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Short contribution – Fire at the Wildland Urban Interface

Critical conditions for the ignition of cedar needle fuel bed as a result of firebrands accumulation

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1. Introduction

It is well known that flaming and glowing particles are a major cause of wildland and wildland-urban interface fires (Cohen 2000; Caton *et al.* 2017). In recent years, many papers devoted to this problem have studied firebrands trajectory in the airflow, their transportation distance (Ellis 2000; Anthenien *et al.* 2006; Kortas *et al.* 2009; Song *et al.* 2017) and evaluated firebrands ability to ignite fuel beds(Manzello *et al.* 2008; Filkov *et al.* 2016; Kasymov *et al.* 2016; Fateev *et al.* 2017). However, the problem still requires further research, as, in particular, critical conditions for the ignition of the fuel bed as a result of firebrands accumulation depending on their size, shape and ambient conditions remain largely unknown.

It should be noted that the interaction of flaming (burning) and glowing particles with the fuel bed is a complex process, which requires both theoretical and experimental approaches. The earlier papers demonstrated that flaming particles ignite the fuel bed more easily; for this reason, our research has been focused on glowing particles.

As was shown in(El Houssami *et al.* 2016), during surface fires tree bark and twigs turn into glowing particles. Therefore, the aim of the present work is to study accumulation of glowing twigs of various sizes and their interaction with forest fuel beds. In particular, the paper studied fuel bed ignition time, flaming and smouldering duration times and the heat flux critical value sufficient to ignite the fuel bed.

2. Methods and Results

An experimental setup was created which permitted to simulate firebrands accumulation with a controlled number of firebrands being dropped and which in turn allowed to evaluate their effect on the fuel bed (fig. 1).

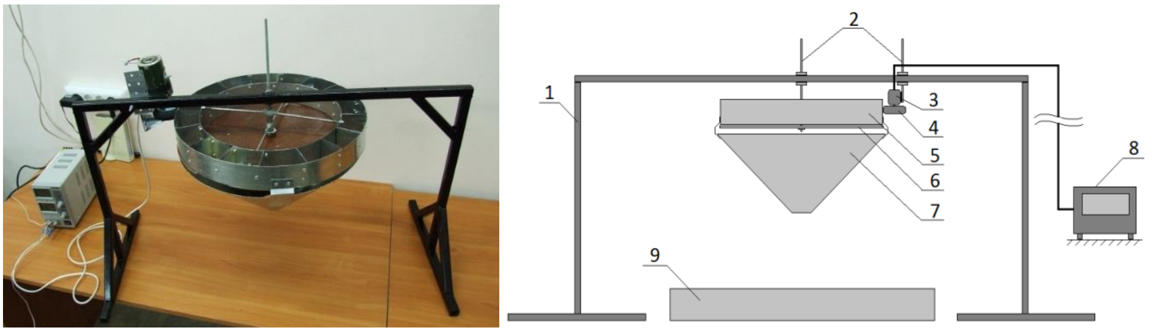

Figure1 - Experimental setup to simulate firebrand accumulation on the fuel bed: 1 – rack; 2 – adjusting bolts; 3 – electric motor; 4 – driving wheel; 5 – box; 6 – disk-separator; 7 – funnel; 8 – adjustable power supply; 9 – tray

Birch tree cylindrical samples with diameters of 6 mm, 8 mm, 10 mm, 12 mm, 14 mm and 50 mm in length were used as firebrands (fig.2).

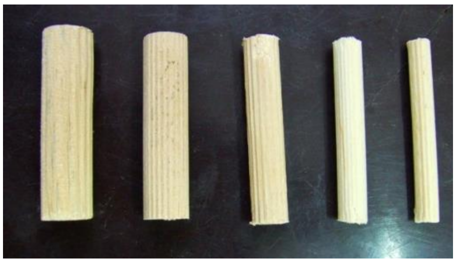

Figure 2 - Firebrand samples

The moisture content was determined using the AND MX-50 moisture analyser. The firebrands moisture content and the fuel bed (cedar needles) were 4.2 ± 0.2 % and 6 ± 0.2 % respectively. A thermal imaging camera JADE J530SB and a video camera Canon HF R88 were used to evaluate the firebrands temperature and to record the experiment. Three repetitions were performed for each experiment, three successful or unsuccessful ignitions in a row. In case of one or two ignitions, the number of experiments was increased to reach at least three ignitions for statistical analysis.

The following procedure was used for the experiment: cedar needles were placed on the tray (9) to simulate a fuel bed with a density of 56 kg/m^3; firebrands were put into the box (5) and heated with gas burners until they began to glow while the whole process was controlled with the thermal imaging camera. The frequency of firebrands drops on the tray (9) was regulated by changing the electric motor rotation speed (3). The precision of firebrands drops was regulated by adjusting the height of the setup over the fuel bed using adjusting bolts (2) and funnel (7). The experiment started with dropping one particle every 4 seconds until reaching a total of 10 particles. If the fuel bed was ignited, fresh cedar needles were put on the tray (9). Three repetitions were carried out for each experiment. Fuel bed ignition was defined as a moment when a flame appeared over the fuel bed, which was recorded with a video camera. Fuel bed smouldering was defined as continuous uninterrupted smouldering caused by firebrands and which lasted for 5 min.

A preliminary series of experiments was carried out in the absence of wind and with wind speed of 1.5 m/s with firebrands 50 mm long and with diameters of 6 mm and 8 mm. Under the chosen experimental parameters in the absence of wind fuel bed ignition did not occur except on a few occasions when fuel bed smouldering was initiated and lasted for 3 min after the firebrands had stopped burning. With the wind speed of 1.5 m/s, the fuel bed ignition was observed and was started by eight 6 mm particles, or by six 8 mm particles, i.e. an increase in the firebrands diameter led to a decrease of the number of firebrands required ignition to occur.

During the next experimental stage, particles with diameters of 10 mm, 12 mm and 14 mm and the wind speed of 1–1.5 m/s will be used to evaluate both the probability of ignition depending on the number of particles and the critical heat flux produced by them.

3. Acknowledgements

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