CSIRO PUBLISHING

International Journal of Wildland Fire
http://dx.doi.org/10.1071/WF10124

Effects of flame interaction on the rate of spread of heading and suppression fires in shrubland experimental fires

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Abstract. Suppression fires are frequently used in wildland firefighting operations. However, little is known about how suppression fires behave and how the main front and the suppression fire interact. Lack of information limits the operational use and effectiveness of suppression fires and compromises the safety of firefighters. A series of experimental fires were conducted in a shrubland fuel complex in Galicia to quantify the effect of the interaction between a heading fire burning upslope with the prevailing wind and a suppression fire burning downslope from a control line against the wind. An empirical model was developed to estimate the possible effect of interaction between fronts on the rate of spread of both fronts. For heading fires, the explanatory variables were: wind speed on the windward side of the fire, distance between fronts and slope angle. In contrast, for suppression fires, the only significant explanatory variable was the distance between fronts. The models reflected the observed low to moderate acceleration in the rate of spread of both fronts and the short distance over which interaction occurred (<20 m). The study revealed that the safe and effective use of suppression firing is more limited than previously expected. In fact, with moderately high wind velocities on flat and moderately steep terrain, the use of line firing appeared unsafe.

Additional keywords: fire fighting, in-draft, mixed heathland wildfire behaviour.

Received 8 November 2010, accepted 11 April 2012, published online 26 July 2012

Introduction

Suppression firing is frequently used in wildfire control operations. The National Wildfire Coordinating Group of the USA considers three types of suppression fires: burning out, strip firing and counterfiring (NWCG 2011). Burning out involves setting fire between the control line and the edge of the fire to consume fuel between these, without specifically seeking an interaction with the edge of the fire. Strip firing implies setting fire to one (line firing) or more strips of fuel, with the aim of them burning together (Perry 1990; Pyne *et al.* 1996). Finally, a counterfire is a fire set between the main fire and backfire to hasten the spread of the backfire, a fire set along the inner edge of a control line to consume the fuel in the path of a wildfire or change the direction of power of the convection column of the fire (NWCG 2011). The latter two techniques are used to change the direction of the main fire front, to slow down the fire progress and to ensure that embers fall within a burned area, while also improving the safety of firefighters (Brown and Davis 1973; Gaylor 1974; Luke and McArthur 1986; Perry 1990; Montiel *et al.* 2010).

Although the above terminology is the most commonly used, there is a lack of consensus regarding the terminology of fire-suppression methods (e.g. Gaylor 1974; Perry 1990; Miralles *et al.* 2010) and an effort to unify terms is urgently needed.

Although suppression fire is an effective, economic and commonly used technique in wildfire control (Davis 1959; Arévalo 1968; Chandler *et al.* 1983; Pyne 1984; Luke and McArthur 1986; Perry 1990; Teie 1994; Martínez and Aguirre 1997; Martínez 2009; Castellnou *et al.* 2010; Miralles *et al.* 2010; Montiel *et al.* 2010), its scientific basis is unclear (Finney and McAllister 2011). Although suppression fires are more successful with light fuels (Gaylor 1974; Chandler *et al.* 1983), they are also widely used in shrubland fires in NW Spain and elsewhere (Montiel *et al.* 2010).

A critical point in the use of suppression fire is the safety of the firefighters. It is generally accepted that suppression-fire ignition is a risky operation and that considerable skill and adequate timing are required for its success (e.g. Gaylor 1974; Chandler *et al.* 1983; Perry 1990; Bradshaw 2011). Two main points remain to be clarified from an operational point of

