

Travel Rates of Alberta Wildland Firefighters Using Escape Routes

M.E. Alexander, G.J. Baxter and G.R. Dakin

Abstract

This paper summarizes the results of a recently completed project on “Travel Rates of Ground Crews over Escape Routes” undertaken in 2001-2003 by the Forest Engineering Research Institute of Canada in the province of Alberta. Travel rates of four different types of wildland firefighters were determined by recording the time taken to cover a 250 m run or course. Six different fuel type/slope cases were examined with and without carrying pack/tool on both improved and unimproved routes. Travel rates are presented here in English or Imperial units -- i.e., feet per minute (ft/min) and chains per hour (ch/hr) -- for the benefit of possible American users of the information.

Introduction

When fire behaviour becomes threatening, firefighters disengage the fire and travel along escape routes to reach safety zones to avoid being entrapped or burned-over (Beighley 1995). In spite of the fact that the concept of escape routes has been a formally recognized element of wildland firefighter safety for almost 50 years (McArdle 1957; Moore 1959), there is surprisingly little quantitative data or information available on firefighter travel rates using escape routes other than two recent studies (Butler and others 2000; Ruby et al. 2003). This paper summarizes the results of recent research on the subject carried out by the Wildland Fire Operations Research Group of the Forest Engineering Research Institute of Canada (FERIC). Copies of the two FERIC publications upon which this paper is based (Dakin 2002; Baxter et al. 2004) are available for downloading from the FERIC Wildland Fire Operations Research Group's website (<http://fire.feric.ca>) and have also been including in these proceedings. Dakin (2001) did present an initial progress report on the research project described here at the 2001 International Wildland Fire Safety Summit.

Methods

In 2001 the FERIC Wildland Fire Operations Research Group initiated a project to study the rates of travel on simulated escape routes by individual members of the various types of fire suppression crews used in Alberta (Fig. 1). The first report on the project (Dakin 2002) documented the travel rates of Type I Helitack and Type II crew firefighters on level ground in four fuel types (two natural forest stand types, grass, and logging slash) commonly found in Alberta (Fig. 2). The second report on the project (Baxter et al. 2004) dealt with the travel rates of Type I Rappel and Helitack crew firefighters on a moderately steep slope (26%) in two fuel types (grass on a powerline and a white spruce stand) similar in structure to those studied by Dakin (2002); the travel rates of Type III crew firefighters in two of the fuel types/terrain situations described by

Marty Alexander, PhD, RPF, is a Senior Researcher, Greg Baxter is a Researcher, and Gary Dakin is a Associate Contract Researcher with the Forest Engineering Research Institute of Canada – Western Division, Wildland Fire Operations Research Group, Hinton, Alberta. email: greg.baxter@gov.ab.ca

In: Butler, B.W and Alexander, M.E. Eds. 2005. Eighth International Wildland Firefighter Safety Summit: Human Factors - 10 Years Later; April 26-28, 2005 Missoula, MT. The International Association of Wildland Fire, Hot Springs, SD.

Type I Firefighters - Rappel

- Member of 7-person ASRD Helitack Crew Type 1- Rappel (HAC1-R) unit
- Hired seasonally to work as initial attack specialists (rappel capable)
- Weight limit – 180 lb. (82 kg)
- Minimum physical fitness requirements consists of the following (20-minute rest is allowed between phases):

Shuttle Run: Complete a minimum of ninety (90) 20 m (66 ft) runs back and forth, or 1800 m in total (5905 ft) at pre-determined beeps starting at 8.2 seconds per run and progressing faster throughout the remainder of the runs.

Upright Row: In a standing position, back against the wall, knees slightly bent, and hands placed shoulder width apart on the bar, lift a 23 kg (51 lb.) barbell to chest height. A metronome will be set at 40 beats per minute or 20 lifts per minute. The standard is 18 repetitions per minute.

Pump/Hose/Carry/Drag: Must be completed in under four minutes and ten seconds; for safety purposes must be performed wearing a hard hat, coveralls, and work boots. The time starts when the pump is placed on the ground. Start by carrying 30 kg (65 lb.) Mark III pump 100 m (328 ft) without stopping -- 50 m (164 ft) out and back. Then pick up four (4) 30 m (100 ft) lengths of 3.8-cm (1.5-inch) hose weighing 31 kg (68 lb.) putting it over the shoulders and carrying it a distance of 300 m (984 ft) – 75 m (246 ft) out and back twice. Upon completion of the above, pick up a charged length of hose and drag it 50 m (164 ft) out and back twice for a total of 200 m (656 ft). Hose lengths must be pulled over the shoulder with one hand and grasped behind the back with the opposite hand to pass this test.

Type I Firefighters - Helitack

- Member of variable-sized (4-8 persons) ASRD Helitack Crew Type 1 (HAC1) unit
- Hired seasonally to work as initial attack specialists (non-rappel capable)
- Minimum physical fitness requirements consists of the following (20-minute rest is allowed between phases):

Walk: 4.8 km (3 mi.) with a 20.4 kg (45 lb.) backpack within a maximum of 45 minutes.

Upright Row: Same as above for Type I Firefighters – Rappel.

Pump/Hose/Carry/Drag: Same as above for Type I Firefighters – Rappel.

Type II Contract Firefighters

- Member of 8-person ASRD Sustained Action Crew – Type 2 (SAC2) unit
- Hired on short-term contractual basis as sustained action specialists
- Minimum physical fitness requirements consists of the following (20-minute rest is allowed between phases):

Walk: 3.2 km (2 mi.) with a 11.4 kg (25 lb.) backpack in a maximum of 30 minutes.

Upright Row: Same as above for Type I Firefighters – Rappel.

Pump/Hose/Carry/Drag: Same as above for Type I Firefighters – Rappel.

Type III Emergency Firefighters

- Member of 8-person ASRD Sustained Action Crew – Type 3 (SAC3) unit
- Hired on an emergency basis as required as sustained action specialists on large fires
- Minimum physical fitness requirement:

Walk: Same as above for Type II Contract Firefighters

Fig. 1. Description of wildland firefighter types utilized by the Forest Protection Division of Alberta Sustainable Resource Development (ASRD). For a more complete description, see http://www3.gov.ab.ca/srd/wildfires/fpd/fw_ws_wfc.cfm



**Black Spruce Stand – 0% Slope
(FBP System Fuel Type C-2)**



**White Spruce Stand – 26% Slope
(FBP System Fuel Type C-2)**



**Lodgepole Pine Stand – 0% Slope
(FBP System Fuel Type C-3)**



**Lodgepole Pine/White Spruce
Logging Slash – 0% Slope
(FBP System Fuel Types S-1/2)**



**Grass on Pipeline – 0% Slope
(FBP System Fuel Type O-1b)**



**Grass on Powerline – 26% Slope
(FBP System Fuel Type O-1b)**

Fig. 2. Representative ground views of the six course runs involved in the FERIC project on firefighter travel rates carried out in central and west-central Alberta.

Dakin (2002) were also included. The level ground runs were conducted near Whitecourt, AB in 2001 and the slope runs were carried out near Hinton, AB in 2002-3. A very brief description of the methodology used to determine travel rates follows. The two previously referred to FERIC publications should be consulted for detailed information.

Travel rates were determined on the basis of individually timed runs over a 820-ft (12.4 ch or 250 m) courses in six different fuel types/slope situations (Fig. 2) involving several different types of firefighters ((Fig. 1) on both natural or unimproved and improved routes (i.e., cleared trail and flagged). The fuels and vegetation on the course runs examined matched the Boreal Spruce (C-2), Mature Jack or Lodgepole Pine (C-2), a mixture of Jack or Lodgepole Pine Slash (S-1) – Spruce/Balsam Slash (S-2), and Standing Grass (O-1b) fuel types found in the Canadian Forest Fire Behavior Prediction System (Forestry Canada Fire Danger Group 1992; DeGroot 1993; Taylor et al. 1997). Runs were made with and without a pack/tool. The pack weighed 15 lb. and the tool compliment consisted of a fire shovel. Type I firefighters have a higher level of physical fitness requirement than Type II and Type III firefighters (Fig. 1); these standards are based work carried out by the British Columbia Forest Service and the University of Victoria's Sport and Fitness Centre in the early 1990s (Bachop 2000).

Results and Discussion

The travel rate results for all of the course runs undertaken in the project are summarized in Table 1 and represents a total of 360 timed runs (i.e., course runs times 4 or 2). A total of 39 firefighters, including three females, of varying ages, heights and weights participated in the project (Table 2). As expected, travel rates do vary amongst and between the type of fire crews and the fuel type/slope steepness as well as route condition (i.e., natural or improved) and whether one is carrying a pack and tool or not also has an influence. Closer examination of the travel rates presented in Table 1 reveals the following:

- The fastest overall times occurred in the improved-no pack/tool courses, followed by the improved-pack/tool and then by the natural-no pack/tool courses, and finally the slowest times represented by the natural-pack/tool courses.
- The O-1b and S-1/2 fuel types were the easiest to travel over and the C-2 fuel type was the hardest while the C-3 fuel type was of intermediate difficulty.
- There was less variation in travel rates among individual crew members on improved routes.
- Travelling uphill dramatically decreases the pace a firefighter is able to achieve.
- Carrying a pack and tool slows down a firefighter's rate of travel regardless of whether they are on an open, improved route or in a natural, standing timber cover type. Dropping one's pack and tool could allow a firefighter to increase his travel rate by up to 20%.
- Firefighters can be expected to move up to 40% faster on improved routes. Thus, simply constructing a rudimentary trail (e.g., removing or cutting through large deadfall) and flagging (Beckley 2001) or marking the route in some manner can decrease the overall time taken to reach a safety zone.
- Thus, by using an improved escape route and dropping one's pack and tool, firefighters can travel up to two times faster than if they attempted to travel over an unmarked/unimproved route with their pack and tool. Precious seconds gained by these actions could mean the difference between life and death on the fireline.

Table 1a. The mean, standard deviation (SD), and range (minimum and maximum values) of Alberta wildland firefighter travel rates in feet per minute (ft/min) and number of observations for all combinations sampled in the FERIC project

Crew type	Fuel type(s)	Slope (%)	Travel rate (ft/min)								Course runs (no.)
			Pack/tool				No pack/tool				
			Natural		Improved		Natural		Improved		
			mean ± SD	range	mean ± SD	range	mean ± SD	range	mean ± SD	range	
I	C-2	0	312±39	207–430	551±56	328–745	361±59	226–534	663±33	466–833	12
II	C-2	0	308±43	249–541	518±43	358–630	328±36	259–443	646±16	548–754	7
III	C-2	0	279±39	203–371	469±43	344–623	371±26	321–495	564±33	420–712	8
I	C-2	26	226±23	184–266	- ^a	- ^a	253±30	220–354	- ^a	- ^a	8
I	O-1b	0	440±52	315–768	781±23	285–892	646±36	469–790	879±39	613–1092	8
II	O-1b	0	417±39	321–571	712±30	551–928	512±36	370–640	879±16	772–984	9
III	O-1b	0	305±69	171–476	552±49	344–731	390±46	289–630	735±39	482–928	8
I	O-1b	26	- ^a	- ^a	282±46	210–367	- ^a	- ^a	338±52	243–456	8
I	C-3	0	423±52	318–745	640±30	541–879	446±36	338–594	712±33	590–944	7
II	C-3	0	377±30	295–495	594±23	518–735	469±20	410–508	731±26	571–879	8
I	S-1/2	0	462±39	338–577	745±36	541–892	607±36	462–768	781±62	462–964	7
II	S-1/2	0	407±49	259–551	646±30	548–794	571±16	512–626	807±16	721–912	8

^a Combination not sampled.

^a Combination not sampled.**Table 1b. The mean, standard deviation (SD), and range (minimum and maximum values) of Alberta wildland firefighter travel rates in feet per minute (ft/min) and number of observations for all combinations sampled in the FERIC project**

Number of observations for all combinations sampled in the PERC project											
Crew type	Fuel type(s)	Slope (%)	Travel rate (ch/hr)								Course runs (no.)
			Pack/tool				No pack/tool				
			Natural		Improved		Natural		Improved		
			mean ± SD	range	mean ± SD	range	mean ± SD	range	mean ± SD	range	
I	C-2	0	283±35	188–391	501±51	298–677	328±54	205–485	603±30	424–757	12
II	C-2	0	280±39	226–492	471±39	325–573	298±33	235–403	587±15	498–685	7
III	C-2	0	254±35	185–337	426±39	313–566	337±24	292–450	513±30	382–647	8
I	C-2	26	205±21	167–242	- ^a	- ^a	230±27	200–322	- ^a	- ^a	8
I	O-1b	0	400±47	286–698	710±21	259–811	587±33	426–718	799±35	557–993	8
II	O-1b	0	379±35	292–519	647±27	501–844	465±33	336–582	799±15	656–895	9
III	O-1b	0	277±63	155–433	457±45	313–665	355±42	263–573	668±35	438–844	8
I	O-1b	26	- ^a	- ^a	256±42	191–334	- ^a	- ^a	307±47	221–415	8
I	C-3	0	385±47	289–677	582±27	492–799	405±33	307–540	647±30	536–858	7
II	C-3	0	343±27	268–450	540±21	471–668	426±18	373–462	665±24	519–799	8
I	S-1/2	0	420±35	307–525	677±33	492–811	552±33	420–698	710±56	420–876	7
II	S-1/2	0	370±45	235–501	587±27	498–722	519±15	465–569	734±15	665–829	8

^a Combination not sampled.

^a Combination not sampled.**Table 2. Physical characteristics of the Alberta wildland firefighters by crew type and gender that participated in the FERIC project**

SD = standard deviation and range represents the minimum and maximum values

Crew Type	Sex	Age		Height		Weight		Number of firefighters
		Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	
I (slope)	M	26.1±3.3	22 – 28	5'11"±2.7	5'8" – 6'4"	180±17.4	165 – 205	7
	F	25		5'11"		158		1
I (level)	M	24.5±3.9	19 – 30	6'0"±2.3	5'7 – 6'5"	183±3.1	177 – 186	13 ¹
	F	21.0±1.4	20 – 22	5'7.5"±0.7	5'7 – 5'8"	-		2 ¹
II	M	29.0±5.9	20 – 37	5'11.5"±1.2	5'10" – 6'2"	197.6±14	169 – 220	8
III	M	37.5±10.9	26 – 54	5'10"±3.9	5'5" – 6'2"	179±9.3	165 – 188	8

¹The weight of six of the 13 males and both females was inadvertently not recorded.

There are a few anomalous results evident in Table 1. For example, the travel rates for Type II firefighters in the C-2 fuel type on the natural course with no pack/tool are not in line with the equivalencies for Type I and III firefighters. The authors consider this to be a reflection of the inherent variation when dealing with human subjects.

The question naturally arises: Could the firefighters that participated in this project have gone any faster? They appeared to have given a maximal effort and it is unlikely that they could have gone much faster. A crude way of answering this question though is to look at the peak heart rate recording with heart monitors during each run (Dakin 2001) and comparing that to the maximal heart rates achieved on the shuttle run test which is supposedly a maximal test (Leger and Lambert 1982). It was found from these analysis that in every run undertaken, the mean heart rate was within ~95% (range: 94.0– 98%) of the maximal heart rate, which was impressive considering the short duration of the individual runs (usually less than 2 minutes). Therefore, it appears that the firefighters used in this project gave a maximal effort during each course run and were therefore unlikely to have been able to go much faster than they did.

How do the results from the FERIC project on firefighter travel rates compare with previous studies (Butler et al. 2000; Ruby et al. 2003)? There appears to be some general agreement on certain aspects and divergence on other points.

Butler et al. (2000) used two published wildfire case studies to determine general travel rates for firefighters over rough terrain. Firefighters on the 1949 Mann Gulch Fire in north-western Montana (Rothermel 1993) travelled across and up slope (18%) at an average rate of 168 ft/min (153 ch/hr) and at one point increased their rate to between 360-480 ft/min (327-436 ch/hr). This latter rate is presumed to be possible for only a short period of time and is probably not sustainable by most firefighters for any significant distance when travelling uphill over rough terrain (Butler et al. 2000). Firefighters on the 1994 South Canyon Fire in west-central Colorado (Butler et al. 1998) travelled at an average rate of 240 ft/min (219 ch/hr) over the rough but relatively flat portions of the fireline they were using as an escape route. Their average rate of travel decreased to 180 ft/min (164 ch/hr) on the 10-30% uphill sections of the fireline and to 120 ft/min (109 ch/hr) on the even steeper slopes (30-50%).

On the basis of the reconstructed travel rates of firefighters involved in the Mann Gulch and South Canyon fires, Butler et al. (2000) suggested that the average sustainable travel rates for firefighters over rough but flat terrain would average about 264 ft/min (240 ch/hr) with faster rates as high as 420 ft/min (382 ch/hr) possible given stable footing. They pointed out that as the slope steepens a firefighter's rate of travel decreases proportionally. For a relatively gentle slope (i.e., 10-20%) they considered an average rate of travel to be around 210 ft/min (191 ch/hr) and the average sustainable rate decreases to ~ 120 ft/min (109 ch/hr) for slopes of 20-40%. For slopes greater than 40%, they suggest that firefighters travel rates would diminish to less than 60 ft/min (55 ch/hr).

Ruby et al. (2003) carried out a field simulation at the site of the South Canyon Fire similar to the present study comparing firefighter travel rates with and without pack/tool along a 2165 ft (32.8 ch or 660 m) hiking trail exhibiting a 21% slope. They found on average a 22% increase in travel rates amongst eight males and a 26% increase amongst five females. The average rate of travel with a 35 lb. pack, Pulaski tool and fire shelter for males and females was 206 ft/min (187 ch/hr) and 160 ft/min (145 m/min), respectively. Conversely, the average rate of travel with just a Pulaski and a fire shelter

for males and females was 262 ft/min (238 ch/hr) and 217 ft/min (197 ch/hr), respectively.

Both Dakin (2002) and Baxter et al. (2004) highlighted and discussed the importance of tool/pack dropping in increasing firefighter travel rates. As was pointed out at the 1995 Wildland Firefighters Human Factors Workshop (Putnam 1995), between 1990 and 1994 U.S. wildland fire agencies lost 23 people who might have survived had they simply dropped their tools and packs for greater speed in escaping the advancing fire front. A firefighter's reluctance to drop their equipment seems to be ingrained in human nature and the culture of wildland firefighting (i.e., loss of identity) as evident by the following passage taken from a children's book on wildland firefighting dealing with escape during a fictional wildfire event (Godfrey 1985, pp. 57-58):

"Let's leave the wajax [back-pack pump] and the tools so we can run faster Good Boy". It would have felt good to throw down the shovel and axe. They were heavy and they did slow me down. And I knew the wajax must be heavy for Good Boy. It still had water in it. But something inside told me to hang on to the tools. "I think we should keep them, Good Boy", I said. He looked at me, as if I were just being silly. "It's all we have to fight the fire," I pointed out. "I know it isn't much, but it's something. If we leave them behind and just run, then we are no better off than the deer".

The FERIC project report on firefighter travel rates by Baxter et al. (2004) also highlighted and discussed in some depth the importance of the "power of the slope" in regards to the deadly interaction of factors affecting fire behavior and firefighter safety – i.e., a firefighter's travel rate decreases while a fire's rate of spread increases with increasing slope steepness (Fig. 3). As Beaver (2004) has pointed out, the net result is "everything bad for the firefighter versus everything good for the fire". A fire burning up a 26% slope will spread about two times faster than a similar fire on level ground (Forestry Canada Fire Danger Group 1992). Under very strong winds, the convection column of a fire burning on a steep slope will not lift away from the surface. In such cases, the flames will be blown directly into the unburnt fuels, resulting in very high rates of spread (Cheney and Sullivan 1997). The analysis presented here in Figure 3 illustrates that even the most fit firefighters are not able to sustain maximum travel rates for even a short period of time without being overtaken by a fast spreading fire. A fire spreading at 197 ft/min (179 ch/hr) would overrun firefighters in 6-7.5 minutes depending on the fuel type and whether they had decided to drop their tools and packs or not.

Conclusions

The FERIC fire research project as overviewed in this paper provided the first of its kind type of data on firefighter travel rates in Canada. This has now enabled fire operations personnel in Alberta to make quantitative judgments about escape routes within the context of the **LACES** (Lookout(s) – Anchor point(s) – Communication(s) – Escape routes – Safety zone(s)) wildland firefighter safety system (Thorburn and Alexander 2001). In fact, because of the similarity in fuel structure to many other forested regions of Canada, the information actually has even wider applicability, including sections of the U.S. (e.g., Alaska, Lake States, Northeast and the Rocky Mountains).

While confirming the presumed influence of equipment dropping on travel rates, this project has provided new insights into the dynamics associated with travel over escape routes by wildland firefighters. For example, the advantages of improving the condition and identification of an escape route on a firefighter's performance level. The project and the resultant publications have also increased the awareness and appreciation for the values of escape routes in regards to wildland firefighter safety. The information as presented here has refocused attention on the importance of time in relation to fire behavior and firefighter safety. A safety zone isn't much good to a firefighter if isn't able to reach the safety zone before the fire does.

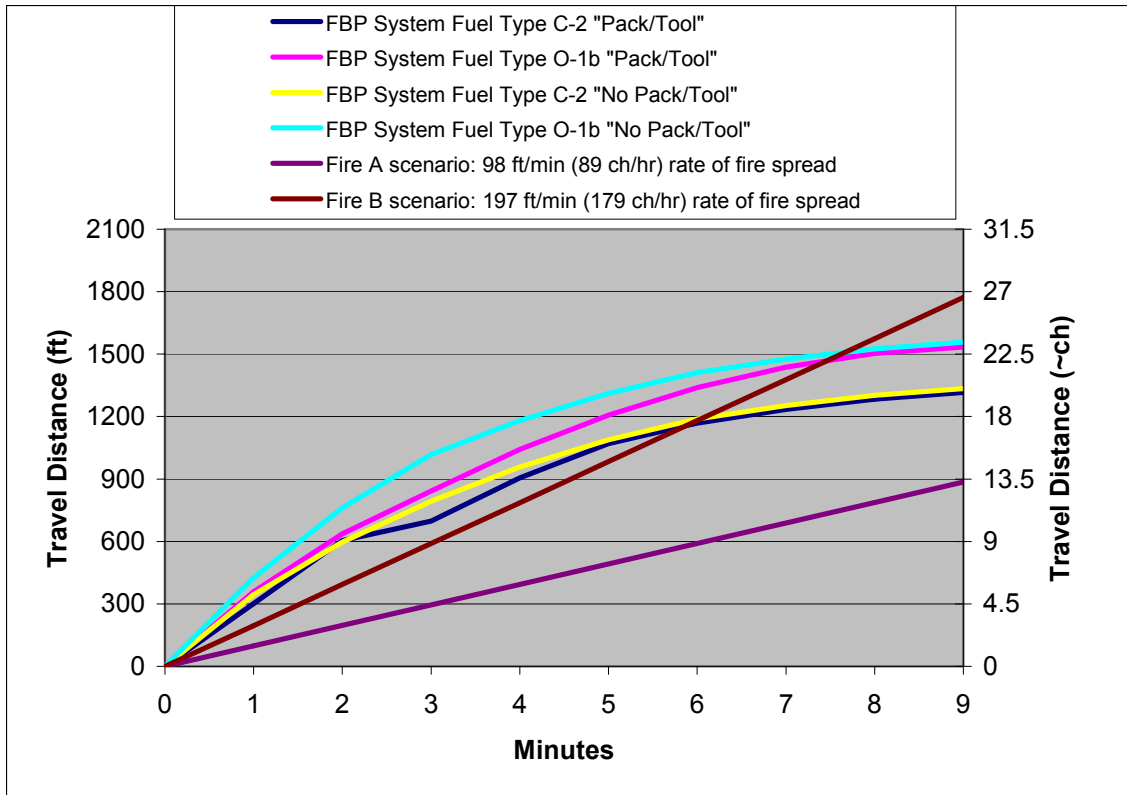


Fig. 3. Simulation comparing distance travelled versus the elapsed time since the decision was made to use an escape route for various firefighter travel rates on a 26% slope in relation to fire spreading on level ground (scenario A) versus a 26% slope (scenario B). The assumption is made that the fire and firefighters are equidistant from the safety zone.



References

- Bachop S (2000) BCFS physical fitness standards – challenges, changes and lessons learned. In 'Proceedings of 2000 International Wildfire Safety Summit'. (Eds. BW Butler and K Shannon) pp. 24-30. (International Association of Wildland Fire, Montana City, MT)
- Baxter G, Alexander M, Dakin G (2004) Travel rates of Alberta wildland firefighters using escape routes on a moderately steep slope. Forest Engineering Research Institute of Canada Advantage Report. Vol. 5 No. 25. Pointe Claire, QC and Vancouver, BC. 15 pp.
- Beaver AK (2004) Science & Planning Supervisor, Yukon Wildland Fire Management, Whitehorse, YT. Personal written communication, April 14, 2004.
- Beckley B (2001) Flagging for firefighting escape routes and safety zones. USDA Forest Service, Missoula Technology and Development Center Tech Tip 0151-2399-MTDC. Missoula, MT. 2 pp.
- Beighley M (1995) Beyond the safety zone: creating a margin of safety. *Fire Management Notes* **55(4)**, 21–24. [reprinted as: *Fire Management Today* **64(1)**, 78–81. 2004]
- Butler BW, Bartlette RA, Bradshaw LS, Cohen JD, Andrews PL, Putnam T, Mangan RJ (1998) Fire behavior associated with the 1994 South Canyon Fire on Storm King Mountain, Colorado. USDA Forest Service, Rocky Mountain Research Station General Technical Report RMRS-RP-9. Ogden, UT. 82 pp.
- Butler BW, Cohen JD, Putnam T, Bartlette RA, Bradshaw LS (2000) A method for evaluating the effectiveness of firefighter escape routes. In 'Proceedings of 2000 International Wildfire Safety Summit'. (Eds. BW Butler and K Shannon) pp. 42-53. (International Association of Wildland Fire, Montana City, MT)
- Cheney P, Sullivan A (1997) Grassfires: fuel, weather and fire behaviour. (CSIRO Publishing: Collingwood, Australia) 102 pp.
- Dakin G (2001) The determination of ground travel rates by fire crews using escape routes in variable fuel types and terrain factors. In 'Proceedings of 2001 International Wildland Fire Safety Summit' (Eds. BW Butler and D Mangan) 6 pp. (International Association of Wildland Fire, Montana City, MT).
<http://www.iawfonline.org/summit/2001%20Presentations/proceedings.htm>
- Dakin G (2002) Ground rates of travel by fire crews using escape routes: an interim report. Forest Engineering Research Institute of Canada Advantage Report. Vol. 3 No. 15. Pointe Claire, QC and Vancouver, BC. 7 pp.
- DeGroot WJ (1993) Examples of fuel types in the Canadian Forest Fire Behavior Prediction (FBP) System. Forestry Canada, Northern Forestry Centre Poster with text. Edmonton, AB.
- Godfrey M (1985) Fire! Fire! (Series Canada). (Collier Macmillan, Canada, Inc.: Don Mills, ON) 91 pp.
- Forestry Canada Fire Danger Group (1992) Development and structure of the Canadian Forest Fire Behavior Prediction System. Forestry Canada, Science and Sustainable Development Directorate Information Report ST-X-3. Ottawa, ON. 63 pp.
- Leger LA, Lambert J (1982) A maximal multistage 20 m shuttle run test to predict VO_{2max} . *European Journal of Applied Physiology* **49**, 1-5.
- McArdle RJ (1957) Standard fire fighting orders. *Fire Control Notes* **18(4)**, 151.

- Moore WR (1959) Training in the ten standard fire fighting orders. *Fire Control Notes* **20(3)**, 58-60.
- Putnam T (1995) Findings from the wildland firefighters human factors workshop – improving wildland firefighter performance under stressful, risky conditions: towards better decisions on the fireline and more resilient organizations. USDA Forest Service, Missoula Technology and Development Center Technical Report 9551-2855-MTDC. Missoula, MT. 76 pp. [updated 1996]
- Rothermel RC (1993) Mann Gulch Fire: a race that couldn't be won. USDA Forest Service, Intermountain Research Station General Technical Report INT-299. Odgen, UT. 10 pp.
- Ruby BC, Leadbetter III GW, Armstrong DW, Gaskill SE (2003) Wildland firefighter load carriage: effects on transit time and physiological responses during simulated escape to safety zone. *International Journal of Wildland Fire* **12**, 111–116.
- Taylor SW, Pike RG, Alexander ME (1997) A field guide to the Canadian Forest Fire Behavior Prediction (FBP) System. Canadian Forest Service Northern Forestry Centre Special Report 11. Edmonton, AB. 60 pp.
- Thorburn RW, Alexander M E (2001) LACES versus LCES: adopting an “A” for “anchor points” to improve wildland firefighter safety. In ‘Proceedings of 2001 International Wildland Fire Safety Summit’ (Eds. BW Butler and D Mangan) 13 pp. (International Association of Wildland Fire, Montana City, MT).
<http://www.iawfonline.org/summit/2001%20Presentations/proceedings.htm>

The Authors

Marty Alexander has been employed by the Canadian Forest Service (CFS) since 1976, specialized in studying the physical aspects and impacts of wildland fires, including the practical application of such knowledge to fire management issues; he worked in Australia and New Zealand for nearly four years (1989-93) while on professional development leave. He was one of the developers of the Canadian Forest Fire Behavior Prediction System (and is considered the CFS authority on the Canadian Forest Fire Danger Rating System) and co-organizers of the International Crown Fire Modelling Experiment undertaken in the Northwest Territories, 1995-2001. Marty has been heavily involved in fire behavior training on a national basis since 1994. Marty received his B.Sc. (1974) and M.Sc. (1979) degrees in forestry from Colorado State University and a Ph.D. degree (1998) in forestry from the Australian National University. Prior to joining the CFS, Marty worked part-time and seasonally from 1972-74 in various positions for the Colorado State Forest Service (assistant to State Fire Protection Forester) and USDA Forest Service (National Fire Danger Rating Project, Bighorn Interagency Hotshot Crew, wilderness fuel inventory, slash burning). In 2003, Marty received the International Wildland Fire Safety Award from the International Association of Wildland Fire for his research and other efforts related to fire behavior and firefighter safety. He is currently on secondment to the FERIC Wildland Fire Operations Research Group from the CFS.

Greg Baxter has been a Researcher with the FERIC Wildland Fire Operations Group since its formation in January 2001. He has worked on a number of FERIC projects including debris management, the fire risk of ATV's in Alberta's forests, travel rates of firefighters in various fuel and terrain conditions, and fire behaviour along linear

disturbances. Greg completed his undergraduate studies at the University of Victoria in 1977 majoring in Physical Geography and received his M.Sc. degree from the University of Alberta in 1994. Since that time he has worked for the Canadian Forest Service (Edmonton and Victoria) and *Forest Research* in New Zealand for two and a half years. He also consulted for two years where he developed fire management plans for Skagit Provincial Park as well as Okanagan Mountain Provincial Park in British Columbia. Greg worked as a seasonally as a member of the Alberta Forest Service's provincial helitack program from 1985-1991.

Gary Dakin worked for the Alberta Land and Forest Service (ALFS) for 35 years in all aspects of fireline duties. In October 2002 he retired from the ALFS and began working with the FERIC Wildland Fire Operations Research Group on contract as an Associate Researcher. Gary began his forestry career in 1967 as seasonal employee and in 1969 became a Forest Officer on permanent staff based out of Beaver Lake Ranger District in the Lac La Biche Forest. In 1974 he took a lateral transfer to the Worsley Ranger District in the Peace River Forest where in 1975 he was promoted to Ranger-in-charge. Gary moved twice in 1980. During the spring he moved to Kinosis as a Forest Officer III and later that fall he was promoted to Forest Protection Technician for the Lac La Biche Forest. In 1982 Gary was promoted to the position Chief Ranger of the Fort McKay District in the Athabasca Forest. This resulted in a move to Fort McMurray where he received. In 1986 he was promoted to the position of Forest Protection Officer for the Athabasca Forest headquartered in Fort McMurray. In 1994 Gary took a lateral transfer to the Edson Forest as the Forest Protection Officer and in 1996 he moved to Whitecourt as the Regional Forest Protection Officer for the Northern East Slopes Region. During 1999, changes to the way the Forest Protection Program was conducted resulted in Gary becoming the Forest Protection Officer for the Woodlands Forest Area. Gary is certified as a Fire Line Safety Officer and a Type II Incident Commander and is used on a Provincial Type I Fire Management Team as an Operations Chief, a position he held until his secondment to FERIC in March 2001. He is also certified as a Fire Boss II, and has served on a Provincial Type I Fire Management Team as a Line Boss I. Gary has been involved with fire line equipment research throughout his career and took part in the International Crown Fire Modelling Experiment in the Northwest Territories from 1997-2001 where he conducted research on personal protective equipment (PPE) including fire resistant clothing, fire shelters, safety zones, and issues related to the wildland-urban interface. Beginning in March 2001, he worked for the FERIC Wildland Fire Operations Research Group on secondment until his retirement from the Alberta Land and Forest Service in October 2002. Since that time Gary's work with the FERIC Wildland Fire Operations Research Group has included research related to escape routes and sprinkler systems for fire protection while assisting in other group activities.

