Fire behavior in moderately heavy logging slash: documenting the past with photographs

Martin E. Alexander
Canadian Forest Service (retired). Present address:
University of Alberta, Department of Renewable Resources & Alberta School of Forest Science and Management, Edmonton, Alberta, Canada T6G 2H1, mea2@telus.net

Abstract
Color photographic documentation is presented of an experimental prescribed fire conducted 45 years earlier in logging slash resulting from the clear-cutting of an eastern North American spruce-fir stand. This includes pre- and post-burn views as well as photographs taken during the free-burning stages of the fire from both the ground and the air. This paper thus serves to supplement the original fire behavior case study account of this experimental prescribed fire as prepared by A.G. Randall of the University of Maine. It is noteworthy that the fuelbed structure tended to resembled a blowdown situation in many respects.

Keywords: Canadian Forest Fire Danger Rating System; Fireline intensity; Fuel consumption; Prescribed burning; Rate of fire spread; Wildland fuels.

1. Introduction

Randall (1966) published a reasonably well-documented account of a prescribed burning operation conducted in moderately heavy logging slash resulting from the harvesting of a spruce-fir stand two to three months earlier[1]. This prescribed fire was carried out on an experimental basis for hazard abatement and site preparation purposes in June 1965 in the eastern region of the State of Maine, USA. In 1984, I published on a comparison of the observed fire behavior and impact of the Randall (1966) experimental prescribed fire with the existing decision aids of the Canadian Forest Fire Danger Rating System such as the Muraro (1975) Prescribed Fire Predictor (Alexander 1984)[2]. This analysis provided me with the opportunity to communicate with A.G Randall at some length about his case study work, including provision of photos.

While the official written record of an experimental prescribed fire is an integral part of the fire behavior documentation process, there is no substitute for photographs. The primary purpose of this paper is to present some of the photos (13 in total) provided by A.G. Randall that were taken before, during and after this experimental prescribed fire.

[1]Note that print copies of Randall (1966) can still be ordered from the Maine Agricultural and Forest Experiment Station (http://www.umaine.edu/mafes/publications /forestry.htm). Refer to publication # MP675. Copies of this publication are also available from the Fire Research Institute library as document # 24573 (http://www.fireresearchinstitute.org/).

[2]Copies of Alexander (1984) are available from the Canadian Forest Service Bookstore (http://bookstore.cfs.nrcan.gc.ca/detail_e.php?recid=45424) in print and electronic formats.

2. Recapping the Randall Experimental Prescribed Fire Behavior Case Study

The burn unit, referred to as Block 8, consisted of a 4-hectare clear-cut block measuring ~200 x 200 m in size and oriented due north (Figure 1). A bulldozer was used to create a 8-m wide mineralized fireguard around the block. The site was level and fairly well drained. Sixty percent of the merchantable overstory was comprised of red spruce (*Picea rubens*), white spruce (*P. glauca*), and balsam fir (*Abies balsamea*). The other 40 percent of the stand composition consisted of various species of northern hardwoods and conifers Stand basal area and dominant tree height were on the order of 25 m^3/ha and 20 m, respectively (Randall 1974).

Figure 1. Oblique pre-burn aerial photograph of the clear-cut block associated with the Randall (1966) experimental prescribed fire. Photo by J. Marsh, Maine Forest Service.

The stand was clear-cut in March and April of 1965 with all stems greater than 5.0 cm in diameter-at-breast height being harvested. The felled pulpwood and sawlogs, totalling 202 m^3 (stacked) per hectare, were yarded with horses. The type of logging operation, which left the area covered with a continuous layer of moderately heavy (5.42 kg/m^2), needle-bearing slash (Figure 2), and its timing, resulted in very little disturbance to the organic layer (averaging 9.2 cm in depth and 8.35 kg/m^2 in oven-dry weight per unit area). The needles attached to woody debris were in a "red" state or condition (Figure 2).

On the day of the burn – June 11, 1965 – the 1:00 pm EDT fire weather observations from the nearest (located 19 km away) permanent fire weather station were:

Dry-bulb temperature – 16.7 ^oC;
Relative humidity – 46%
10-m open wind speed – 24 km/h
Number of days since 24-h rainfall amount $\geq$0.6 mm – 3

The burning conditions associated with this experimental prescribed fire, expressed in terms of the six standard components of the Canadian Forest Fire Weather Index System (Van Wagner 1987), were as follows:

Fine Fuel Moisture Code (FFMC) – 87	Initial Spread Index (ISI) – 9.4
Duff Moisture Code (DMC) – 35	Buildup Index (BUI) – 45
Drought Code (DC) – 153	Fire Weather Index (FWI) – 20

Figure 2. Pre-burn ground photograph of the moderately heavy logging slash fuel complex associated with the Randall (1966) experimental prescribed fire. Photo by R. Barr.

Ignition of the experimental prescribed fire began at 2:07 pm EDT. A hand-held drip torch was used (Figure 3), beginning at the northeast corner of the cut block (Figure 4). The firing pattern employed consisted largely of a single, head fire ignition which, under the influence of gusty northwesterly winds, allowed for the flame front to spread diagonally across the cut block (Figures 5-6). Backfiring was used to help maintain control of the fire and in an attempt to attain complete burn coverage over the entire cut block (Figure 7).

Figure 3. Ground photograph showing the commencement of ignition of the Randall (1966) experimental prescribed fire in moderately heavy logging slash fuels with a hand-held drip torch by A.G. Randall himself. Photo by R. Barr.

Head fire rate of spread averaged 10.1 m/min with associated flame heights ranging from 4.6-6.1 m and occasionally higher (Figures 8 and 9). Byram's (1959) fireline intensity was calculated to be ~14 900 kW/m.

While spot fires did occur immediately adjacent to the cut block on two separate occasions, these were easily handled by the on-site ground forces resulting in no major control problems being encountered. Smouldering or sub-surface burning was minimal, which greatly aided mop-up and patrol operations.

The depth of burn averaged 4.6 cm. This equated to a 50% reduction in depth and a 23% reduction in fuel load, however no mineral soil was exposed. Woody slash fuel consumption amounted to 3.22 kg/m^2 (i.e., a 59% reduction), with nearly complete consumption of pieces less than 5.0 cm in diameter (Figure 10).

Figure 4. Oblique aerial photographs of the clear-cut block associated with the Randall (1966) experimental prescribed fire: top – view from the southwest, shortly after ignition in the northeast corner; bottom – view from the north, taken fairly soon after ignition. Photos by J. Marsh, Maine Forest Service.

Figure 5. Oblique aerial photographs of the clear-cut block associated with the Randall (1966) experimental prescribed fire showing the advancing flame front following ignition: top – view from the east; bottom – view from the southwest. Photos by J. Marsh, Maine Forest Service.

Figure 6. Oblique aerial photographs of the clear-cut block associated with the Randall (1966) experimental prescribed fire showing the advancing flame front following ignition: top and bottom – views from the west. Photos by J. Marsh, Maine Forest Service.

Figure 7. Oblique aerial photograph of the clear-cut block associated with the Randall (1966) experimental prescribed fire viewed from the northwest during the later stages of firing and active flame spread. Photo by J. Marsh, Maine Forest Service.

Figure 8. Ground photograph of the flaming front associated with the Randall (1966) experimental prescribed fire in moderately heavy logging slash. Photo by A.G. Randall.

Figure 9. Ground photograph of the propagating flame front associated with the Randall (1966) experimental prescribed fire in moderately heavy logging slash relatively soon after ignition. Photo by R. Barr.

3. Value to Wildland Fire Research and Management

Quantitative documentation of wildland fire behavior undertaken in past field studies continue to be a valuable source of key reference data in developing new models and/or testing new theories. The experimental prescribed fire documented by Randall (1966) certainly represents a case in point. This experimental prescribed fire was, for example, eventually added to the database used in the development of the White Spruce-Balsam Slash (S-2) fuel type of the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992; Taylor *et al.* 1997).

Because of the logging methods employed in the clearcutting operation (i.e., yarding with horses as opposed to use of mechanical skidders), the resulting logging slash fuelbed associated with the Randall (1966) experimental prescribed fire tended to resemble a blowdown fuel complex in many respects even though the commercial roundwood had

been removed from the site by the harvesting process. There is at the present time very little quantitative, empirical information available on fire behavior in any of the blowdown fuel types occurring in western and northern North America.

The pre-burn woody fuel load (5.42 kg/m^2) and fuelbed height (estimated to be ~1.0 m) of the Randall (1966) experimental prescribed fire (Figures 2, 3 and 11) is comparable to some of the blowdown fuel situations found following the 1999 Independence Day wind and rain storm in northern Minnesota (Ottmar *et al.* 1999; Gilmore *et al.* 2003; Woodall and Nagel 2007). This makes the Randall (1966) experimental prescribed fire unique in that it represents a very valuable data or reference point in comparison to the other empirical data collected on fire behavior from outdoor experimental fires in slash carried out in 1960s and 1970s (that involved mechanized logging methods) as used in the development of the models for the slash fuel types in the FBP System.

Figure 10. Immediate post-burn ground photograph of the clear-cut block associated with the Randall (1966) experimental prescribed fire in moderately heavy logging slash. Photo by R. Barr.

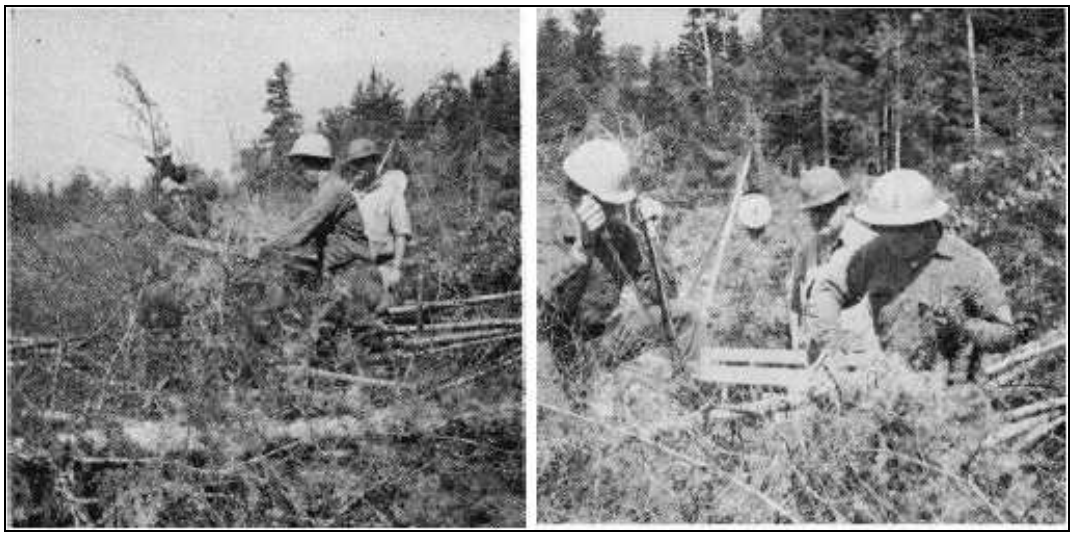

Figure 11. Sampling of the pre-burn woody fuel loads associated with the Randall (1966) experimental prescribed fire in moderately heavy logging slash (from Randall 1966). Note the height and density of the slash fuelbed in relation to the sampling crew members.

4. Concluding Remarks

Wildland fire behavior case studies have traditionally emphasized wildfires (e.g., Alexander 2009). Alexander and Taylor (2010) have pointed out that prescribed fire behavior case studies (e.g., Taylor and Wendel 1964; Gilmour and Cheney 1968) are equally as valuable if not more so given the ability to obtain pre-burn fuels information. While Randall (1966) did include some photographs in his case study publication, modern-day publishing technology has made the collection of the color photographs included in this paper possible. The present paper coupled with the original publication of Randall (1966) along with the hindsight comparison by Alexander (1984), constitutes yet another example of a more or less complete contribution available for deposit in the "Fire Behaviour Knowledge Base" (http://www.fbkb.ca) being developed by McAlpine and Wotton (2009).

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