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Interactions of Landscape and Wildfire: Landscape Management Implications

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Abstract

Around half a million hectares of land in Southern Europe are consumed every year by wildfires which cause great environmental and socio-economic effects. Changes in climate and land use have increased the risk and danger of fire in recent decades. This paper analyzes scientific knowledge available on the relationship between the Mediterranean ecosystem and wildfires, with a focus on their implementation to identify landscape management recommendations and strategies that may be implemented to encourage ecosystems that are less fire-dangerous. The key results are that socio-economic factors have positively supported improvements in land management leading to an increase in fire risk in the past decade, major wildfires become more regularly occurring and the increase in fires occurrence promotes homogenous ecosystems protected by fire-prone shrub lands. There are also major gaps in knowledge about the challenges to address these issues and the policy and landscape management response that need to be adopted.

Key words: Climate Change, Fire Regime, Fire Hazard, Landscape Changes, Land Use/Land Cover Changes, Land Management, Mediterranean

Introduction

Every year in southern Europe about 45 000 forest fires are happening and about 0.5 million hectares of woodland and other rural areas are being burnt. In the last several decades the volume of fires has continued to grow dramatically given the resources invested over fire prevention and control. The environmental and socio-economic impact of wildfires is increasingly worried, particularly under a climate change atmosphere that will lead to rising wildfires in Europe in terms of severity and frequency[1]. At landscape level, wildfires come from a complex interaction between ignition sources, topography, weather and the coverage of the land. The land cover from a management perspective (related to the nature of vegetation and the loads of fuel) is the only landscape aspect that affects the fire behavior[2], [3]. Because of the abundance and arrangement of disturbance susceptible patch, wildfires begin at the local epicenter (ignition point) and spread across countries. Fire propagation rate by vegetation heterogeneity can be simplified or retarded. Therefore, fire inclination influences the spatial structure of fire combustion and spreads through environments, i.e. the differential fire activity of multiple soil-capacity forms not similarly prone to heat[4], [5]. Understood this connection between the vegetation trend and the spread of fire would help to establish guidelines for management of landscape rates to reduce the risk of fire in

Mediterranean ecosystems. The concept of fuel breaks of scale landscape is a simple application of such information, whose primary aim is to reduce fuel loads or to adjust the spatial structures of combustion fuel (i.e. the landscape structure) to make it disperse more efficiently, burn with less strength and severity and less expensive for combating a wildfire in well maintained landscape[6], [7]. Nonetheless, recognizing the ties between vegetation fires does not restrict management to a fuel break design, since it also allows identifying land use rules and the design and implementation of landscape policy goals (total flame patterns), ranging from forest and urban development policies, rural development. In this paper, the scientific literature available concerning fire-like relationships and landscape trends and provide a critical assessment of scientific findings with important implications for landscape management[8], [9]. It is the area of the European Mediterranean that is the most vulnerable to fire, with significant knowledge gaps in scientific research. The format of this analysis has been structured as a sequence of pages, each beginning with a term that provides an important message for landscape managers and policies and then discusses the scientific support that is available[10]. The final area discusses general recommendations, knowledge gaps and future trends in climate change for landscape managers.

1. The Position of Land Usage / Land Cover has increased the Risk of Mediterranean Landscape in Recent Decades:

Modifications of land use / land cover (LULC) are related to the fire hazard as a result of changes in plant structure and the distribution of fuel load which are the main driving factors of fire severity, together with the topography and the atmosphere. Thus, LULC change is directly associated with changes in the patterns of landfill fuel and fire hazard. Increased fire risks are anticipated where improvement in LULC has encouraged the increase of plant biomass (fuel load), such as those caused by abandoning land (e.g. crop estate on abandoned fields, pastures or woodlands) or afforestation operations. In comparison, other LULC improvements reduce the risk of fire in conjunction with biomass removal (for example, field clearance or forest harvesting).

1.1. Land Cover Affects the Patterns of Fire:

Fire hazards in ecosystems have been analyzed to validate the variations of numerous LULC-based fire hazards. Various studies have shown that, in spite of the presence of this covering in the landscape, the ground covering is the one most vulnerable to burning, that is to say, with a larger proportion of area burnt than predicted in various places in the Mediterranean basin: Italy, France, Spain, Portugal and Greece. This can be explained by several reasons, namely the lower importance given to the battle against fire in shrub land (as the least valuable ground cover assumption), the number of human irritation induced (e.g. burning for land management purposes, such as the development of pastures) and the higher rate of spreading fire in this LULC. In addition, the shrub lands are a common type of land cover on the steeper slope with a higher fire rate due to their shallower land which prevents dense forest from developing and abandoning hard-to-mechanize terrace cultivation. Alternatively,

the LULC is less fire-prone and burns in less than its landscape surface area in cultivated (especially those containing irrigated plants). The main reasons why agricultural areas are low fire resistant are their low combustibility, as well as their geographic association with human presence which enables faster detection of fires and easier fire fighting. Forests are generally more prone to fire than agricultural areas, but less prone to fire than hamlets. In a forest-related background, research in Portugal indicate that mature forests with broad leafed leaven and mixed forests are generally low risk for fire in contrast to oak, eucalyptus or pine- and eucalyptus mixed trees. Nevertheless, the layout of forests may be more important in determining risk than the composition of forests. In addition, the different types of forests may be explained by different fuel structures, such as the degree of canopy closure which restricts the growth and conservation of high-humidity vegetation of a grassy or shrubby fuel bed. There is some proof that develop evergreen oak timberlands can even become 'self-defensive' against fierce blazes, to the point of fire self-elimination notwithstanding scene synthesis, scene arrangement likewise has solid ramifications for fire danger. For instance, the spatial examples framed after the deserting of country zones have made scenes of high instability through expanding essentially the accessibility and contiguity of fuel loads. A few examinations have affirmed that fire risk was more noteworthy in the more touching and homogeneous portions of land. Different investigations applied imperviousness to fire rules to LULC types at the size of fire occasions or at both stand and scene scales and demonstrated that scene protection from fire was adversely impacted by the spatial contiguity of LULC, and emphatically affected by the assorted variety coming about because of fuel differentiate at fire edges. Reproduction models additionally demonstrated that fire spread and conduct were incredibly impacted by the spatial dissemination of powers.

1.2. Landscape Changes Have Been Expanding Fire Risk in the Most Recent Decades:

Investigations of LULC changes in the Mediterranean Europe regularly have a period range of 30e50 years, since the 1950's (agreeing with the most readily accessible aeronautical photos) to the start of the XXI century, in spite of the fact that there are special cases. The typical expansion of an examination territory is 3000e5000 ha, but on the other hand is exceptionally factor. Flying photos, satellite pictures and land use or land spread maps have been the most widely recognized wellsprings of information utilized. Countless examinations have given proof of expanded fire risk in Mediterranean country territories, principally because of the expanded front of woods and shrublands in regions with previous lower fuel loads and fire danger (for example farming or peaceful land). For instance, Van Doorn and Bakker (2007), in a district of southern Portugal, enrolled a 75% decrease in the territory of agrarian fields during the period 1985e2000, and an expansion in matorral (shrubland) and woodland ranches. For entire Italy, a 74% expanding expansion in backwoods spread during the period 1960e2000, and 20% abatement in farming regions. A few different investigations have indicated comparable examples of progress across various nations: Portugal, Spain, France, Italy, Greece and Israel, among others. Horticultural land deserting, including the

decay of peaceful exercises, is the significant driver of scene changes and expanded fire peril, for the most part in sloping zones. This surrender is brought about by the low monetary productivity of these territories and is regularly connected with maturing, displacement and country populace decays. Peripheral rural land, frequently situated in more extreme inclines, is the first to be surrendered. Vegetation progression at that point prompts scour infringement and timberland advancement. Regardless of whether cultivating exercises don't vanish totally, the surrender of conventional acts of abuse of timber and wood assets add to expanding fire risk. Reforestations and forestations, which have been advanced in the Mediterranean locale in the most recent decades, both under the extent of woodland arrangements, or, all the more as of late, as an approach driven administration elective in deserted rural land (for example have accomplished certain natural objectives (for example to build carbon sink limit or to stop desertification forms), however have likewise expanded fire danger while making enormous zones with homogeneous even-matured stands of combustible species.

2. The Role of Environment, Landscape Models and Fire-Restraint Policies in the Mediterranean Area are Becoming More Important:

2.1. Large Fires Become More Popular:

The recent history of the Mediterranean basin is relatively new in large fires (LF). The importance of LF in the Euro-Mediterranean was illustrated recently in extraordinary fire seasons. LFs account for a small fraction of the total amount of fires but account for a high percentage of the total area of land burned within the Mediterranean basin. They prefer to be present under unique, very unusual synoptic meteorological conditions (like high temperatures, prolonged drought and strong wind), have distinct behavioral patterns and disperse mechanisms, lower choices for suppression and are more detrimental to ecosystems depending on their levels of recurrence as well as on the landscape scale. Whilst studies have shown that LF incidence has decreased in Spain in recent decades, others have shown that patterns in Portugal, France and Europe have risen or declined over time over a span of ca. 20 years. For example, researchers have been studying LF in Portugal over the past 21 years and have noticed a cyclical pattern of extreme fire sizes for a return period of 3e5 years, suggesting that it could be a more than meteorological consequence of vegetation recovery (ie. fuel retention rating) post-fire reactions. 20 years indicated regional patterns can be quite complex. Other studies, on the other hand, found a significant rise in LF frequency in the Valencia region (Spain) duration from 1973e2006 relative to 1873e1972. In summary, although there has been an increase in the number of fireworks and total burnt areas in southern Europe, there is a clear trend toward -LF, as regional variation is common. Nevertheless, existing evidence suggests a monotonous or cyclically elevated LF level in several areas.

2.2. Fire Weather is Much More Important in Determining Fire Propagation than the Landscape Pattern:

Whether land patterns or meteorological conditions are the main controls for fire expansion or whether temperatures alone can explain the recent and projected fire trends in the Mediterranean basin are still under discussion. While landscape plays a less important role in determining what is burnt by fires, selectivity in the Mediterranean by fire towards certain types of LULC appear to have been less important in certain areas such as the boreal forest, the scenery plays a more crucial part in the spread of fire. Overall, inter-annual variation in burning areas is closely associated with annual drought, temperature or hybrid climate indices. This is illustrated by recent international remote sensing experiments and is used in regional fire models. Such indicators are true for the Mediterranean region and at the landscape level, with simple indices such as summer rainfall which explain significantly the yearly variability in burned area. For example the majority of fires occur at Cantabria (northern Spain) with "Suradas," a meteorological event combining high winds and low moisture leading to high-risk situations. The events of fire brands and spot fires could be further promoted by extreme fire weather, which results in indirect climate-related extreme fire events in relation to burned area. In the Mediterranean region, people-intensive fires have mainly caused natural combustion, but studies have shown that lightning fires have also occurred and some of the largest recorded fires are associated with this source. Therefore, an increase in natural ignitions, also affected by solar activity may induce a LF event.

2.3. Policies on Fire Suppression Rise Large-Scale Burning:

Fire control measures can also contribute to flame accumulation and LF outbreaks using a model of dynamics of vegetation and spilling of fire optimized with real data from 2 areas on the Iberian Peninsula, in order to assess the effects on the frequency of LF of various fire fighting capacities. However, their calculations found that the same total annual area of combustion but with a higher proportion of LF was obtained by higher firefighting efficiency or a reduced number of ignitions. Indeed, reinforced funding for fire-resistance policies (especially following catastrophic fire seasons) appeared in the Mediterranean countries, if not in combination with fuel management, to reduce small, yet not large, fires. Greece has been the source of incidents since the devastating fire season of 2000. As some have warned, a strong 2001e2006 fire control policy that appeared temporarily to succeed has not resolved the fire problem in the country. In 2007, Greece suffered its worst fire season ever, mostly as a result of the fuel build-up, with fires over 20000e30000 ha.

3. In Particular Locations and Formerly Burned Areas, Greater Fire Occurrence Produces Homogeneous Ecosystems Surrounded by Shrub lands*:*

In contrast to what could be anticipated in the fuel age paradigm of reducing fuel from wild fires, there is evidence that areas previously burnt are characterized by greater risk of burning compared to areas never burned. Therefore, the risk of future fires is reduced. It therefore appears that previous fires determine conditions that favor a new fire within a relatively short period of time. The repetitive combustion phenomenon may result in several spatial legacies that affect fire incidents, located within each other and contribute to a deep spatial

dependency on fire in previously incinerated areas. The mechanisms to which repeated burning can contribute and the consequences are summarized below.

3.1. In Particular, Topographical Locations the Risk of Fire is Higher:

Topography can influence the fire frequency and propagation rate (altitude, exposure, slopes). The factors behind these topographical results can be classified in the shape of the dynamics of fire combustion, fire activity, and fuel biomass in particular. Disengagement is not easy as these processes are interconnected and space-size (i.e. grain and extent) dependent. The topography deals with local winds, microclimates and, on the other hand, the vegetation type, fuel loads and humidity content. Several studies showed topographical influences on composition and structure of vegetation, transpiration and drying conditions, vegetation dynamics, the severity of fire and regeneration in post-fire vegetation. Moreover, human activities can explain some of the observed topographical effects on fire. For example, in certain regions greater inflammatory risks at higher altitudes were calculated due to an increased likelihood of sunlight and human use of fire in pasture management for livestock. In another region, high ignition risk is attributed to the presence of highways, human settlements as well as urban interfaces in flat and lower elevated areas.

3.2. The Fire Frequency Creates Shrub Land Homogenous Areas:

Many pine forests have a low fire level resistance. In East and Central Spain, for instance, *Pinus halepensis* and *Pinus pinaster* forests are very poorly tolerant when often burnt, and are converted into middle to long-term shrubland after burning. The explanation for this transition is related to the reproductive biology features of these pines. *P. halepensis* persons achieve full reproductive capacities by a canopy seed bank in their serotinous cones when they are 15e20 years old. Therefore, if a fire takes place over a pine stand with a return period less than this time window, pines will not regenerate, and the system of vegetative species is turned into a grass and shrubs dominated structure. A similar pattern for *Pinus brutia* forests should be expected.

Conclusion

The main consequences for policy and landscape management of the scientific research result. Four key issues that need clear environment and policy recommendations have been established. Population decrease, the abandonment of land by agriculture or the pastoral sector and the subsequent natural forest regeneration policies, notably in the former agriculture areas contribute to a' rural exodus' and a widespread increase in vegetation biomass, particularly in mountainous areas in Europe and subsequent increases in fire hazard. This phenomenon can only be effectively tackled by policies to improve the socio-economic conditions of rural people, promote new migration to rural areas, and pursue policies of agricultural development that facilitate practices to reduce the risk of burning, such as farming and livestock grazing. Such policies primarily apply not to land management but to

agriculture and rural development as well as economic issues. One of the most serious consequences of abandoning traditional practices is that in mountainous villages that traditionally are surrounded by a belt of agricultural land acting as a fuel pit landscape, forests and bogs now have a large fire hazard in the vicinity of houses and other infrastructures.

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