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Spot fires: fuel bed flammability and capability of firebrands to ignite fuel beds

Anne Ganteaume[A,D], *Corinne Lampin-Maillet*[A], *Mercedes Guijarro*[B], *Carmen Hernando*[B], *Marielle Jappiot*[A], *Teresa Fonturbel*[C], *Pedro Pérez-Gorostiaga*[C] *and José A. Vega*[C]

[A]Cemagref UR EMAX, 3275 Route de Cézanne, CS 40061, F-13182 Aix-en-Provence, France.
[B]Centro de Investigación Forestal, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Ctra de La Coruña km 7, E-28040 Madrid, Spain.
[C]Departamento de Protección Ambiental, Centro de Investigación Forestal de Lourizán, Xunta de Galicia, E-36080 Pontevedra, Spain.
[D]Corresponding author. Email: anne.ganteaume@cemagref.fr

Abstract. A series of tests were conducted under laboratory conditions to assess, first, the capacity of several fuel beds to be ignited by firebrands and to sustain a fire and, second, the capability of different types of firebrands to ignite fuel beds. Fuel beds and firebrands were selected among the most common in southern Europe. Regarding fuel bed flammability, results show that grasses are more flammable than litter and, among litters, *Pinus* species are the most flammable. The increase in bulk density and fuel moisture content involves an increase in the time to ignition, and a decrease in the other flammability parameters. The capability of firebrands to ignite fuel beds is higher when the firebrands drop in the flaming phase and with no air flow than in glowing phase with air flow. Logistic regression models to predict fuel bed ignition probability were developed. As a whole, results show a relationship between ignition probability of fuel bed and type or weight of firebrands. *Pinus pinaster* cone scale, *P. halepensis* cone scale, and *Eucalyptus globulus* leaf and bark can have ignition probabilities at least twice higher than pine bark when falling while in flaming combustion.

Additional keywords: ember, ignition probability, spotting, wildfire.

Introduction

Fire spotting, with production of flaming or glowing particles transported downwind, may cause secondary wildfires ahead of the main front. Therefore, fire prevention and firefighting strategies must take into account this phenomenon. Both ember transport and landscape-scale fire models are well detailed in the literature (e.g. Tarifa *et al*. 1965; Albini 1979, 1981, 1983; Rothermel 1983; Finney 1998; Gardner *et al*. 1999; Hargrove *et al*. 2000), but other aspects of fire spread by spotting remain less known, such as the ignitibility of fuel beds by point sources or the capability of firebrands to ignite fuel beds. The characteristics (species, moisture content, density, etc.) of the fuel that receives the brand and the vegetation that is the source of firebrands may influence the occurrence of a spot fire. Several laboratory studies of fire spread in different types of fuel bed used a line ignition and pine litter (Rothermel and Anderson 1966; Delaveaud 1981; Ventura *et al*. 1988; Viegas and Neto 1990; Vega *et al*. 1993; Valette *et al*. 1994; Mendes-Lopes *et al*. 1998; Guijarro and Hernando 2000). Although this kind of ignition is appropriate for fire-spread studies, it does not provide any information for fire spotting in which the ignition occurs from a point source. Blackmarr (1972) and Ferreira (1988) experimented with point-source ignitions using dropped lit matches. Recently, Manzello *et al*. (2006*a*, 2006*b*, 2006*c*) investigated the ignition of fuel beds found in the wildland–urban interface areas using an apparatus that allowed the ignition and deposition of single or multiple firebrands. Some authors (Blackmarr 1972; Ferreira 1988; Viney and Hatton 1989; Frandsen 1997; Lin 1999; Hargrove *et al*. 2000; Plucinski and Anderson 2008) have also investigated the ignition probability of fuel beds in relation to their characteristics, but they did not take into account firebrand characteristics. Nevertheless, it is important to carry out fire studies using commonly found firebrands that cause spot fires and to develop a prediction of the capability of different firebrands to ignite fuel beds as a function of brand and fuel bed characteristics.

In this framework, one of the objectives of the present work is to assess the capacity of several fuel beds to be ignited by firebrands and to sustain a fire through the study of their flammability (*Fuel bed tests*). The other objective is to assess the capability of different types of firebrands to ignite fuel beds (*Firebrand tests*), analysing the ignition probability of the firebrands as a function of physical variables of firebrands and fuel beds.

Material and methods

Tests of the flammability of fuel beds and the capability of firebrands to ignite fuel beds were conducted under laboratory conditions by three research teams (INIA, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, and CIF,

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