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Ground rates of travel by fire crews using escape routes: an interim report

Abstract

Escape routes and safety zones are key criteria that can influence firefighter safety on the fireline. This project has documented travel rates for various types of Alberta fire crews in four common fuel types. The report presents the first year study results.

Keywords

Firefighters, Escape routes, Safety zones, Fuel types, Travel rates, Wildfire, Fire protection.

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Introduction

In Alberta an important part of fire safety awareness, training, and operational practices is *LACES*. This simple acronym reminds firefighters to establish *Lookouts*, work from *Anchor points*, and establish *Communications*, *Escape routes* and *Safety zones* (Thorburn and Alexander 2001). Escape routes and safety zones are key to firefighter safety on the fireline. Escape routes are predetermined pathways used by firefighters to reach a safety zone, which offers a refuge from burn-over when threatening fire behaviour occurs (Beighley 1995). The ability of a wildland firefighter to reach this safety zone in enough time to ensure personal safety requires investigation.

The speed at which firefighters travel on foot through various fuel types and terrain conditions has received little research attention from the scientific community even though it is a critical factor in firefighter safety (Figure 1). Case studies of travel rates of firefighters have been done following fire tragedies (e.g., the 1994 deaths on Storm King Mountain in Colorado), and travel rates have been re-enacted (e.g., the 1949 Mann Gulch fire in Montana where 16 smoke jumpers perished) (Butler et al. 2000). However, little or no research has been carried out to provide firefighters with operational guidelines for determining travel rates for ground crews under different environmental conditions. It should be noted that the studies done by Butler et al. represent rates of travel in panic situations—not a controlled exit.

This study is investigating travel rates under a variety of fuel and slope conditions, and crew characteristics. The results can be used by fire personnel to identify when firefighters may be at risk due to working too far from their safety zone. This report describes the first year results. Although the study will continue, the interim information is of value to firefighters as they approach the 2002 fire season. However, the results should be used with caution as more data need to be collected.

Figure 1.
Firefighter travelling through grass fuel type on level terrain.



Objectives

The objectives of this project are to document the travel rates of various types of Alberta fire crews in four common fuel types¹ and on two slope classes. A fireline field guide will be produced upon completion of the project. This field guide can be used by firefighters and fire bosses to assist in determining the time required to reach a given safety zone, and therefore when firefighters are at risk due to working too far from that zone.

The following questions were posed:

- At what rate does a fire crew travel?
- Do travel rates vary depending on crew type?
- Do travel rates differ for individuals with and without equipment and packs?
- Do travel rates differ between an improved route and a natural escape route?
- How does slope influence travel rates?
- How closely do test results reflect an individual's maximum physical performance?

Fieldwork in the fall of 2001 addressed the first four questions and further work is scheduled to fully address all project objectives in 2002.

Methodology

Travel routes were established near Whitecourt within fuel types representative of those found in Alberta (Appendix I). The fuel types selected for study and their Canadian Forest Fire Behavior Prediction (FBP) equivalents are:

- Black spruce² stand: FBP System Fuel Type C-2 (Boreal Spruce)
- Grass: FBP System Fuel Type O-1b (Standing Grass)
- Mature lodgepole pine³ stand: FBP System Fuel Type C-3 (Mature Jack or Lodgepole Pine)

- Lodgepole pine and white spruce logging slash: FBP Fuel Types S-1 (Jack or Lodgepole Pine Slash) or S-2 (Spruce/Balsam Slash).

Improved and natural routes, each 250 metres in length, were established within the same representative stands or areas. Improved routes had trails cleared and marked with flagging tape while natural routes were as found.

Four crew types were selected and represent fire crews commonly used in Alberta:

- Type I: Rappel crews (rappel-capable crews, initial attack specialists)
- Type I: Heli-attack crew (non-rappel crews, initial attack specialists)
- Type II: Contract crews (short-term contracts, sustained action specialists)
- Type III: Emergency firefighters (hired as required, sustained action on large fires)⁴

Each firefighter made four runs through each fuel type: on each of the two routes (improved and natural), with and without packs (i.e., four specific situations). The runs were made in random order. A standard issue pack with 6.8 kg of gear, and a fire shovel were carried as an equipment complement. Travel times were measured at 100 and 250 m and radioed back to the starter who recorded the data. Only one person was on the course at a time.

¹ Defined by the Canadian Forest Fire Behaviour Prediction (FBP) System (Forestry Canada Fire Danger Group 1992; De Groot 1993; Taylor et al. 1997).

² Black spruce, *Picea mariana*.

³ Lodgepole and jack pine, *Pinus contorta* and *banksiana*.

⁴ The four crew types have different fitness requirements. Rappel crews: shuttle run; upright row; pump/hose/carry/drag. Heli-attack crews: 4.8 km, 20.4 kg walk in 45 minutes; upright row; pump/hose/carry/drag. Type II: 3.2 km, 11.4 kg walk in 30 minutes; upright row; pump/hose/carry/drag. Type III: 3.2 km, 11.4 kg walk in 30 minutes.

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Results

Table 1 shows the number of trials completed during 2001, by fuel and crew type. Data collection should be completed in 2002 for all types of Alberta fire crews and the slope categories.

The slowest, fastest and average times (in seconds) for crew types I and II in the four FBP fuel types are presented in Figure 2. These graphs show the range of times experienced by the crews based on the course they ran. Only crew type I Heli-attack and crew type II are presented in this report as crew types III and I Rappel did not complete all courses.

Discussion

A consistent pattern is clear in Figure 2 (a-d). When mean travel times are compared for each crew, the fastest overall times occur in the improved/no pack courses, followed by improved/pack and then by natural/no pack and finally (the slowest travel rates) the natural/pack courses.

Mean times for the improved/no pack trials are almost half that of the natural/pack trials. This provides strong evidence that in these selected fuel types if firefighters had to retreat to safety zones, their safety would be much improved if they travelled on improved escape routes (Beckley 2001) and abandoned their tools and pack. Anderson (2001) has suggested that a firefighter can increase rate of travel by 15–30% by dropping tool (s) and pack.

Other findings from this study are:

- Rating the fuel types in order of ease of travel (from hardest to easiest): black spruce stand (FBP System Fuel Type C-2) was the hardest; the mature lodgepole pine stand (FBP System Fuel Type C-3) intermediate in difficulty and the standing grass (FBP System Fuel Type O-1b) and lodgepole pine logging slash (S-1) tied as the easiest.

Table 1. The number of trials by fuel and crew type

FBP System Fuel Type(s)	Type I crew	Type II crew
C-2 boreal spruce	44	28
O-1b standing grass	36	32
C-3 mature pine	40	32
S-1/S-2 pine/spruce slash	28	32

- Dropping hand tools and packs allowed firefighters to travel 1.2 times faster regardless of fuel type or trail condition.
- Type I (Heli-attack) and II fire crews had similar travel rates in all fuel types.
- The range of times (difference between fastest and slowest times) on improved routes was narrower than the range on the natural courses, suggesting that improving a trail would allow the slower members of the crew to keep up with the others.

Conclusions and implementation

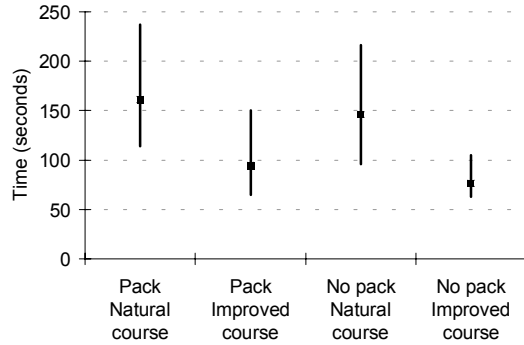
Any work done to improve the escape routes, even as simple as marking or flagging a route, decreases the time required to reach the safety zone.

Running with a pack will slow the firefighter whether on an improved escape route or running through standing timber. Dropping packs to reach the safety zone will improve travel rates.

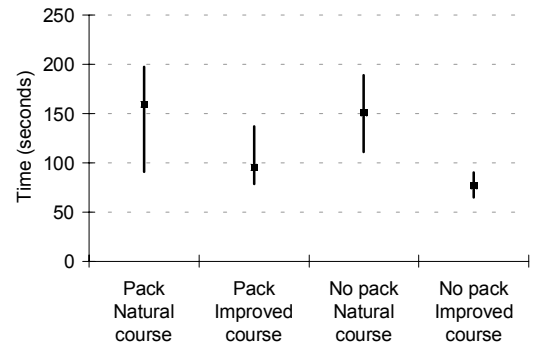
These results are released as an interim report to make the information available before the 2002 fire season, with more complete results available for the 2003 fire season. The results of this study can be transferred to firefighters and fire managers through training courses or conferences (Dakin 2001), the circulation of this report in hard copy or via the website (<http://fire.feric.ca>). The trials will be completed in 2002 and the final report on travel times will be published in early 2003. A field guide will also be prepared in 2003.

Figure 2 a-d. The range and mean times for crew type I and II by fuel type. Times are for 250 m courses.

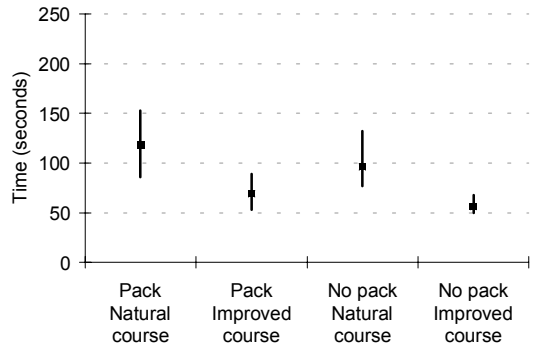
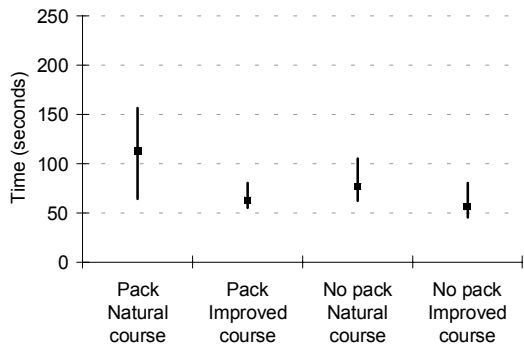
Type I crew (Heli-attack)



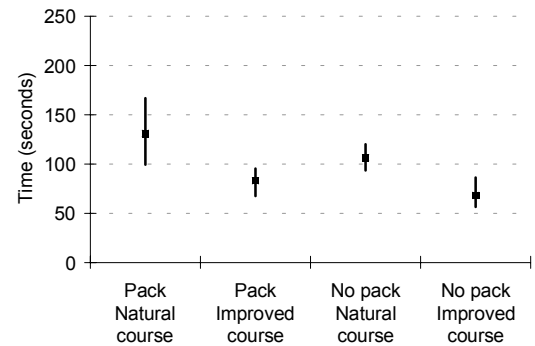
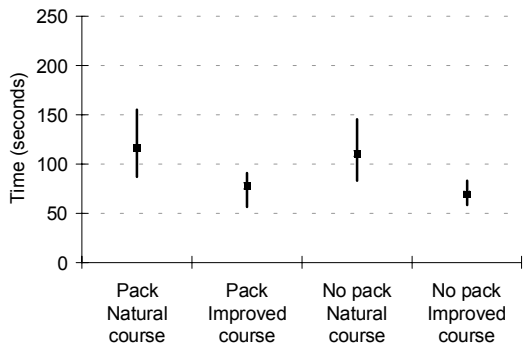
Type II crew



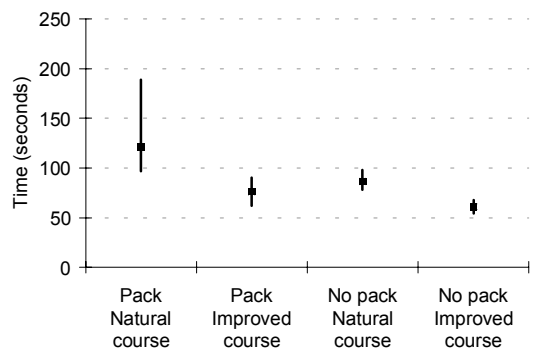
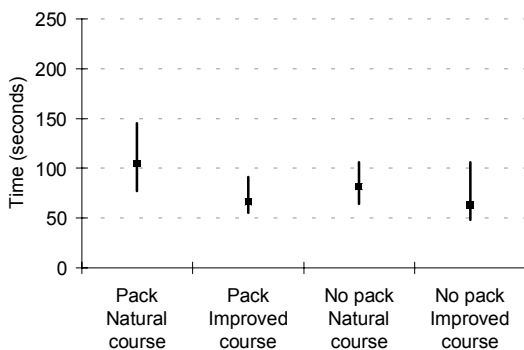
a) Black Spruce (FBP System C-2) fuel type for Type I and II crews on level terrain.



b) Grass (FBP System O-1b) fuel type for Type I and II crews on level terrain.



c) Mature Lodgepole Pine (FBP System C-3) fuel type for Type I and II crews.



d) Slash (S-1/2) fuel types for Type I and II crews.

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Appendix I

Representative photos of areas used for the timed trials



Black Spruce (FBP System Fuel Type C-2)

Fuel type characteristics ^a

Forest floor: continuous feather moss: and/or *Cladonia*: deep, compacted organic layer; wet.

Surface and ladder fuels: continuous shrub; low to moderate downed woody fuels. Tree crowns extend nearly to ground, flaky bark.

Stand structure: moderately well stocked black spruce stands.

Surface fuel loading: 1.31 t/ha.

Fuel characteristics ^a

Forest floor: continuous dead grass litter; organic layer absent to shallow and moderately compacted. Solid ground.

Surface and ladder fuels: continuous standing grass; sparse or scattered shrubs and downed woody fuel.

Stand structure: open area, no stand structure.

Surface fuel loading: 7.98 t/ha.



Standing Grass (FBP System Fuel Type O-1b)



Mature Lodgepole Pine (FBP System Fuel Type C-3)

Fuel characteristics ^a

Forest floor: continuous feather moss; moderately deep, compacted organic layer. Solid ground.

Surface and ladder fuels: sparse conifer understory, sparse down woody fuels: tree crowns separated from ground.

Stand structure: fully stocked lodgepole pine stands; mature.

Surface fuel loading: 32.37 t/ha.

Fuel characteristics ^a

Forest floor: continuous feather moss; discontinuous needle litter; moderately deep, compacted organic layer. Solid ground.

Surface and ladder fuels: continuous slash, moderate loading and depth; high foliage retention; absent to sparse shrub and herb cover.

Stand structure: slash from clearcut logging; mature lodgepole pine stands to one log depth.

Surface fuel loading: 38.93 t/ha.



Lodgepole Pine Logging Slash (FBP System Fuel Type S-1)

^a fuel characteristics from Forestry Canada Fire Danger Group (1992) and De Groot (1993).