Advances in Forest Fire Research

DOMINGOS XAVIER VIEGAS
EDITOR

2014
Live fuel moisture and wildland fire behaviour

Philip Zylstra

Centre for Environmental Risk Management of Bushfires, University of Wollongong, Northfields Ave, Wollongong NSW 2522, pzylstra@uow.edu.au

Abstract

Live fuel moisture content (LFMC) is a parameter that affects the flammability of plants, and the capacity to measure it remotely makes it an accessible variable for use in fire behaviour models. Although the effect of LFMC on the flammability of fuel particles has clear theoretical support however, the way in which this relates to fire behaviour is complex and difficult to quantify so that empirical studies of heath and forest fires at times yield weak or ambiguous results.

This study examines the way in which moisture affects fire behaviour by using a process-based conceptual framework (Zylstra 2011) to identify feedbacks and complexities that may confound empirical analysis. Z11 links empirically-derived sub-models of flammability characteristics within a dynamic physical framework where heat is transferred convectively across spaces between leaves, branches, plants and plant strata. The ignitability, combustibility and sustainability of flame from burning leaves interacts with the geometry of the fuel array to determine whether flame will spread across horizontal spaces affecting rates of spread, and vertical spaces affecting flame heights.

Factors are identified that should be considered explicitly in experimental design if LFMC is a consideration, and physical arguments presented to show that where such a range of conditions is not present in the experimental design, the results are inadequate to draw conclusions. In some cases, practical considerations will prevent the lighting of experimental fires under the full range of necessary conditions so that the best understanding will be derived from modelling results. In such cases, misleading conclusions will be drawn unless the model can adequately reflect the complexity presented here.

There exists a strong physical argument for the effect of LFMC on fire behaviour, however this effect is not straightforward and will drive threshold changes and feedbacks. Such changes may represent sudden and dangerous escalations in fire behaviour, so understanding and quantifying these is important. Z11 is a model that can calculate such thresholds and can be used to both inform experimental design and risk-based decision making.

Keywords: Fire behaviour, live fuel moisture, flammability, Forest Flammability Model, complex systems

1. Introduction

Live fuel moisture content (LFMC) is a readily accessible metric that can be measured to varying levels of precision via remote sensing (Yebra et al. 2013). Physical arguments suggest that it has an influence on fire behaviour as the presence of moisture affects the flammability or ignitability, combustibility and sustainability (Anderson 1970) of leaves; however debate exists as to the extent and nature of the influence in field conditions and it is therefore rarely or inadequately considered as a component of fire behaviour modelling.

Ignitability has two components – the minimum temperature of ignition (Philpot 1970) and the time to ignition (Gill and Zylstra 2005). While the minimum temperature or endotherm appears to be a chemical property, time to ignition is the time taken for a leaf to be heated to ignition and relates to both the surface area to volume ratio and the thermal inertia of the leaf. Various studies (e.g. Xanthopoulos and Wakimoto 1993; Weise et al. 2005; Madrigal et al. 2011) have identified moisture content as a major influence in this, although more recent studies at higher temperatures (Engstrom et al. 2004; Fletcher et al. 2007) have failed to find a relationship.

While the effect of moisture on particle ignition is widely accepted under most conditions, the