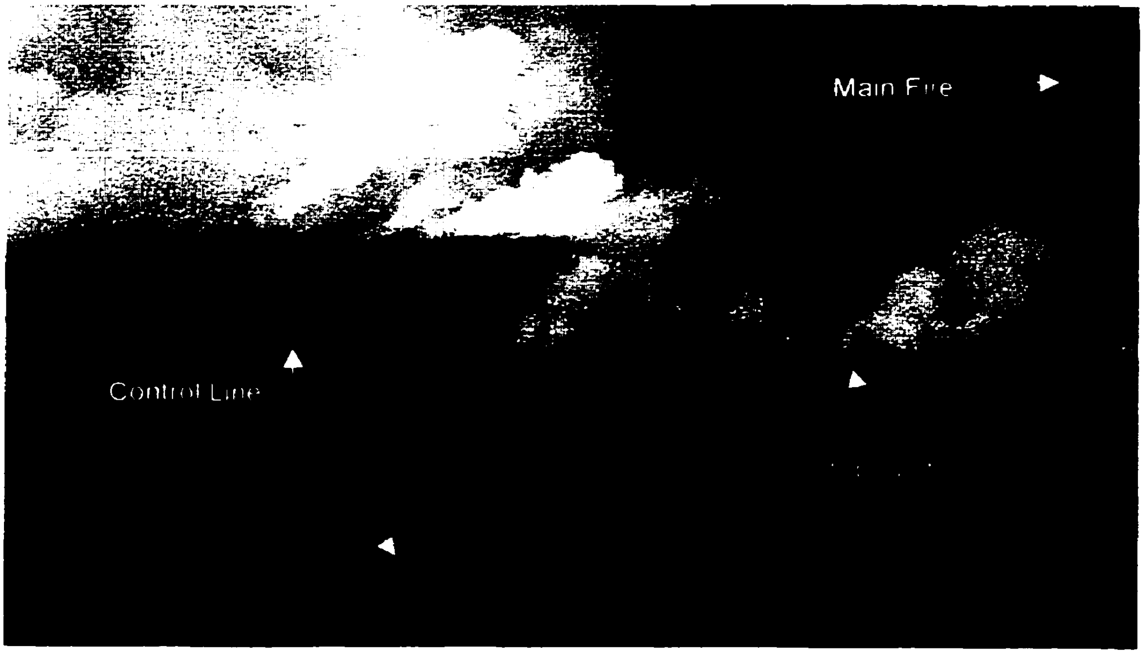

Photo 5: The lake pictured above was a natural barrier used as a control line. The objective of the burnout was to remove the unburned fuel between the fire (located off the picture to the right) and the lake.

Burnouts can also be conducted in situations where the wind is not from a favorable direction. Experienced burners can create their own indraft to pull a strip of set fire into the main fire regardless of the wind direction, provided the ambient wind speed is not excessively strong. This is done by "lighting up" the existing fire with the helitorch. A strip of fire is set along the existing edge of the main fire, and as the strip builds in momentum, released heat serves to "wake up" the fire edge which subsequently begins to burn with increased intensity. A powerful indraft is created by the re-lit fire edge, and if the indraft is stronger than the prevailing wind, it can be utilized for burning out and directing the set fire against the wind.

When using the above procedure, the heat of the fire must be maintained to prevent loss of the indraft. Lighting consecutive strips parallel to the fire edge starting adjacent to the fire and working out toward the control line accomplish this. The distance between strips is variable and ultimately depends on the burning conditions, which, in turn, influence the strength of the indraft. A final strip is then lit adjacent to the inside edge of the control line. Because the final strip is under the influence of the indraft, the last of the unburned fuel is consumed between the second last and final strip, and the outer fire edge of the final strip backs against the indraft until it burns up to the edge of the control line. If all goes well, the fire stops at the control line due to an insufficient amount of fuel required for the fire to continue its spread. In many cases, further suppression action is not required and a fire can often be left to go out on its own (Photo 6).

By starting the burnout strips close to the fire after "lighting it up", a burner can keep an eye on the progression of the burn. If a burner chooses only to light up the fire edge and subsequently light a strip adjacent to the control line, there is a possibility the burnout may fail. This could happen by overestimating the influence of the indraft. If the prevailing winds were stronger than the indraft, and blew in a direction away from the main fire, the newly lit fire could get out of control and possibly make the situation worse. For this reason, burnouts, which are conducted when the prevailing winds are not from a favorable direction, will generally be carried out by re-lighting the fire edge and progressively burning out toward the control line as described previously. This insures the indraft effect has an influence on the aerially lit strip fires throughout the burnout's duration.

The width of the control line used in burning out is variable. Creeks as narrow as 30 centimetres have been used (Roberts, pers. comm. 1999). The necessary requirement is that the control line forms a break in the fuel, thus only where fuel bridges the break can a fire potentially escape. Grass-covered beaver dams pose a particular problem on many creeks used for control lines as the dams provide a path for the fire. Therefore, these areas may require ground suppression, bucketing, or water bombing to prevent a fire's escape during a burnout. However, by studying the burnout area prior to conducting the burn, potential escape points such as these can be noted and the appropriate action can be taken. This could include wetting down the escape points (e.g., using water bombers, ground crews, or helibucketing) prior to conducting the burn. Alternatively, another option may be keeping a helicopter with a bucket on standby to hit these spots if required after the burnout commences.

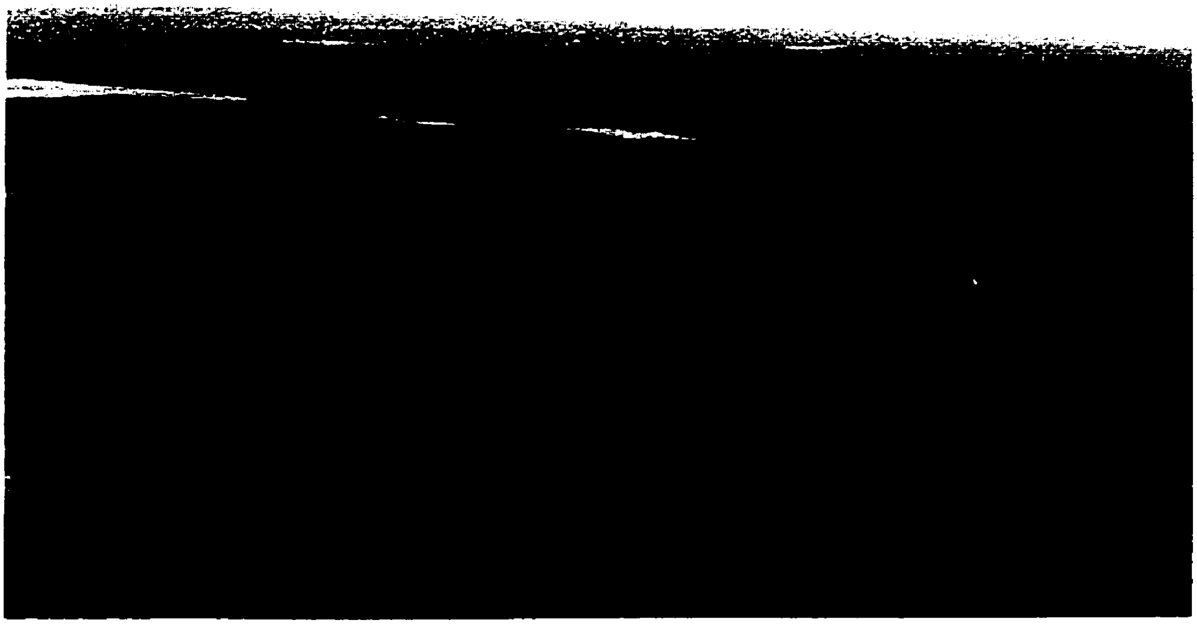

Photo 6. The creek pictured above was used as a control line for a burnout operation. The above picture was taken two years following the burnout. At the time the burn was conducted, the main fire was located approximately 700-1000 metres from the creek. Successive ignition strips were set parallel to the fire's edge starting adjacent to the fire. The final ignition strip was set along the creek and subsequently backed against the indraft to the water and went out. Follow-up suppression action was not required anywhere along the control line.

One of the main requirements for a successful burnout is that burning conditions must be such that a set fire will spread, preferably with enough intensity to remove both surface and aerial fuels (Van Nest 1989). If a complete removal of the aerial fuel is not achievable due to a high foliar moisture content or moderate to high humidities, a surface burn may be all that is required. Without the surface fuel the potential for crown fire activity is reduced, as this fuel is required to generate heat needed to initiate crowning (Van Wagner 1977). Without the crowning potential, there is virtually little risk that a fire can escape. Only under extreme burning conditions, or when the control line is fairly narrow is there a potential that high winds or flaming slash can generate firebrands or radiant heat sufficient to ignite fuels across the line.

2.7b Backfiring

Backfiring is a technique that is used to knock the head of a moving crown fire out of the forest canopy thereby slowing the fire and reducing the distance it spreads. Backfiring differs from burning out in that it is used on the active (lee) side of the fire (Figure 2). Heat, poor visibility, and turbulence are more severe on this side of the fire; thus, conducting a backfire strategy involves a higher element of risk. By definition, a backfire is a fire that spreads, or was set to spread, into or against the wind (Merrill & Alexander 1987). In effect, burning out against the wind as described earlier is a form of backfiring.

When used in crown fire suppression, backfires are lit within the indraft influence in front of the head (or heads) of an advancing fire (Figure 2). The backfire is drawn into the main fire against the prevailing wind and as the two fires move toward each other, the converging walls of flame cause the wind-tilted convection column of the head fire to "stand up" vertically. A high-intensity wall of flame rises into the air as the fires meet, which within minutes, will disappear leaving a smoldering surface fire. The net effect is that a backfire removes fuel and oxygen from a crown fire and temporarily knocks it down from the canopy. Residual heat from the main fire will continue to maintain the indraft and hold the new leading edge of the backfire on the surface for a period of time. Eventually, the prevailing wind will overcome the residual heat indraft, fanning the outer edge of the backfire. The fire may once again climb into the canopy and take a run; however, when this occurs, a new backfire can be lit to repeat the process and knock the fire down again. This procedure can be repeated continually and it can effectively hold a fire from advancing a large distance during the burning period. Alternatively, backfiring in this manner can be used to "walk" a fire to a control line in much the same way as the strip-firing method of burning out against the wind (Roberts pers. comm. 1999). By walking a fire to a control line, the fire reaches the control line with less intensity, and it may be possible to prevent it from being overrun.

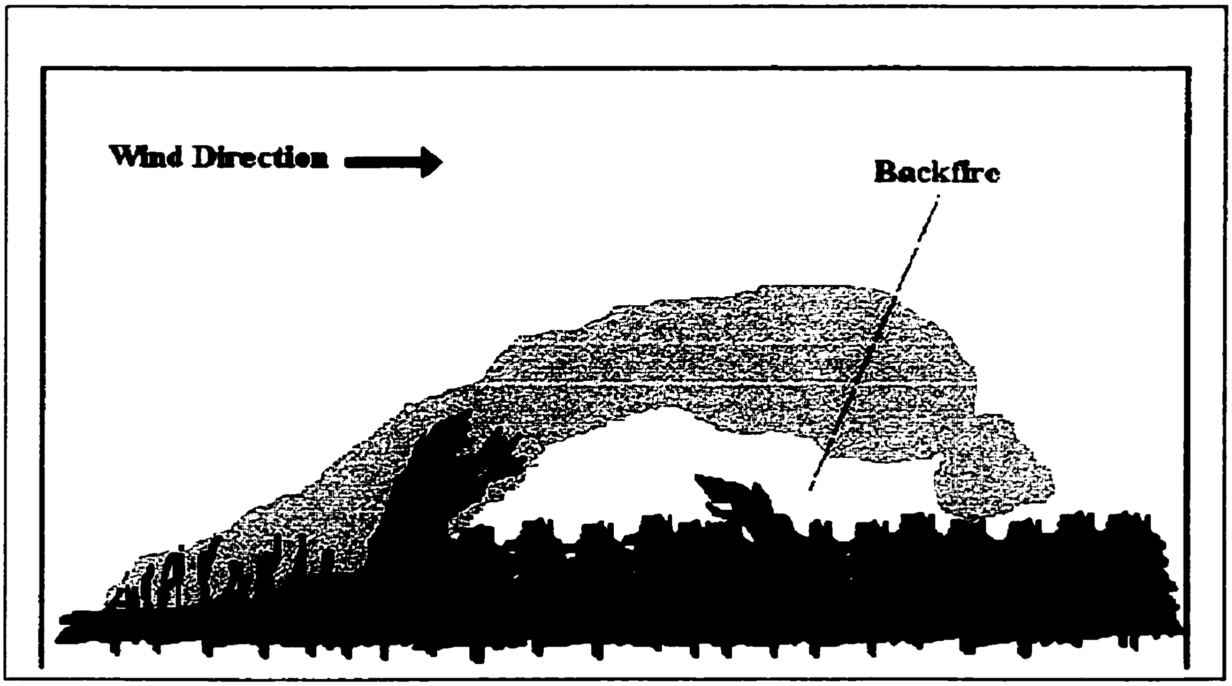

Figure 2. The diagram demonstrates the location of a backfire within the influence of the convection indraft. The indraft draws the backfire into the main fire resulting in the consumption of fuel between the two fires. To be effective, a backfire must be lit within the influence of the indraft, which is located within the smoke curl in advance of the main fire. (See text for a detailed description of backfiring).

In addition to knocking down a crown fire, backfiring can also be an effective way to improve visibility for airtankers. This is accomplished by "standing up" the convection column as described earlier. The effect is that smoke, which previously curled over the leading edge of the fire due to the ambient wind, is entrained in the vertical convection column leaving the fire's edge exposed. The improved visibility and "knocked down" flame front can allow airtankers to attack the leading edge of the fire, which prior to the backfire may not have been possible nor effective due to smoke and/or the fire's intensity.

Standing up the convection column also serves to reduce spotting. Firebrands previously carried short distances horizontally by the wind get lofted up with the column and extinguish before they can settle on unburned fuel (ETC 1995). This can be particularly effective in preventing a fire from jumping a large barrier such as a lake or wide river.

A final advantage of backfiring is the ability it provides for altering a fire's spread direction in the event that a particular value is in the path of the oncoming fire. A burner can change a fire's spread direction by strategically igniting intense fires in the vicinity of the advancing head. Strong indrafts from these fires can exceed the prevailing wind and pull the head fire off its main direction of spread. By maintaining the indraft with successive fires, the head which once threatened the value no longer spreads toward it, and in effect becomes a lower-intensity flank fire which can then be possibly attacked with air tankers or some other suppression means.

A major difference between backfiring and burning out is the amount of planning involved in the operation. Although various authors and publications (Merrill & Alexander 1987; Van Nest 1989; ETC 1995; SFFMB 1995) state that burning out is a routine and small scale operation compared to backfiring, this is not the case. Backfiring is visually more spectacular and involves a higher element of risk than burning out, however, it is used less frequently and on a significantly smaller scale (Roberts, pers. comm. 2000). Burnouts are an offensive strategy that require extensive planning and are often conducted on a scale of kilometres. Backfiring, on the other hand, generally does not exceed a scale of a few hundred metres and is a defensive tactic that is used when a fire takes a run and suppression personnel want to try and stop or slow the advance of the head(s).

A fire run is not easily predicted; therefore, backfiring is difficult to plan. It is an option that is used infrequently because it requires a burn team in place during the period when a fire has the most potential to take a run. Ideally, a burn team should be on site as soon as a fire escapes initial attack. After the first burning period, there are generally few backfiring windows due to residual smoke from the fire (Robert, pers. comm., 2000).

2.7c Burning Off

Burning off is much like burning out in that it is a planned offensive strategy. Burning off is simply a backburning operation that involves the ignition and consumption of islands of unburned fuel within the perimeter of a fire (Merrill & Alexander 1987). Burning off is a smaller operation than burning out, and it is generally conducted during mop-up. The objective is to remove any unburned fuel that may have the potential to flare up at a later time and produce firebrands that may cause spotting beyond the extinguished fire perimeter.

2.8 Summary

Backburning, although having the potential for use on its own in certain circumstances, is not a replacement for other methods of fire suppression. A successful backburn requires specific weather, fuel, and burning conditions to be effective; conditions that may not always be present on every fire. As a result, there will be times when the technique cannot be used.

Several factors must be taken into consideration before a backburn strategy is undertaken. For example, the weather and burning conditions must be such that an aerially lit fire will ignite easily and sustain combustion to remove both crown and aerial fuels. High humidity and fuel moisture content will not allow this to be achieved, and consequently a burnout may not work. Similarly, high wind speeds can cause turbulent conditions in front of a fire making it too dangerous to get within the effect of the indraft and backfiring may not be possible. Backburning frequently involves flying close to the heat of a wildfire; therefore, a helicopter pilot experienced in flying in such conditions is a necessity. Burning conditions, weather, and pilot competence are only a few of the factors that must be considered. The burn plan, availability of follow-up suppression resources, airtanker coordination, and ground crew placement are other things that must receive attention. By no means is this an exhausted list, many other factors are involved. Successful backburning involves more than simply lighting strips of forest on fire, as the potential to exacerbate a fire or put ground crews in jeopardy is real and must be avoided at all costs. Only when all bases have been covered should any backburning commence.

The application of backburning is a skill that must be learned through actual hands on experience; it is not something that can be taught in a classroom setting. The principles are relatively straightforward but it is much more complex than simply pulling the trigger. An Ignition Boss must be experienced and have a thorough understanding of all aspects of fire suppression, fire organization and an excellent knowledge of fire behavior. The risk of causing a large amount of damage by improperly igniting a backburn is too high to leave in the hands of inexperienced personnel. At present, Manitoba has four qualified Ignition Bosses and three in training. An attempt is made to have a trainee accompany a qualified Ignition Boss on backburn operations to gain experience; however, this is not always possible and happens infrequently. There may be very few, if any, backburn operations during a season, or it may not be possible logistically to get a trainee together with a Burn Team before it is dispatched. Training is an ongoing process; however, it is very difficult to achieve.

Chapter 3

RESEARCH METHODS

3.1 Summary

This study involved the evaluation of backburning and direct attack suppression on five case-study forest fires from the 1995 fire season. The primary focus of the study was to do a comparative analysis of the costs involved with both types of suppression focusing on the cost-effectiveness of backburning. Four of the five fires that were examined involved both backburning and direct attack while one of the fires involved backburning as the only suppression method used.

3.2 Methods

The primary method used to achieve the specific objectives of the study was a thorough review of records and data maintained by the Manitoba Conservation Fire Program on the fires in question. Primarily, suppression cost expenditures, fire weather information, and logistical fire action information formed the bulk of the data required to permit the analysis. Information sources for the data included the provincial Fire Program's National Fire Information System (NFIS) database[3], Environment Canada meteorological records, file records and other related documentation, fire personnel field notes, informal interviews with personnel involved in the respective fires, and personal notes and recollection[4].

To permit a comparison of backburning vs. direct attack suppression costs, it was necessary to choose fires that used both suppression techniques and separate the costs of each on the fire. In the current record keeping system of Manitoba Conservation, individual records for backburning and direct attack suppression costs are not separated. All suppression costs for a fire are lumped together and are recorded into the following cost categories: aircraft,

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[3] The National Fire Information System is a fire management computer program used by Manitoba Conservation for tracking fire expenditures, fire weather information, resource allocation, and various other fire-related activities and costs.

Emergency Fire Fighter personnel, equipment and supplies, equipment rental, and total fire costs.

The first step in comparing backburning to direct attack was to separate the cost of each suppression method on each fire. As backburning generally involved very few aircraft (usually the ignition helicopter and possibly back-up bucketing support), personnel, and supplies, the most practical method to separate the costs associated with each suppression method was to calculate backburning costs from the total fire cost and assume all other costs were associated with direct attack. This was a valid assumption as all suppression costs in the absence of any backburning would have been entirely for direct attack.

To calculate backburning costs, it was necessary to determine the aircraft hours and the equipment and supplies used to conduct the backburn. This information was provided through field records of the burn operation and the personal notes of the author, Burn Team personnel, and other individuals involved with the fire. Once the amount of resources required to conduct the backburn were determined, it was possible to calculate the associated costs using data from the provincial Fire Program's NFIS database. Payroll costs for Burn Team members and Manitoba Conservation staff were not included in the study. This payroll information is not recorded in the NFIS database. Only casual hire fire fighter payroll expenditures are recorded.

Direct attack costs were calculated by subtracting the calculated backburning costs from the total fire costs. As mentioned above, this calculation was made under the assumption that total fire costs were comprised of both direct attack and backburning.

It should be noted that there may have been minor costs associated with backburning that may have been missed and were not included in the calculation of backburning. For example, there were costs associated with obtaining the helitorch fuel and delivering the drums to the mixing site whether it be via vehicle or aircraft. However, due to a lack of records, it was impossible to calculate these costs and include them as part of the backburning. Consequently, they would be considered as part of the direct attack costs. As mentioned, these costs were

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[4] The author is a member of the provincial Backburn Team that was responsible for the planning and execution of all backburning on each of the case-study fires.

considered minor, and as the study results will show, they became insignificant when comparing the costs of the two suppression methods.

To compare backburning with direct attack costs in any meaningful way, a common unit of measure was required. The unit of measure chosen was the cost per kilometre of fireline secured by each suppression technique. A unit comparing the cost per hectare would have been inadequate simply because the size of a fire does not reflect the amount of suppression required. Large fires do not necessarily cost more than small ones to put out particularly if a significant amount of the fire goes out on its own. For this reason, it was felt that comparing the length of fireline secured by backburning and direct attack would produce a more meaningful result. The main objective of fire fighting is to secure a fire's perimeter to stop it from spreading, thus it was reasonable to compare the length of fireline secured by both methods. The area covered by the fire was not a factor.

Determining the fire perimeter secured by backburning and direct attack involved reviewing fire maps kept in the individual fire files and those from fireline personnel. In general, these records were very poorly kept and there existed no more than a final fire map showing only the perimeter location. To delineate the backburn-secured from direct attack-secured fireline, it was necessary to consult with individuals involved in the fires and the backburn.

Calculating the length of fireline secured by both suppression methods required digitizing the fires into ARC VIEW GIS format and outlining backburn and direct attack secured areas. Using the distance measurement features of the GIS program, the length of fireline secured by each method was accurately calculated.

Chapter 4

DATA ANALYSIS

A Review of Five Case Study Fires

4.1 Summary

This section outlines the results of the suppression cost analysis of backburning on the five case-study wildfires. In addition, a comparison with direct attack costs on each fire has also been completed. Total fire costs are listed, and a cost/kilometre for backburn and direct attack secured fireline was calculated for each suppression method.

The five fires in the study have all been documented using the same format with each case study being comprised of three sections. The first section of each study is the Background. The purpose of this section is to provide a brief history of the fire and details such things as the location, fire weather observations, observed fire behavior and values at risk. This sets the stage for the second section of each fire, which is a brief summary of the suppression strategies that were used.

In the Suppression section of each case study, a brief description is provided of both the backburn and direct attack objectives on the fire, comments on the outcome of the backburning, and a measure of the fire perimeter secured by both direct attack and backburning. The final section of each case study is a Suppression Cost Comparison. It is here where a comparison of the costs involved with each suppression method was calculated. Total fire suppression costs are listed and both backburn and direct attack costs are broken down into as much detail as was possible from the records that were available. A suppression cost/kilometre was calculated for backburning and direct attack to provide a comparable measure of each suppression method for securing one kilometre of fireline.

The description of each case study fire has been completed in a point form format. This format was necessary due to the lack of records available for each fire. It was not possible to outline daily direct attack objectives and accomplishments. In several cases it was impossible to interpret what had exactly happened on each fire on a day to day basis. Records for each fire in many cases contained no more than a one page final fire report containing only point form information on location, priority zone, fire size, etc.; a copy of the firefighter payroll journals; and a map of the fire, which in many cases was incomplete and did not have a detailed record of crew placement or a record of the daily fire spread. For this reason, the point form format to describe each fire was chosen. An attempt to describe what occurred on each fire in a chronological order would have been no more than speculation. The author was involved with backburning on each fire, which aided in completing each case study; however, where there was doubt as to what had occurred on each fire, additional information was provided through personal communication with other individuals involved on the fires. This proved to be valuable for confirming the records that were available and for filling in any gaps where information was missing. An accurate record of the costs for each fire was available, but it was the details of the suppression strategies and accomplishments, particularly direct attack, that were lacking. Regardless, enough data could be compiled to achieve the objectives of the study and provide a reasonably accurate analysis and comparison of the costs of backburning versus direct attack. Where possible, maps are used to illustrate the fire location, burnout and backfire areas, and the fireline secured by both direct attack and backburning. These serve to assist the reader in understanding the suppression activity that took place on each fire.

The following fires are the subjects of the case study analysis:

1. The 1995 Girouard Lake Fire - backburning and direct attack
2. The 1995 Sickle Lake Fire - backburning and direct attack
3. The 1995 Fox Mine Fire - backburning and direct attack
4. The 1995 Metcalf Bay Fire - backburning and direct attack
5. The 1995 Eaton Lake Fire - backburning only

4.2 CASE STUDY 1: GIROUARD LAKE FIRE #105-187

I) BACKGROUND

Ignition Date: June 19, 1995

Ignition Source: Lightning

Location: 55° 31′ 00″ x 101° 27′ 00″
Located approximately 16 kilometres south of the community of Pukatawagan (Figure 3).

Priority Zone: Red

Fuel Type and Terrain:

60% C3 - Immature Jack Pine
10% 01a - Grass and shrub covered swamp and lowlands
30% C2 - Boreal Spruce

Fire was located in typical Precambrian Shield terrain characterized by combined forest-covered and exposed rock ridges surrounded by low-lying muskeg.

Fire Weather Observations at Ignition (Noon Wx):

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
16.0	77.0	90.0	19.0	0	88.5	39.2	319.9	9.0	60.0	22.6

Observed Fire Behavior:
Intermittent torching. Predominantly surface fire.

Spread Potential: Unlimited

Values at Risk (Figure 4):

a) Community of Pukatawagan located approximately 6 kilometres north of the fire.

b) 1,000 000 cubic metres of merchantable timber east of the railway tracks near Rafter. Estimated value, $25,000,000.

c) Railway bridges east of the fire.

II) SUPPRESSION SUMMARY

Date of Initial Suppression: June 25, 1995

Date of Control: July 30, 1995

Called Out: August 19, 1995

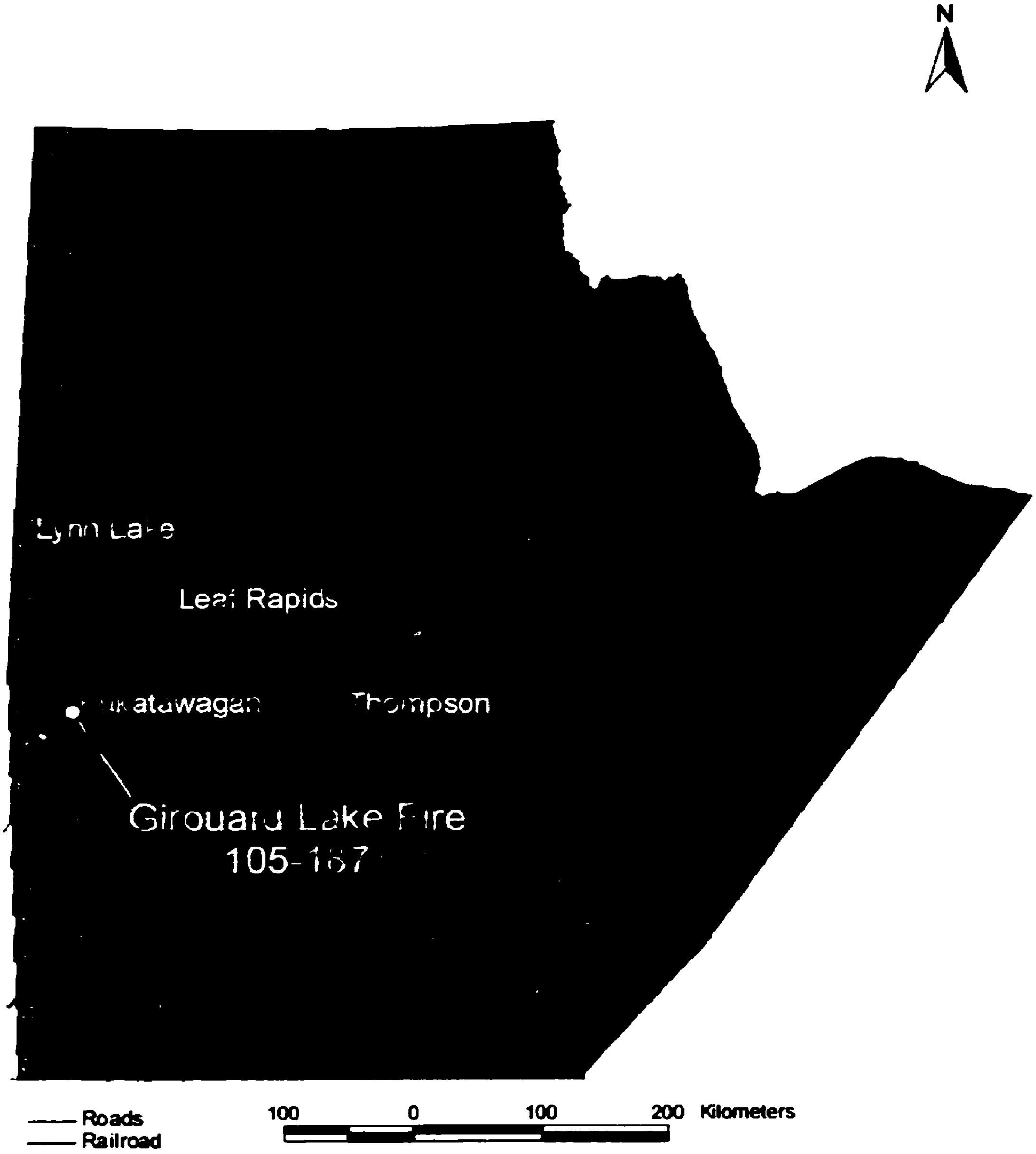

Figure 3. Location of the 1995 Girouard Lake Fire # 105-187.

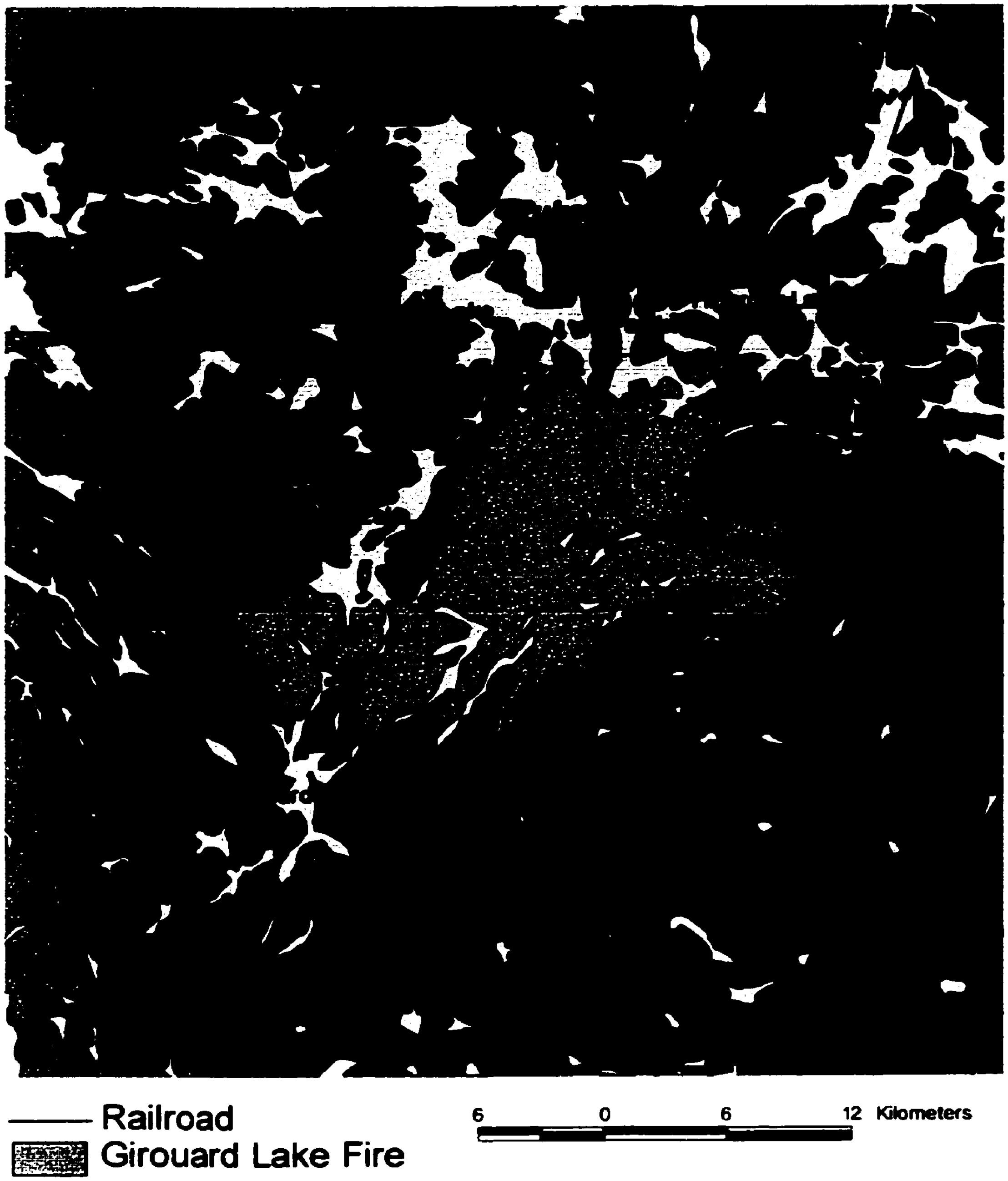

Figure 4. Values at risk. Note: An accurate map of the fire size and location prior to backburning was unavailable.

Suppression Strategy:
The first suppression activity on the fire was backburning to secure the north and west flanks of the fire. Following this, direct attack suppression was used to secure the east and south flanks.

A) Backburning

Backburn Date(s): June 25-27, 1995

Backburn Objectives:

June 25, 1995 (Figure 5)
Backfiring
The first activity on the fire consisted of backfiring which occurred on the north flank of the fire near the railroad tracks. The main objective of the backfiring was to slow the fire's progress to the north and try to flank the fire into CN rail tracks and protect the fish camp at Pawistik.

A cold front passage at approximately 15:50 switched winds from 160° to 300. The fire had moved east in several places with the wind shift and jumped the railway tracks. Backfiring was used on the northeast side to prevent spotting over the Churchill River and also to slow the fire's progress to the east.

Burnout (Figure 5)
As the wind shifted, the smoke cleared on north side of the fire. It had burned up to the Churchill River in places and had jumped to a large island. A burnout was conducted to achieve the following objectives:

1. to burn out fuel along Pukatawagan and Highrock Lakes in areas where fire had not reached the banks on its own;

2. to burn off the remainder of the island where fire had spotted; and,

3. to straighten the fireline south of Pawistik for direct attack to cut off the fire from the fish camp.

June 26, 1995 (Figure 5)
Burnout
The main objective was to secure approximately 15 kilometres of fireline on the northwest and west side of the fire between Pukatawagan Lake and Morin Lake.

June 27, 1995 (Figure 5)
Burnout
The main objective was to secure approximately 14 kilometres of fireline on the southwest side of the fire along a creek system between Girouard and Morin Lakes.

Fire Wx Observations at Burnout:

June 25 (1300 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
17.0	59.0	135	13.0	0	88.0	60.1	278.5	6.2	78.0	19.8

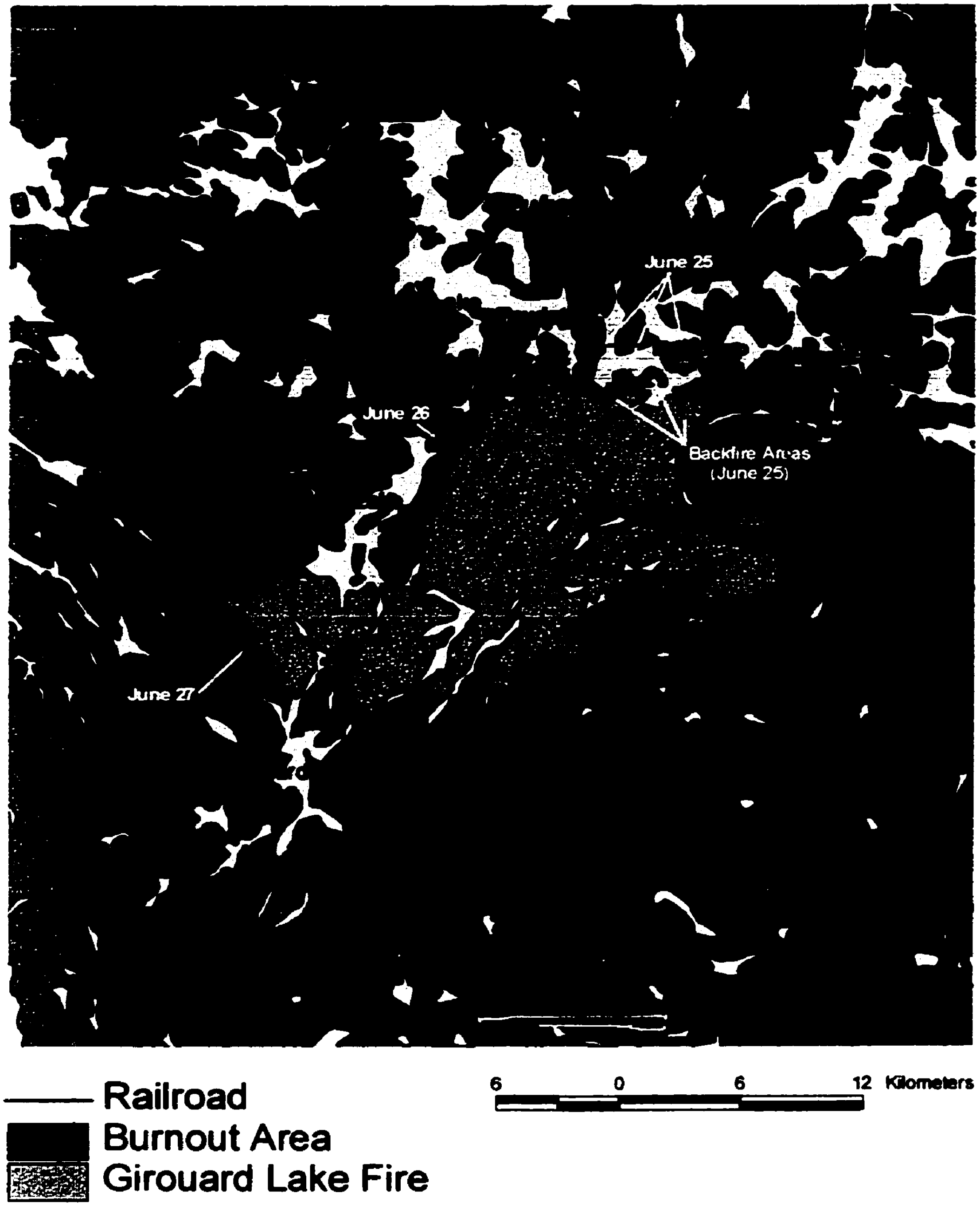

Figure 5. Location of the burnout and backfire areas. See text for description.

June 26 (1300 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
27.0	32.0	180	12.0	0	91.5	65.1	286.8	9.6	83.1	28.0

June 27 (1300 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
21.0	38.0	360	12.0	0	91.3	68.7	294.0	9.4	86.7	28.2

Fire size prior to backburn (Ha): Unknown

Final fire size (Ha): 25,225

Total perimeter length (km): 132

Backburn secured perimeter (km) (Figure 11) 54.1

Percentage of total perimeter: 41%

Comments:

June 25 (Figure 6)

Backfire

Prior to the wind shift from the cold front passage, backfiring was successful in slowing the fire's spread toward the fish camp and preventing spotting over the Churchill River. However, it was not possible to flank the fire into the railway tracks due to the wind shift and the fire jumped the tracks between Pawistik and Rafter.

Burnout

All burning out was successful. The fireline was secured to the Churchill River in the northeast corner. The island where the fire had jumped was burned off and secured. Fireline was straightened south of the fish camp and secured with ground crews immediately following the burn.

June 26 Burnout (Figure 6)

All burning out was successful. The fireline between Pukatawagan and Morin Lakes on the northwest flank of the fire was secured and did not require any follow-up suppression.

June 27 Burnout (Figure 6)

All burning out was successful. The southwest corner of the fire was secured between Morin and Girouard Lakes. Follow-up suppression was not required.

B) Direct Attack

Direct attack dates: June 25 - July 30, 1995

Duration of direct attack: 35 days

Figure 6. Map showing the final Girouard Lake Fire following the burnout showing the location of fireline secured by direct attack and backburning.

Direct Attack Objectives:
The main objective was to secure the fire perimeter on the south and east side of the fire from the north shore of Girouard Lake to Highrock Lake with ground suppression and air attack. The primary objective was to prevent the fire's spread to the east into the merchantable timber east of Pawistik. The north and west perimeter were secured by burning out and did not require direct attack suppression.

Firefighters:	Approximately 200
Direct attack secured perimeter(km) (Figure 11):	52
Percentage of total perimeter:	39%

III) SUPPRESSION COST COMPARISON

A) Backburn Costs

Ignition Helicopter Bell 206B (CF-ZSJ) 19.6 hours @ $650.00/hour	$ 12,740.00
Helicopter Fuel 2,295 litres @ $ 0.635/litre	$ 1,457.00
Helitorch Fuel Gasoline – 3075 litres @ $ 0.497/litre	$ 1,528.00
Petrolgel Gelling Agent 120 litres @ $ 11.06/litre	$ 1,327.00

B) Direct Attack Costs

Aircraft Rotary and Fixed Wing	$ 493,196.00
Air Attack Air Tankers – CL 215 Bird Dog	$ 75,574.00
Fire Fighting Personnel	$ 211,900.00
Service and Supply Costs	$ 246,686.00
Equipment Rental	$ 15,580.00

c) Total Suppression Costs

TOTAL SUPPRESSION COST:	$ 1,059,988.00
Direct Attack	
TOTAL COSTS:	$ 1,042,936.00
PERCENTAGE OF TOTAL:	98%
COST/km (52 km):	$ 20,056.00
Backburning	
TOTAL COSTS:	$ 17,052.00
PERCENTAGE OF TOTAL:	2%
COST/km (54.1 km):	$ 315.00

4.3 CASE STUDY 2: SICKLE LAKE FIRE #105-201

I) BACKGROUND

Ignition Date: June 20, 1995

Ignition Source: Lightning

Location: 56° 34′ 16″ x 100° 33′ 19″
Located approximately 25 kilometres southeast of Lynn Lake, Manitoba (Figure 7)

Priority Zone: Green

Fuel Type and Terrain:

60% C3 - Immature Jack Pine
30% O1a - Grass and shrub covered swamp
10% C2 - Boreal Spruce

Fire was located in typical Precambrian Shield terrain characterized by combined forest-covered and exposed rock ridges surrounded by low-lying muskeg.

Fire Weather Observations at Ignition (Noon Wx):

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
28.0	45.0	130.0	19.0	0	88.5	39.2	319.9	9.0	60.0	22.6

Observed Fire Behavior:
Intermittent crown fire at head. Surface fire with intermittent torching at flanks and rear.

Spread Potential: Unlimited

Values at Risk (Figure 8)

a) Community of Lynn Lake.
b) Sickle Lake Lodge approximately 6 kilometres southwest of the fire and the lodge outcamp on the north end of Sickle Lake.
c) Closure of highway 391.

II) SUPPRESSION SUMMARY

Date of Initial Suppression: June 21, 1995

Date of Control: Unknown

Called Out: August 19, 1995

Figure 7. Location of the 1995 Sickle Lake Fire #105-201.

Suppression Strategy:
The fire was considered a limited action fire. The main area of concern was the south flank of the fire. Direct attack was focused on the south flank between Sickle Lake and Beatty Creek as well as the northwest corner of the fire (Figure 8). A burnout took place nine days after initial suppression to secure a large portion of the fire perimeter to natural barriers on the north and east flanks.

A) Backburning

Backburn Date(s): July 2, 1995

Backburn Objectives:
The main objective was to secure the east and north flanks of the fire to natural barriers with a burnout. The west side was secured by Sickle Lake and the south was being held with ground crews and air support. The fire had burned close to both the Keewatin River north of the fire and Beatty Creek to the east. The focus of the burnout was to use Beatty Creek and the Keewatin River as a barrier to secure the fire along the entire east and north flank (Figure 8).

Fire Wx Observations at Burnout - July 2 (1300hrs):

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
28.0	45.0	130.0	19.0	0	88.5	39.2	319.9	9.0	60.0	22.6

Comments:
All burning out was successful. The entire fireline on the north and east side of the fire was secured by burning out to the Keewatin River and Beatty Creek (Figure 9). There were two small areas where the fire had crossed the control line and required direct attack suppression (Figure 10). The fire had jumped the control line prior to the burnout and was not actioned until the burnout was completed.

Fire size prior to backburning (Ha):	12,774
Final fire size (Ha):	15,850
Total perimeter length (km):	68
Backburn secured perimeter (km) (Figure 10)	33.6
Percentage of total perimeter:	49%

B) Direct Attack

Direct Attack Dates: June 21 - unknown (records unavailable)

Duration of Direct Attack: Unknown (records unavailable)

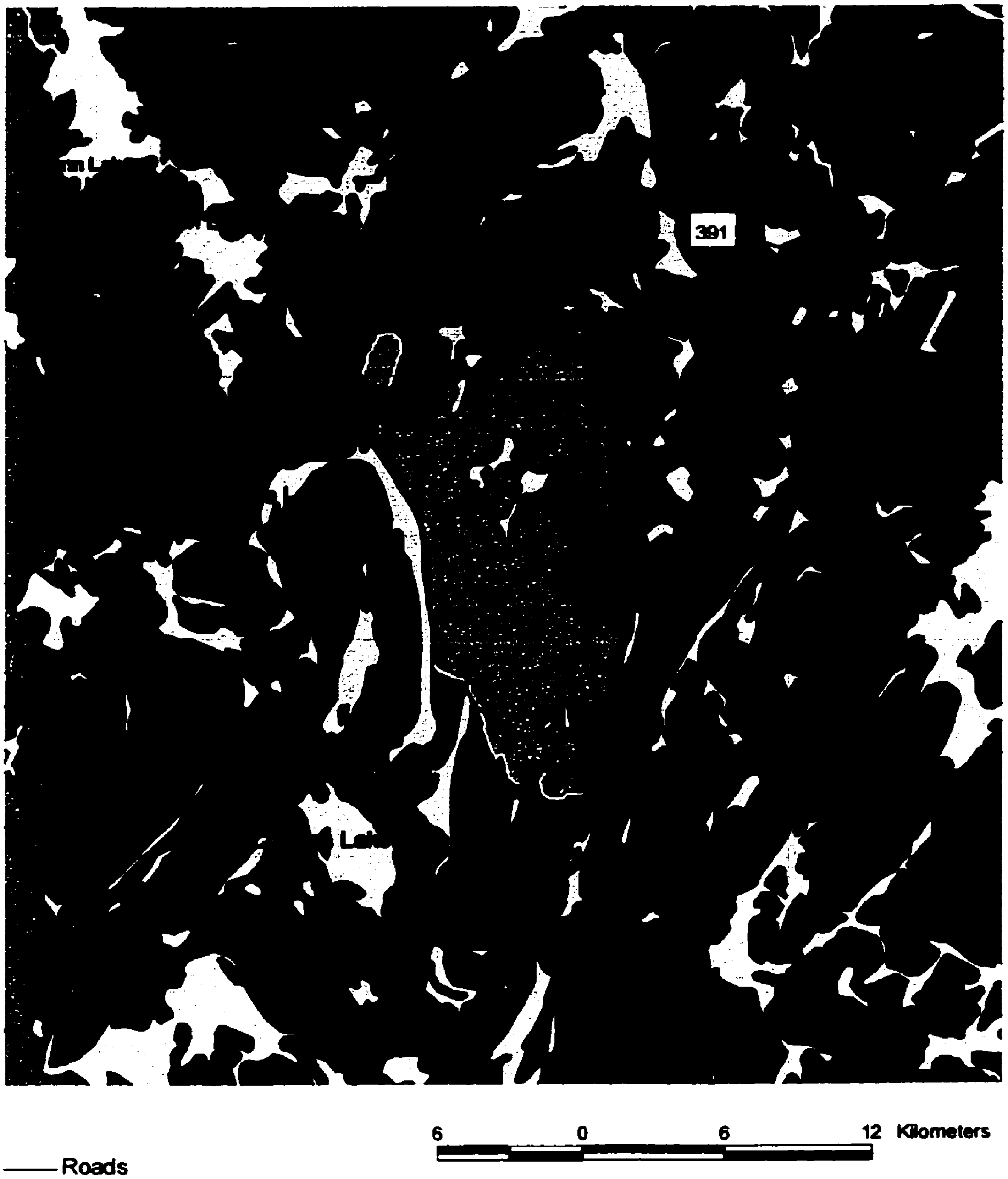

Figure 8. The Sickle Lake Fire location prior to backburning. Note the location of the values at risk and the location of fireline that received direct attack suppression.

Figure 9. Location of the burnout area.

Figure 10. Map showing the final Sickle Lake Fire location and the fireline secured by direct attack and backburning. Note the two escape points where the fire had crossed the control line on the northeast corner. The fire had jumped prior to the burnout and was not actioned in these areas until the burnout was completed.

Direct Attack Objectives:
The fire was considered a limited action fire. Suppression action was concentrated on the south flank near Sickle Lake Lodge. A small segment of perimeter was actioned on the northwest corner of the fire to prevent spread toward the community of Lynn Lake. Suppression resources were limited due to multiple fires.

Firefighters:	Approximately 100
Direct attack secured perimeter (km) (Figure 10):	19.0
Percentage of total perimeter:	28%

III) SUPPRESSION COST COMPARISON

a) Backburn Costs

Ignition Helicopter Bell 206B (CF-ZSJ) 6.1 hours @ $650.00	$ 3,965.00
Helicopter Fuel 713 litres @ $0.635/litre	$ 453.00
Helitorch Fuel Gasoline – 820 litres @ $ 0.497/litre	$ 408.00
Petrolgel Gelling Agent 32 litres @ $ 11.06/litre	$ 354.00

b) Direct Attack Costs

Aircraft Rotary and Fixed Wing	$ 220,569.00
Air Attack Air Tankers – CL 215 Bird Dog	$ 9,400.00
Fire Fighting Personnel	$ 65,000.00
Service and Supply Costs	$ 78,650.00
Equipment Rental	$ 3,828.00

c) Total Suppression Costs

TOTAL SUPPRESSION COST:	$ 382,627.00
Direct Attack	
TOTAL COSTS	$ 377,447.00
PERCENTAGE OF TOTAL	99%
COST/km (19.0 km)	$ 19,865.00
Backburning	
TOTAL COSTS	$ 5180.00
PERCENTAGE OF TOTAL	1%
COST/km (33.6 km)	$ 154.00

4.4 CASE STUDY 3: FOX MINE FIRE #105-042

I) BACKGROUND

Ignition Date: May 30, 1995

Ignition Source: Lightning

Location: 56° 38′ 18″ x 101° 42′ 23″
Located approximately 47 kilometres southwest of Lynn Lake, Manitoba (Figure 11).

Priority Zone: Green

Fuel Type and Terrain:

30% C3 - Immature Jack Pine
10% C4 - Mature Jack Pine
30% C2 - Boreal Spruce

Fire was located in typical Precambrian Shield terrain characterized by combined forest-covered and exposed rock ridges surrounded by low-lying muskeg.

Fire Weather Observations at Ignition (Noon Wx):

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
26.0	30.0	320.0	19.0	0	91.7	45.1	284.8	14.2	64.6	32.2

Observed Fire Behavior:
Full crown involvement at head. Intermittent torching at flanks. Rear mainly surface fire with intermittent candling.

Spread Potential: Unlimited

Values at Risk (Figure 12):

a) Community of Lynn Lake located 44 kilometres to the northeast
b) McGavock Lake Lodge located 12 kilometres to the southeast.
c) Several cottages on small lakes between the fire and Lynn Lake.

II) SUPPRESSION SUMMARY

Date of Initial Suppression: May 30, 1995

Date of Control: June 3, 1995

Called Out: July 15, 1995

Suppression Strategy:
Initially, suppression activity was entirely direct attack. Two burnouts were conducted on separate days to secure the west and south flanks of the fire to lakes and creeks. The north flank of the fire was secured with direct attack. Three places in the burnout area required follow-up direct attack to provide a control line where natural barriers were absent.

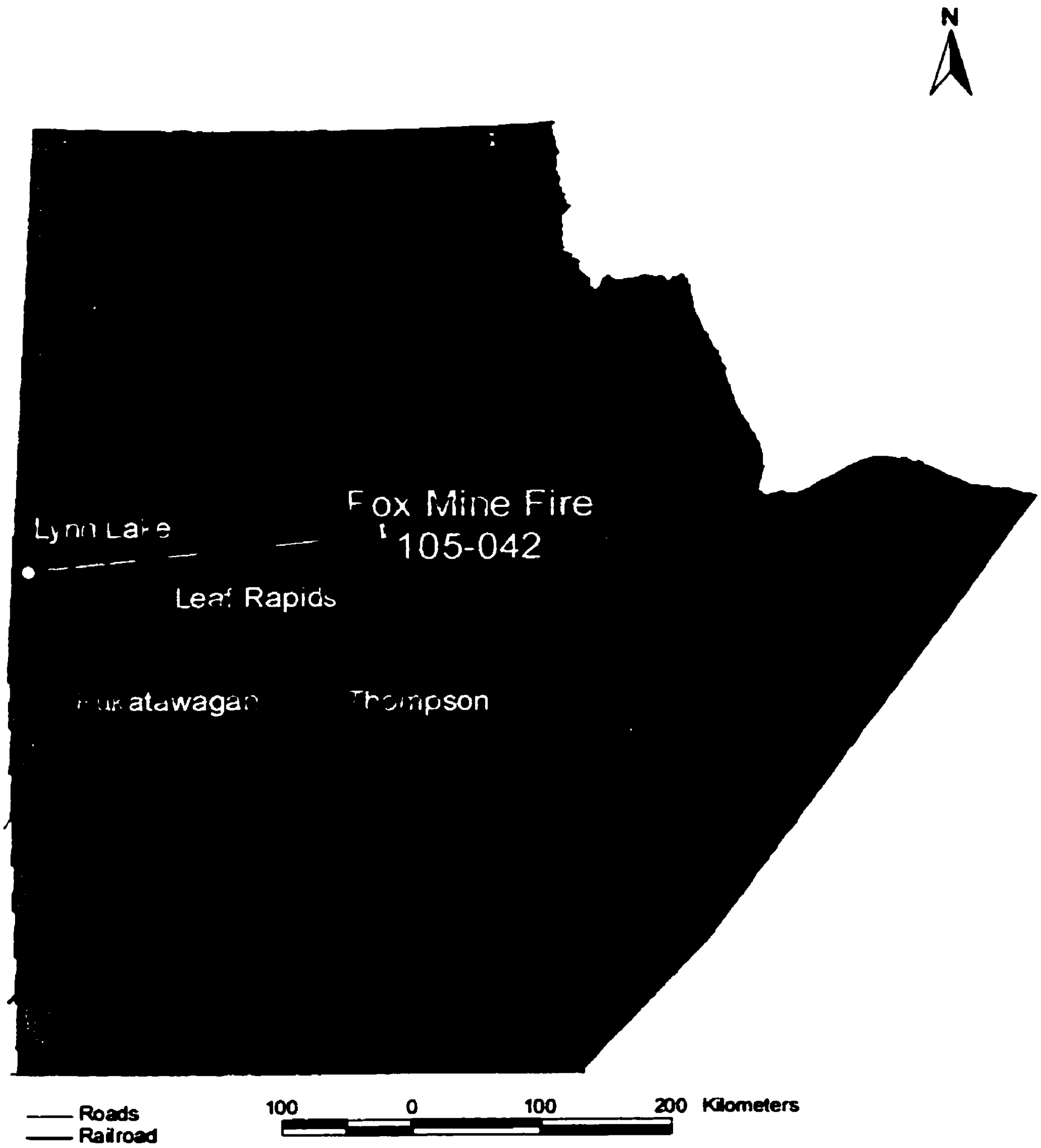

Figure 11. Location of the 1995 Fox Mine Fire #105-042.

A) Direct Attack

Direct Attack Dates: May 30 – June 10, 1995

Duration of Direct Attack: 12 Days

Direct Attack Objectives:
The initial objective was containment of the entire fire perimeter. The fire took a few runs to the south and southeast making control difficult. Line was overrun and crews had to be pulled on the south flank (Figure 12). Once the decision to burnout the south and west flanks of the fire was made, direct attack focused on securing the north and east flanks.

Firefighters:	150 (estimated)
Total Fire Perimeter (km):	22.1
Direct attack secured perimeter (km)(Figure 16):	9.2
Percentage of Total Perimeter:	42%

B) Backburning

Backburn Date(s): June 1 & 2, 1995

Backburn Objectives:

June 1, 1995
A burnout on the west flank of the fire would be used to secure approximately 2 kilometres of fire perimeter into the Laurie River (Figures 12 & 13).

June 2, 1995
The main objective was to burnout from the Laurie River along the northeast shore of Tod Lake to McWhirter Lake and along a creek system up to the east flank of the fire. A successful burnout would secure the entire south perimeter except for three areas where a fuel break did not exist. Direct attack was required in these areas (Figure 14).

Fire Wx Observations at Burnout:
June 1, 1995 (1800 Hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
20.1	40	80	7.0	0	91.1	52.3	298.0	7.1	72.8	21.2

June 2, 1999 (1500 Hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
24.2	36	180	11.0	0	90.4	55.6	305.3	7.9	76.4	23.4

Figure 12. Location of the Fox Mine Fire prior to the June 1 burnout. The map shows the fire growth from May 31-June 1 prior to the burnout. Note the location of the proposed burnout area and the fireline that was lost when the fire took a run to the south.

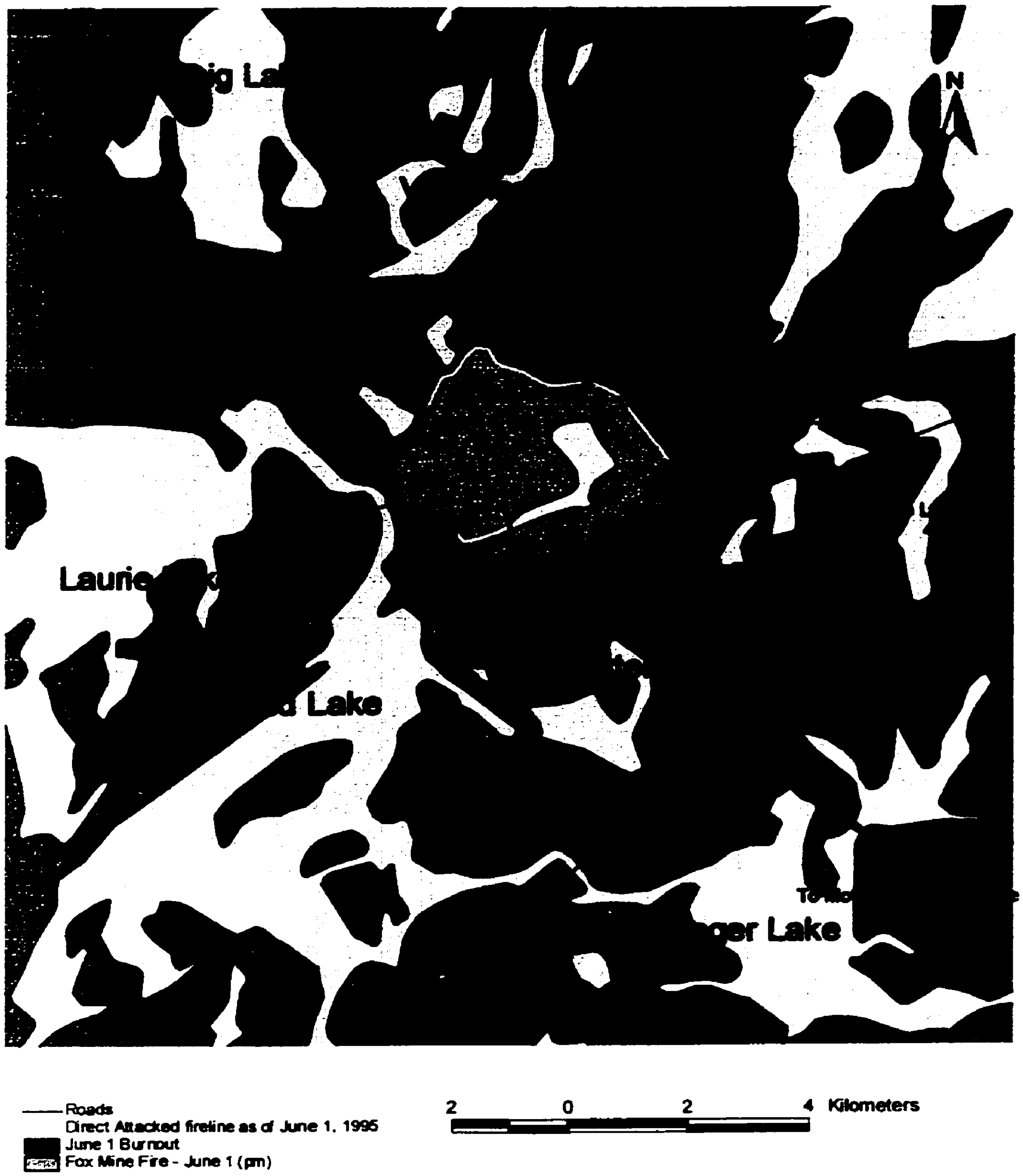

Figure 13. Location of the June 1 burnout area.

Figure 14. Location of the proposed creek/lake system to be used as a control line for the June 2 burnout.

Fire size prior to backburn (Ha):	1,216
Final fire size (Ha):	2,304
Total fire perimeter (km):	22.1
Backburn secured perimeter (km)(Figure 21):	8.8
Percentage of Total Perimeter:	40%

Comments:

June 1, 1995 Burnout
The burnout was successful in securing approximately 2 kilometres of fireline along the Laurie River on the west flank of the fire (Figure 13). Direct attack was not required in the area after the burnout.

The south flank of the fire remained hot and needed to be secured. The success of the burnout initiated a decision from the overhead team to burnout the south flank the following day. The burnout would double the size of the fire but would secure a significant amount of fireline. Direct attack would only be required in three areas where a natural fuel break did not exist.

June 2, 1995 Burnout
Winds were forecasted to be southeast at 15-20 kph. On site winds were southwest at 15 kph. A southeast wind would have been optimum. With southwest winds it was necessary to backfire in some downwind locations and flank the fire on the south and east sides. This was known before the burnout commenced and was discussed with the Suppression Boss. The green light was given.

The burnout was successful and secured approximately 7 kilometres of fireline on south flank of the fire. Ground crews were used in the three areas where a natural fuel break did not exist. The ground crews established a wet line prior to the burnout and extinguished the fire in their areas shortly after the burnout was completed. This was the only direct attack support required and comprised approximately 1 kilometre of the fireline in the burnout area. The fire was brought under control the following day (Figure 15).

Figure 15. Location of the June 2 burnout. Note the three areas on the south of the fire that required direct attack suppression. An adequate fuel break did not exist in these areas and ground crews were used to secure the fireline following the burnout.

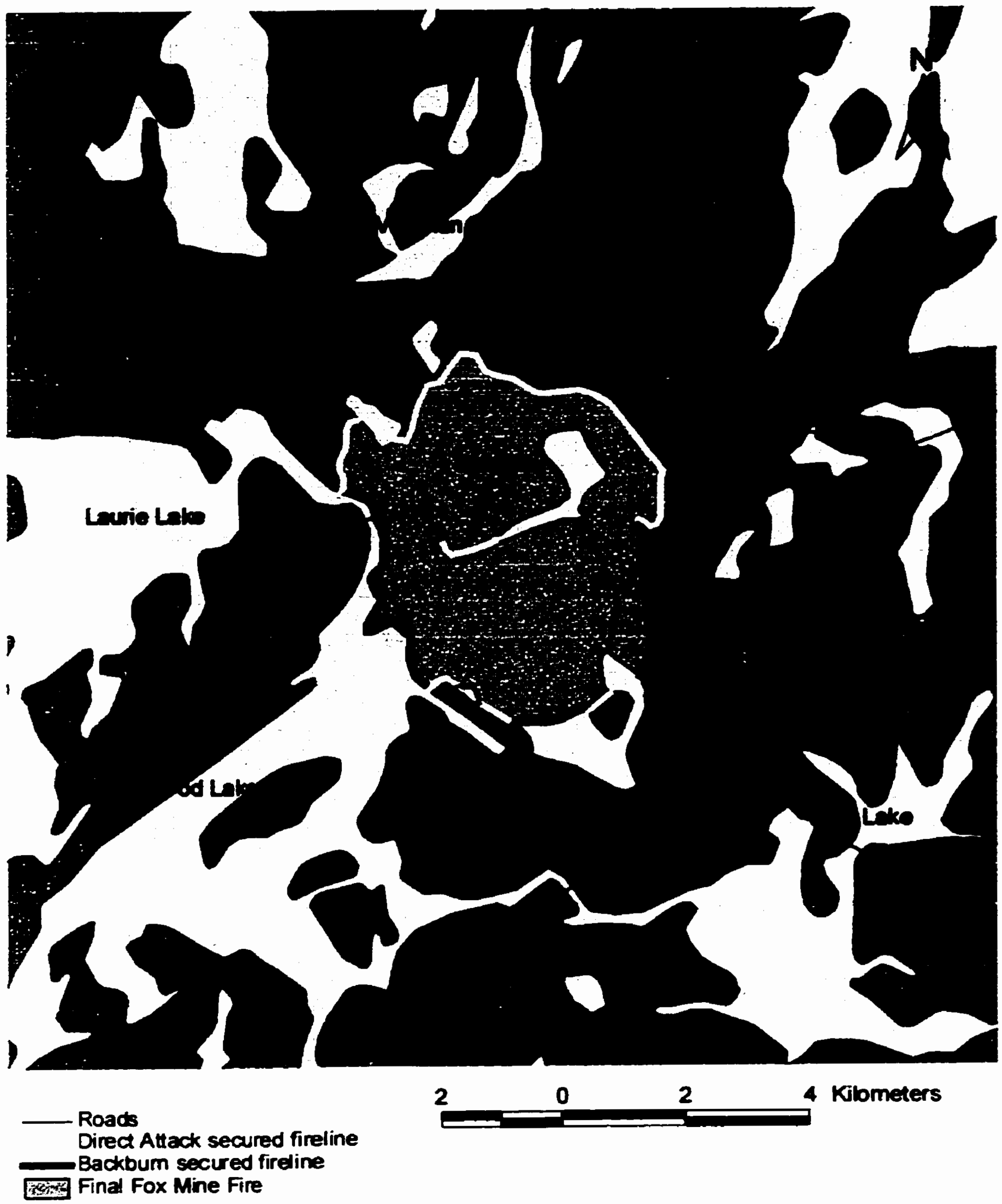

Figure 16. Map showing the final Fox Mine Fire and the location of fireline secured by direct attack and backburning.

III) SUPPRESSION COST COMPARISON

a) Backburn Costs

Ignition Helicopter Bell 206B (CG-EKM) 6.3 hours @ $235.00/hour (Contract rates)	$ 1480.00
Helicopter Fuel 737.0 litres @ $0.635/litre	$ 468.00
Helitorch Fuel Gasoline – 1435 litres @ $ 0.497/litre	$ 713.00
Petrolgel Gelling Agent 56 litres @ $ 12.50/litre (estimated)	$ 619.00

b) Direct Attack Costs

Aircraft Rotary and Fixed Wing	$ 145,178.00
Air Attack Air Tankers – CL 215 Bird Dog	$ 46,504.00
Fire Fighting Personnel	$ 43,400.00
Service and Supply Costs	$ 65,228.00
Equipment Rental	$ 13,615.00

c) Total Suppression Costs

TOTAL SUPPRESSION COST: $ 317,205.00

Direct Attack

TOTAL COSTS	$ 313,925.00
PERCENTAGE OF TOTAL	99%
COST/km (9.2 km)	$ 34,122.00

Backburning

TOTAL COSTS	$ 2893.70
PERCENTAGE OF TOTAL	1%
COST/km (8.8 km)	$ 328.00

4.5 CASE STUDY 4: METCALF BAY FIRE #102-045

I) BACKGROUND

Ignition Date: May 29, 1995

Ignition Source: Lightning

Location: 56° 24′ 00″ x 100° 53′ 00″
Located on a large peninsula on Granville Lake approximately 40 kilometres west southwest of the community of Leaf Rapids, Manitoba (Figure 17).

Priority Zone: Green

Fuel Type and Terrain:
100% C2 Boreal Spruce

Fire was located in typical Precambrian Shield terrain characterized by combined forest-covered and exposed rock ridges surrounded by low-lying muskeg.

Fire Weather Observations at Ignition (Noon Wx)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
12.5	54.0	135.0	8.0	0	87.3	32.1	266.1	4.3	49.4	11.7

Observed Fire Behavior:
Full crown involvement at head. Intermittent torching at flanks. Rear mainly surface fire with intermittent candling.

At approximately 1300 hours on May 30 the wind increased to speeds between 17-23 kph out of the north. The fire took a run in several places and was observed to spot up to 500 metres.

Spread Potential:
The fire was located on a very large peninsula on Granville Lake (Figure 18). The surrounding water reduced the spread potential in all areas except where the peninsula extended from the mainland. However, numerous large islands in close proximity to the peninsula provided a path to the mainland. With the burning conditions observed and the spotting that occurred, the water afforded little protection to the fire's spread. Spread potential on the mainland was unlimited.

Values at Risk: (Figure 18)

a) Community of Granville Lake (22 km south of fire)

b) Aesthetics (Shoreline of high-use sport fishing lake)

c) Community of Leaf Rapids (40 km northeast of fire)

II) SUPPRESSION SUMMARY

Date of Initial Suppression: May 30, 1995

Date of Control: June 14, 1995

Called Out: August 6, 1995

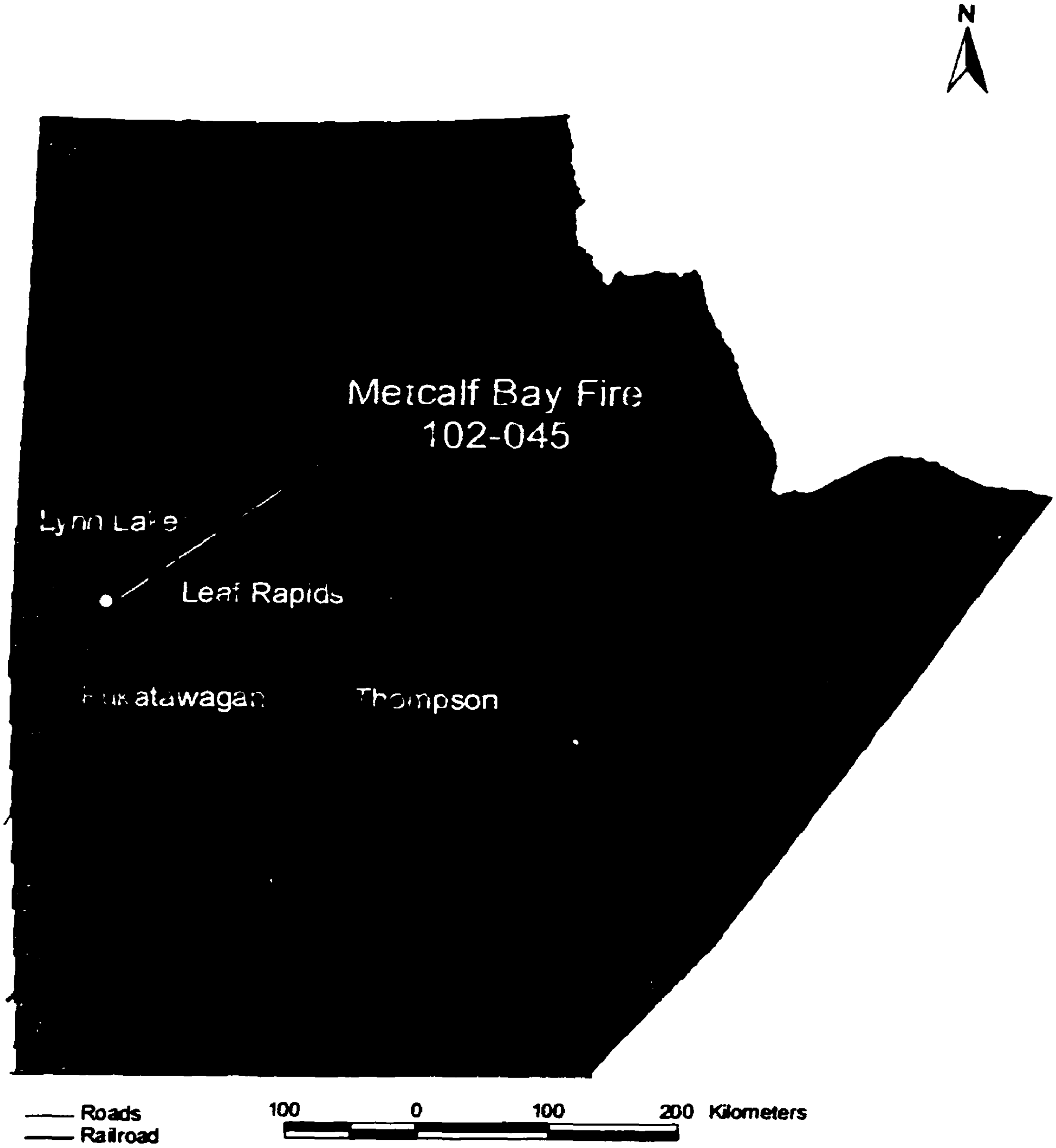

Figure 17. Location of the 1995 Metcalf Bay Fire #102-045.

Figure 18. Location of the Metcalf Bay Fire prior to backfiring and burning out on May 31.

Suppression Strategy:
The main strategy was to contain the fire within the confines of the peninsula. Although the fire was in low-value timber and was a low priority, it could not be abandoned. It was too early in the fire season and had the potential to spot to the mainland if left unattended. Eventually the fire would be a threat to the communities of Leaf Rapids and Granville Lake.

Suppression was primarily backburning combined with direct attack. Backfiring was used to prevent spotting to the mainland in the initial stages. A burnout was used at a later date to remove an approximate 500 metre strip of fuel around the entire shoreline of the peninsula to reduce spotting potential to the mainland. A direct attack was required to secure a control line where the peninsula extended from the mainland as a natural fuel break was not available in this area.

A) Backburning

Backburn Date(s): May 31, June 1, 10 & 11, 1995

Backburn Objectives:

May 31
The fire took a run in several places toward the south. Backfiring was required in front of the fire between Kosapachekaywinasinne Lake and the shoreline of Granville Lake. The main priority was to prevent the fire from spotting across the chain of islands to the mainland and threaten the community of Granville Lake (Figure 19).

A burnout was started on the west side of the fire. The objective was to secure the fire perimeter across the peninsula in the area where it extended from the mainland. The small creeks and the shorelines of Dobbyn and Watt Lakes were used as a control line and a direct attack with ground crews was required in areas where a fuel break did not exist. The burnout began late in the day and could not be completed prior to dark.

June 1
The main objective was to complete the burnout on the northwest side of the fire from the previous day.

June 2 - 9
Approximately 10 millimetres of rain fell on the fire the night of June 1 and into the morning of June 2. Backburning was not an option with the burning conditions that followed and the Burn Team was released. The fire had grown a considerable amount during the day on June 1 with several runs to the north . The fire had burned to the shore of Granville Lake and was no longer a threat to spot across the lake to the south. In addition, the fire was secured along the portion of the peninsula attached to the mainland.

The entire fire perimeter on the northeast and east side of the fire remained hot and still had the potential to escape off the peninsula with southwest winds. The fire was still low priority and did not receive approval for a large expenditure on suppression. Ground crews used to secure the west side of the fire were moved into a few spots on the east side but were later pulled when the perimeter heated up and took a run in several places to the northeast on June 9 (Figure 20).

An escaped fire analysis was completed on June 9 and a Regional decision was made to burn off the entire peninsula. The Burn Team was re-called that night and arrived at the fire the morning of June 10.

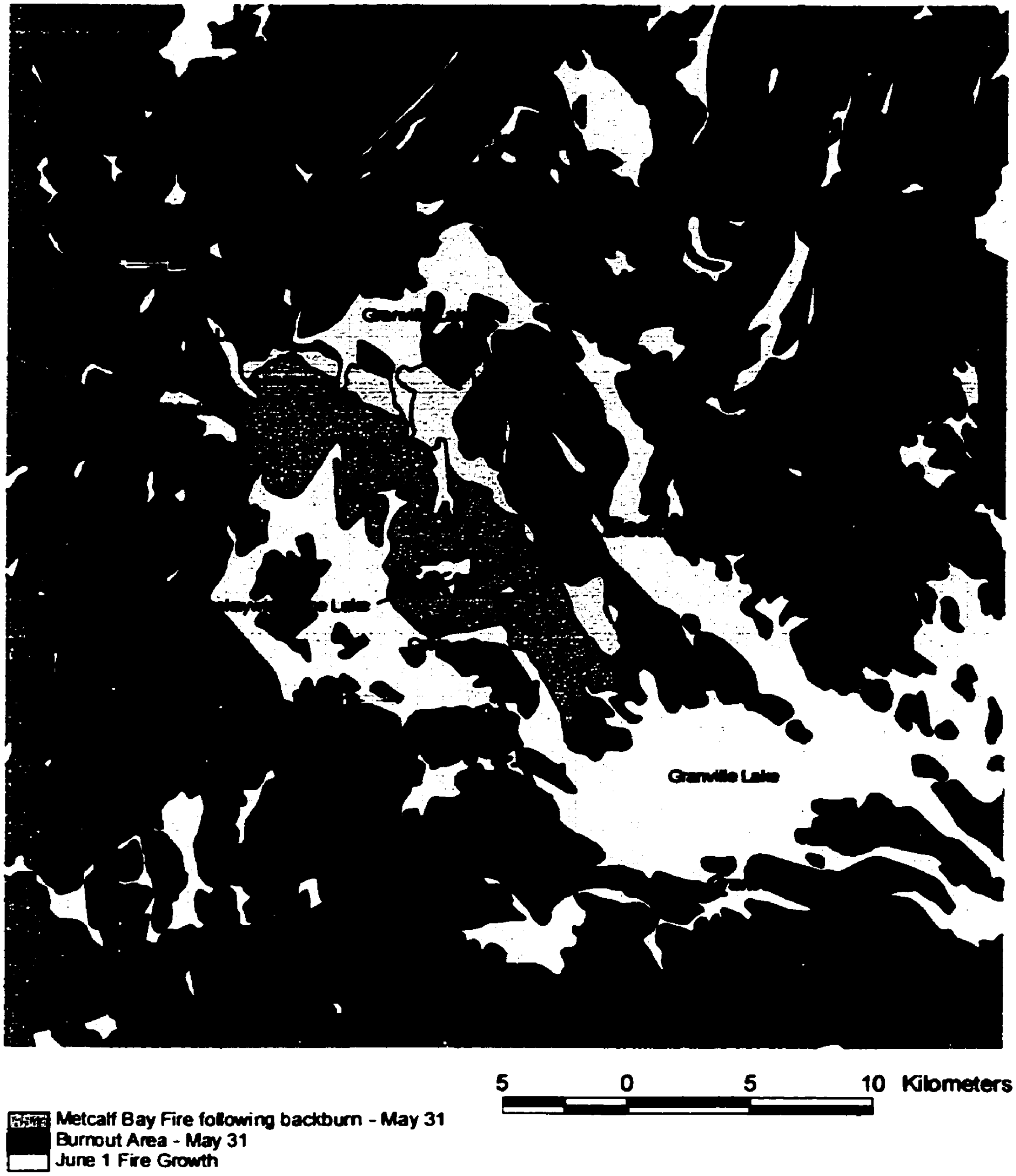

Figure 19. Location of the Metcalf Bay Fire on June 1 following the backfiring and burning out from the previous day.

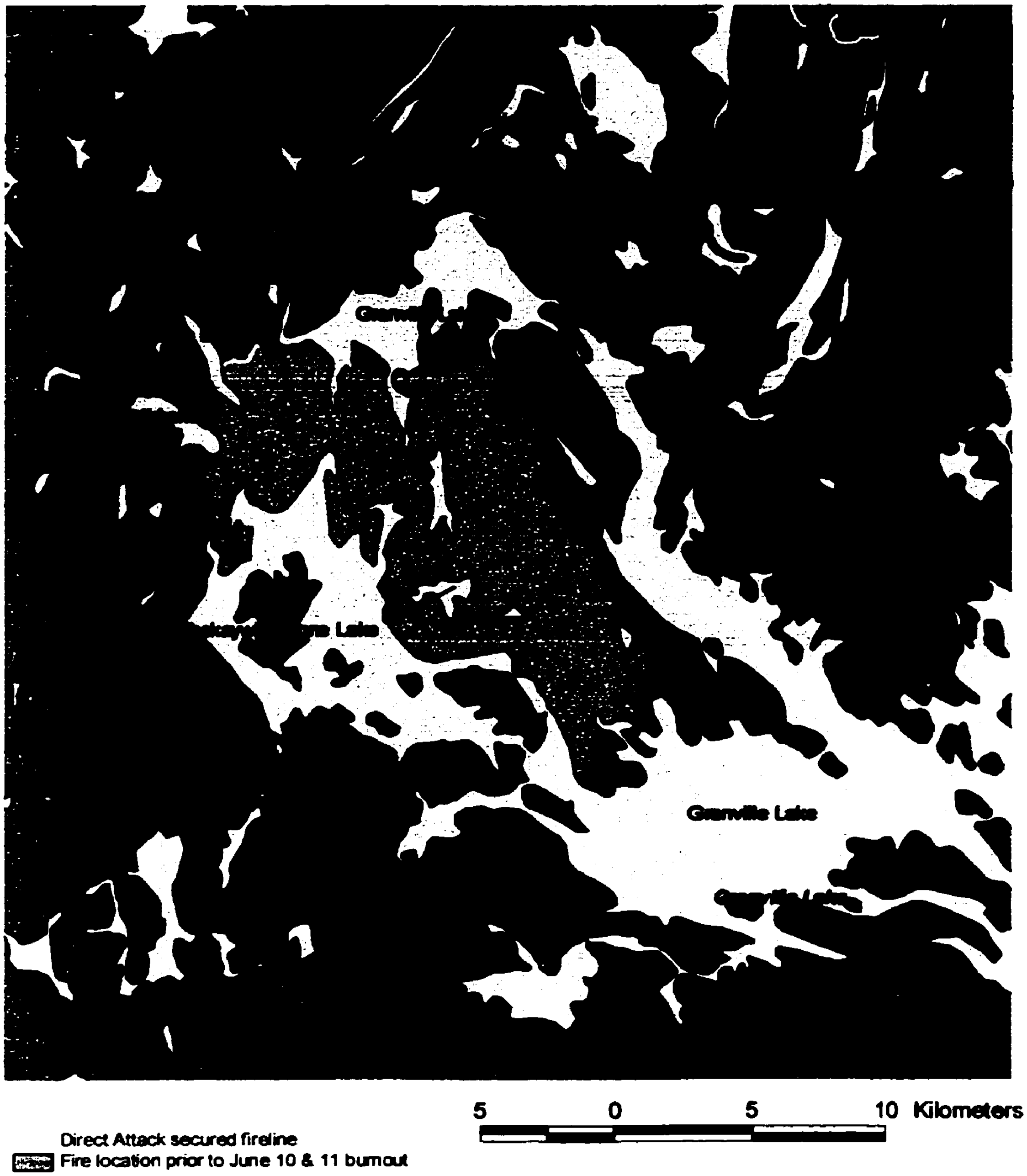

Figure 20. Location of the Metcalf Bay Fire prior to the June 10 & 11 burnout operation. Note the location of direct attack on the northwest corner. This was the only area of the fire requiring direct attack to secure the fireline. A direct attack was attempted on the northeast side of the fire but due to extreme fire behavior and a lack of suppression resources it was later abandoned. The exact location is not known.

June 10 & 11
The main objective was to burnout the entire shoreline to secure the fire to the peninsula along the east and south shore. The burnout involved tying the fire into the shore where possible and burning a 500-700 metre fuel break along water's edge. Eliminating the fuel along the peninsula shoreline removed the potential for fire to spot to the mainland and the centre of the peninsula was left to burn on its own (Figure 21).

Fire Weather Observations at Burnout/Backfire:

May 31 (1600 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
20.5	43.0	45	6.4	0	91.3	41.3	280.1	7.1	60.4	19.1

June 1 (1700 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
20.9	39.0	180	5.4	0	90.7	44.8	287.5	6.2	64.5	18.0

June 10 (1600 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
25.8	21.0	0	11.5	0	93.7	37.7	311.6	12.7	57.9	28.3

June 11 (1500 hrs)

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
29.8	20.0	315	5.7	0	94.7	43.5	320	11.0	64.9	27.1

Fire size prior to backburning (Ha): 4000 (estimated)

Final fire size (Ha): 18,300

Total Fire Perimeter (km): 151

Backburn secured perimeter (km) (Figure 22): 88.1

Percentage of total perimeter: 58%

Comments:

May 31, 1995
Backfire
Backfiring was successful in slowing the head fire spread south of Kosapachekaywinasinne Lake and preventing spotting to mainland. The fire did spot to islands in two places; a small island burned off completely; and another small spot started on a larger island but was quickly extinguished with hand tools. A small trapper's cabin burned along north shore when a wind shift caused by a passing thunder cell directed a head fire toward the cabin. A burnout around the cabin was considered but it required a fire pump and hose to wet down the cabin and area prior to commencing. The equipment could not arrive on the scene in time and the main fire consumed the cabin before the burnout could be attempted.

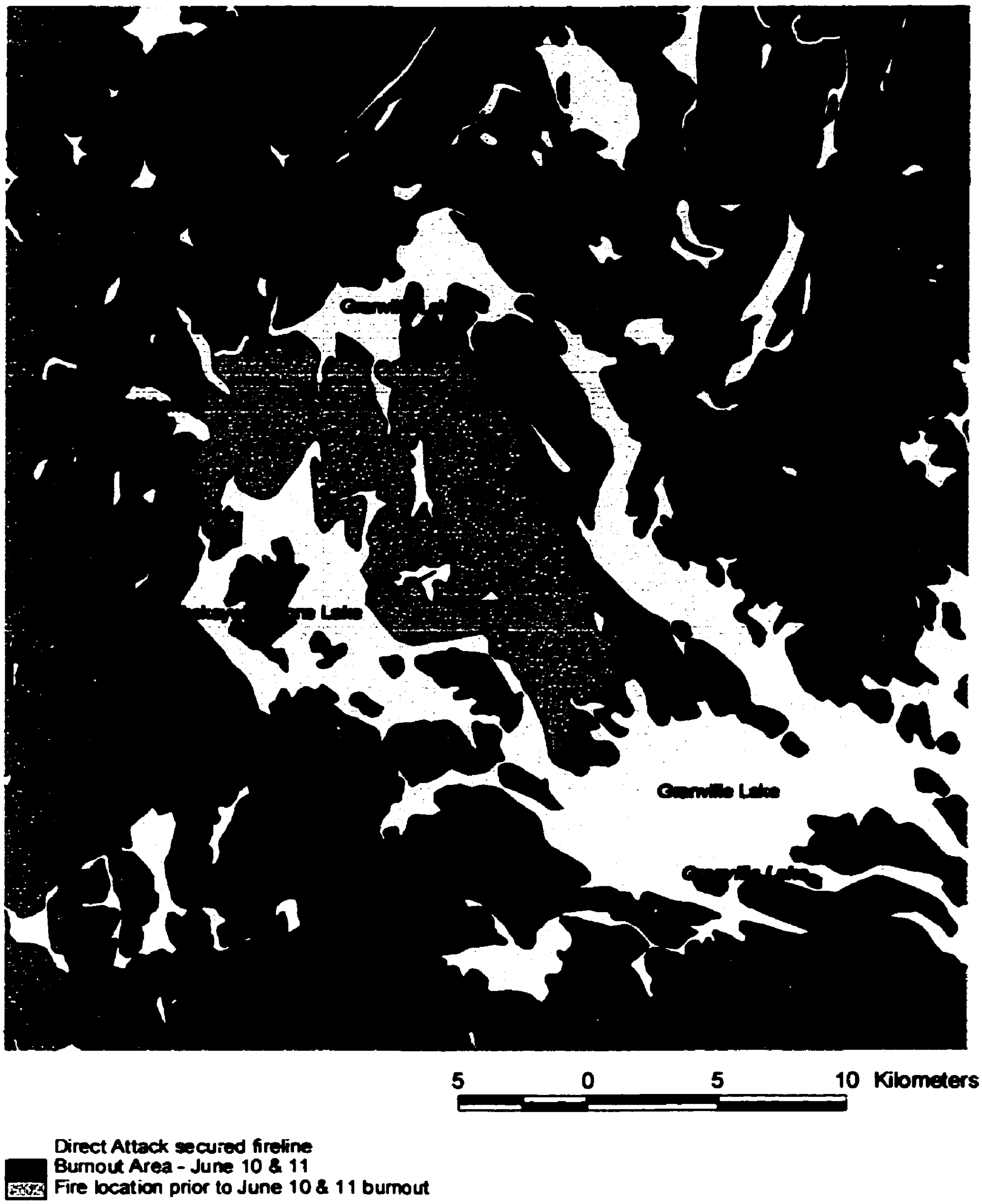

Figure 21. Location of the June 10 & 11 burnout area.

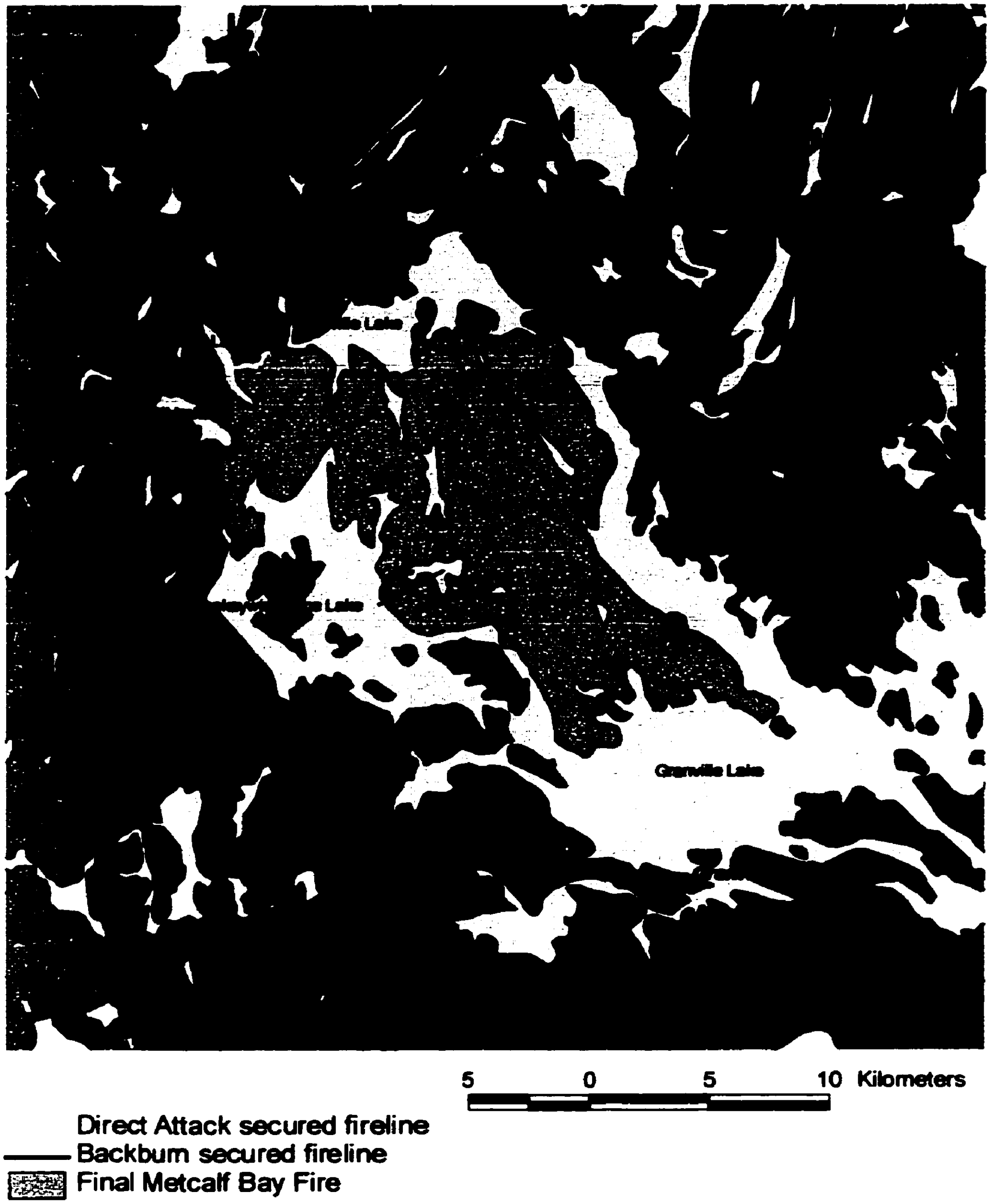

Figure 22. Map showing the final Metcalf Bay Fire and the location of fireline secured by direct attack and backburning.

Burnout
The burnout was successful in securing fire perimeter to creeks and ground crew lines on the northwest side of the fire. However, there was not enough time to finish the burnout and it was completed the next day.

June 1, 1995
Burnout
Minor clean up and completion of the burnout area from the previous day. The burnout was successful in securing the fireline. The ignition helicopter and Burn Team was seconded for backburning on Fox Mine Fire #105-042.

June 10 & 11
Burnout
The entire perimeter of fire was successfully secured with the burnout and back-up direct attack support where the peninsula extended from the mainland. The entire peninsula was not burned off. Only a wide enough fuel break to prevent the fire from spotting to the mainland was burned. Once the shoreline and the mainland were secured, the fire was left to burn on its own.

B) Direct Attack

Direct Attack Dates: May 30 - July 8, 1995

Duration of Direct Attack: 15 days

Direct Attack Objectives:
The initial direct attack strategy was to cut off fire from spreading to the mainland on the northwest side. This strategy was combined with the burnout to establish a control line across the peninsula where it joined the mainland.

The fire perimeter was secured on the south and west side following the rain on June 1&2. An attempt was made to direct attack approximately 17 kilometres of the fire perimeter on the north and east side but was later abandoned when extreme burning conditions returned. Direct attack objectives were then focused on providing back-up support for the burnout in areas where a natural fuel break did not exist. Primarily in the northwest sector of the fire where the peninsula extended to the mainland.

Firefighters:	60
Direct attack secured perimeter (km) (Figure 22):	1.9
Percentage of total perimeter	1%

III) SUPPRESSION COST COMPARISON

a) Backburn Costs

Ignition Helicopter Bell 206B (CG-EKM) 14.6 hours @ $235.00/hour (Contract rates)	$ 3431.00
Helicopter Fuel 1708 litres @ $0.6350/litre	$ 1,085.00
Helitorch Fuel Gasoline – 2870 litres @ $ 0.497/litre	$ 1,426.00
Petrolgel Gelling Agent 112 litres @ $ 11.06/litre	$ 1,239.00

a) Direct Attack Costs

Aircraft Rotary and Fixed Wing	$ 117,126.00
Air Attack Air Tankers – CL 215 Bird Dog	$ 840.00
Emergency Fire Fighting Personnel	$ 40,400.00
Service and Supply Costs	$ 28,084.00
Equipment Rental	$ 1,190.00

c) Total Suppression Costs

TOTAL SUPPRESSION COST: $ 194,821.00

Direct Attack	
TOTAL COSTS	$ 187,640.00
PERCENTAGE OF TOTAL	96%
COST/km (1.9 km)	$ 98,757.00
Backburning	
TOTAL BURNOUT COSTS	$ 7,181.00
PERCENTAGE OF TOTAL	4%
COST/km (88.1 km)	$ 81.00

4.6 CASE STUDY 5: EATON LAKE FIRE #105-251

I) BACKGROUND

Ignition Date: June 27, 1995

Ignition Source: Lightning

Location: 56° 36′ 23″ x 101° 02′ 35″
Located approximately 27 kilometres south of Lynn Lake, Manitoba (Figure 23).

Priority Zone: Green

Fuel Type and Terrain:

60% C3 - Immature Jack Pine
30% 01a - Grass and shrub covered swamp
10% C2 - Boreal Spruce

Fire was located in typical Precambrian Shield terrain characterized by combined forest-covered and exposed rock ridges surrounded by low-lying muskeg.

Fire Weather Observations at Ignition (Noon Wx):

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
17.0	55.0	320.0	28.0	0	89.5	62.5	369.0	16.2	87.8	35.9

Observed Fire Behavior:
Full crown involvement at head. Intermittent torching at flanks. Rear mainly surface fire with intermittent candling.

Spread Potential:
Unlimited spread potential to the north and south. The north was considered high priority for the potential threat to Lynn Lake. The south was of no concern. The spread potential to the east was limited by the 1993 Finch Lake burn and to the west by a 1989 burn.

Values at Risk (Figure 23):

a) Community of Lynn Lake

II) SUPPRESSION SUMMARY

Date of Initial Suppression: July 3, 1995

Date of Control: July 3, 1995

Called Out: July 15, 1995

Suppression Strategy: Burnout strategy only. No direct attack suppression.

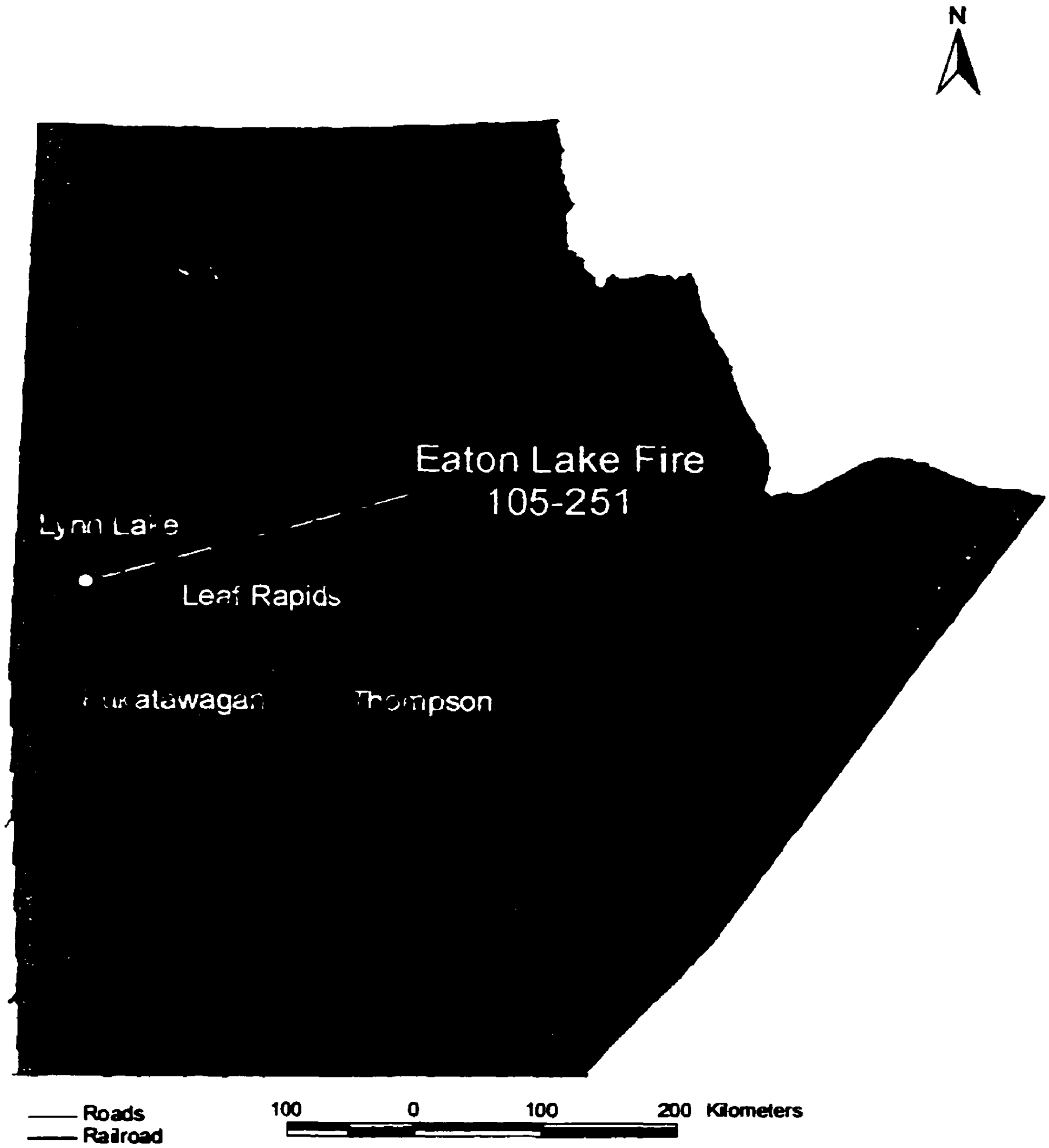

Figure 23. Location of the 1995 Eaton Lake Fire #105-251.

A) Backburning

Date(s): July 3, 1995

Objectives:
The main priority was to eliminate spread potential to the north. The primary objective was to use a creek system to the north of the fire as a control line and burnout between the 1993 Finch Lake burn to the east and the 1989 burn to the west (Figure 24). A successful burnout would secure the north flank of the fire and eliminate any potential threat to Lynn Lake. Spread to the south was of no concern and with limited east and west spread in the old burns, the fire could be left to burn and be monitored.

Fire Weather Observations at Burnout - July 3, 1995 (1600 Hrs):

Temp	% Rh	WD	WS	Rain	FFMC	DMC	DC	ISI	BUI	FWI
16.0	36.0	330	9.0	0.0	88.8	73.9	406.0	5.7	101.5	21.4

Fire Size at Initial Suppression (Ha): 585 Ha

Final Fire Size (Ha): 4111 Ha

Total Fire Perimeter (km): 38.2

Backburn Secured Perimeter (km)(Figure 26): 6.8

Percentage of Total Perimeter: 18%

Comments:
The burnout was successful. The north flank of the fire was secured between the Finch Lake and 1989 burns (Figure 25). Burning achieved a complete removal of surface and aerial fuels and was completed in 6.3 hours. No follow-up suppression was required. The fire was monitored and left to go out on its own (Figure 26).

b) Direct Attack

No direct attack action required.

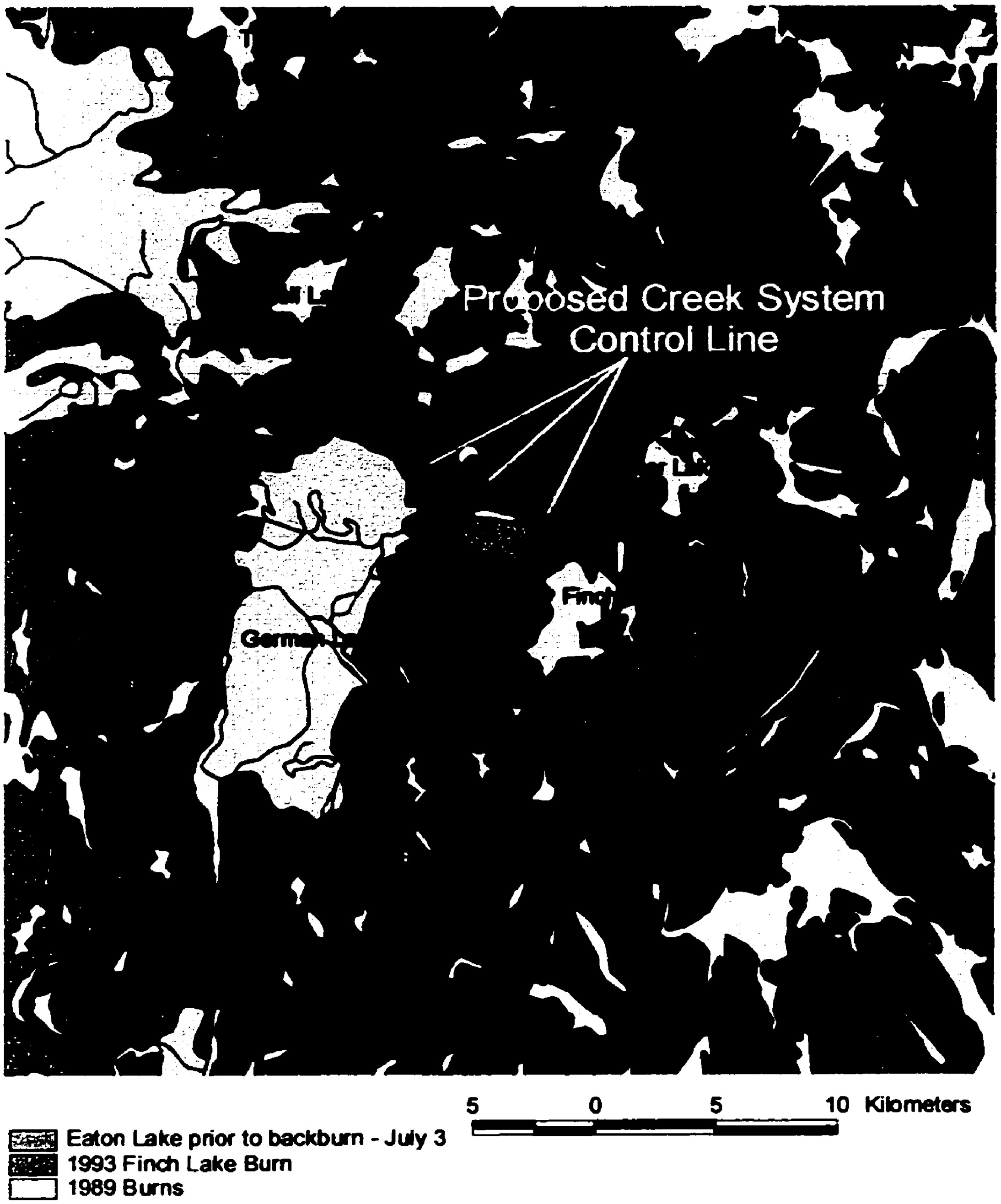

Figure 24. Location of the Eaton Lake Fire prior to the burnout and the creek system that was used as a control line.

Figure 25. Location of the burnout area.

Figure 26. Map showing the location of the final Eaton Lake Fire and the fireline secured by backburning.

III) SUPPRESSION COST SUMMARY

a) Backburn Costs

Ignition Helicopter Bell 206B (CF-ZSJ) 6.3 hours @ $650.00/hour	$ 4,095.00
Helicopter Fuel 737.0 litres @ $0.635/litre	$ 468.00
Helitorch Fuel Gasoline – 820 litres @ $ 0.497/litre	$ 408.00
Petrolgel Gelling Agent 32 litres @ $ 11.06/litre	$ 354.00

b) Additional Costs

Aircraft Monitoring and reconnaissance.	$ 2,417.00

c) Total Suppression Costs

TOTAL SUPPRESSION COST:	$ 7,742.00
TOTAL BACKBURN COSTS	$ 5,325.00
PERCENTAGE OF TOTAL COSTS	69%
COST/km (6.8km)	$ 783.00

Chapter 5

RESULTS AND DISCUSSION

5.1 Results

The results of the comparison of backburning to direct attack suppression costs are summarized in Table 1 and Figures 27 & 28.

	Girouard Lake Fire	Sickle Lake Fire	Fox Mine Fire	Metcalf Bay Fire	Eaton Lake Fire
Total Fire Costs	$1,059,988.00	$382,627.00	$317,205.00	$194,821.00	$7,742.00
Backburn Costs	$17,052.00	$5,180.00	$2,893.00	$7,181.00	$5,325.00
% of Total	2%	1%	1%	4%	69%
Direct Attack Costs	$1,042,936.00	$377,447.00	$313,925.00	$187,640.00	$0.00
% of Total	98%	99%	99%	96%	0%
Total Fire Perimeter (km)	132	68	22.1	151	38.2
Backburn Secured (km)	54.1	33.6	8.8	88.1	6.8
% of Total	41%	49%	40%	58%	18%
Direct Attack Secured (km)	52	19	9.2	1.9	0
% of Total	39%	28%	42%	1%	0%
Non-actioned perimeter (km)	25.9	15.4	4.1	61	31.4
% of Total	20%	23%	19%	40%	82%
Backburn Cost/km (secured fireline)	$315.00	$154.00	$329.00	$81.00	$783.00
Direct Attack Cost/km (secured fireline)	$20,056.00	$19,865.00	$34,122.00	$98,757.00	N/A
$/km Cost Ratio Direct Attack/Backburn	64:1	129:1	104:1	1,212:1	N/A
Duration of Backburn	19.6 hrs	6.1 hrs	6.3 hrs	14.6 hrs	6.3 hrs
Duration of Direct Attack	35 days	unknown	12 days	15 days	N/A

Table 1. *Summary table of backburning and direct attack cost comparisons for the case study fires.*

Backburning is an extremely cost-effective technique for securing fireline when compared to direct attack. In all of the case studies where backburning was used in conjunction with direct attack, backburning accounted for less than 4% of the total suppression cost. The Eaton Lake Fire was an exception as backburning was the only suppression technique used. On the Eaton Lake Fire, backburning comprised 69% of the total costs. The remaining 31% of the costs were associated with reconnaissance flights to monitor the fire following the burnout.

Although backburning comprised a small portion of total suppression costs, it has been shown that it was used to secure a significant amount of fireline on each fire, on average, approximately 40-60% of the total actioned fireline. Again the Eaton Lake fire was the exception as backburning was only used to secure a small length of fireline while the rest of the fire was left to burn. Backburning only secured 18% of the total fire perimeter, however this was the only area of concern on the fire.

When the cost to secure one kilometre of fireline by backburning and by direct attack is compared, the cost-effectiveness of backburning is very evident. For example, backburning was used to secure approximately 40% of the total fire perimeter on both the Girouard Lake and Fox Mine fires. This was approximately the same amount of fireline secured by direct attack on the same fires. Using these fires as an example, costs ranged between $20,056.00 and $34,122.00 to secure one kilometre of fireline with direct attack compared to $315.00 and $329.00 to secure one kilometre of fireline with backburning. When represented as a ratio of costs per kilometre, direct attack costs can exceed backburning costs by over 100 to 1. The analysis of the Metcalf Bay fire showed that this ratio can be as high as 1200 to 1. However, this ratio was high because there was a considerable expenditure on direct attack on a piece of fireline that had to be abandoned when it was overrun. The costs associated with the abandoned direct attack were incorporated into the calculation of total direct attack costs, and since only a small amount of fireline was secured by this method (1.9 km), the direct attack cost per kilometre was

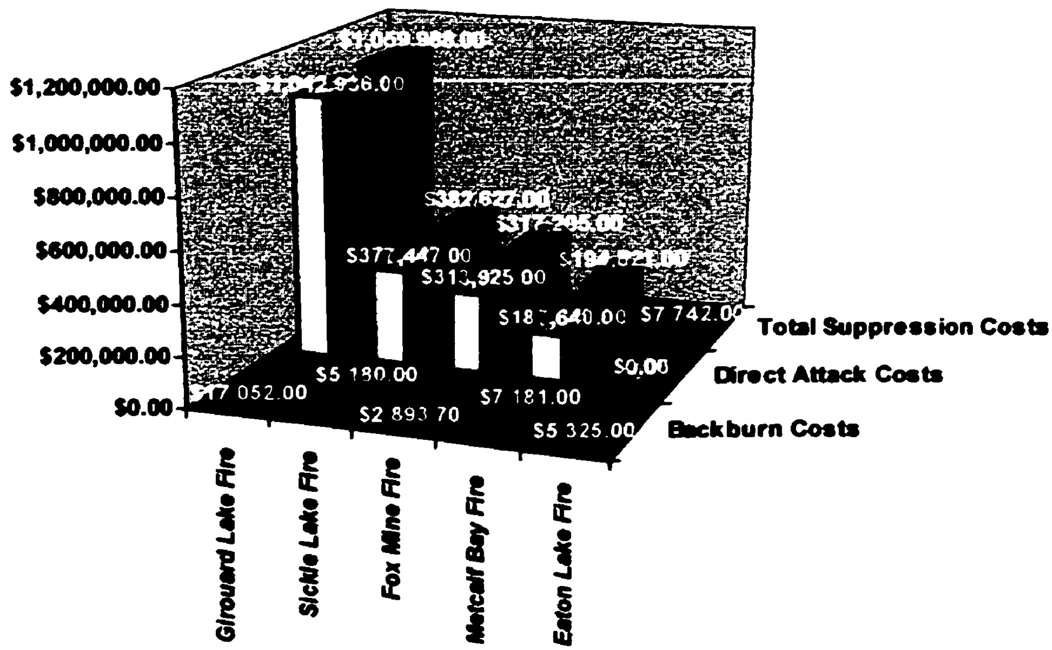

Figure 27. Comparison of backburning and direct attack costs.

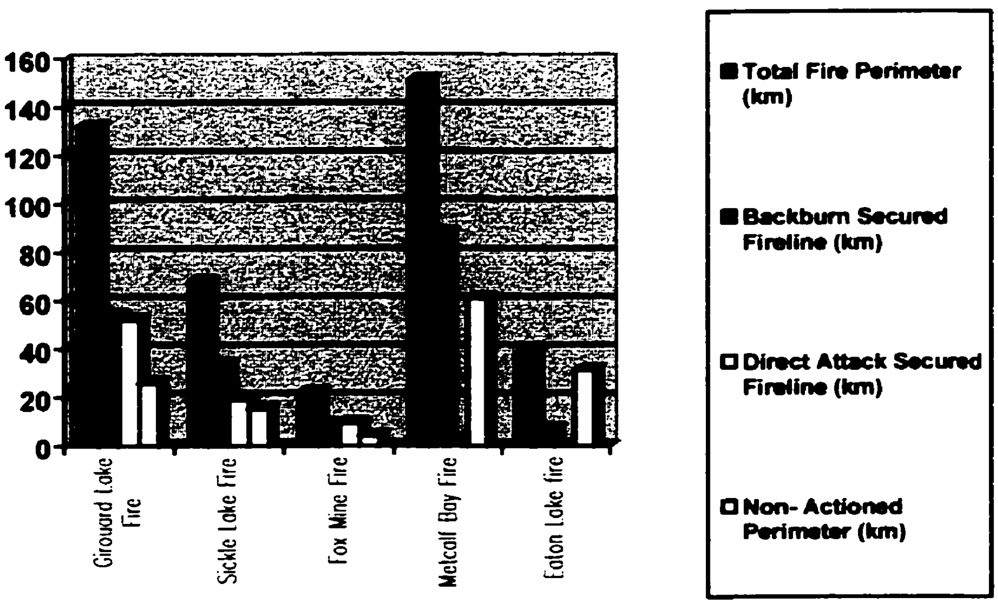

Figure 28. Fireline secured by backburning and direct attack.

very high for the Metcalf Bay fire. A ratio in the range of 100-200 to 1 would be a more conservative estimate for most fires involving both backburning and direct attack.

Obviously, any reduction in the amount of fireline requiring direct attack can result in a considerable reduction in total suppression costs. It would be difficult to calculate what suppression costs would have been on each fire had a backburn strategy not been used. One can only speculate where a direct attack may have taken place as it is not known where the fireline would have been when one would have been attempted. It would be wrong to assume that if backburning secured a given amount of fireline that the same amount of direct attack would have been prevented; it could be more or less. However, one can be confident that total suppression costs would have been significantly higher on each fire if direct attack was the only suppression technique used. Without backburning, there would have been more fireline to secure by direct attack and it is likely that containment of each fire would have taken a longer period of time.

Although direct attack suppression was not used on the Eaton Lake fire, the fire was included in the study to demonstrate that under ideal conditions, backburning can be used by itself to secure a fire at a relatively low cost. A total of 6.8 kilometres of fireline were secured at a cost of $783.00 per kilometre, a cost still well below direct attack. A direct attack on the Eaton Lake fire, if one had been used, would likely have resulted in total suppression costs being at least an order of magnitude higher than the actual costs that were incurred with backburning. It is interesting to note that on all the fires where a combination of backburning and direct attack were used, the costs to secure one kilometre of fireline by direct attack exceeded the cost of the entire backburn operation for the fire.

5.2 Discussion

The cost effectiveness of backburning can be attributed to three primary factors. These include:

1) A small amount of equipment and personnel are required to conduct a backburn operation. On each of the case study fires, the only equipment required for the backburn operation was a light helicopter (Bell 206 Jet Ranger), a helitorch c/w spares, an appropriate amount of drummed helitorch fuel and gelling agent, helicopter fuel and 3-6 personnel. This is a standard equipment and personnel requirement for backburning in Manitoba and has been the configuration used on numerous backburn operations regardless of the size. Therefore, the cost to mobilize a Burn Team and equipment to a fire is relatively constant, inexpensive, and is not dependant on the size of the backburn operation. Backburn costs, however, will increase if additional helicopters are required for slinging helitorch fuel to the mixing site, or when waterbombers and helibucketing are used to reinforce a control line.

Direct attack costs are considerably higher than backburning simply due to the nature of this type of suppression. Direct attack is labor-intensive and involves deploying a large number of personnel and supporting them with aerial attack, transportation, equipment and supplies required to complete the task of securing fireline. All this equipment and manpower comes at a high cost, which increases as the size and duration of the suppression effort grows.

2) Backburning can be used to secure a large amount of fireline in a relatively short period of time. As illustrated by the case study examples, backburning was used on each fire to secure an equivalent amount of fireline as direct attack; however, this was accomplished in a fraction of the time. The longest burn operation took place on the Girouard Lake Fire over a period of 19.6 hours and resulted in 54.1 kilometres of secured fireline. The shortest burn operation was the Sickle Lake burnout, which took 6.1 hours and secured 49% of the fireline. Under the right burning conditions, a backburn operation can be used to secure a considerable amount of fireline in a matter of hours as opposed to a direct attack which may take days or weeks to achieve. By decreasing the amount of fireline requiring direct attack, the length of time required to put a fire out may be shortened thereby reducing overall costs.

3) The costs to backburn do not increase significantly as the amount of fireline increases. In general, increased backburn costs are associated with the length of time required to complete a burn operation, not the size of the fire. As a burn operation becomes more complex, it requires more flight time for the ignition helicopter and thus an increased cost. However, there are no additional resource requirements or extra equipment required except for additional helicopter fuel, helitorch fuel and gelling agent. Consequently, backburning costs do not increase in proportion to the amount of fireline that has to be secured. In fact, as the length of fireline secured by backburning increases, the cost to secure a kilometre of fireline decreases.

Direct attack costs, on the other hand, can increase significantly in proportion to the amount fireline that needs to be secured. The increased cost is associated with the requirement for more suppression resources and/or the extra time required to secure additional fireline. Thus, as a direct attack fire suppression effort increases in magnitude, so do the associated costs.

This study has shown that under the right conditions, a successfully applied backburn strategy can be extremely beneficial to a suppression effort. The main benefits arise from being able to secure a large amount of fireline in a relatively short period of time at a substantially low cost. Securing any amount fireline with a backburn reduces the amount of direct attack suppression required thereby preventing a potentially high expenditure on total suppression costs. These benefits are the primary justification why backburning with a helitorch is a strategy that should be considered at every opportunity. It is an efficient and cost effective suppression technique for today's fire manager who must frequently make and justify suppression decisions on the basis of their potential cost.

As a final comment, it should be noted that each of the fires in the study occurred during the 1995 fire season. This was an extremely busy season in Manitoba and suppression resources were stretched to the limit due to multiple fires throughout the province. As a result, the direct attack costs used in the study do not necessarily reflect what they may have been in a normal fire season when more suppression resources are available. In a normal year, a fire would receive a larger commitment of resources than one during the 1995 season; consequently, direct attack costs would be higher. It is possible that the direct attack cost figures in the study are low.

Chapter 6

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

6.1 Summary

This study involved a review of backburning and direct attack suppression on five wildfires in northern Manitoba[5]. All fires occurred during the 1995 fire season. Backburning was utilized in conjunction with direct attack on four of the five fires; the fifth fire was actioned using a backburn strategy only.

The intent of the study was to evaluate backburning on each fire to determine and document: 1) the specific backburn objectives and whether they were achieved; 2) the amount of fireline secured by backburning and direct attack in relation to the total fire perimeter; 3) the costs associated with backburning and direct attack in relation to total suppression costs; and 4) a comparative measure of backburning and direct attack costs. This study served to be the first formal evaluation completed on the use of backburning in the Manitoba Forest Fire Program.

Completion of the study involved a thorough review of records and data maintained by the Manitoba Conservation Fire Program on each of the case study fires. Information sources for the data included the Fire Program's National Fire Information Database, Environment Canada and Fire Program meteorological records, file records and other related documentation, fireline personnel field notes, and informal interviews and discussion with personnel involved in the respective fires. The bulk of the data required for the analysis included suppression cost expenditures, fire weather information, and logistical fire action information. Each fire was reviewed separately outlining the fire weather conditions and circumstances leading up to suppression, the values at risk, specific backburning and direct attack objectives, suppression costs, and the fire perimeter secured by backburning and direct attack. The intent was to isolate backburning from direct attack on each fire and complete a comparison of the two suppression techniques on the basis of cost and effectiveness in securing fireline.

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[5]The author is a member of the provincial Backburn Team that coordinated and executed the backburn operations on each of the case study fires.

6.2 Conclusion

The study has demonstrated that when successfully utilized, backburning is an efficient and effective suppression technique. On all the case study fires, the suppression objectives of the backburn operation were met. A significant amount of fireline was secured and at no time did the backburning result in any of the fires escaping beyond the natural barrier control lines established in the pre-burn planning. The only exception was the Sickle Lake Fire which had two small areas that required direct attack suppression beyond the backburning control lines; however, the fire had jumped in these areas prior to the burn operation and was extinguished immediately following the burnout.

On the basis of cost, backburning is an extremely cost-effective suppression technique compared to conventional direct attack suppression. It was demonstrated on fires where backburning was used in conjunction with direct attack, the burn operation accounted for less than 4% of the total fire suppression cost. At the same time, it was shown backburning was used to secure as much, or more fireline as direct attack over a period of hours as compared to days. For example, 54.1 kilometres or 41% of the total fire perimeter, was secured on the Girouard Lake Fire in 19.6 hours using a backburn strategy as compared to 52 kilometres, or 39% of the fire perimeter secured with direct attack in 35 days. When the cost to secure one kilometre of fireline with backburning was compared to direct attack, the study revealed that the ratio of direct attack suppression costs can exceed backburning costs by as much as 1200 to 1. Suppression costs ranged from $81.00 to $783.00 for a kilometre of fireline secured by backburning compared to $19,866.00 to $98,758.00 for a kilometre of fireline secured by direct attack.

The cost effectiveness of backburning is attributed to three primary factors. First, a backburn operation can be conducted with a relatively small amount of resources. The only requirement is an ignition helicopter, a helitorch c/w supplies, helitorch fuel, gelling agent, fuel for the helicopter, and 3-4 personnel; regardless of the size of the operation. Direct attack, on the other hand, is labor-intensive and involves the use of several aircraft, a large number of personnel, and a considerable amount of equipment and supplies to support the suppression effort.

Second, backburning can be used to secure a large amount of fireline in a relatively short period of time whereas direct attack to secure an equivalent amount of fireline can take several days or even weeks. The length of time required for direct attack combined with its high cost is the primary reason why suppression costs are high on fires that require several days or weeks to contain. It only stands to reason that a suppression technique that achieves the same objectives of securing fireline in a matter of hours as compared to one that takes days will be less expensive. Backburning is one such technique.

The third and final factor that attributes to the cost effectiveness of backburning is that the costs to backburn do not increase significantly as the size of a fire or a backburn operation increases. The only factors that contribute to increased backburn costs are the amount of time that is required for the ignition helicopter, additional helicopter fuel, and additional helitorch fuel and gelling agent. On the other hand, it is possible that total direct attack costs can increase significantly as the length of the fireline requiring direct attack increases. More suppression resources may be required and/or the length of time required to secure the fireline may increase. This will not necessarily have a significant impact on the cost per kilometre to secure the fireline but rather will add to the total suppression cost.

The objective of this study has not been to promote backburning as a replacement for direct attack. Backburning is an extremely effective method of securing fireline when the conditions are ideal for a burn operation to be conducted safely, successfully, and with minimal risk of making a fire situation worse. It is a unique suppression strategy that can be used, and may be the only alternative, in extreme burning conditions when other suppression methods are ineffective. However, when backburning is not an option, the only other feasible method of extinguishing a fire is by direct attack. Direct attack is still the primary method of fighting fire and will continue to be. The primary intent of this study was to calculate and document the cost effectiveness of backburning as a fire suppression technique. Direct attack costs were used primarily as benchmark for comparison.

Backburning is a controversial topic among fire personnel. There are individuals that feel that setting a fire to help put one out is a contradiction in terms and that it simply burns more forest than it protects. This is not always the case. The intent of backburning is to contain a fire within the confines of natural barriers to prevent its spread. If a backburn is not attempted and a fire cannot be controlled by conventional suppression techniques, there is the possibility that the fire on its own would have burned more forest than any backburn in trying to bring it under control. There will always be situations where it may be more feasible to burn a large area to secure a fire, but this is a decision that fire managers must make and it requires consideration of a number of factors; cost being one of the most important. Forest fire fighting is an expensive undertaking and this study only served to demonstrate that backburning with a helitorch is an effective suppression technique. When applied successfully under the right conditions, it is an efficient and cost effective fire management tool.

6.3 Recommendations

1. It is recommended that Manitoba Fire Program fire managers consider backburning on all fires when conditions are favorable; however, this does not include those where direct attack would be more feasible. Backburning should be considered on fires that may require a large suppression effort or may pose control problems due to extreme fire behavior. Any amount of fireline secured through a backburn operation will decrease the amount of direct attack required which consequently will reduce total suppression costs. This cost saving will increase in direct proportion to the length of fireline that can be secured.

2. It is recommended that Manitoba's Burn Teams be incorporated into the provincial Initial Attack Preparedness System and be put on standby and positioned into areas of high fire danger according to a formal alert system similar to the provincial Air Attack and Initial Attack forces. At present, Burn Teams are put on standby under the discretion of the Provincial Duty Officer in consultation with the Regional Duty Officers. This only occurs after a fire situation arises. In some cases, a Burn Team is not dispatched and cannot be in place before the window to burn is lost resulting in a missed opportunity to be effective in containing the fire. Formalizing an alert system for Burn Teams would serve to put teams in place where they can be dispatched rapidly and assist in containing fires to a small size and subsequently minimize total suppression costs. Any alert system developed for Burn Teams should be based on higher levels of fire danger when problem fire behavior is expected. At lower danger levels, burning conditions are not usually favorable for backburning and direct attack is more feasible.

3. It is recommended that Manitoba Fire Program consider assessing Observation Zone fires in their early stages for backburn opportunities. Fires in Manitoba's Observation Zone are generally left to run their course and burn on their own. These fires are monitored and will only receive suppression action if a value is threatened (community, lodge, etc.). In some cases when a value is threatened, it may be from a fire that was being monitored and was

not anticipated to be a problem. However, burning conditions may have been favorable for the fire to grow large and eventually become a threat. This can be the case with fires that start early in the spring and have all fire season to burn. Northern Manitoba is abundant with natural barriers that can be used as control lines to contain a fire. It may be possible to reduce the threat to known values by containing or cutting off a fire in its early stages before it becomes a problem and an expenditure on a large suppression effort is required.

4. It is recommended that Manitoba Fire Program develops and provides more training for all program personnel on the use of backburning in fire suppression. The recommended training would not be for the actual "hands on" application of the technique but rather as information sharing on *where, when, and why*, backburning should be used. The results of this study could be used for demonstrating the effectiveness of successfully applied burn operations. Although the use of backburning is increasing in Manitoba, there are still fire managers who are skeptical and unfamiliar with the technique. If backburning is to be used efficiently, all personnel involved in fire suppression from the management level to the field should have a sound understanding of the technique. This will ensure that the request for a Burn Team is made when a backburn can be most effective rather than after a burn opportunity is lost. Potential suppression costs may be prevented.

5. It is recommended that Manitoba Fire Program develop formalized Ignition Boss training using remote low priority fires for practical backburning experience. Every season there are remote fires, particularly in the Observation Zone, that do not pose a threat to life, property, or other values which could be used for training on different ignition techniques and patterns. There is still much to be learned with regards successful application of backburning and any opportunity to provide both experienced personnel and those in training with the opportunity to fine tune their skills will benefit the Fire Program. Based on the results of this study, the potential cost savings from a successful backburn executed by well-trained personnel would

far exceed the expenditure on training.

6. One final recommendation, though not specifically directed to Manitoba Fire Program, is that other fire management agencies should consider incorporating a formalized burn program into their forest fire suppression programs. Manitoba's provincial capital expenditure on the Burn Program to its present state was approximately $100,000 over a period of 7 years (Roberts, pers. comm., 2000). This is a relatively small investment considering that a successful backburn operation has the potential to recover this cost in a few hours of burning on one fire.

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APPENDIX 1

Glossary of Terms

Source:

Merrill, D.F. & Alexander, M.E. (eds). 1987. Glossary of Forest Fire Management Terms. 4th ed. National Research Council of Canada. Canadian Committee on Forest Fire Management. Ottawa, Ontario. publ. NRCC no. 26516. 91 p.

aerial attack - A fire suppression operation involving the use of aircraft to deliver fire fighting forces, suppressants, or retardants to or on a fire.

aerial fuels - See ***crown fuels***

aerial ignition - The ignition of fuels by dropping incendiary devices or materials from aircraft.

air attack - See ***aerial attack***

airtanker - A fixed-wing aircraft for dropping suppressants or retardants on fires.

attack - The actual physical fire fighting operation.

back - That portion of the fire perimeter opposite the head; the slowest spreading part of the fire.

backburning (backburn) - Any fire suppression strategy that uses fire to achieve a suppression objective. Generally, for large scale backburning, aerial ignition is used as an ignition method.

backfire - A fire spreading, or set to spread, into or against the wind.

backfiring (backfired)- A form of indirect attack where extensive fire is set along the inner edge of a control line or natural barrier, usually some distance from the wildfire and taking advantage of indrafts, to consume fuels in the path of the fire, and thereby halt or retard the progress of the fire front.

burn or burned area- Any unit of land over which a fire of any kind has spread. Recommended SI unit for burned area is hectares (Ha).

burning conditions - The state of the combined components of the fire environment that influence fire behavior and fire impact in a given fuel type. Usually specified in terms of such factors as fire weather elements, fire danger indexes, fuel load, and slope.

burning out (burnout) - A fire suppression operation where fire is set along the inside edge of a control line or natural barrier to consume unburned fuel between the line and the fire perimeter, thereby reinforcing the existing line and speeding up the control effort. Generally a limited, small-scale routine operation as opposed to backfiring.

burning period - That part of each 24-hour day when fires are generally the most active. Typically, this is from mid-morning to sundown, although it usually varies with latitude and the time of the year.

contain - (to contain a fire) To take suppression action as needed, which can reasonably be expected to check the fire's spread under prevailing conditions.

control a fire - To complete a control line around a fire, any spot fires therefrom, and any interior island(s) to be saved; burning out any unburned areas adjacent to the fire side of the control lines; and cooling down all hot spots that are immediate threats to the control line until the lines can be expected to hold under foreseeable conditions.

control line - A comprehensive term for all constructed or natural fire barriers and treated fire perimeter used to contain a fire.

convection - In meteorology, vertical atmospheric motion in a predominantly unstable atmosphere. Convection is used often to imply only upward vertical motion, and in this sense is opposite to subsidence.

convection column - The definable plume of hot gases, smoke, firebrands, and other combustion by-products produced by and rising above a fire.

crown fire - A fire that advances through the crown fuel layer, usually in conjunction with a surface fire.

crown fuels - The standing and supported forest combustibles not in direct contact with the ground that are generally only consumed in crown fires (e.g. foliage, twigs, branches, cones).

direct attack - A method whereby the fire is attacked immediately adjacent to the burning fuel.

drip torch - An incendiary device (aerial or hand-held) that releases slow-burning flaming fuel at a predetermined rate.

escaped fire analysis - The process of deciding what action to take on an escaped fire. This involves a review and analysis of the threats to public safety, values at risk, resource management objectives, probable fire effect(s), existing fire load, present and anticipated fire behavior, availability of suppression resources, probability of successful control, and feasible fire suppression methods, to minimize costs, and reduce fire damage(s) and/or maximize the fire benefits(s). The decision may be to maintain, increase, decrease, or discontinue the fire suppression effort.

extreme fire behavior - A level of fire behavior that often precludes any fire suppression action. It usually involves one or more of the following characteristics: high rate of spread and frontal fire intensity, crowning, prolific spotting, presence of large fire whirls, and a well-established convection column. Fires exhibiting such phenomena often behave in an erratic, sometimes dangerous, manner.

fire behavior - The manner in which fuel ignites, flame develops, and fire spreads and exhibits other related phenomena as determined by the interaction of fuels, weather, and topography.

firebrand - A piece of flaming or smouldering material capable of acting as an ignition source.

fire danger - A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control, and fire impact.

fire front - The strip of primarily flaming combustion along the fire perimeter; a particularly active fire edge.

fireguard - A strategically planned barrier, either manually or mechanically constructed, intended to stop or retard the rate of spread of a fire, and from which suppression action is carried out to control a fire. The constructed portion of a control line.

fire indices - Components of the Canadian Forest Fire Weather Index (FWI) System that provide numerical ratings of relative fire potential in a standard fuel type (i.e., a mature pine stand) on level terrain, based solely on consecutive observations of four fire weather elements measured daily at noon (1200 hours local standard time or 1300 hours daylight saving time) at a suitable fire weather station; the elements are dry-bulb temperature, relative humidity, wind speed, and precipitation.

fireline - (1) That portion of the fire upon which resources are deployed and are actively engaged in suppression action. In a general sense, the working area around a fire. (2) Any cleared strip used to control a fire. Loosely synonymous with fireguard.

fire management - All activities required for the protection of burnable forest values from fire and the use of fire to meet land management goals and objectives.

fire management plan - A statement, for a specific area, of fire policy and prescribed action. NOTE: May include maps, charts, tables, and statistical data.

fire perimeter - The entire outer edge or boundary of a fire.

fire season - The period(s) of the year during which fires are likely to occur, spread, and do damage to forest values sufficient to warrant organized fire control.

fire weather - Atmospheric properties and meteorological processes that affect fire behavior. This includes temperature, atmospheric pressure, wind direction and velocity, and humidity.

firebrand - A piece of flaming or smouldering material capable of acting as an ignition source.

firebreak - An existing barrier or change in fuel type (to one less flammable than that surrounding it), or a wide strip of land on which the native vegetation has been modified or cleared, that act as a buffer to fire spread so that fires burning into them can be more readily controlled. Often selected or constructed to protect a high value area from fire. In the event of a fire, may serve as a control line from which to carry out suppression operations.

fire perimeter - The entire outer edge or boundary of a fire. Recommended SI units are metres (m) or kilometres (km).

fire suppression - See ***suppression.***

fire weather - Collectively, those weather parameters that influence fire occurrence and subsequent fire behavior (e.g. dry bulb temperature, relative humidity, wind speed and direction, precipitation, atmospheric stability, wind(s) aloft).

flank(s) - Those portions of the fire perimeter that are between the head and back of the fire which are roughly parallel to the main direction of spread.

forest protection - That branch of forestry concerned with the prevention and control of damage to forests arising mainly from human action (particularly unauthorized fire, grazing and browsing, felling, fumes, and smoke) and of pests and pathogens, but also from storm, frost, and other climatic agencies.

fuel - Any substance or composite mixture susceptible to ignition and combustion.

fuelbreak - See ***firebreak***

fuel buildup - Accumulation of fuels.

fuel type - An identifiable association of fuel elements of distinctive species, form, size, arrangement, and continuity that will exhibit characteristic fire behavior under defined burning conditions.

head fire - A fire spreading, or set to spread, with the wind (up slope in the absence of wind).

head of a fire -That portion of a fire having the greatest rate of spread and frontal fire intensity which is generally on the downwind and/or up slope part of the fire.

helibucket - A specially designed rigid or collapsible container slung by a helicopter and used for picking up and dropping suppressants or retardants on a fire. Size of bucket load is compatible with the size of the helicopter.

helitorch - A specialized drip torch, using a gelled fuel, slung and activated from a helicopter.

Ignition Boss - The individual responsible for overall helitorch operations. He ensures necessary planning, application of the plan, safety and overall success of the operation.

Ignition Technician - The individual responsible for helitorch maintenance and operation and all ground operations at an aerial ignition staging area.

indraft - Air that is drawn into a fire and replaces hot air that rises as a result of convection.

indirect attack - A method whereby the control line is strategically located to take advantage of favourable terrain and natural breaks in advance of the fire perimeter and the intervening strip is usually burned out or backfired.

initial attack - The action taken to halt the spread or potential spread of a fire by the first fire fighting force to arrive at the fire.

limited action (fire) - A fire that is receiving little or no suppression action, especially beyond initial attack, because of resource management priorities, fire load or other agency constraints. A fire on which any action taken is less than the agency's normal standard for full suppression. May involve one or more of the following conditions: a decision to let the fire burn freely, reconnaissance and mapping only, resource staging to await more favourable control conditions, site-specific action to protect a local value, mop-up of fire perimeter once the weather conditions facilitate easy control.

mop-up - The act of extinguishing a fire after it has been brought under control.

natural barriers - Barriers that slow or restrict the advance of the fire front and are not constructed as part of the suppression effort. These include lakes, streams, swamps, rock outcrops, roads, and in some instances, deciduous vegetation cover.

out of control - Describes a wildfire not responding or only responding on a limited basis to suppression action such that perimeter spread is not being contained.

perimeter - See ***fire perimeter.***

preparedness - Condition or degree of being able and ready to cope with an anticipated fire situation.

preparedness system - A plan detailing the condition or degree of being able and ready to cope with an anticipated fire situation.

presuppression - Those fire management activities in advance of fire occurrence concerned with the organization, training, and management of a fire fighting force and the procurement, maintenance, and inspection of improvements, equipment, and supplies to ensure effective fire suppression.

project fire - A fire of such size, complexity and/or priority that its extinction requires a large organization, high resource commitment, significant expenditure, and prolonged suppression activity.

project team - A group of experienced fire personnel that are designated to coordinate suppression, administrative and equipment and supply management duties on a project fire.

run (running) - A type of fire behavior where a fire rapidly spreads with a well-defined head.

running crown fire - A fire that advances in the crown fuel layer only.

spotting - The behaviour of a fire producing sparks or embers that are carried by the wind and which start new fires beyond the main fire perimeter.

spot fire - A fire ignited by firebrands that are carried outside the main fire perimeter by air currents, gravity, and/or fire whirls.

suppression - All activities concerned with controlling and extinguishing a fire following its detection.

under control - Having received sufficient suppression action to ensure no further spread of the fire.

wildfire (wildland fire) - Any fire occurring on wildland except those under prescribed burning conditions.