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Research article

Clearing shrubland and extensive livestock farming: Active prevention to control wildfires in the Mediterranean mountains

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ABSTRACT

Forest fires are one of the main environmental problems in Mediterranean environments and different fire prevention policies have been applied: livestock grazing, prescribed fires and a combination of both. However, none present satisfactory results. In that context, in 1986 the Regional Government of La Rioja started the Plan for Shrub Clearing (PSC), combining shrub clearings and livestock grazing to control fires and improve the land management of abandoned mountain areas. Our study aims to analyse the effects of shrub clearings on forest fires in La Rioja and to compare the main results with those observed in Spain in the last 30 years. We apply an interdisciplinary methodology based on the analysis of the evolution of cleared areas, the evolution of wildfires in La Rioja and Spain, mapping land use and land cover changes, and quantifying the combustibility. Results obtained in La Rioja are very positive compared with the evolution of Spain, both in the reduction of the number of fires and the burned areas. Decreases in the combustible material, fuel load and biomass and in the occurrence of fires (> 1 ha) were observed. In addition, clearing shrubland and extensive livestock provided other environmental benefits (i.e. mosaic landscapes, ecosystem services). Finally, this study suggested that they are good and sustainable techniques to prevent and control wildfires and they could be used as a land management strategy in other Mediterranean areas.

1. Introduction

Wildfires are very common in the Mediterranean European countries: every year, they cause significant economic and environmental losses, and even human lives (Shakesby, 2011). The climate of the Mediterranean environments makes them highly prone to fires, as summer is dry and hot with frequent lightning storms (Pereira et al., 2005; Amraoui et al., 2015). Indeed, fire has been an essential part of the ecosystems and landscapes in the Mediterranean area since at least the Miocene era, with humans intervening in the fire regime over the last 10,000 years (Daniau et al., 2010).

Fire has been used since Pre-history as a management tool to remove trees and shrubs to create agricultural land and pastures (Rius et al., 2009; Bal et al., 2011; Seijo and Gray, 2012; Pausas and Keeley, 2014), giving rise to highly heterogeneous cultural landscapes with a great deal of biodiversity (Antrop, 1993; Farina, 2000; Lasanta et al., 2005; Varga et al., 2018). However, throughout the 20th century, especially after 1960, fire regimes changed, with an increase in frequency and magnitude (Pausas and Keeley, 2009), causing serious damage to ecosystems and human infrastructures (Westerling et al., 2006; Rodrigues et al., 2013). Approximately 65,000 fires occur each year in Europe, and about 85% of the total burned area is in the Mediterranean European countries (San-Miguel-Ayanz et al., 2013). Several reasons have been put forward for the increase in fires: i) climate change and rising temperatures with a prolonged hot season (Pausas and Fernández-Muñoz, 2012); ii) policies prohibiting the use of fire for agricultural purposes, leading to a larger amount of combustible material (Minnich, 1983; Piñol et al., 2007; Curt and Frejaville, 2018); and iii) rural abandonment followed by revegetation that increases the combustible biomass (Moreira et al., 2011; Seijo and Gray, 2012; Pausas and Fernández-Muñoz, 2012).

More than 95% of fires in Europe are due to human causes, through accident or intent (San-Miguel-Ayanz et al., 2013). In Spain, for example, lightning strikes account for just 4% of the fires (de la Riva and Pérez-Cabello, 2005). In the Mediterranean mountains, the main causes of wildfires are depopulation of the countryside, farm abandonment,

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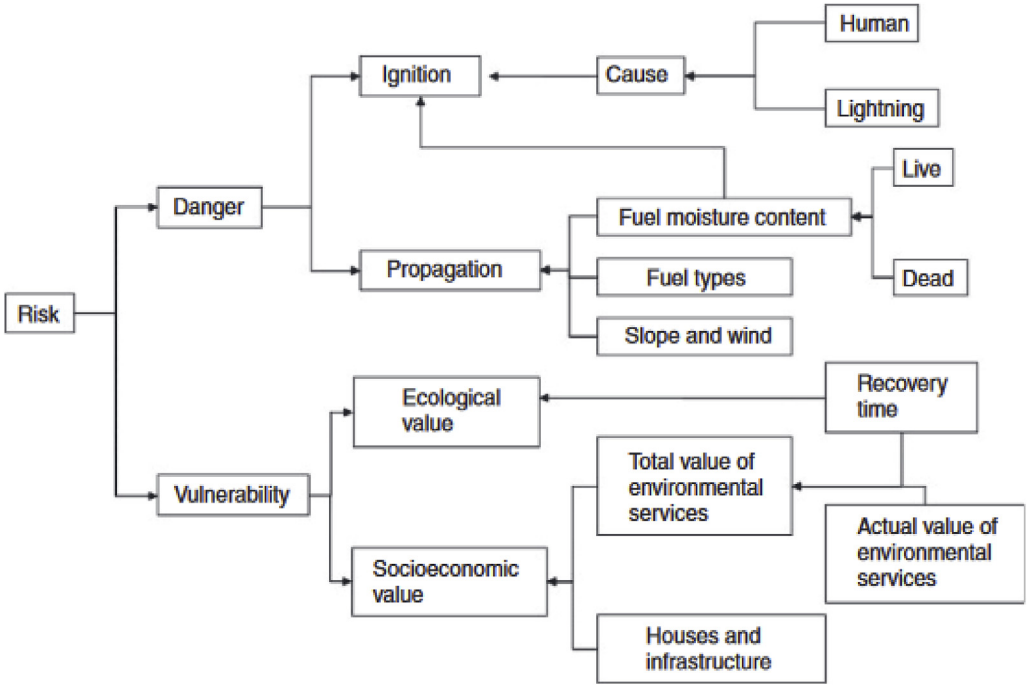

Fig. 1. Framework for an integrated analysis of variables affecting fire risk assessment (based on Chuvieco et al., 2012).

the loss of the forest's function, mass reforestation with pines, and reduction of pasture areas since the mid-20th century, leading to a rise in shrubland and forest, landscape homogenization and, in short, an accumulation of combustible biomass (Scarascia-Mugnozza et al., 2000; Chauchard et al., 2007; Serra et al., 2008; Pausas and Keeley, 2009).

Among the proposals for modelling fire risk appearing in scientific literature, the one developed by Chuvieco et al. (2012) integrates the concepts of vulnerability and fire danger at the same level (Fig. 1). While the former relates to the potential effects of fire and assessment of the resources affected at an ecological and socio-economic level, fire danger includes factors affecting ignition and propagation of fire (Chuvieco et al., 2012). Among these, the fuel type sums up the properties of the vegetation that plays a crucial role in the propagation of fire and the amount of energy released and, thus, on the magnitude of the consequences for the ecosystems involved. In theory, more fuel could justify greater intensity (temperature and exposure time to flames) and therefore, much more destruction of key elements in the process of post-fire recovery (alteration of the seed banks, changes in physical and chemical soil properties, dieback of vegetation, etc.).

Regardless of competition from other types of factors, assessment of the vegetation in terms of combustibility is a complex task. In this context, the fuel models enable characteristics of the vegetation affecting the behaviour of fire to be simplified (size, compacting, density, chemical substances, etc.). One of the best-known classifications is the one proposed by Rothermel (1983), and adapted in the 1980s to the plant formations in Spain (MAPA, 1989). This author proposes 13 models of vegetation structure, depending on its combustibility. These models are identified by a quantity of fuel available (T/ha) and are arranged in 4 groups, based on combustibility and the propagation mode: pasture, shrub, litter below trees and felling residues.

Land managers try to control wildfires by prevention policies. Some of them seek to reduce the fuel by clearing shrubland. With this in mind, prescribed burning or prescribed fires are used, meaning planned fire to burn the accumulated fuel in a controlled manner (Fernandes et al., 2013). Many regional and national governments in Mediterranean areas of Europe finance prescribed burning (Ascoli et al., 2013), in some way similar to the burn-off traditionally done by shepherds to remove shrubland and promote pasture regeneration (Meitalié, 2006). Prescribed fires started in the United States and reached the Mediterranean European countries in the 1960s (Liacos, 1986). In the 1980s, they were carried out fairly frequently in Portugal, Spain, France and, to a lesser extent, in Italy (Montiel and Kraus, 2010). At present, approximately 10,000 ha/year are managed via prescribed burning in the European Mediterranean region (Fernandes et al., 2013). However, prescribed burning is not effective as the sole instrument to control the invasion of shrub into pasture (Briggs et al., 2005; Heisler et al., 2004; Nadal-Romero et al., 2018; Badía et al., 2017). The combination of controlled burning and guided grazing has been suggested as a good method to restore the ecosystems in areas with a long history of fires and grazing (Fuhlendorf et al., 2009; Ascoli et al., 2009; Komac et al., 2013), although the low number of livestock currently observed in many mountain areas leads to the failure of the fire-pasture balance (Ruiz-Mirazo et al., 2012).

Livestock grazing is another method used to try to control an accumulation of fuel. The European Union has strongly supported extensive livestock farming since 1992 with its Common Agricultural Policy (CAP), through the payment of subsidies, and extensification policies. In subsequent reforms of the CAP, measures promoting extensive livestock farming have been amplified, due to its socio-economic contribution, the preservation of the environment in depressed areas, and the provision of ecosystem services (Bernués et al., 2014). Against this backdrop, extensive livestock farming has been used as a tool to prevent shrubland expansion and densification by subsidising grazing in particular places, such as the fire-breaks and strategic areas to prevent fires or control their propagation (Lasanta et al., 2014). However, various studies have evidenced that grazing alone, with the present numbers of livestock in the Mediterranean mountains, is insufficient to prevent the advance of shrub (Bartolomé et al., 2000; Casasús et al., 2007; Ruiz-Mirazo et al., 2011; Álvarez-Martínez et al., 2016), which increases the likelihood of dangerous pasture fires, a difficult and sensitive issue in the Mediterranean countries of Europe (Ruiz-Mirazo et al., 2012).

In La Rioja (Spain), the Regional Government started an action plan in 1986 (henceforth called the Plan for Shrub Clearing, PSC) which combines shrubs clearing with livestock grazing. The PSC aims to control fire and boost the sustainability of mountain areas through