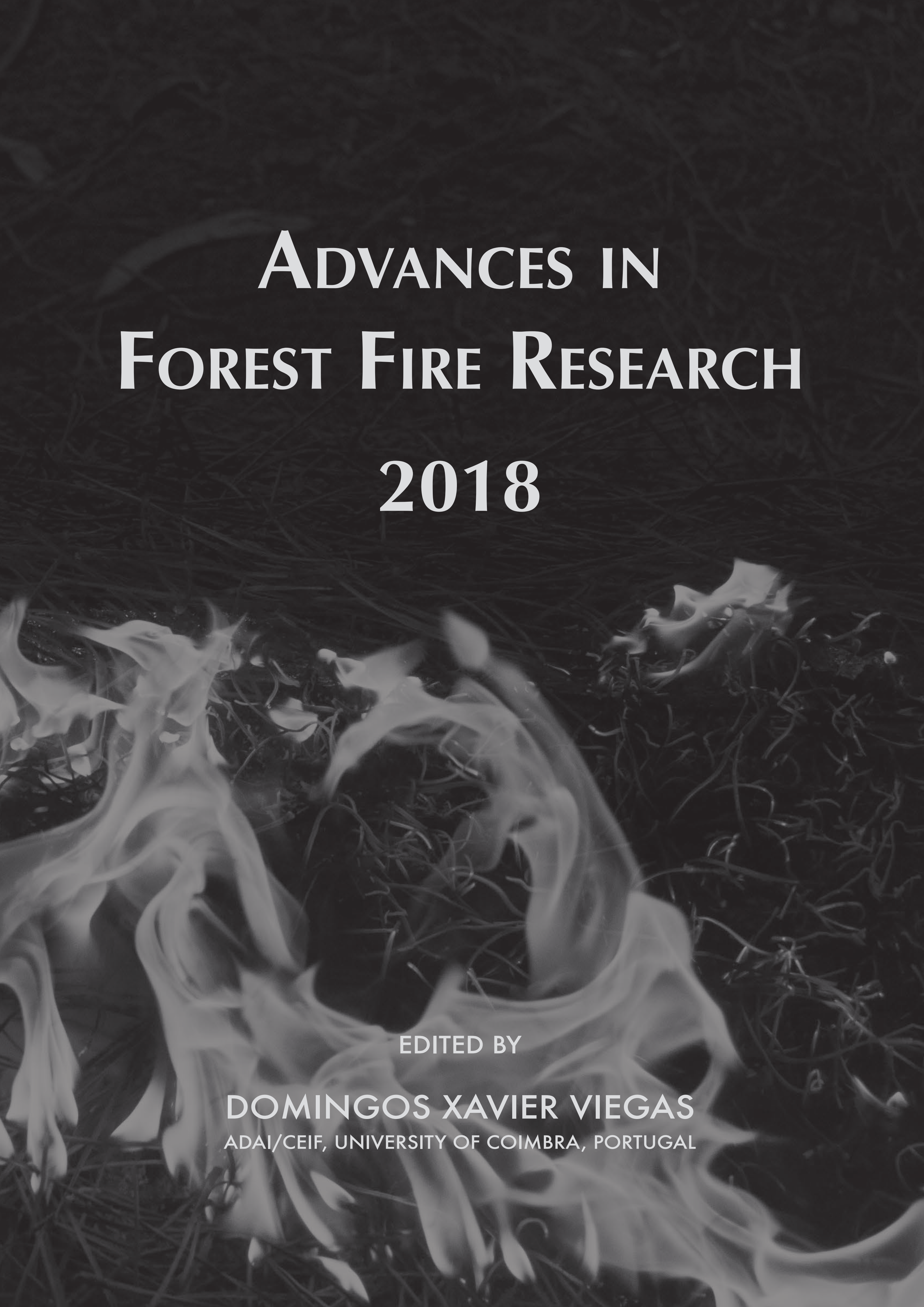

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Short contribution – Fire Management

Field-tested laboratory-derived models to predict forest fire front spread rate

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1. Introduction

Forest fire-spread rate models provide crucial support to decision support in fire management, such as assisting wildfire suppression operations. Most modelling studies aim at predicting fire spread rate (R) for wind- or slope-driven fires (Sullivan et al. 2014). Even so, the ability to estimate basic fire spread rate (R_0), i.e., on level ground in the absence of wind, is relevant because it provides a measure of fuel bed flammability and some modelling approaches estimate R by multiplying R_0 by a wind or slope factor (e.g., Rothermel 1972). Conversely, wind-driven fire spread rate (R_U) has been the motivation of many modelling efforts. Slope has also a strong effect on fire spread. However, when the distance travelled is sizably larger than distances between landscape undulations, R is satisfactorily equated to that of a fire spreading across a corresponding expanse of flat ground (Sullivan et al. 2014). As a result, the distance travelled by large fires is mainly a function of wind speed. Yet, a field-tested empirical R_U model for fire spread in generic vegetation is currently lacking.

In this work, we present results of laboratory experiments to analyse fire spread under R_0 and R_U conditions. The data are used in the development of models for fire propagation in generic fuel beds. Fuel beds were built from natural vegetation, mimicking the real-world structure of litter and shrubs. Empirical models were derived using regression analysis.

2. Data and methods

We conducted laboratory fire spread experiments in litter and shrub-like fuel beds. Some of the tests to measure R_0 (n = 220) were immediately followed by a R_U test in an identical fuel bed (n = 108), to isolate and assess the effect of wind. Shrub-like fuel beds were composed of vertically-placed tree or shrub twigs, sometimes under-layered by litter (Figure 1). We used various plant species (*Pinus pinaster* Ait., *Eucalyptus globulus* Labill., *Eucalyptus obliqua* L'Her., *Acacia mangium* Willd., *Quercus robur* L., *Pinus resinosa* Sol. ex Ait.) and fuel beds were often composed of mixed dead and quasi-live vegetation. Quasi-live fuels were collected live, with fuel moisture content (M) decreasing as a function of storage time. R and M were measured in all tests and flame length and angle were also assessed in some of the trials. All fuel beds were at least 1-m long and 1 to 1.2-m wide.

We used regression analysis to relate R_0 with the pertinent variables. The effect of wind was assessed the same way and the wind effect and R_0 were multiplied to predict R_U. The laboratory-derived relationships were then tested against independent laboratory and field fires. Independent datasets were retrieved from the literature and included fire spread in no-wind and no-slope conditions, as well as wind-driven fires.

Figure 1 - Wind-driven fire spread test in a fuel bed of Eucalyptus globulus leaves litter over layered by quasi-live E. globulus twigs.

3. Initial results and conclusion

Our results show that both R_0 and R_U models can be predicted by a single formulation and a common set of variables, independently of vegetation type. Although the models were fitted to laboratory experiments data, they were tested against independent laboratory and field fires data, and hence justify further testing in other real-world fire spread situations for a wider range of fuel complexes.

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