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Analysis of large fires in European Mediterranean landscapes: Lessons learned and perspectives

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ABSTRACT

Extreme fire events, also referred to as "megafires," are not uncommon events on a global scale; they tend to happen a steady frequency in different parts of the world, although, at a local or regional scale, they constitute unique and severe fire episodes. Even if there is not a complete agreement on the term, megafires often refers to those fire events that cause catastrophic damages in terms of human casualties, economic losses, or both. In this article we analyze some of the most damaging fire episodes in Europe in the last decades. Our analysis relates the events to existing conditions in terms of number of fires and burnt areas in the countries and regions where they occurred, showing that these large fire episodes do not follow the general trend of those variables and constitute outstanding critical events. Megafires are characterized on the basis of the meteorological and fire danger conditions prior to the event and those under which they develop. Impact is assessed in terms of total burnt area, estimates of economic losses, if available, and number of human casualties caused by the megafire event. We analyze fire-fighting means available for the extinction of each megafire, as reported in the annual reports of the European Commission, to determine if fire spread might have been related to lack of available means for initial control and extinction. All countries where the reported megafires took place are in fire prone areas where active fire campaigns take place every year. Our results determine that megafires are critical events that stand out with respect to the average conditions in the respective countries; in all cases, the impact of the fires set a record damage in the country or region where the megafire event took place. It is shown that, in the cases under study, megafires were driven by critical weather conditions that lead to a concentration of numerous large fires in time and space (fire clusters). It is shown that these megafire events occurred independently of the large expenditures in forest fire fighting means and increased preparedness in the countries where they took place. The simultaneity in fire ignitions and the rapid fire spread prevented efficient initial fire attacks. Therefore, megafires occur independently of the available fire means in the countries and are set under control only when the weather conditions improve and facilitate fire fighting. Our analysis supports a series of recommendations that are seek to promote fire-prevention oriented forest management and increase awareness on potential extreme fire events to prevent the occurrence of megafires in Mediterranean regions.

1. Introduction

Fire is an integral component of Mediterranean ecosystems since at least the Miocene (Dubar et al., 1995). Although humans have used fires in the region for tens of thousands of years (Goren-Inbar et al., 2004), it is only in the last 10,000 or so that man has significantly influenced fire regime (Daniau et al., 2010). The use of fire as a management tool has persisted until these days, although the second half of the past century saw a major change and a regime shift due to abandonment of many unproductive lands (Moreno et al., 1998; Pausas and Fernández-Muñoz, 2012). Although fire still is a traditional management tool in some rural areas for control of vegetation and enhancement of pastures for cattle feed, most fires these days are no longer related to the management of the land (San-Miguel-Ayanz et al., 2012a,b).

The European Mediterranean region is a highly populated area where nearly 200 Million people live in just 5 European Union countries, Portugal, Spain, France, Italy and Greece. Population density varies but remains very high with about 2500 inhabitants/km^2 in the French Riviera (with peaks of up to 750,000 tourists per day during the summer) (Corteau et al., 2007) *versus* an average of 111 inhabitants/km^2 in the region. The region is characterized by an extensive wildland urban interface (WUI). Large urban areas have expanded into the neighboring wildland areas,

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where expensive households are built. The WUI has been further increased by the construction of second holiday homes in the natural environment. Fire prone areas along the Mediterranean coast have been extensively built up, reducing in some cases the availability of fuels, but increasing largely the probability of fire ignition by human causes (Ganteaume et al., 2012). In other areas of the same region, abandonment of the rural environment has lead to low utilization of forests, which are generally of limited productivity, and the subsequent accumulation of fuel loads (San-Miguel-Ayanz et al., 2012a,b; Moreira et al., 2011). The combination of the above factors converts the European Mediterranean region in a high fire risk area (Sebastian-Lopez et al., 2008), especially during the summer months when low precipitations and very high temperatures favor fire ignition and spread.

About 65,000 fires take place every year in the European region, burning, on average, around half a million ha of forest areas (European Commission, 2011). Approximately 85% of the total burnt area occurs in the EU Mediterranean region (San-Miguel-Ayanz and Camia, 2010). Although fires ignite and spread under favorable conditions of fuel availability and low moisture conditions, ignition is generally caused by human activities. Over 95% of the fires in Europe are due to human causes. An analysis of fire causes show that the most common cause of fires is "agricultural practices", followed by "negligence" and "arson" (Vilar Del Hoyo et al., 2009; Reus Dolz and Irastorza, 2003).

Most fires in the region are small, as a fire exclusion (extinction) policy prevails in Europe. Fires are thus extinguished as soon as possible, and only a small percentage escapes the initial fire attack and the subsequent fire fighting operations. An enhanced international collaboration for fire fighting exists among countries in the European Mediterranean region. This facilitates the provision of additional fire fighting means to those in a given country from the neighboring countries in case of large fire events. The trend of large fires, those larger than 500 ha, is shown quite stable in the last decades (San-Miguel-Ayanz and Camia, 2010). However, among these large fires, several fire episodes caused catastrophic damages and the loss of human lives, and they are the scope of our analysis. These extreme episodes are often referred to as "megafires." However, there is neither an agreed definition of the term megafires nor an established common set of parameters to characterize them. Williams et al. (2011) attempted to investigate into the causality of these fires and the factors that may have driven them. They analyzed fires in very diverse biomes, countries and cultures and draw general conclusions on the communalities to all the events. These extreme fires are relatively frequent events with recurrence time of 2–3 years, causing large human, economic and environmental damage altogether. Their ignition and spread occur under favorable weather conditions, often following drought periods, in areas where fuel accumulation favors quick fire spread and high fire intensity; they usually burn out of control and can only be stopped when meteorological conditions support aerial and ground fire fighting.

In Europe, the so-called megafires are not single fire events but clusters of large fires that burn simultaneously and concentrate in space. Despite the high socio-economic impact of the megafires, a methodical analysis of megafire events in Europe has not yet been performed. We propose the use of data available at the European Forest Fire Information System (EFFIS), which integrates information on forest fires from nearly all European countries, to perform a systematic analysis of the megafires in Europe in the last decade. This decade has seen some of the most devastating fires that have ever occurred in the European Mediterranean region. The fires that are analyzed in our study are those that took place in Portugal in 2003 and 2005, northwestern Spain in 2006, and Greece in 2007. Each megafire event is characterized on the basis of four parameters: (1) the singularity of the megafire event as compared to general pattern for all fires in the country, (2) socio-economic impact of the event in terms of environmental and human losses, (3) prevailing fire danger conditions before and during the event assessed on the basis of Canadian Fire Weather Index and the its component the Duff Moisture Code, and (4) the available fire fighting means for fire extinction. The systematic analysis of these megafire events is used for deriving a series of recommendations or lessons learnt that are proposed to support fuel reduction practices, increase awareness on potential megafire events and prevent their occurrence in the Mediterranean region and other similar areas of the world.

2. Materials and methods

2.1. Forest fire database [information sources, fire regimes in Europe and spatial-temporal distribution of fires]

Information on the number and effect of forest fires has been collected in most European Mediterranean countries since the 1980s with a certain degree of variation among countries. At the end of the decade, the European Union realized that benefits could be obtained by an enhanced collaboration among countries and through a harmonized approach for data collection at the Union level. The EU supported the creation and enhancement of information systems in the countries and at the European level by means of several initiatives and regulations (San-Miguel-Ayanz et al., 2012a,b). This cooperation resulted in the collection of the so-called set of core information on forest fires through a series of European Regulations since 1992 until 2006, when the last of them, the Forest Focus regulation -EC 2152/2003 – (European Commission, 2003) expired. However, the mechanism for the collection of these data still remains in the context of the European Forest Fire Information System (EFFIS) that was created to support the countries and the European Commission in collecting forest fire information and improving forest fire prevention (San-Miguel-Ayanz et al., 2011). The basis of the analysis performed in this manuscript is thus the European fire database in EFFIS (Camia et al., 2010).

Although forest fires are a natural phenomenon in many parts of the world, they are the result of intensive human activity and pressure on the environment in the European Mediterranean region (Oliveira et al., 2012). As mentioned above, most of them (over 95%) are the result of human activities (Vázquez and Moreno 1998; San-Miguel-Ayanz and Camia, 2010; Catry et al., 2010). Wildfires cause large environmental and economic damages and result in the loss of human lives (San-Miguel-Ayanz and Camia, 2010), especially in the Mediterranean region, which has a high population and human settlement density. Trends in number of fires and burnt areas in the Mediterranean region are presented in Fig. 1.

Fig. 1 shows a noticeable increase of forest fires in EU Mediterranean region since the 1990s until the year 2000, with some degree of inter-annual variability. Since then, the pattern of number of fires is noticeably decreasing although with some inter-annual variability that includes peaks in the years 2000, 2003, 2005 and 2009. However, most of the damage caused by fires is the result of a small number of large fires. Fig. 2 shows how about 2% of the fires in the EU Med region account for over 80% of the total area burnt (Camia and San-Miguel-Ayanz, 2011).

Despite the large damages caused by forest fires, the analysis of the large fires (i.e., $\geqslant$500 ha) does not show an increasing trend in the last decades. Fig. 3 shows the trend of fires larger than 50 ha in the Mediterranean region in the last decades, grouped in three fire-size classes – larger than 50 ha, 100 ha and 500 ha. It is noticeable that fires larger than 500 ha show little variability among years and an overall decreasing trend, while this has not prevented the occurrence of megafire events.