FOREST AND RURAL FIRE RESEARCH

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The Bucklands Crossing Fire Burnover

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Introduction

The Bucklands Crossing wildfire of 24 March 1998 involved an incident where a crew of eight firefighters were burned over, resulting in four of them being injured. The purpose of this *Fire Technology Transfer Note* is to briefly describe the factors leading up to the incident and to outline the general findings from the investigation that followed. It is not the intention to describe the incident in great detail, as a full case study report is being prepared. However, it is important that a brief description of the incident is circulated so that the key lessons can be learned and any mis-interpretation based on lack of information is avoided.

Incident summary

At 7.47 am on Tuesday, 24 March 1998, a fire was reported by a local musterer on his way to work near Bucklands Crossing, some 40 km north of Dunedin. The fire is believed to have been ignited by sparks resulting from powerlines contacting adjacent vegetation in high winds. Initially, NZ Fire Service crews from Waikouaiti and Palmerston responded. They were later supported by crews from Dunedin City Council, local forestry companies and DOC. Two helicopters were also used, although the strong, gusty winds initially prevented effective aerial fire suppression.

At around 11.25 am, a crew of eight rural firefighters were burned over while attempting to suppress a backburning sector of the fire. On parking their appliance on the crest of a steep ridge in a burnt out area of the fire, the crew were deploying a hoseline downhill towards a fire edge burning slowly downslope. The fire had already burnt out the catchment on one side of this ridge and was backburning beneath manuka scrub down into the adjacent catchment from where the crew were deploying the hoseline. Before being able to charge the hoseline, the crew were overrun by a “fireball” exploding from the gorse-filled gully beneath them. Three firefighters sustained burn injuries, one serious, while a fourth crew member received a cut to the hand whilst evacuating. The driver and another crew member took shelter behind the appliance and, along with the remaining two crew members, were uninjured.

The fire continued to burn for several hours after the incident before being contained later in the day. However, mopping up of hot spots continued over the next seven days and the fire was not declared out until April 2. The fire burned an area of around 200 ha, including two small woodlots of radiata pine totalling 20 ha; the remainder of the area was grazed pasture and manuka or gorse-covered slopes. Several kilometres of fencing was damaged and some stock were also lost.

The fire environment

The fire occurred in very rugged terrain, comprising of steep slopes which drop sharply to the meandering course of the Waikouaiti River below. Steep slopes of 30-40° are common, and many rock outcrops occur throughout the fire area. Several side gullies drain into the main river course with steep, narrow ridges between.

The burnover occurred on one of these ridges, which consisted of a 30° slope on the lee side which had been burned over earlier, a narrow ridge crest some 4-5 m wide, and a 25° slope on the upwind side leading down to the scrub fuels under which the fire was backburning.

Fuels in the broader fire area consisted of radiata pine woodlots, manuka/kanuka and gorse scrub, and grazed pasture, some with scattered tussock. The fire initially burnt through a stand of pine beneath the powerline, before spreading across a road into grazed pasture and into another woodlot. The fire also burned through several areas of manuka/kanuka scrub, which tended to occur on the drier ridge faces, and in mixed scrub containing natives, gorse and other woody weeds on damper faces above the river.

Dense 2-3 m tall manuka/kanuka covered the lee side of the ridge on which the incident occurred. This had been burned out earlier in a very rapid uphill fire run. Grass fuels with scattered short tussocks covered the open ridgetop where the appliance was parked, and this too had been burnt out prior to the crew arriving. These grass fuels extended some 30-40 m down the upwind slope to 3-4 m tall manuka/kanuka scrub. This scrub was initially only underburnt, but burned out completely at a later time. The manuka/kanuka stand extended some 30-50 m to the gorse-filled gully bottom below.

The fire occurred during hot, windy conditions in a period of extended dryness[1]. Recorded temperatures on the day of the fire reached 27 ºC (Fig. 1), and higher values were reported at the fire site. Gale force nor'westerly winds that exceeded 80 km/h initially restricted aerial suppression operations and, although they dropped off during the day, the erratic strength and direction of the wind contributed to unpredictable fire behaviour.

[1] Weather and FWI System values for midday on March 24 were: temperature 25.5 ºC, relative humidity 35%, wind speed 16 km/h, 6 days since >0.6 mm rain, FFMC 92.0, DMC 41, DC 569, ISI 12.9, BUI 70, and FWI 31.

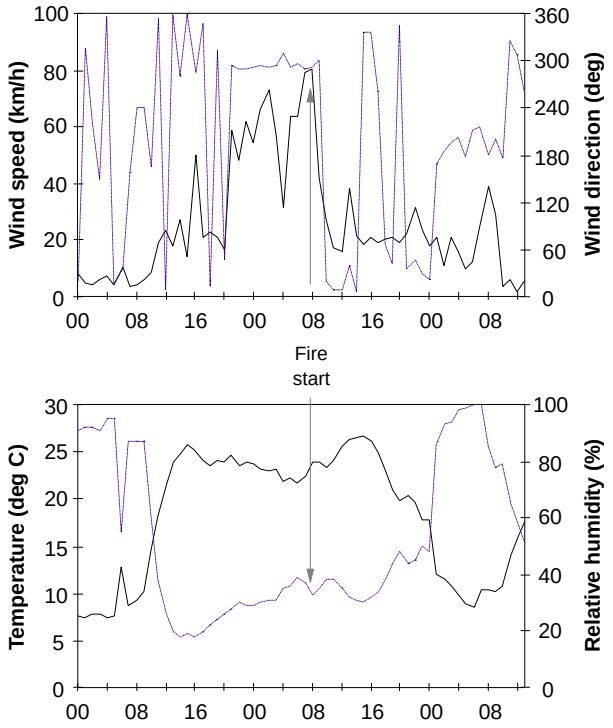

Figure 1. Hourly weather values before, during and after the initial run of the Bucklands Crossing Fire, using weather data from the Rock and Pillar weather station some 40 km northwest and inland of the fire site.

Key issues for consideration

A number of points identified following the Bucklands Crossing fire and the firefighter burnover have broader application to rural firefighting in New Zealand. These include:

Fire behaviour:

Fire behaviour during the early stages of the Bucklands Crossing Fire comprised a series of rapid uphill runs from the fire's origin, interspersed with periods of slower spread as the fire backed down the opposite slopes. This was also the case on the ridge where the crew was deployed, as it had been burned out well before the crew arrived. The fire was observed to be backburning slowly downslope in the litter layer beneath the manuka/kanuka stand, with flame lengths of about half a metre. Fire activity was also seen in the gully below, where flame heights would reach 1-2 m as the fire occasionally flared up in gorse fuels. However, this fire activity did not change during the 35-40 minute period the Crew Boss spent reconnoitring this sector.

As the crew were in the process of laying a hoseline, the Crew Boss suddenly heard the noise of the fire approaching from below. Several of the crew describe being knocked to the ground by a shock wave and then hit by a "fireball exploding". This is analagous with a "flashover", where an explosion results from the ignition of trapped, unburned gases which are given off by fuels as they are preheated. Although rare, the flashover phenomenon can occur in vegetation fires when gases are trapped in topographic pockets or accumulate over a broad area when there is a temporary lull in air movement (Merrill and Alexander 1987).

Fireballs were reported by pilots at other stages of the Bucklands Crossing Fire, and similar gas explosions have been reported during other New Zealand fires in steep terrain[2]. Such a flashover is also believed to have been responsible for many of the 14 deaths on the South Canyon[3] Fire (Putnam 1995), where it appears victims may have been overtaken by a blast of superheated air which exploded just before it arrived. Such an effect would be needed to knock people to the ground as occurred at South Canyon and during this Bucklands Crossing Fire.

Although the firefighters involved believe this was not the case, the "fireball" may also have been the result of the combined effects of wind and slope driving the flame front uphill through the preheated scrub canopy. The collapse of the fire front as such a run reached the end of the scrub stand would tend to push flames along the ground and this, together with the pulsing of the flame front as volatile gases are burned, would be sufficient to create extreme flame lengths capable of reaching the 30-50 m to the ridge where the fire appliance was parked.

Whatever the cause, there were no obvious indicators that warned the firefighters that the potential for extreme fire behaviour existed, such as an increase in wind or fire activity. However, like so many others, this incident can be summed up by the four common denominators that have been found to contribute to fire behaviour on fatal and near-hit fires (Wilson 1977, Millman 1993):

- most incidents occur on small fires or on isolated sectors of larger fires;
- flare-ups generally occur in light, flashy fuels;
- most fires are innocent in appearance before unexpected changes in wind speed and/or direction result in flare-ups;
- fires respond to topography, running rapidly uphill on steep slopes.

Firefighters should therefore be aware of these common denominators, and of the potential for problem fire behaviour to occur if they are present.

More research is also required to determine why this fire behaviour occurred, and whether it is particular to certain topographic, fuel or atmospheric conditions.

Protective clothing:

The firefighters burned over during the Bucklands Crossing Fire were saved from more severe injuries by the short duration of their exposure to heat and flame, the fact that they were correctly attired in their protective clothing, and that they received immediate attention from onsite medical services.

The crew were all wearing Nomex coveralls as supplied by the National Rural Fire Authority (NRFA). All had these buttoned up over the top half of the body and around the neck, and the sleeves rolled down (not rolled up or tied around the waist as they had been earlier during the fire). The Nomex *3A* fabric maintained its integrity despite direct flame contact and extreme exposure to radiant heat. The material suffered extreme discolouration and became brittle, but the fabric stayed in one piece. Most of the damage to the coveralls was done while cutting them off to give medical treatment.

Other materials such as the NRFA shoulder badges were melted or destroyed, but did not contribute to the burn injuries. Conduction of heat through the fabric to the skin by reflective strips also requires further investigation, as burned stripes were observed on the back and

[2] For example, the 1996 Bergin's Point Fire in Northland (A. Gamble, Far North District Council, *pers. comm.*).

[3] Also known as Storm King Mountain.

arms of one firefighter. These strips may hold heat longer and result in more severe burning. A further observation regarding protective clothing was that the wearing of a second layer of clothing beneath the coveralls can significantly reduce the amount of burning. A cotton T-shirt with short sleeves provided better protection than a singlet, which resulted in additional burns to the shoulder areas. Cotton rugby shorts also provided extra protection to the hip and buttocks area.

All the firefighters were wearing fibreglass helmets of the type supplied by the NRFA. These were correctly attached with the chin strap done up and the neck skirt down. The integrity of the fibreglass helmet was maintained despite extreme exposure to heat, and the discolouration of one of the firefighters' helmets provides ample evidence of this. Standard plastic forestry-type hard hats would almost certainly have melted under similar conditions. The additional protection provided by the neck skirt and, to a lesser extent the visor, almost certainly also prevented several of the firefighters from sustaining more serious burn injuries.

In light of this incident, and following other recent developments, the NRFA Equipment Working Group is reviewing current standards for protective clothing. It proposes to circulate guidelines on minimum requirements for protective clothing in the near future.

Training:

The crew involved in the burnover incident had an average of three to five years experience in vegetation firefighting as a volunteer rural fire force. All had undertaken training in accordance with the national standard course on the Fundamentals of Forest and Rural Firefighting and had been assessed accordingly. Two of the crew had undertaken and attained the national standard Crew Boss course certificate, and the Crew Boss had recently attended the Initial Attack Fire Boss course. The use of the knowledge gained by the crew from this training was instrumental in preventing more serious injuries.

For example, the crew were well versed in the need for and the correct use of all their protective clothing. In addition, the Crew Boss undertook a prolonged size-up of the area prior to calling for the crew, carefully considering crew safety and potential fire. He also briefed the crew prior to deploying, paying particular attention to escape routes and insisting that the driver back the appliance in.

A possible weakness may have been in only focussing on the immediate area in which the crew was working, so that there was a lack of appreciation of fire behaviour potential in the broader fire environment. The lack of a lookout in a location where they could observe fire activity also meant that no warning could be given.

Conclusion

Firefighters must have a knowledge of personal safety and vegetation fire behaviour, and must apply this at all times during size-up and ongoing fire suppression. They must also have an appreciation of potential fire behaviour in the broader fire environment rather that just in the immediate area in which they are working.

In addition, firefighter training should utilise reminders such as the Common Denominators, LCES (Lookouts, Communications, Escape routes and Safety zones), Fire Orders and Watchout Situations to reinforce potentially problematic aspects of fire behaviour and firefighter safety. All training undertaken must also emphasise the correct use of protective clothing, and examples such as this incident can be used to clearly demonstrate the benefits of picking up on the lessons learned.

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