COMPARATIVE ANALYSIS OF POLICIES TO DEAL WITH WILDFIRE RISK

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ABSTRACT

Fires are the main driver of land degradation in forest areas in Mediterranean sub-humid regions and are likely to increase as a result of climate and other global changes. To prevent deleterious processes induced by fire, several policies and strategies have been implemented at national and regional scales. We perform a comparative study of policies and strategies of Portuguese and Spanish (Comunitat Valenciana) cases in order to assess the differences between them and identify their roles in forest fire prevention and in combating and mitigating impacts. To this end, we analyse the sustainability objectives stated in the legislation of each country to identify the strategies used to deal with forest fires and the extent to which they are integrated to achieve the sustainability objectives they pursue. The comparative analysis includes an assessment of sustainability, evaluated by the explicitness of the objectives, and identifies how the lines of action contribute to reach these objectives. We found different levels of complexity and that the adoption or rejection of some of the techniques is closely related to the tradition and the experience of local communities. This analysis highlights the importance of local characteristics and the stakeholders, involvement in designing effective strategies to reduce fire risk. Copyright © 2014 John Wiley & Sons, Ltd.

KEYWORDS: forest fires; strategies; policies; legislation; Portugal; Spain

INTRODUCTION

The establishment and coordination of policies, defining strategies and actions are fundamental to mitigate desertification processes. The efficiency of these policies and strategies will ultimately influence landscape sustainability, including environmental and socio-economic dimensions. Forest fires are the main deleterious process in Mediterranean sub-humid regions (Ferreira et al., 2009). Albeit a natural phenomenon, increasing frequency of wildfires, with increasingly shorter return periods resulting from global changes (e.g. climatic, land-use and management practices changes), induces severe soil degradation processes (Tábara et al., 2003; Ferreira, 2009; Ferreira et al., 2009; Nunes, 2012; Collins et al., 2013; Moreno et al., 2013).

In the Iberian Peninsula, socio-economic transformations led to major changes in management practices and to the landscape structure over the last 70 years, causing a decrease in management pressure on forest and rangeland areas and allowing fuel loads to increase (Ferreira et al., 2009; Nunes, 2012; Collins et al., 2013). These changes resulted from depopulation, an ageing remaining population and the abandonment of traditional rural practices such as grazing, wood collection and farming and have reduced the detection and fast intervention capacity linked to fire, thus boosting forest fire risk (Busenberg, 2004; Kalabokidis et al., 2008; Ferreira et al., 2009; Nunes, 2012; San-Miguel-Ayanz et al., 2013). Loss of control over the fuel load is considered the prevailing factor that explains the increase of forest fire risk (Tábara et al., 2003; Ferreira et al., 2009; Nunes, 2012; Moreno et al., 2013). This new reality is also affected by extreme climatic events (Ferreira, 2009; Nunes, 2012). The increasing occurrence of abnormal, very hot weather conditions, that may not particularly affect fire occurrence in an intensively managed landscape, is now a major factor of fire incidence and therefore of ecosystem degradation in the mostly un-managed landscape.

Although policies must foresee and develop strategies to reduce wildfire risk, they need to be maintained flexibly to accommodate environmental variability and trends as well
as innovations in risk management solutions. At the same time, they need to incorporate changing societal needs and interests. Risk management solutions are the subject of this paper and are analysed later. They range from techniques implemented at the plot level, such as understorey management or the creation of pasture areas, to the construction of infrastructure and the development of integrated and participatory landscape management strategies such as forest intervention zones (ZIFs). All such solutions have to accommodate changing interests driven by an ageing population. Landscape and economic diversification is required, in order to generate income leveys to reverse depopulation and entice the remaining youth to stay. It should also consider plantation diversity to enhance both the landscape and economical incomes.

Forest fire mitigation and adaptation strategies to a more frequent fire regime and measures within policy and law vary widely. They can be bound together, integrated and even coincide at the plan and infrastructure implementation levels. This gives rise to a number of opportunities to develop policies with multiple objectives of maintaining and increasing biodiversity, landscape quality and ecosystem services, as well as the livelihoods of local communities. The co-benefits of combining fire mitigation and adaptation measures make their adoption all the more compelling. Conflict may jeopardize the implementation of a given approach (Maas et al., 2012), so effective policies must reconcile conflicting societal values and perceptions of the problem through the ways in which it is addressed.

In this paper, we analyse current laws and policies in Portugal and in the autonomous community of Valencia (Comunitat Valenciana), Spain, to evaluate whether they follow primarily a fire prevention and/or suppression strategy and to identify what is driving the strategies. This analysis provides insight to the policies, implementation actions and their performance, which is essential to improve the frameworks needed to deal with the fire problem. Attention is paid to technical solutions, the involvement of key actors and stakeholders, and the way interventions are structured.

The pertinence of this approach lies in the number of fires, and the fact that the burned area has not decreased significantly, despite efforts and financial resources geared towards implementation of actions in the field. We question whether the legal framework and strategy to reduce fire hazard are robust or whether new, more integrated strategies need to be implemented.

MANAGING FIRE IN THE MEDITERRANEAN CLIMATE REGIONS

Historical Context

Mediterranean Basin ecosystems have long been shaped by humans who intensely used ecosystem resources and changed the natural land cover, which was typically composed of forests and woodlands (Grove & Rackham, 2001). Agro-pastoralism has existed in the region since at least the mid-Holocene, when fire started to be used intensively to open the canopy and increase herbaceous associations (Lepart & Debussche, 1992). Ancestral communities started to use fire as a tool to manage the landscape and build a more secure milieu for humans (Keeley, 2002). Traditional fire management practices have regained visibility while searching for new approaches to deal with increasing fire risk (Arkle & Pilliod, 2010; McCaw, 2013). Understanding how, when and why local communities use and manage fire is extremely important in developing and implementing fire management strategies (Ganz & Moore, 2002).

In many countries, the overwhelming forest fire problem is a consequence of large-scale land-use changes over the past century. This is the case in Portugal, where the forest fire problem started in the mid-1970s, after a profound land-use change process that began in the 1930s (Ferreira et al., 2009). Fires evolved from being insignificant prior to the 1970s (<150 fires, <6,000 ha burned annually in Portugal), to an issue of concern after that (~117,000 and 187,000 ha annually burned in Portugal and Spain, respectively, between 1980 and 2005) (Ferreira et al., 2009). One reason for this increase was that marginally productive agricultural lands were either converted to forest plantations or abandoned. Increased wildfires accompanied land abandonment (Margaris et al., 1996; Moreno, 1999), a pattern that has been attributed to biomass accumulation in forest and shrub areas in wet Mediterranean regions (Fairbrother & Turnley, 2005; Ferreira et al., 2005a). Following widespread afforestation, a policy of complete fire suppression was implemented in Portugal, which, in combination with the out-migration of an extremely high percentage of the local population, led to an abnormal fuel load that built up to high fire frequency, spread and behaviour.

The Comunitat Valenciana, Spain, witnessed a similar process of rural abandonment from the 1950s. This increased the frequency of large fires from the late 1970s and became a persistent problem in the following decades (Pausas, 2004b). The main current land-use change process at landscape scale occurring throughout the Mediterranean Basin is the replacement of local species with very flammable vegetation in the early successional stages (Bonet & Pausas, 2007). Changes in traditional land uses and lifestyles resulted in farmland abandonment and led to an increase in accumulated fuel of early successional species, with high connectivity between the fuel stages (i.e. litter layer, shrubs, tree canopies). This, together with the increase in population in the wildland/urban interface (and thus increased fire ignitions, e.g. Keeley et al., 1999) and the rise in temperatures, may explain the sudden escalation of burned areas during the 1970s in Comunitat Valenciana (Pausas, 2004a).
The Portuguese and Comunitat Valenciana cases present an interesting comparison because their legal frameworks to tackle forest fires present significant differences due to both historical reasons and diverging strategic choices. In this paper, we aim to identify the differences between the two systems and understand the processes that result in those differences. This is particularly important if we are to design better and relevant forest fire policy frameworks.

**Evolving Legislation Frameworks**

Improving wildfire prevention, mitigating fire impacts and recovering burned ecosystems involve applying planning, design and performance standards that master the organization, infrastructures and management of forest and rangeland areas. The legal framework plays an important role in this process. The internal consistency of the documents that embody the legal framework strategy and the extent to which they include the stakeholders’ views and aspirations is of paramount importance in successfully tackling the problem.

Although immediate fire suppression is to some extent disconnected from long-term wildfire management, long-term adaptations to wildfire risk can significantly reduce the challenges of fire suppression. Laws and regulations linked to wildfire management often have to integrate the existing legal frameworks at all vertical and horizontal levels of government to be effective. In addressing wildfire risk, it is necessary to review and coordinate existing laws and regulations and develop new solutions to provide enhanced expert guidance in various fields (forestry, infrastructures, agriculture, etc.), make key policy decisions, enlist the support of multiple stakeholders and engage communities within and adjacent to fire-prone areas (Maas et al., 2012).

Many policy decisions have to be made as fire mitigation and adaptation initiatives are developed. Among the challenges of constructing a fire risk management legislative framework are potential conflicts between short-term goals of reducing fire risk and long-term goals of adapting forest and landscape structures to the new equilibrium post-change. Adaptation measures may in some instances conflict with mitigation measures (adaptation may require a complete change of land use, which will collide with the construction of mitigation infrastructures or specific land management practices that become redundant). Careful consideration must be given to these competing interests and to the diversity of actions to be taken.

Engagement of a broad range of stakeholders, both governmental and private, is needed to craft optimal decisions, inspire individual action and create the political will to implement adaptation action steps, while promoting mutual learning (Stringer et al., 2006). To achieve optimal results, a coordinated effort is needed to harmonize measures and legal revisions by the legislative branches of European, national, regional and local governmental authorities and agencies that can influence forest planning and management and wildfire prevention and reduction. In this regard, it is important to note that the European Union (EU) has changed the structure of countries’ laws, especially environmental laws, in fundamental ways: first, in what concerns pollution and degradation prevention, reappraising the impacts on neighbouring areas and, second, by promoting greater involvement of the public in decision-making processes (Konisky & Beierle, 2001; Reed, 2008).

Wildfire risk management depends on local societal, economic and environmental characteristics. The diversity of these characteristics across Europe is why, in the light of the subsidiarity principle, the EU does not have a specific legislation body on wildfire or its prevention. Yet, there is a framework set by the Report to the Standing Forestry Committee (EU, 2012) contributing to the development of a new EU Forest Strategy. This is used by Portugal and Spain to guide implementation of specific measures depending on the characteristics of the territory, the socio-economic context and the cultural/traditional background.

**FIRE MANAGEMENT IN PORTUGAL AND COMUNITAT VALENCIANA**

**Policy Frameworks**

Forest fires have always occurred and will continue to occur in Mediterranean regions. The objective of a fire prevention strategy is to reduce the burned area. Such a strategy is rooted in sustainability principles designed to maintain ecosystems and the definition of measures to optimize forest planning and management. In Portugal, the entire fire mitigation strategy is based on legislation that governs the forest area and its management (Figure 1). Law and regulatory enforcement (any policy, law or regulation approval by the Government) is implemented and monitored by the Institute of Conservation of Nature and Forests (ICNF).

In Spain, the strategy follows a path similar to Portugal, although with a slightly different structure (Figure 2). After approval by the central Government, enforcement is performed by each of the regional Spanish communities that have legislative autonomy to establish laws and guidelines for their territory. The Civil Protection agency that coordinates emergency responses is involved in this process as the responsible entity for approving the emergency plans of the separate autonomous communities. This process is therefore different from the Portuguese process where the same plan and actions are enforced across the entire country.

The Spanish process includes the definition of preferential actions to prevent and fight wildfires at the autonomous community level, allowing better adaptation to local environmental, socio-economic and cultural conditions. This may be considered beneficial because decisions are designed
to consider the local territorial conditions, as well as local acceptance and rejection. For instance, prescribed fire is forbidden in the Comunitat Valenciana but is allowed in Catalonia, Galicia, Asturias and Castilla-León. This makes comparison with the Portuguese case study more interesting and fruitful.

The various documents issued at national and autonomous region levels are complementary, allowing actions in different areas with the common goal of reducing the area burned. The strategic sustainability objectives (SO) that endorse the approaches of both Portugal and the Comunitat Valenciana are shown in Table I.
Lines of Action

According to Figures 1 and 2, several solutions are enforced to deal with wildfires, including strategies and approaches that combine some of these solutions. For instance, construction of ZIFs can include prescribed fire that is a widespread technique used to manage fuel loads in rangelands and forest stands. Table I presents a description of the solutions in a sequence of increasing complexity. Spanish solutions to some extent overlap the Portuguese ones. For example, Spain’s ‘Preventive forest practices’ and the ‘Fragmentation of Forest Areas’ are basically equivalent to the Portuguese ‘Forest Stand Management and Recovery’.

Promotion of Grazing

This measure encourages grazing activities in forest and rangeland. In mountain areas, small ruminants, particularly goats, are used to manage the fuel load in the understory vegetation and therefore reduce wildfire risk. The introduction of grazing implies the promotion of landscape and economic diversity, which will help build conditions for human population to increase.

Fire Suppression Infrastructure

Fire suppression infrastructure refers to the equipment and infrastructure set in the landscape to help suppress fires. It includes the detection and fighting of forest fires and comprises lookout towers, as well as small first intervention brigades that patrol the forest areas during dry spells to detect and extinguish forest fires at an early stage. It also includes the road network that allows fast interventions, the existence of water tanks and fire breaks.

Prescribed Fire

Prescribed fire is probably the most controversial technique of wildfire prevention, although it was initially used to reduce forest fire risk by reducing organic matter accumulation and increasing landscape diversity. In Portugal, prescribed fire was originally used by shepherds to clear forest and shrubland and improve pastures in sparsely inhabited mountain areas, before the mid-20th century reforestation effort. In the last two decades, prescribed fire has been slowly and steadily re-introduced as a forest and shrubland management practice (Fernandes & Botelho, 2003). Prescribed fire consists of the burning of rangeland and understory under forest stands in winter, when environmental conditions allow for a low-intensity and low-temperature burn, therefore reducing soil and ecosystem degradation impacts. It is typically performed against the wind, from the top to the bottom of the slope (Ferreira et al., 2005b; Stoof et al., 2012).

Forest Stands Management and Recovery

An effort is underway to introduce new ideas in the reforestation process in Portugal (Silva & Pascoa, 2002). This includes establishment of a network of fuel management strips, strategically distributed across the landscape. Road and firebreak locations can be optimized to reduce fire progression risk by providing fuel discontinuity. Several techniques can be used (Silva & Lima, 2002). Land planning

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Table I. Relevant objectives and milestones in the legislation from Portugal and Comunitat Valenciana (Spain)

<table>
<thead>
<tr>
<th>Legislation</th>
<th>SO</th>
<th>Relevant objectives and milestones</th>
<th>Fire prevention (P)</th>
<th>Fire suppression (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal PNDFCI 1</td>
<td></td>
<td>Increase regional resilience to forest fires</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduction of wildfire occurrence</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improve the efficiency of wildfire combat and management</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>strategies</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Recover and rehabilitate burned ecosystems</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implementation of a functional and efficient management</td>
<td>P/S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comunitat Valenciana (Spain)</td>
<td></td>
<td>Preventive afforestation</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>State law on forest fires</td>
<td></td>
<td>Planning for the prevention of forest fire occurrence</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Management of fire use and fire ignition aftermath activities</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organization of fire extinguishing</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Promote collective actions</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recover burned areas</td>
<td>P/S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Punishment System</td>
<td>P</td>
<td></td>
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</tbody>
</table>

SO, sustainability objectives defined in the legislation of the two countries.
is of paramount importance in this context, as it serves as a guideline for the concerted management of the ZIF. These plans allow the ranking and identification of fire risk and promote the creation of discontinuity to reduce fire progression. The revamped reforestation process is also guided by fire prevention philosophies that translate into different solutions and practices for various geomorphologic landscape units, the management of different vegetation types, and the choice of the correct tree species for the specific climatic regions that often vary by microclimatic conditions (Gomes & Silva, 2002).

**Forest Intervention Areas (ZIF)**
The ZIF approach was integrated in the restructuring of the Portuguese legal framework for forest management and for the protection of forest against wildfires after the catastrophic wildfires in 2003. The main objectives of the ZIF approach are as follows: i) to promote the efficient management of forests; ii) to mitigate the current constraints to forest intervention, namely land structure and size; iii) to develop structural measures to defend forests against fires; iv) to give spatial coherence to the interventions; v) to apply national rules and guidelines, provided by the National Forest Strategy and the PNDFCI (Figure 1) and by the regional and municipal plans; and (vi) to promote sustainable forest management. The process constitutes three major stages: i) the legal procedure; ii) the planning stage; and iii) the implementation stage. The first stage concerns legal requirements needed to implement the ZIF. The supporting founding group needs to promote local meetings to encourage other landowners to join in and should prepare the entire formal requirement for submission to ICNF.

Each ZIF is managed by a single entity and approved by landowners and producers who are responsible for defining the Forest Management Plan (PGF), where the forestry operations and activities are defined following the guidelines of the Regional Forest Plan and the Specific Plan for Forest Intervention (PEIF). The plan is approved by ICNF. The implementation of interventions and actions defined in the PGF and PEIF is the responsibility of forest owners. Funding is provided by ZIF members through a common fund to implement actions for mutual benefits and by national and European public financial instruments. Active involvement of landowners in all ZIF stages is a key factor for its success (Martins & Borges, 2007). Several information sessions and public meetings have to take place to make landowners become ZIF members. For further details, please refer to Valente et al. (2013).

**ANALYSIS OF THE PORTUGUESE AND COMUNITAT VALENCIANA STRATEGIES**

**Alignment of Actions with Strategic Objectives**
In both Portugal and the Comunitat Valenciana, fire management strategies include prevention and suppression (Table I). The Spanish strategy actively promotes collective action as a key approach to reduce burned area. In Portugal, given the small and dispersed property structure, such a collective approach is also desirable and sometimes pursued in the ZIF context, although not as explicit as in the Comunitat Valenciana. Analysis of how the SOs are pursued by the actions envisaged in the legislation and implemented in the field allowed us to study the level of consistency of the policies and likelihood of attaining those aims. Table II shows how the actions contribute towards achieving the SOs defined in the legislation and evaluates their complementarity for Portugal. We evaluated the effectiveness and significance of the actions taken to deal with the wildfire problem using a strategic environmental assessment (SEA) methodology (Therivel, 2004). SEA is used to analyse the consistency of the actions envisaged in the legislation and the policy objectives. The approach consisted of identifying all the legislation and plans for a given country or region and assessing their performance against a set of strategic sustainability indicators defined by the country’s strategy. The evaluation was performed by a group of 10 Portuguese and Spanish specialists with known expertise in forest and fire issues who ranked how well the actions foreseen scored

<table>
<thead>
<tr>
<th>Table II. Coherence of the actions proposed with the sustainability objectives (SO) for Portugal. See Table I for explanation of SOs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actions</strong></td>
</tr>
<tr>
<td>Prescribed fire</td>
</tr>
<tr>
<td>ZIF</td>
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<tr>
<td>Fire suppression infrastructures</td>
</tr>
<tr>
<td>Forest stands planning and recovery</td>
</tr>
</tbody>
</table>

●, complementarity; X, conflict; —, no relation; 1, slightly significant; 2, significant; 3, very significant.
against the objectives, based on a consensus agreement process, supported by a Delphi methodology (Landeta, 2006). Experts with evaluations different from the average exposed their reasons to the group. This allowed the discussion of arguments that could have been forgotten and helped to reach a consensus.

There is some degree of complementarity between the application of prescribed fire and the majority of SOs to prevent the occurrence of forest fires in Portugal. The ZIF presents the most significant relations with the SOs. This derives from the fact that ZIFs are not a direct action but rather a management guide for private producers in order to create economies of scale and allow more effective land management. The conflict with SO 3 (Table II) arises from the fact that ZIF forest management options may not stem from the strategies defined and give priority to economic performance. These might clash with more sustainable actions, reducing their effectiveness. Nevertheless, this conflict is insignificant, as wildfires are such an overwhelming threat that they may imply the total ZIF’s asset loss. ZIFs are based on a philosophy of forest multifunctionality aimed at creating diversified land uses and activities such as production forest, conservation, pasture and agriculture.

Fire suppression infrastructure has an important positive relation with SOs 1–3. Nevertheless, infrastructure is unable to tackle the forest fire problem alone, making it necessary to use other techniques to reduce fire occurrence. Impacts on SO 4 and 5 are non-existent or irrelevant. SO 1 (improving the territory’s resilience to wildfires) was awarded the highest scores, as all three approaches/techniques significantly contribute to this objective. Forest stand planning and recovery is the solution that better fulfils the SOs, as it acts by preventing wildfires through the adoption of more suitable afforestation planning practices. It should be noted that the measures contribute to fulfilling the SOs and in some places are actually implemented together in a complementary way.

Table III presents the same analysis performed for the Comunitat Valenciana in Spain. Preventive forestry and infrastructure networks stand out as the actions that best contribute to achieving the SOs of the Comunitat Valenciana strategy with no conflicts. The actions taken to fragment the land use in forest areas and promote grazing may create conflict, especially with SOs 3, 5 and 6. In what concerns forest fragmentation, conflicts may arise if the actions taken do not match the principles of association and if there are significant differences with the SOs of post-fire management actions. In what concerns the promotion of grazing, conflict may arise with SO 3, related to fire management and the identification of ignition causes, as fire can be used by shepherds to improve grazing areas, which leads to enhanced wildfire ignition risk. SOs 1 and 2, related with fire prevention, are those better fulfilled, as all the measures contribute to their achievement. A major drawback is their poor relation with collective action and with post-fire recovery. This is a result of the strong preventive character of the Spanish strategy to combat wildfire.

**Impacts of Actions on Sustainable Development**

Despite efforts to prevent wildfires, fire is a key natural factor in Mediterranean ecosystems, which is why it is impossible and undesirable to completely eradicate them. Although prevention is the touchstone of current strategies to reduce the impact of wildfires, it is of utmost pertinence to develop contingency plans for wildfire occurrence. The occurrence of fire is not *per se* a deleterious process. What is of concern is their increasing frequency, as it does not allow the ecosystems to achieve the climax stages. A second concern is the large extent of burned areas, which leads to the destruction of biodiversity and disrupts ecosystems that are targeted for preservation and conservation and, at the same time, fire disturbs the local human communities at the economic and social level. A key impact is observed on the soils that, due to the increasing fire frequency, fail to recover, with significant impacts on the water cycle and erosion rates (for instance, Ferreira et al., 2005a). Wildfires release a significant amount of carbon into the atmosphere and reduce

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**Table III. Coherence of the actions proposed by the Comunitat Valenciana (Spain) and the effect on their SOs**

<table>
<thead>
<tr>
<th>Actions</th>
<th>SO 1 preventive afforestation</th>
<th>SO 2 planning</th>
<th>SO 3 fire management</th>
<th>SO 4 fire combat</th>
<th>SO 5 collective actions</th>
<th>SO 6 recovery</th>
<th>SO 7 sanction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventive silviculture</td>
<td>●3</td>
<td>●3</td>
<td>●2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Fragmentation of forest areas</td>
<td>●3</td>
<td>●3</td>
<td>—</td>
<td>—</td>
<td>X2</td>
<td>X2</td>
<td>—</td>
</tr>
<tr>
<td>Grazing promotion</td>
<td>●2</td>
<td>●1</td>
<td>X1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Infrastructure networks</td>
<td>●1</td>
<td>●2</td>
<td>●1</td>
<td>●3</td>
<td>●3</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

●, complementarity; X, conflict; —, no relation; 1, slightly significant; 2, significant; 3, very significant.

the forest area, decreasing the amount of CO$_2$ captured and stored, especially in the soil and the above ground biomass. This is highly relevant in the present context where the carbon footprint is used as a sustainability indicator at the regional scale.

All measures used to prevent fire should be studied and implemented under an emergency and prevention plan to apply fire contingency solutions for different scenarios. Thus, planning is a touchstone to the achievement of SOs. To evaluate those objectives, we defined a set of criteria to measure the environmental impact of the legislation framework, based on authors’ knowledge of the degradation effects of fire (Table IV). Results were pooled from all authors to identify a positive or negative impact. Pooled results are presented in Table IV, in which SOs in the legislation are linked to potential impacts on wildfire risk reduction, soil protection, biodiversity, water resources, economy and risk for the populations.

Table IV shows that endangered human populations are positively affected by the actions implemented in Portugal. In Spain, reduction of fire risk, economic risk and risk for human populations are most positively affected. In Portugal, the preventive character is not so evident; many forest areas are abandoned, and the owners are not even known. This makes it difficult to adopt a preventive policy if there is no one to put it into practice.

Despite the geographic closeness of Portugal and Spain, prescribed fire is not applied in many Spanish regions and is not allowed in the Comunitat Valenciana. This results from the different agricultural traditions (wildfire was not traditionally used) and the possible lack of knowledge about the technique. Preventing the occurrence of forest fires helps to reduce the risks to ecosystems and to humans. Nevertheless, as fire is a key factor in Mediterranean ecosystems, it is important for it to occur in a controlled and monitored way, for instance through the use of prescribed fire.

The key strategy to prevent wildfires has always been the process of land management planning. The definition of conservation measures adapted to the characteristics of the territory and its ecosystems, their biodiversity, conservation of the soil’s basic functions and the maintenance of environmental integrity must ensure that actions are consistent, effective and sustainable. The policies in Portugal and the Comunitat Valenciana and their implementation in the territory reflect societal traditions. One of the main differences is the use of prescribed fire in the Portuguese case study. This practice was forbidden during the Estado Novo (fascist) regime, in the 1930s following a period of afforestation that demanded a complete ban of fire. In the Comunitat Valenciana case, prescribed fire was not a traditional technique; hence, it is not envisaged as a solution.

Although the SOs in the two study cases converge on strategies to increase the resilience to forest fires, there are some differences between them. Most notably, the Portuguese policies directly address the problem of wildfire occurrence with a prominent role for prescribed fire and other understorey control actions, whereas in the Comunitat Valenciana, priority is given to fire suppression and wildfire prevention is carried out at the planning level. Both cases present recovery objectives, and the seriousness of the threat and the aftermath impacts justify the importance of management activities.

**Consideration of Multiple Objectives**

To achieve sustainability, the actions must be designed to allow the integration of fire prevention in harmony with economic objectives, landscape diversity and the security of populations. Without economic sustainability, the entire strategy is doomed, and with no social benefits, there is a risk that lack of commitment of the local population will hinder implementation of any strategy. New forms of

<table>
<thead>
<tr>
<th></th>
<th>Reduction of wildfire risk</th>
<th>Soil protection</th>
<th>Biodiversity</th>
<th>Water resources</th>
<th>Economy</th>
<th>Reduce risk for populations</th>
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<td>Fire suppression</td>
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<td><strong>Comunitat Valenciana</strong></td>
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<td>Preventive silviculture$^*$</td>
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$^*$Seen as a strategy and not as a measure since it integrates a set of actions.
governance involving the stakeholders are a touchstone of the Portuguese approach, essentially through implementation of the ZIF strategy. The Comunitat Valenciana also promotes collective approaches, or the involvement of local communities and other stakeholders in the planning processes. This is a touchstone in the entire implementation strategy to prevent wildfires and improve forest ecosystem resilience. It is fundamental to improve, intervene, maintain, clean or reforest, but more importantly, human action is fundamental to preserve the forest areas.

The continuous increase in fire frequency and intensity has led to questioning of the effectiveness of costly technologies for fire suppression and, therefore, emphasizes holistic management and proactive approaches, mostly focused on prevention activities (Ganz & Moore, 2002). These approaches demand the involvement of stakeholders in policy-making to increase the social acceptance and implementation of actions. Up to the most recent policies, legislation and strategies, there was a poor involvement of stakeholders in both Portugal and Spain. This realization allows for defining policy actions to reduce fire occurrence that call for owners’ liability, with the definition of effective penalties, of practical and rapid implementation, together with the definition of strategies to encourage more intensive land management and the promotion of integrated strategies to manage natural assets.

Also, the policies and strategies to promote rural development have not met the desired objectives. The depopulation that resulted from this failure has led to the primacy of more practical and direct measures and actions connected with the prevention of fire (Ferreira et al., 2009). Although those measures and actions are rooted in ancient management practices and traditions, they lack an integrated vision of local and regional sustainable development.

The acceptance or not of prescribed burning is a major difference between Portuguese and Spanish (Comunitat Valenciana) policies related to wildfires. The fact that evolving policies represent implementation strategies and measures that are rooted in what is accepted by the populations can be argued to hinder the development of innovative land management options, as it does not allow testing of new solutions.

Grazing is a measure widely used in both countries. Nevertheless, although it promotes landscape diversity, the selective effect of feeding has a negative impact on biodiversity and may compact the soil if the carrying capacity is exceeded. For this reason, it is not ranking in the top of the best preventive actions.

The fragmentation of forest areas to build a mosaic landscape reduces the spread of wildfires, as fragmentation acts as a barrier to fire progression due to the discontinuity of the landscape. However, if treated areas are large and abundant, it may generate impacts on the animal species that inhabit these territories, as their habitat may be sharply reduced. Nevertheless, in areas where commercial forest stands are dominant, landscape fragmentation can help to increase biodiversity. Another problem of fragmentation that occurs in regions with micro-parcels (such as in Portugal) is the lack of any kind of control over the land use. This may result in the exclusive dominance of commercial crops. This constitutes a significant structural drawback of the Portuguese policy. When an overall plan does not exist in areas of micro-property, the owners will not be able to develop a strategic view of the territory and will act according to their own interests in terms of obtaining the highest income possible. Even when a plan exists, owners might not like the land use that is planned for their land and will disregard it. The individual management of such small parcels is not sustainable and is hardly profitable.

Several authors have argued about the benefits of non-industrial private forest owners’ cooperation (Kittredge, 2005; Rickenbach et al., 2005; Stringer & Harris, 2014). There is an ethical and moral problem in implementing a plan in a given area without the consent of the owners. This is particularly so in areas with small properties, where one owner may be authorized to implement a forest commercial crop whereas another has to maintain a rangeland. In this respect, the association of forest producers and the integrated management of forest basins, an approach included in the ZIF system, is a step forward for integrative landscape management towards wildfire reduction and sustainability.

Participatory Planning and Complementarity of Actions

The adoption of preventive forestry, integrating actions to reach the different sustainability criteria for a given territory, is expected to become a successful strategy. The development of a strategy based on territorial characteristics and social and economic objectives can serve to improve the participatory process and involve the local communities in land management. In this spirit, Portugal has developed the ZIF approach, which establishes an association, in most cases led by private landowners (although it may be promoted by local entities such as municipalities). The ZIFs have spatial continuity and common characteristics that are defined to associate the owners and forest producers in a common policy and joint forest management strategies. Such strategies include fire prevention measures and also the prosecution of economic, environmental and social objectives towards sustainability. ZIF implementation reduces wildfire risk because it deals with both land management and fuel management. The key strategy to prevent wildfires is strongly rooted in the process of land management planning.

From the success of the ZIF model, we became aware of the importance of designing integrated measures able to integrate the different key actors involved in the process of
Planning and managing a given territory. The participation of stakeholders in the decision-making process is mandatory to improve management actions and the coordination between the different entities with responsibility in the territory, not only from the wildfire perspective but also those with responsibilities in nature conservation and economic development. The actions must meet the multiple functions of forest areas, as a prerequisite to improve its value as a natural asset.

The other studied strategies and techniques (Table IV) provide answers to certain sustainability criteria, with none answering fully to all criteria. In what concerns the post-fire actions, reforestation has highly positive impacts and should ideally be performed according to the techniques of preventive forestation to reduce fire risk in the future and improve fire suppression structures. The characteristics of pristine forest and native species from each region must be taken into consideration when developing recovery actions to improve the functioning and resilience of ecosystems and soils.

All the actions imply a reduction of wildfire risk and their impacts for the population. Soil protection is hampered by techniques that involve the use of heavy machinery that promote the concentration of overland flow and runoff, therefore increasing soil erosion potential. Overgrazing will have the same impact owing to soil compaction. The fragmentation of forest areas may also induce soil degradation if it implies an increase in infrastructure or soil deleterious actions as a consequence of land-use change. Water resources impacts are related to the disruption of natural water processes within the ecosystems. Any action that induces fast runoff processes and decreases soil water retention and aquifer recharge will have a negative impact on water resources.

Some of the actions will have a positive impact on biodiversity as a result of an increase in landscape diversity, which creates a diversity of conditions allowing a higher number of different species to prosper. This applies to all actions with the exception of grazing and infrastructure network implementation. Landscape diversity also has an important role in the economy. Land uses are often directly or indirectly linked to one or more economic activities, a reason why a more diverse landscape allows for diversification of income sources and income amounts.

CONCLUSIONS

A strategy towards sustainability can only be developed within a framework that is embodied by a specific vision or policy and consequent legislative framework that both defines the specific aims in a broader sustainable development perspective and builds and directs a set of actions towards achieving those aims. This includes setting the thresholds of action, defining which actions are allowed and which are not, and optimistically, how the actions to be implemented should be integrated to attain the best benefits.

The overwhelming impacts of wildfires in the two study areas led to the development of specific strategies to deal with the problem. From the analysis of the policies and legal framework, we can state that many of the approaches and techniques are alike, although some differences exist. From analysing the differences, we become aware that the solutions stem from the communities’ experience and tradition. This has decisive importance in setting the plan and in defining what is and is not allowed. Furthermore, the community vision also influences the value attributed to the resources, how they are managed and the value attributed to their interaction with the actions developed to defend them from wildfires.

In the entire process, public participation can be of utmost importance for the development of a common vision and the definition of actions that are accepted by consensus, therefore binding all stakeholders together. The latest approaches reflect this need to include the stakeholders in the decision-making process, in Portugal under the ZIF strategy and in the Comunitat Valenciana through the promotion of collective approaches. The two case studies revealed complex approaches, based on tradition, to face a fire management issue that originated from the 1970s. The current policy and legislation structure reflects a learning process to address a problem that only became relevant after that. This work highlights two main topics of consideration in building a successful policy and legal framework, namely inclusion of stakeholders in the decision-making process and accounting for local characteristics, with special emphasis on the local traditions, knowledge and mindsets in the strategies to tackle the wildfire problem. In the Portuguese case, this focus led to the return to traditional techniques such as prescribed fire that had been banned for more than 50 years, as well as to integrated management of mountains and rangelands. These traditional techniques were improved with the inclusion of modern scientific and technical knowledge that increases safety and improves performance.

Integration and coherence are desirable in setting the policy and legal mindsets, especially because several of the actions foreseen can produce conflicts with SOs. Although some conflicts may become significant, the conditions under which this may arise can be identified and ruled out. Fragmentation of forest zones in the Comunitat Valenciana may conflict with the promotion of collective approaches, as it may impact stakeholders differently and may hinder the recovery of burned areas. This may nevertheless be overcome through the implementation of a joint management unit, as in the Portuguese ZIF, which is expected to strengthen collective approaches and will improve post-fire response.
In what concerns the impacts on the sustainability criteria, some actions may have a negative influence on the preservation of some criteria. For this reason, it is important to develop integrated approaches, binding together different actions, even if they act at different management scales. It is necessary that the strategic actions taken to reduce the burned area aim also to prevent land and soil degradation. This will ensure that the natural functions and services of these lands are available for future generations.

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