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Towards an establishment of a wildfire risk system in a Mediterranean country

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ABSTRACT

Wildfire is one of many natural hazards affecting the Mediterranean basin; its consequences could be fatal for individuals and beyond repair for the environment. While factors worldwide included in a fire ignition are unstandardized, in this paper, we built a model from literature-cited factors – fourteen elements were included – to highlight the probability of wildfires' occurrence in the Lebanese forest. It was named Three-Type Model (TTM), where forests were classified into three types: pine, oak and mixed. Validations have been conducted by using thirty percent of datasets versus the other seventy percent; then, by comparing its accuracy to another model that study the forest as one unit only. Accuracy assessment of the model reached above 83%, and it could be portable to other Mediterranean-climate forests.

In addition, we produced a wildfire risk map by combining fire ignition-related factors with vulnerability-related variables. Results show that 15.9% of the Lebanese regions and 43.46% of the total amount of wildfires are human-induced wildfires. The majority of human-induced wildfires exists in a medium to high wildfire-ignition probabilities classes and in oak forests, representing approximately 93 and 83% of these wildfires, respectively. We concluded as well that only 1.6% of the Lebanese forest is at high risk of wildfire ignition. The implementation of our methodology in different Mediterranean countries is easy and straightforward, mainly because of the reduction of the ignition parameters as well as the usage of remote sensing datasets. It shall help decision-makers and official authorities in preventing, pre-suppressing and battling this phenomenon.

1. Introduction

Wildfires may be a natural phenomenon; however, it often occurs coupled with many negative impacts on human safety, health, regional economies and global climate change. The environmental effects of wildfires, including erosion, landslides, introduction of invasive species, and changes in water quality, are often more disastrous than the fire itself (USGS, 2006).

Mediterranean countries, including Lebanon, are always at high risk of fire. Pausas et al. (2008), for instance, has discussed the possible effects of this phenomenon in the region. Several authors have discussed the short-term effect of wildfires (Arcenegui et al., 2008; Hernández et al., 1997; Naveh, 1974; Piñol et al., 2005). Others have evaluated the physical changes such as soil erosion (Andreu et al., 2001; Inbar et al., 1997; Pardini et al., 2004; Shakesby, 2011) and hydrological response (Doerr et al., 2006; Lavabre, 1993; Mayor et al., 2007; Shakesby et al., 1993) in post wildfires. And numerous studies have modeled the propagation of wildfires (Moreira and Russo, 2007; Morvan and Dupuy, 2004; Pennington, 2007; Soto et al., 2013; Wilson et al., 2010).

In the literature, there is some ambiguity between "hazard", "vulnerability" and "risk" terms (Bentz et al., 1993; Hardy, 2005; Mhawej et al., 2015). By risk, political ecologists mean the compound function of biophysical hazard exposure and peoples' vulnerability, i.e., their ability to anticipate, respond to, and recover from a hazard event (Collins, 2008; Wisner et al., 2004). Vulnerability is then the consequences of a natural phenomenon, of given intensity, on a subject (Brugnot, 2013; Lollino et al., 2014). Then, the same phenomenon could have different vulnerabilities based on the studied subject. As a relational term, vulnerability refers to the combination of factors that influence the degree to which someone's life, livelihood, property, or assets are put at risk by the occurrence of a hazard event (Wisner et al., 2004). On the other hand, hazard is the probability of occurrence of a potentially damaging phenomenon, in one place, and at a certain time (ADPC, 2008; Griffiths, 2001; Marinos, 1997). It could be divided as well into two subcategories: number of occurrence and intensity.

Several studies have been conducted to detect or minimize the wildfire hazard, both on the scale of the Mediterranean basin (Chuvieco and Congalton, 1989; Kalabokidis et al., 2013; Moreira et al., 2009; Piñol

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et al., 1998) and locally (Faour et al., 2006a, b; Karouni et al., 2014a, b; Sakr et al., 2011). An assessment of the wildfire risk has been conducted as well (Baeza et al., 2002; Kaloudis et al., 2008; Millington et al., 2008; Mitri et al., 2015). The usage of remote sensing techniques has become a vital tool in those assessments. These techniques provide full coverage of the studied area, both temporally and spatially, with reduction of personal and costs. In this context, numerous wildfire risk studies were based on the Geographic Information System (Arroyo et al., 2008; Chuvieco, 2012; Chuvieco and Congalton, 1989; Díaz-Delgado et al., 2002; Koutsias and Karteris, 2003; Malak and Pausas, 2006; Ruiz-Gallardo et al., 2004). However, previous studies are missing the comprehensive list of factors affecting the forest fire ignition. In each research, factors used are questionable because they were selected based purely on the authors' knowledge and experiences. Furthermore, several authors (e.g. Faour et al., 2006a, b; Masri, 2005; Stone et al., 2010) noticed the lack of standard driving forces used in wildfire risk studies.

In this paper, we focused on two objectives: the first was to build a wildfire hazard model, by using a literature-based, comprehensive list of ignition-related factors; this model shall assist future creation of wildfire hazard maps, within the Mediterranean-climate forests, even when historical wildfires datasets were missing. In addition, using a reduced set of parameters results in an efficient and reduced-cost prediction system, especially for developing countries; the second was the creation of the wildfire risk map for the Lebanese forests, with a spatial resolution of 1 km, to visualize and assess the actual condition of the wildfire's risk. It has been produced by the combination of hazard and vulnerability maps. Actually, datasets of factors used in these maps, dating from 1980 to 2014, were collected from satellite imageries and ground measurements. Ultimately, the wildfire risk map allows fire managers to implement fire prevention initiatives and plan for potential fires, thus contributing to the development of sustainable forest management plans.

2. Study area

Lebanon is localized on the eastern shore of the Middle East Basin. With an area of 10,452 km2, almost 20% of its total area is covered by forest (Fig. 1). Nearly 13% (i.e. 282 km2) of it is a habitat to pine trees. Over its half contains oak trees (i.e. 1077 km2). The rest is occupied by different type of trees and covering 778 km2 or 36% of the total forest area. In fact, the Lebanese forest is characterized by high vegetation biodiversity (i.e. 2500 species, including 92 endemic plants) (Faour et al., 2006a). It is considered a national heritage, a fascinating landscape, and a recreation zone.

In Lebanon, most forest fires occur between June and October with a maximum frequency in August and September, 25% and 27 of fires percent, respectively (Faour et al., 2006b). The burned areas can be subject to intense rainfall, which may increase the problem of water erosion

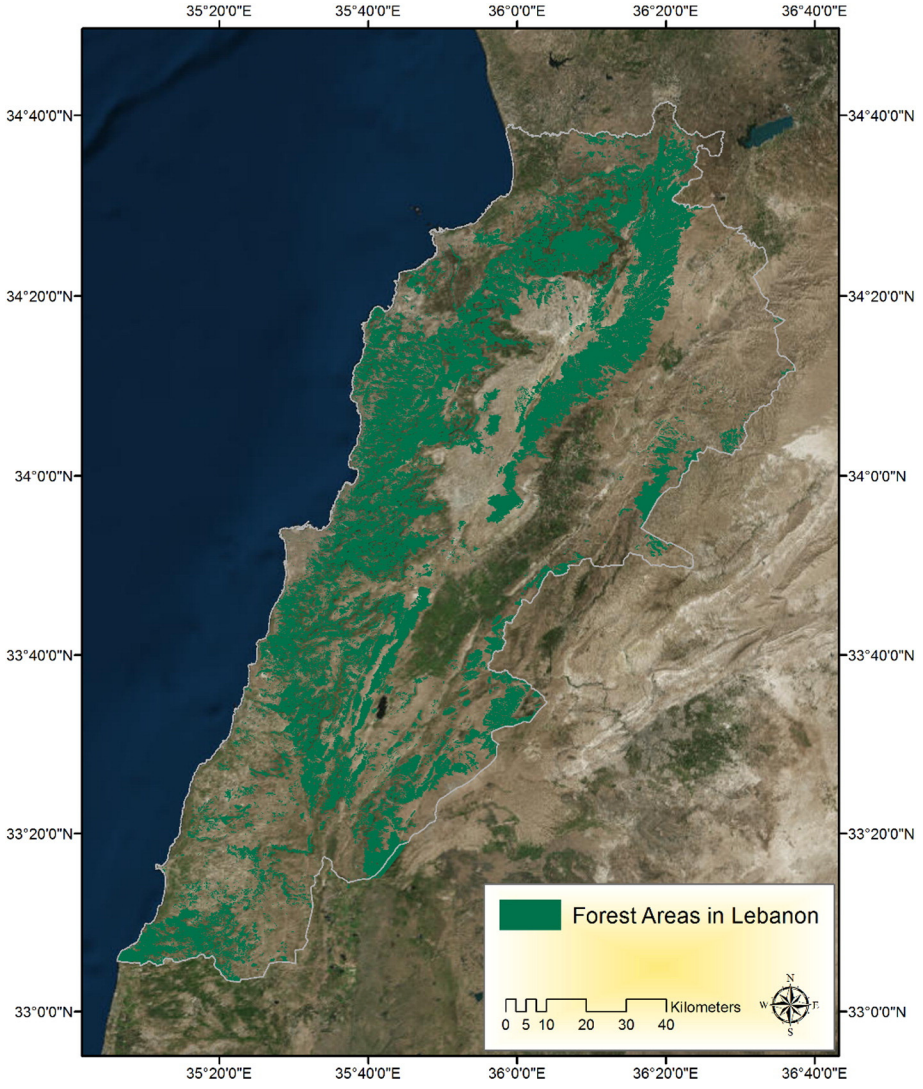

Fig. 1. Location of the Lebanese Forests.