Calibration assessment of forest flammability potential in Italy

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Fuel flammability is defined as the relative ease with which a fuel will ignite and burn with a flame. Different forest types have different intrinsic "baseline" flammabilities, depending on the susceptibility to burn of the main tree species that build up the forest cover. In this perspective, we apply a forest-type based approach to classify and map the flammability level of the forests in Italy. Baseline forest type-based flammability values provided at European level have been assigned to a national forest types map, derived from Corine Land Cover 2006. Flammability values have been then further calibrated against the Burned Area Selection Ratio, a measure of the actual incidence of wildfires among different forest types. Accordingly, a calibrated flammability index was derived by simple linear regression, so that predicted flammability reflects more accurately the observed fire incidence among different forest types in Italy. Findings show that the flammability of forest types ranges from low to high: on average, the 17% of the forest cover has medium to high flammability, with wide regional variability. Notably, in four Regions (Sardegna, Sicilia, Puglia, Calabria) over one third of total forest area has medium to high flammability. Large scale mapping of forest flammability is crucial to define long-term priorities among forest areas as to how to distribute fire management effort. Areas falling into medium to high flammability classes should be given priority for implementing fuel management treatments in order to mitigate fire hazard from the stand to the landscape scale.

Keywords: Fuel Flammability, Fire Hazard, European Forest Types, Burned Area Selection Ratio, Fire Management

Introduction

Fuel flammability is defined as the relative ease with which a fuel will ignite and burn with a flame (Stacey et al. 2012). It plays a paramount role in the reaction of wildland fuels to heat exposure, thus influencing the spatial pattern of fire ignition risk. Accordingly, flammability is a key determinant of fire hazard, *i.e.*, the degree of both ease of ignition and fire suppression difficulty of the fuels (FAO 2006).

According to Anderson (1970) and Trabaud (1976), flammability can be defined through three variables that describe how well the fuel ignites (ignitibility), how well it burns (combustibility) and how long it burns (sustainability). Notably, in Mediterranean trees (*e.g.*, Pinaceae and Cupressaceae) the abundance of organic oils and organic volatile compounds and terpenes, whose flash points are low, largely contributes to the ignition and spread of fire (Alessio et al. 2008); at the same time, the susceptibility to burn of any given fuel is manifested only under particular weather conditions, as it is largely dependent on fuel moisture content.

The general sense of the flammability concept can be easily grasped, but it is harder to define it more closely for scientific purposes (Gill & Zylstra 2005). Although flammability components can be measured by laboratory and field experiments (*e.g.*, Madrigal et al. 2009), translation of laboratory results to field conditions is highly problematic (Fernandes & Cruz 2012). Moreover, field experiments are usually expensive (White & Zipperer 2010).

As a matter of fact, many variables do affect fuel flammability at leaf, plant and forest stand level, including structural characteristics of the fuels, moisture content, chemical composition and fuel spatial arrangement (Xanthopoulos et al. 2012). The interplay of forest composition and stand structure is crucial to influence forest fuel flammability at stand scale. On one hand, the "baseline" flammability level of a forest type is primarily driven by the fuels produced by the main tree species that build up the forest cover. On the other hand, fire hazard might be widely variable even in stands composed of flammable forest species, depending on forest stand structure and fuel accumulation (Fernandes 2009).

Considering that fire management resources are limited, it is crucial to provide fire managers with operational methodologies to assess fire hazard over large forest areas (a country or a region). A landmark approach to fire hazard mapping is fire behavior modeling. Fuel models are mathematical representations of fuel properties within a specified location (Stacey et al. 2012), used to predict and plot likely fire spread and intensity by means of fire behavior models, packaged into decision support systems (*e.g.*, FARSITE - Finney 1998, BehavePlus - Heinsch & Andrews 2010). However, the implementation of fire modeling on a large scale is inherently limited by the difficulty and high cost of yielding accurate geospatial data on fuels (Keane et al. 2001). In this perspective, a large scale map of forest flammability potential can be a valuable decision support tool to assess need and priorities in fire management, *e.g.*, to support the effectiveness of fire prevention, detection and allocation of fire fighting resources (Blasi et al. 2005). Following this line, the paper presents a methodological framework to classify and map the flammability level of main Italian forest types by processing spatial data on forest cover composition and recent fire history. Baseline forest type-based flammability values provided at European level by Xanthopoulos et al. (2012) have been calibrated against the Burned Area Selection Ratio (*BASR*), a measure of the actual incidence of wildfires among different forest types (Bovio et al. 2014).

Study area

Land covered by forests in Italy (*sensu* FAO 2001) amounts to 8.8 millions of hectares, nearly 30% of the country's terri-

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