Land Use Policy 56 (2016) 179–188

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

# Wildfires, forest management and landowners' collective action: A comparative approach at the local level

Maria João Canadas[a,b,*], Ana Novais[a,b], Marco Marques[a]

[a] Instituto Superior de Agronomia (ISA)/University of Lisbon, Portugal
[b] Forest Research Centre(CEF)/Tapada da Ajuda, 1349-017 Lisboa, Portugal

ARTICLE INFO

*Article history:*
Received 23 July 2015
Received in revised form 29 March 2016
Accepted 27 April 2016

*Keywords:*
Collective action
Forest management
Wildfire risk
Private forest owners
Territorial context
Fire management policies

ABSTRACT

The increase in frequency and extent of fires in Portugal has favoured the approval of a new legal frame for forest management, the Forest Intervention Zone (FIZ). Under this frame, a large contiguous surface involving numerous owners is subject to a single management plan, providing an opportunity for cooperation. Since 2005, 161 zones have been created but only half of them have had their management plan approved and very few are nearing its implementation.

Cooperation amongst private forest owners has usually been explained at the owner level. In an approach at the local level we examine local constraints and key-factors for cooperative landscape management. Building on the theory of collective action, a typology of FIZ/territories is established by Cluster Analysis using a group of ecological and socioeconomic variables expressing the characteristics of natural resources, owners' group, institutional arrangements, and external environment of FIZs.

Three clusters are identified. Where FIZs are smaller and biophysical resources impose greater wildfire susceptibility, the transaction costs for collective management are highest due to more numerous, aged, and dispersed owners and the absence of a land registry. Conversely, larger FIZs have fewer owners, more powerful management bodies, and higher public financial incentives, leading to greater performance rate. Nonetheless, since their resources are less fire-prone, and private profitability is higher, public support for collective action has a lower social return.

Addressing the heterogeneity of local systems of ecological and socioeconomic constraints is therefore a challenge faced by public policy makers seeking to mitigate wildfire risk.



## 1. Introduction

Wildfire is one of the main risks facing forests and rural areas in Mediterranean-climate zones. Frequency, severity, and extent of fires have been on the rise for the last 40 years and are expected to increase in the scenario of global climate change (Santos-Pereira et al., 2006; Fernandes et al., 2011). In Southern European countries fire hazard has been aggravated by socioeconomic and land-use changes in recent decades, namely agricultural and rural abandonment, dissociation between farming and forest activities, and shrubland growth (Baptista, 2010; Fernandes et al., 2014)

Despite the prevalence of fire suppression strategies, supranational authorities and the scientific community recognize that prevention is not only preferable but also a cost effective way to manage fires when compared to fire suppression (MCPFE, 2010). Fuels management is therefore discussed with regard to its potential to buffer the extent and severity of fires (Ager et al., 2006; Fernandes, 2013; Collins et al., 2013).

Because more than half of Europe's (EU-27) or the USA's forests are privately owned and non-industrial owners account for a considerable part of that area (Pulla et al., 2013; Mondal et al., 2013), landownership structure is viewed in those contexts as an obstacle to the implementation of fuel management strategies. The small scale of most of those landowners hinders the necessary landscape-level management (Bengston et al., 2001; Schulte et al., 2008; Gass et al., 2009). Multi-owner arrangements come then as solutions for individual owners to manage their land as part of larger units (Stevens et al., 1999; Rickenbach et al., 2004; Van-Gossum and De-Mayer, 2006).

Portugal presents the greatest density of burned area by territorial surface in all of Europe (Pereira et al., 2006). The years 2003 and 2005 stand out for that ratio and the emergence of extremely large fires, i.e. continuous burned areas covering 10,000 ha or more (Rego et al., 2013). The country also has the highest proportion

* Corresponding author at: Instituto Superior de Agronomia (ISA)/University of Lisbon, Portugal.
*E-mail addresses:* mjcanadas@isa.ulisboa.pt (M.J. Canadas), ananovais@isa.ulisboa.pt (A. Novais), marco.nevesmarques@gmail.com (M. Marques).

http://dx.doi.org/10.1016/j.landusepol.2016.04.035
0264-8377/

(73%) of forest land owned by non-industrial private forest (NIPF) owners, with the smallest average size: most owners hold small (≥1 to <5 ha) and very small (<1 ha) forests scattered over several holdings (Radich and Baptista, 2005; Baptista and Santos, 2005; Pulla et al., 2013).

Seeking to overcome what has been portrayed in Portugal as the small-scale property's huge problem, the adjustment of forest ownership structure has long been an ambition of the State and foresters (Pinho and Santos, 2012). The aftermath of the catastrophic summers of 2003 and 2005 provided the political momentum to address that purpose through the approval of a new legal frame for forest management, the "Forest Intervention Zone" (FIZ). The FIZ legislation (2005, revised in 2009) prescribes that the State is responsible for promoting the constitution of forest holdings large enough to enable efficiency gains in their management, thereby increasing "territorial resilience to fires".

The FIZ law calls for establishing a multi-owner contiguous surface of at least 1000 ha (in 2005, 750 ha in 2009) and that a minimum of half of this working area is owned by enrolled members. To be created, the FIZ should also have a managing body (MB), responsible for drawing up a single Forest Management Plan (FMP) for the whole area. This plan is then to be approved by the National Forest Authority, subject to compliance with the regional spatial plans devised by this entity. Once approved it would become mandatory inside FIZ boundaries for members and even non-members. Public funding for the establishment and first two years of operation was afterwards foreseen as well as positive discrimination in accessing rural development policy tools.

Compared to other multi-owner arrangements reported in the literature, the innovative character of this frame stems from its ambition to take the landscape as the effective management unit with a centralized planning approach (Kittredge, 2005; Schulte et al., 2008).

The first FIZ was created in 2006. By 2012 there were already 161 FIZs, whose accumulated area exceeded 800,000 ha and included more than 20,000 members (owners). This success was diminished in the implementation figures: only half of the FIZs had seen their FMP approved and only a negligible fraction was close to implementing coordinated management on individual properties. As FIZs range from North to South in the Portuguese Mainland, this implementation deficit shows considerable regional differences. At odds with initial legal goals, the approval of collective management plans has been slower precisely for those FIZs where wildfire susceptibility is greatest.

This innovative frame for multi-owner management and its policy context configure a policy instrument intended to promote the reduction of wildfire risk (Van-Gossum and De-Mayer, 2006; Brukas and Sallnäs, 2012), which needs owners' collective action. The aims of this study are: (1) explain regional differences in the performance of multi-owner management under FIZs by comparing the ecological and socioeconomic structural constraints to collective action; and (2) discuss from a socioeconomic perspective the enforcement (carrots or sticks) of cooperative management for mitigating wildfire risk under this legal frame, providing guidance for the reformulation of the policy instrument.

## 2. Analytical framework

Multi-private-owner cooperation for wildfire risk mitigation is still a largely unexplored matter of research (Fischer and Charnley, 2012). In order to build the analytical framework for our approach on NIPF owners' cooperation, we first address the issue of scale and nature of management for wildfire risk mitigation in which the need and goal of cooperation is conceptualized. The choices of the unit of analysis (the organization and its territory rather than the owner), and of the theoretical frame (collective action theories) are also addressed below.

### 2.1. *Management for wildfires risk mitigation: the scale and nature of its production*

From an ecological point of view landscape-level management is considered to be the appropriate scale for enhancing environmental and nature conservation values (Ask and Carlsson, 2000; Bengston et al., 2001; Gass et al., 2009; Schulte et al., 2008). Most of the values or outputs procured at that management level are non-marketable ones and can be pure or impure public goods (Ostrom, 2003).

Reduced wildfire risk via fuels management (fuelbreaks, stand density, forest composition, fuel treatments like pruning, thinning, clearing of brush or prescribed burning) can be viewed as an environmental value with pure public good characteristics (Busby and Albers, 2010). In fact, as a landscape attribute, it is impossible to exclude anyone from consuming it (non-excludable) and to diminish by anyone's consumption the consumption opportunities for others (non-rival) (Madureira et al., 2013). Because large wildfires affect landscapes with many landowners, thereby making property limits perfectly irrelevant, the risk an individual owner faces is a function of his decisions and those of all other surrounding landowners.

Landscape fire risk mitigation follows a non-linear or threshold production function because its production needs a "certain minimum amount of supply in order to provide significant value" (OECD, 2013). The spatial threshold for wildfire risk mitigation has to do with attaining landscape heterogeneity (patches of distinct forest species and agricultural uses), minimum infrastructures (such as neighbouring roads, fuelbreaks, water supply), key-spot interventions, and scale economies in fuel treatments (Hartsough et al., 2008; Moreira et al., 2011; Collins et al., 2013; Fernandes, 2013). The non-linear relationship between wildfire risk mitigation and scale of fuels management has been established by Ager et al. (2006): fuels treatment on 20% of total area (around 16,000 ha) resulted in 20%–50% reduction in burned area compared to the no-treatment situation.

### 2.2. ***Private owners' cooperation: choosing the unit of analysis***

Most recent literature on wildfires and owners' attitudes and practices refers to homeowners or residents rather than forest owners, and seldom considers the issue of collaboration amongst the latter (Jarret et al., 2009; Brummel et al., 2010; Bihari and Ryan, 2012; Fischer, 2012; Wyman et al., 2012). Busby and Albers (2010) and Fischer and Charnley (2012) address that issue exploring it in mixed ownership landscapes where public lands are relevant, but not in contexts of NIPF predominance.

All of these studies take the individual owner or resident as the unit of analysis, even when the sample covers several geographic locations (Bihari and Ryan, 2012). This is not surprising in light of the more general basis of studies on NIPF cooperation for forest management, which centre on owners' values, attitudes, and motivations in order to explain willingness to cooperate, or preferences toward alternative scenarios of coordination (Stevens et al., 1999; Klosowski et al., 2001; Belin et al., 2005; Berlin et al., 2006; Finley et al., 2006; Vokoun et al., 2010). Owners' segmentation makes it possible to design appropriate messages and adapt incentives for the desired behaviour.

However, the organization and its context can also be found as the unit of analysis in a few studies on NIPF owners' cooperation (Van-Gossum and De-Mayer, 2006; Blinn et al., 2007; Rickenbach, 2009). Investigating "natural resource partnerships" Williams and Ellefson (1996) explore the factors that favour the

success (assessed by duration) of the partnerships they compare. Wolf and Hufnagl-Eichiner (2007) stress the importance of institutional context to explain organizations' performance, identifying three types of resources as critical: financial, skills (technical information), and legitimacy.

Since in our work the success of the cooperative organization has to do with the implementation of management for wildfire mitigation, territorial context becomes important. In fact, geographic differences in wildfire occurrence and susceptibility are well documented and often explained by local biophysical or socioeconomic factors (Verde and Zêzere, 2010; Nunes, 2012; Torres-Manso et al., 2014; Mourão and Martinho, 2014). Considering that our goal is to explain differences in cooperation for wildfire risk mitigation, we take the organization (FIZ) and its territorial context (biophysical and socioeconomic) as the unit of analysis.

In our literature review we find various analytical frameworks used for studying the success of forest landowner cooperatives, namely Relevance-Effectiveness-Utility analysis, SWOT analysis, Importance Performance Analysis of the services provided, and Egocentric Network Analysis of members (Van-Gossum and De-Mayer, 2006; Blinn et al., 2007; Rickenbach, 2009). Nevertheless, a comparison of organizations' performance has rarely been undertaken. In addition, the criteria used for measuring performance seldom include the implementation of multi-owner landscape management (Van-Gossum and De-Mayer, 2006).

### 2.3. ***Owners'*** *collective action and wildfire mitigation: theoretical frame*

In order to compare the organizations' performance and incorporate the public good nature of wildfire risk mitigation in the analysis, we turn to collective action (CA) theories. CA may be broadly defined as action taken by a group (directly or on its behalf through an organization) in pursuit of members' common or perceived shared interests (Olson, 1971; OECD, 2013). Focused on natural resource management, the CA framework has increasingly ensured the integration of the ecological, social, and economic dimensions of the structure, process, and outcomes of CA (Agrawal, 2001; Ostrom, 2011; Ratner et al., 2013). Extensively used in natural resource management by resource users, especially of common-pool resources subject to overexploitation, the CA framework has not often been used to study management by NIPF owners (Ostrom, 2003; Poteete and Ostrom, 2008; Rickenbach, 2009).

The main elements in the CA framework are the context, the action arena, and the outcomes (Ostrom, 2011; Ratner et al., 2013). Key-factors of context can be divided into four categories: resource system characteristics, group characteristics, governance arrangements, and external environment (Agrawal, 2001; Padgee et al., 2006; Sapkota, et al., 2015; Doss and Meinzen-Dick, 2015). Context relevance to explain outcomes has been empirically acknowledged and those sets of factors are recognized as important for overcoming barriers, such as free-riding and transaction costs, and produce larger benefits (Ratner et al., 2013; OECD, 2013). This relevance is otherwise reinforced within the call for comparative rather than single-case analysis (Padgee et al., 2006; Poteete and Ostrom, 2008). In fact, comparisons across distinct contexts have been hindered by the diversity of CA objectives and factors pertaining to that diversity (Meinzen-Dick et al., 2004). As such, comparing groups "undertaking similar activities allows deeper analysis of performance drivers" (Place et al., 2004).

Many variables have been used to express context attributes. Group size is one of the most debated ones (Olson, 1971; Kollock, 1998; Poteete and Ostrom, 2008). Small groups and homogeneity of identities and interests are usually considered more appropriate since these can more easily prevent free-riding and allow face-to-face communication, reducing transaction costs. Likewise, the small-size, and well defined boundaries are seen as favourable attributes of the resource along with clear benefits from the resource and the action (Ostrom, 2003; Ratner et al., 2013). On the other hand, it is also acknowledged that larger groups can cover larger geographic areas and bring greater environmental benefits (OECD, 2013). For larger groups, sound governance arrangements and well devised rules are crucial (Ishiara and Pascual, 2009; López-Gunn, 2012). Whatever the size, financial and non-financial support from governments or other public entities is especially important at the beginning of CA because of higher initial transaction costs.

Considering these challenges, we contend that CA approaches offer a heuristic framework for the integration of ecological and socioeconomic contexts to compare the potential for multi-ownership management aimed at solving a problem of underinvestment, which creates landscapes that are more prone to fire.

## 3. Methodology and data

To explain regional differences in the performance of collective landscape management under the new policy instrument, our unit of analysis is the FIZ and its territorial context, which is assumed to be the county in which most of that FIZ is located. The FIZ is a formal organization having a group of owners (members of the organization), whose leadership is assumed by an entity (the MB) on behalf of the group, and a system of natural resources within an area (the FIZ's working area).

Forest management plan (FMP) implementation, which is expected to promote landscape management for wildfire risk reduction, is our unidimensional measure of CA success (Padgee et al., 2006). Because its achievement is a long-term goal (and therefore the degree of success is still inconclusive), we take the approval of that collective plan (dummy variable, Yes/No) as indicative of current performance. This approval is indeed a step toward FMP implementation as it presupposes a first CA consisting of a plan's appraisal at the general meeting of all forest owners and producers covered by the FIZ, before being submitted to the national authority for approval (Martins and Borges, 2007).

To explore differences in FMP approval across regions, a Cluster Analysis was performed with the Ward method. The variables used to measure the similarity between FIZ/territories are structural indicators of the above-mentioned key-factors for successful CA (Box 1) and rely upon available secondary information (see data sources of Box 1). Besides size, which is expected to relate negatively to performance, the group is also characterized by its social context and ownership structure (size and heterogeneity). Considering the latter, recall that FIZ's members are essentially private owners, but since 2009 common property units (*baldios*) have also been allowed to join as members. Besides resource size, susceptibility to wildfires and land use composition express respectively, the need for collective management to reduce susceptibility (public good) and the probability of obtaining or losing a net benefit from the forest (private good). Sound arrangements are measured by the relationship between the MB and the owner-members, and between the MB and other external entities. Financial and technical support, along with policy temporal context, characterize FIZ's external environment. Since property rights are clearly defined, the availability of land registries allows for an accurate match of each land plot with its owner.

Each of the resulting clusters consists of FIZ/territories having similar basic structural conditions for CA, which are different from the other FIZ/territory clusters. Thus, the solution retained is defined with nine continuous variables selected among those indicators (Box 1—*Variables defining the clusters*). Then, to validate this solution significance tests were performed on other external

**Table 1**
Clusters' social and spatial relevance.

| | Cluster | | | |
|---|---|---|---|---|
| | Small-scale FIZs of pinewoods | Medium-scale FIZs in higher density rural | Large-scale FIZs of montado | Total |
| FIZ's number | 85 | 65 | 11 | 161 |
| (%) | 53 | 40 | 7 | 100 |
| FIZ's total area ($Km^2$) | 2382.7 | 2998.4 | 2967.4 | 8348.5 |
| (%) | 28 | 36 | 36 | 100 |
| Members' number | 11396 | 9029 | 457 | 20882 |
| (%) | 55 | 43 | 2 | 100 |

variables that reflect key-factors (Box 1—*Variables validating the clusters*).

## 4. Results. A typology using the collective action perspective

Three clusters of FIZ/territories were established. The first, *small-scale FIZ of pinewoods* is the most numerous, with 53% of FIZ, followed by *medium-scale FIZ in higher density rural* with 40%, and just 7% for the third cluster, *large-scale FIZ of "montado"*[1] (Table 1). As regards social relevance, the clusters are even more unbalanced, given that the third cluster has just 2% of total owners' membership. Total surface on FIZs is more equally shared among clusters with 28% for the first, and 36% for each of the others.

### 4.1. Resource system characteristics

Average FIZ area increases from the first to the third cluster: 2821 ha, 4730 ha, and 26,994 ha (Table 2). Difference amongst clusters is meaningful in view of FIZs' physical size, and also their compactness (area-perimeter ratio of FIZ), and maximal contiguous surface covered by FIZs (Fig. 1). These three attributes, size, compactness, and contiguity, are highest for the third cluster and lowest for the first (Pinho and Santos, 2012). Considered for FIZ legal approval, the higher values of these attributes define the ideal unit of management sought by the law, in view of landscape-level management.

A clear distinction among clusters is present concerning wildfire susceptibility, forest species, and shrubland. This points to the need to prioritize efforts to mitigate susceptibility precisely in the clusters in which the ideal landscape level for FIZ working area seems hardest to achieve.

Indeed, wildfire susceptibility is higher for *small-scale FIZs,* established in more mountainous regions with more uncultivated area (37% of the surface) resulting from agricultural abandonment or burned forest, and Pine dominance (60% of forest stands' surface). High and very high susceptibility apply to more than two-thirds of these FIZs' area and almost half of them (44%) have over three-quarters of their surface with those degrees of susceptibility. In contrast, *large-scale FIZs* are established in the least mountainous regions with less area of higher fire susceptibility, limited uncultivated land, and have cork oak as the predominant stand. *Medium-scale FIZs* have eucalyptus as their main species and are in between the previous clusters for the other features.

### 4.2. Ownersí group characteristics

Due to the discrepancy between clusters' spatial and social weights, membership is not proportional to the clusters' areas. Average size of groups is 130 owners per FIZ. This figure is exceeded in the first two clusters – large groups – and around 40 for *FIZs of montado*—small groups (Table 2).

Geographic differences of property structure help to explain this situation. Established in landscapes where large estates dominate, average FIZ surface by member exceeds 600 ha for *FIZs of montado*. This average is only 33 ha for *FIZs of pinewoods* and 79 ha for *FIZ in higher density rural*, where common property land makes a slight appearance (3.2% of cluster area). Considering that in most cases FIZ members own around half of the FIZ working area (the minimum required by law), average property size for members ranges between 17 and 330 ha from the first to the third cluster. Expected property size for non-members inside a FIZ boundary is much smaller (Deus, 2010).

Rural density and rural demographic potential also distinguish the clusters. Considering the latter as a proxy for owners' ageing and absenteeism, which might hinder cooperation, the cluster *in higher density rural* has a more favourable situation, the poorest being associated with *small-scale FIZs*.

### 4.3. Governance arrangements

The large majority of FIZs are managed by a forest owners' association (FOA) and as such the nature of the MB introduces no cluster distinction. The same does not apply to MB specificity, average FIZ's area by membership in MB, and MB professionalization. FIZs with a specific MB are overrepresented in *small-scale* cluster (26%), whose MBs have the smallest area by member, 24 ha (Table 2). Management bodies of *FIZ of montado* cluster can be said to present greater professionalization, as they manage on average 3.7 FIZ and more than 800 $km^2$, while those of *medium FIZ* manage 3.3 FIZs and only 175 $km^2$, and *FIZ of pinewoods* manage 2.6 FIZ and less than 100 $km^2$.

### 4.4. External environment. Land registry, and public funding

The existence of a land registry differentiates the clusters considerably. Its absence is more evident in *small-scale FIZ* – only 21% of them have registries – with implications on data availability for ownership structure and remarkably increased owners' identification costs. Instead, all *large-scale* FIZs and more than half of *medium-scale* ones have a registry (Table 2). This reflects the national strategy for land registration which, since the 1930s, has prioritized large-scale property regions and left practically uncovered until today the rural space North of the Tagus River (Beires et al., 2013).

Public financial support is another important factor. For instance, the support foreseen by law for FIZ's constitution and their first two years of operation is directly proportional to the area of the FIZ. Given the difference of FIZ area per member amongst clusters, the potential financial support per member is very uneven: from 568 euros in *small-scale FIZ* to 17,543 euros in *large-scale FIZ*. In view of this legal criterion, each of the FIZ clusters might receive about a third of the total planned amount. For the third cluster, whose surface was mainly constituted after 2009, a share of 36% of

[1] *Montados* are agro-forestry-pastoral systems with cork oaks or holm oaks.

**Table 2**
Clusters' characteristics.

| | | F and $Q^2$ tests | Cluster | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Small-scale FIZs of pinewoods | | Medium-scale FIZs in higher density rural | | Large-scale FIZs of montado | | Total | |
| **Resource system characteristics** | | | | | | | | | | |
| Average area of the FIZ (ha) | | *** | 2821 | | 4730 | | 26994 | | 5243 | |
| Index of wildfire susceptibility | | | 68.3 | | 55.5 | | 23.5 | | 60.1 | |
| Number of FIZ with >75% of the area with high and very high wildfire susceptibility (%) | | (*) | 43.5 | + | 21.5 | – | 0.0 | – | 31.7 | |
| Species' share in the countyś forest stands area (%) | | | | | | | | | | |
| Pine | | *** | 60.6 | | 26.5 | | 8.6 | | 43.3 | |
| Eucalyptus | | *** | 14.8 | | 38.3 | | 26.2 | | 25.0 | |
| Cork oak | | *** | 2.1 | | 13.2 | | 53.3 | | 10.0 | |
| Oak | | *** | 12.8 | | 1.9 | | 0.4 | | 7.6 | |
| Share of shrubland in county's area (%) | | *** | 37.2 | | 23.2 | | 11.3 | | 29.8 | |
| **Owners' group characteristics** | | | | | | | | | | |
| Members' number | | | 134.1 | | 138.9 | | 41.6 | | 129.7 | |
| FIZ area by member (ha) | | *** | 33.2 | | 79.2 | | 659.6 | | 94.6 | |
| Common property area in FIZ area (%) | | (*) | 0.4 | | 3.2 | | 0.0 | | 1.5 | |
| Rural density (rural type) | | *** | 33.7 | | 72.4 | | 11.0 | | 47.8 | |
| Rural demographic potential | | *** | 17.4 | | 33.1 | | 19.9 | | 23.9 | |
| **Governance arrangements** | | | | | | | | | | |
| Number of FIZs with a FOA as MB (%) | | | 83.5 | | 92.3 | | 90.9 | | 87.6 | |
| Number of FIZs with a specific MB (%) | | (*) | 25.9 | (+) | 15.4 | | 9.1 | | 20.5 | |
| Area per member led by the MB of the FIZ (ha) | | *** | 24.1 | | 35.5 | | 393.6 | | 39.2 | |
| MB attributes | FIZs' number per MB | | 2.6 | | 3.3 | | 3.7 | | 2.5 | |
| | FIZs' area per MB ($km^2$) | | 96 | | 175 | | 818 | | 167 | |
| **External environment** | | | | | | | | | | |
| Number of FIZs with land registry (%) | | *** | 21.2 | – | 55.4 | + | 100.0 | + | 40.4 | |
| Number of FIZs (%) with | | *** | | | | | | | | |
| <4000 ha | | | 74.1 | + | 55.4 | | 0.0 | – | 61.5 | |
| >10000 ha | | | 0.0 | – | 9.2 | | 100.0 | + | 10.6 | |
| Number of FIZs established during 2006–2009 (%) | | *** | 69.4 | | 56.9 | (–) | 72.7 | | 64.6 | |
| Weight of FIZs established during 2006–2009 in the cluster area (%) | | | 60.5 | | 56.2 | | 36.9 | | 59.7 | |
| Potential financial support per member (euros) | | | 568 | | 919 | | 17543 | | 1607 | |
| Distribution of potential support per cluster (%) | | | 28 | | 36 | | 36 | | 100 | |
| **Performance** | | | | | | | | | | |
| Number of FIZs with approved FMP (%) | | *** | 40.5 | – | 63.2 | + | 72.7 | + | 51.9 | |

*Note*: Significant at 1%, ***, 2%, **, 5%, *, and 10%, (*); "+" or "-' and "(+)' or '(–)' represent significant deviations from expected values, respectively at $P < 0.05$ and $P < 0.10$.

total potential funding contrasts markedly with its reduced social relevance (2% of total FIZ members).

### 4.5. Performance

Current performance, measured by collective plan approval strongly differentiates the clusters. *Montado* and *higher density* clusters present, respectively, 73% and 63% of FIZs with approved FMP, but the *pinewoods* cluster reveals only 41% of FIZ with this approval. This uneven outcome is at odds with the rationale of the law, which is to overcome the obstacle of small property and reduce susceptibility to wildfires in the regions most affected by wildfires.

## 5. Discussion

The FIZ/territory clusters were briefly characterized. From a socioeconomic perspective we now discuss the capacity to increase public benefits (wildfire mitigation) and overcome transaction costs and other barriers to CA within the clusters. Stakeholders' proposals and claims concerning institutional and political environment to overcome barriers are also interpreted in light of our results.

### 5.1. Management scale, benefits, and transaction costs

When fragmented ownership patterns prevail, owners' CA has often been presented as a condition to achieve management at scales larger than the individual owner and thereby promote environmental benefits (Ask and Carlsson, 2000; Bengston et al., 2001; Schulte et al., 2008; Gass et al., 2009; OECD, 2013).

The forest management units obtained by the FIZ creation in clusters 1 and 2 are further from the ideal unit sought by the policy instrument for wildfire prevention than the units established by the third cluster FIZs. Nevertheless, the scale increase rate for the first units is greater. From less than 20 ha individually managed by member of the *FIZ of pinewoods* to around 3000 ha in joint management, we obtain a ratio of 1:165, whereas this ratio is 1:80 in *FIZ of montado* (from 330 ha to 25,000 ha). Scale growth is essential for establishing fire prevention infrastructures (such as forest roads, fuelbreaks, and water supply) and landscape heterogeneity (Collins et al., 2013; Fernandes, 2013), which are much more difficult for small landowners to achieve individually than for very large estate owners. An increase of scale is also needed to reduce the unit cost of mitigation where fuel treatments are more expensive, as in steeper areas like those of *FIZ of pinewoods* (and *higher density rural*). A more surgical management of fuels coordinated at a larger scale becomes vital in such areas (Ager et al., 2006).

Furthermore, a possible decrease in fire suppression costs borne by public authorities in those territorial contexts of clusters 1 and 2 (the most affected by fires) must be accounted as a potential public benefit of CA. While managing forests for increased fire resiliency can decrease suppression costs, according to the fire-fighting trap concept, favouring fire suppression (over prevention) may instead accelerate the transition to a more fire-prone future

**Box 1**
Comparing local structural conditions and collective action performance.

| Key-factors | Variables | Defining the clusters | Validating the clusters |
|---|---|---|---|
| **Resource characteristics** | | | |
| Resource size | FIZ's area (ha)[1] | y | |
| Resource susceptibility to wildfire | Index of wildfire susceptibility[2] | y | |
| | Classes of area percentage with high and very high susceptibility to fires in the FIZ[1,3] | | y |
| Resource private profitability | Share of Pine in county's forest stands area (%)[3] | y | |
| | Share of Eucalyptus in county's forest stands area (%)[3] | y | |
| | Share of Cork oak in county's forest stands area (%)[3] | y | |
| | Share of Oak in county's forest stands area (%)[3] | y | |
| | Share of shrubland in county's area (%)[3] | | y |
| **Group characteristics** | | | |
| Group size | Number of members | | |
| Ownership size | FIZ area by member (ha)[1] | y | |
| Ownership heterogeneity | Common property area in FIZ area (%)[1] | | y |
| Group social context | Average rural density of the type of rural area in which the county is included (inhab./Km$^2$)[4] | y | |
| | Index of rural demographic potential[4] | | y |
| **Governance arrangements** | | | |
| Associative nature of the MB | Number of FIZs with a FOA as MB | | |
| Specificity of the MB | Number of FIZs with a specific MB (i.e. MB runs a single FIZ)[1] | | y |
| Resource/member ratio of the MB | Area per member led by the MB of the FIZ (ha)[1] | y | |
| Professionalization of the MB | FIZs' number per MB | | |
| | FIZs' area per MB (km$^2$) | | |
| **External environment** | | | |
| Public technical support | Number of FIZs with land registry (%)[1] | | y |
| Financial support | Potential financial support per member (euros) | | |
| | Distribution of potential support per cluster (%) | | |
| Policy context | Number of FIZs established during 2006–2009 (%)[1] | | y |
| | Weight of FIZs established during 2006–2009 in the cluster area (%) | | |
| | FIZ number by classes of area | | y |
| **Performance** | | | |
| Current performance | Number of FIZs with approved FMP (%)[1] | | y |

Data sources: [1] Provided by ICNF; [2] Verde and Zêzere (2010); [3] AFN (2010); [4] Rolo and Cordovil (2014).
Note: y = yes.

and magnify the problem (Hartsough et al., 2008; Moreira et al., 2011; Fernandes, 2013; Collins et al., 2013).

In spite of the long-term benefits of CA, its transaction costs may be a deterrent and help to explain clusters' uneven performance. In fact, the three clusters face considerably different transaction costs for CA. Initial transaction costs relate to the identification, communication, and mobilization of members (OECD, 2013). They are higher for *small-scale* FIZs due to the absence of land registries and group attributes: more numerous, aged, and geographically dispersed owners who are harder to reach by modern communication means. Higher rural density and demographic potential of *medium-scale* FIZs' territorial context may ease intra- and inter-group communication. Because some of the FIZs already have a land registry, this cluster can be placed between the first and third clusters concerning those initial costs. In subsequent phases of common management implementation, bargaining costs associated with negotiation and agreement (time-consuming meetings, efforts in verbal and written communication) and monitoring and enforcement costs (involved in ensuring that all parties keep to the agreement) are expected to increase in more highly fragmented ownership regions and with the number and heterogeneity of owners' goals (Gass et al., 2009; Novais and Canadas, 2010; OECD, 2013).

Besides transaction costs, CA faces barriers such as free-riding and sceptical behaviour, which may have different expressions among clusters. Sceptical behaviour, due to individualistic attitudes, is often mentioned in the literature (Kittredge, 2005) and invoked by common sense voices to explain the current impasse amongst FIZs, although it lacks an empirical basis (Canadas et al., 2014). Free-riding behaviour, i.e. capturing benefits of neighbours' positive externalities without incurring the costs (Kollock, 1998), is expected to vary among clusters and increases with the number of members and other owners inside and outside FIZ boundaries. Low compactness of a FIZ's shape, which curtails congruence between the resources' natural and social (members' ownership) boundaries, favours this behaviour (Padgee et al., 2006; Crowley et al., 2009; Busby and Albers, 2010). For *small-scale* and *medium-scale* clusters free-riding can be anticipated from more numerous non-members inside the FIZ working area or in its vicinity. The small size of individual property and its high fragmentation encourage the perception of powerlessness or irrelevance of one's behaviour (Kollock, 1998). For large-scale FIZs its compact shape and lower fragmentation of holdings reduces ownership numbers and consequently the opportunities for free-riding (Ratner et al., 2013).

A challenge emerges from our results: where wildfire susceptibility is higher (due to slope, land cover, and fire history) and collective management for wildfire mitigation more essential, the greater are the barriers to CA, and most notably its transaction costs.

### 5.2. Policy and institutions. Professionalization and embeddedness

As CA has high long-term benefits (providing environmental public goods is usually a long-term process) and its transaction costs are high, especially in its initial phases, the need for public financial and technical support has been widely endorsed (Stevens et al., 1999; Kittredge, 2005; Finley et al., 2006; Schulte et al., 2008; Madureira et al., 2013; OECD, 2013). Looking through the clustering lenses, however, has shown that public technical and financial support for FIZs (land registry and funding criteria) has not been sensitive to the transaction costs differential among regions. Hence the proposals and claims for policy change expressed by or on behalf of FIZs from clusters 1 and 2 (Canadas et al., 2014).

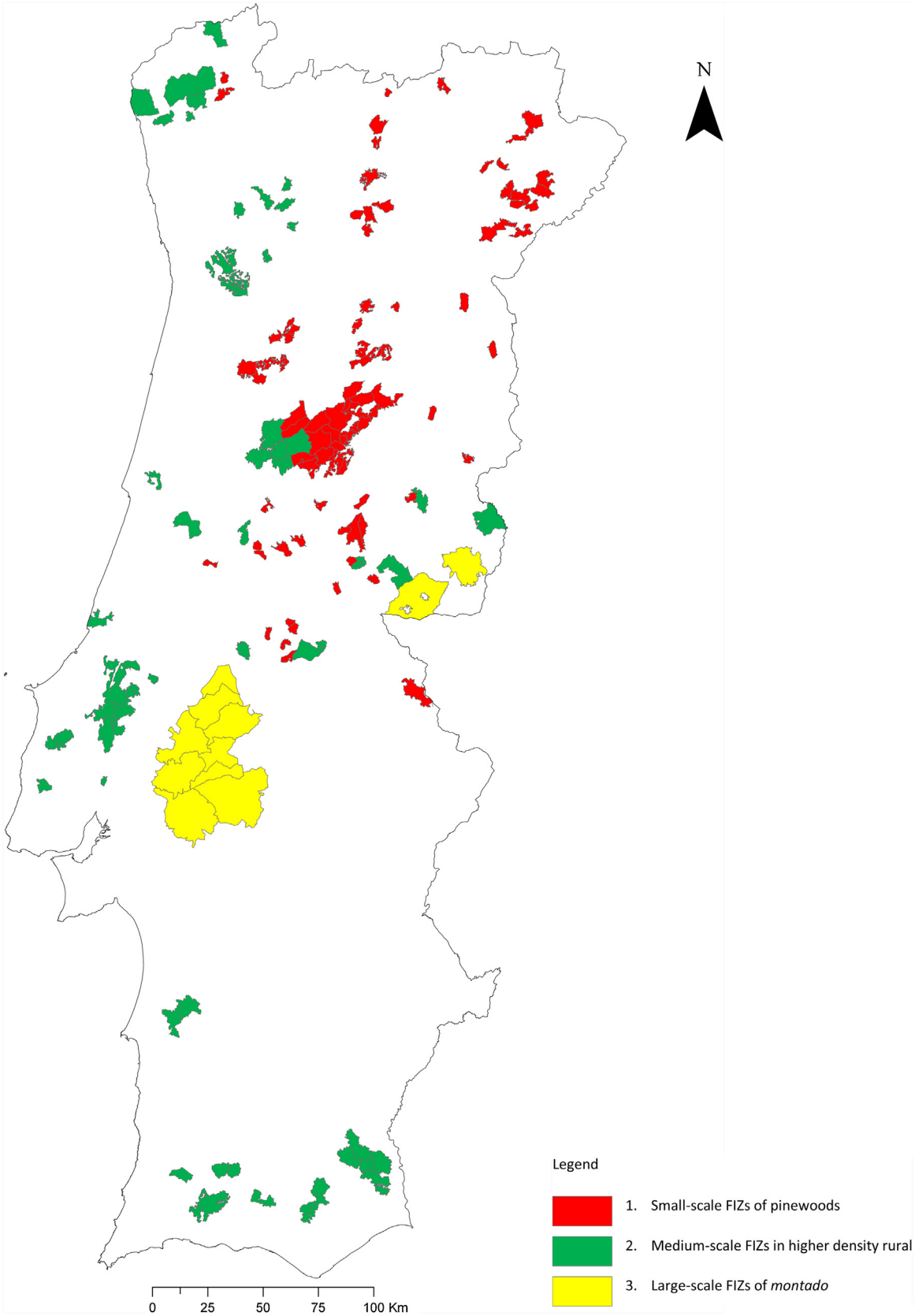


**Fig. 1.** Typology of FIZ/territories.

A first claim concerns the change in public funding criteria, making them proportional to the number of members and attending to the territorial differentiation of land ownership structure. Actual proportionality to FIZ's land area has contributed to the increase in the average size of FIZs established since 2009, despite the reduction in the threshold area from 1000 ha to 750 ha. Change in funding

criteria could allow the delimitation of smaller FIZs, in order to decrease the size of members' groups, thereby reducing transaction costs and possibly free-riding behaviour amongst owners. A second proposal, instead, aims at implementing the model of indirect or assigned management without sacrificing the ideal landscape-level unit of management. In this model the MB is responsible for the execution of FMP interventions, in contrast with direct management, in which the individual owner is responsible for carrying out that plan for his lands. Indirect management should reduce some transaction costs in FIZs with a large number of members and is viewed by some MB as the ultimate goal of FIZ management. This change in the organizations' institutional arrangements requires property rights changes supported by policy. A third claim concerns the elaboration of land registries. Considering that it has been assumed by public authorities in part of the country, and since FOA consider having the required technical skills, they are willing to do it provided that they receive public funding.

Policy disregard over FIZ territorial differentiation has been strengthened by a differential amongst clusters in the professionalization of management bodies. The professionalization in cluster 3 enhances the qualification of its staff, and the capacity for communication and lobbying strategies, as pointed out by Fabra-Crespo and Rojas-Briales (2015) for European forest owners' associations. The importance of this capacity for successful CA has been widely recognized (Blinn et al., 2007; Feliciano and Mendes, 2011; López-Gunn, 2012). In contrast, the MB specificity or local embeddedness favours owners' trust toward the entity, which is crucial for owners' acceptance of MB directives but irrelevant for the provision of external resources, namely financial support (Wolf and Hufnagl-Eichiner, 2007; Mendes, 2011).

Finding the appropriate balance between professionalization and local embeddedness in NIPF contexts in which small ownership prevails is thus a second challenge.

### 5.3. Carrots and sticks. Public and private goods

Financial incentives (carrots) or rules and sanctions (sticks) might help to overcome barriers to cooperative management (Klosowski et al., 2001; Serbruyns and Luyssaert, 2006; Vokoun et al., 2010). Positive discrimination in accessing forest policy programmes was the carrot waved at FIZ members. Even so, effective accessibility criteria to support programmes have been particularly unfavourable for the majority of FIZs with large numbers of owners.

A different proposal to unlock FIZ, more extensively advocated outside associative movement, aims at the enforcement of sticks targeting not only the members, but perhaps the non-members with holdings within FIZ bounds or in its neighbourhood. Such sanctions, which until now have not been implemented, would encourage compliance with the fuel treatments foreseen in the collective FMP (or individual FMP for those outside a FIZ) and prevent free-riding.

Support for these measures can be found in the economics of fire-risk management amongst adjacent stands and owners, namely in mixed ownership landscapes where public lands are numerous. Requiring NIPF landowners to share the government's costs of fire suppression (polluter pays principle) or requiring some level of fuel treatment effort are advised as solutions to prevent free-riding (Crowley et al., 2009; Busby and Albers, 2010; Prante et al., 2011). In order to discuss the effectiveness of extending these measures we must equate the possibility of private and public goods joint production.

In the Western European context the unprofitability of most NIPF sectors with a role in the production of public goods has often been stated (Slee, 2006; Fabra-Crespo and Rojas-Briales, 2015). Slee (2006) contends that "unless the public good elements can be either given value in the market place or appropriately supported by policy, a continued reduction in public goods values seems inevitable". For Fabra-Crespo and Rojas-Briales (2015) this is especially true in cases of high risk, e.g. fire-prone Mediterranean and mountainous regions.

For the Portuguese context, despite a general stated reduction of profitability over the last decade, it must be recognized that forest subsectors like pine, eucalyptus, and cork oak have different economic returns, visible in the evolution of their areas nationwide. Between 1995 and 2010 maritime pine decreased in area by 27%, while cork oak kept the same area and eucalyptus increased 13% (ICNF, 2013). Non-profitability of pine is attested by the fact that manual shrub clearing, which is the most usual work organization mode in the territorial contexts of pine predominance (Novais and Canadas, 2010; Canadas and Novais, 2014), has a cost that is far from being offset by wood products (125 euros/ha.year in at least 20% of the area, against 50 euros/ha.year) (DGRF, 2006). Private profitability in *montados*, besides cork, is nourished by agro-environmental policy. The differentiation of price-product incentives for forest and fuels management is especially unfavourable for *FIZs of pinewoods* in which forest stands are dominated by maritime pine and shrubland covers more than one third of their territory—a result of farm abandonment and absence of natural forest regeneration in repeatedly burnt areas. In such cases CA benefits may be viewed by owners as uncertain and less than their cost (Padgee et al., 2006; Sapkota et al., 2015).

The heterogeneity of Portuguese NIPF owners' economic rationalities and work models must inform the discussion (Baptista and Santos, 2005; Novais and Canadas, 2010). For those owners who avoid bush clearing but carry out harvesting, a stick can be used in order to internalize the negative externality associated with not undertaking fuel treatments. Conversely, for owners who neither bush-clear nor harvest, any stick (regulations, punishments by taxation, or amendments) is fruitless to the extent of this forest's reduced market value. In addition, the absence of a proper land registry hinders their enforcement. This situation and the latter type of owners may be more present in *small-scale FIZs of pinewoods*, where public support for CA might be needed beyond the initial period of FIZ establishment (OECD, 2013).

The endorsement of incentives, sanctions, or other solutions parallels the interests that are established around the forest: taxation (fiscalism) for public funding, rural development, production of wood pulp, biodiversity conservation, and environmental preservation (Canadas et al., 2014). Land ownership restructuring is often advocated in place of small owners' CA. In favour of this is the assumption that small-scale ownership favours fire susceptibility, endorsing owners' negligence or forest unprofitability. Against that replacement is the argument that ownership restructuring may promote a greater dissociation between rural population and rural space, at odds with rural development goals (Canadas and Novais, 2014).

## 6. Conclusions

The issue of cooperation amongst NIPF owners for landscape fuels management is still a largely ignored research matter. Our approach to this issue, using a CA framework, has been fruitful. It reveals that collective management for fire mitigation has different territorial constraints and faces difficult challenges. When higher wildfire susceptibility due to ecological conditions is associated with small NIPF ownership regions: (i) ideal landscape management units can promote large and inefficient group sizes; (ii) increase in public benefit from CA might be greater where barriers to that action (such as transaction costs and potential free-riding) are higher or market incentives are lower; (iii) specificity or non-professionalization of the organizations' management bodies

might promote their local embeddedness and impair their lobbying competencies.

Taking the organization and its territorial context as unit of analysis has allowed the integration of the local system of biophysical and socioeconomic constraints to owners' collective management. We contend that carrying out a geographical comparison of constraints to CA may be a helpful complement to the depth of the case studies, which are the dominant methodological option when it comes to analysing CA for natural resource management. Although the typology established is only a first (and rough) approach, subject to secondary data availability, it shows potential for the comparison of barriers and benefits of CA across different geographical contexts.

The focus of our analysis was the implementation of a policy instrument aimed at promoting a single FMP for a multi-owner contiguous surface. That policy process has emphasized compliance with an ideal model (size and shape) of landscape management. Implicit to the law and its operationalization is the expectation that scale enlargement would solve per se the unprofitability problem of the forest left alone to market forces. The view of FIZs as private owners' CA for the production of wildfire risk mitigation has definitely not been adopted by the policy instrument.

In our opinion these traits of the policy instrument have prevented it from addressing the above-mentioned challenges and have instead created a paradox as revealed by our typology. In fact, public funding has been detrimental for those FIZs/territories where reduction in wildfire risk was most needed and transaction costs were highest.

Here our research joins and informs the claim for more geographically targeted policy instruments to tackle the structural causes that lie behind the greater incidence of large fires for wildfire risk management (Galiana et al., 2013; Aguilar and Montiel, 2011; Montiel, 2013). Considering landscape wildfire risk mitigation as a public good, the typology invites further discussion of the need to distinguish between contexts in which policy incentives are more needed to promote wildfire mitigation (via CA) and those in which market forces could be allowed to work and even trigger CA. Moving on this discussion depends on an empirical ground to distinguish contexts in which sticks (regulations and sanctions) are socially and economically justified and contexts where carrots (financial incentives) may be essential. Indeed owners' CA, as a means to enhance management scale, cannot solve per se the unprofitability problem of some of the forest and expanding shrubland.

## Acknowledgements

The authors are grateful to the anonymous reviewers for their helpful and constructive review of an early draft of this article.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landusepol.2016.04.035.

## References

AFN, 2010. Inventário Florestal Nacional (IFN 5). Lisboa, Autoridade Florestal Nacional/MADRP.
Ager, A., Finney, M., McMahan, A., 2006. A wildfire risk modeling system for evaluating landscape fuel treatment strategies. USDA For. Serv. Proc. RMSR, 149–162.
Agrawal, A., 2001. Common property institutions and sustainable governance of resources. World Dev. 29 (10), 1649–1672.
Aguilar, S., Montiel, C., 2011. The challenge of applying governance and sustainable development to wildland fire management in Southern Europe. J. For. Res. 22 (4), 627–639.
Ask, P., Carlsson, M., 2000. Nature conservation and timber production in areas with fragmented ownership patterns. For. Policy Econ. 1, 209–223.
Baptista, F.O., Santos, R.T., 2005. Os proprietários florestais: resultados de um inquérito, Oeiras, Celta.
Baptista, F.O., 2010. Oespaço rural. Declínio da agricultura. Lisboa, Celta.
Beires, S., Amaral, J., Ribeiro, P., 2013, Ocadastro e a propriedade rústica em Portugal, Lisboa, Fundação Manuel dos Santos.
Belin, D., Kittredge, D., Stevens, T., Dennis, D., Schweik, C., Morzuch, B., 2005. Assessing private forest owner attitudes toward ecosystem-based management. J. For., 28–35 (Jan/Feb).
Bengston, D., Xu, G., Fan, D., 2001. Attitudes toward ecosystem management in the United States, 1992–1998. Soc. Nat. Res. 14, 471–487.
Berlin, C., Lidestav, G., Holm, S., 2006. Values placed on forest property benefits by Swedish NIPF owners: differences between members in forest owner associations and non-members. Small-Scale For. Econ. Manage. Policy 5 (1), 83–96.
Bihari, M., Ryan, R., 2012. Influence of social capital on community preparedness for wildfires. Landscape Urban Plann. 106, 253–261.
Blinn, C., Jakes, P., Sakai, M., 2007. Forest landowner cooperatives in the United States : a local focus for engaging landowners. J. For., 245–251 (July/August).
Brukas, V., Sallnäs, O., 2012. Forest management plan as a policy instrument: carrot, stick or sermon? Land Use Policy 29, 605–613.
Brummel, R., Nelson, K., Souter, S., Jakes, P., Williams, D., 2010. Social learning in a policy-mandated collaboration: community wildfire protection planning in eastern United States. J. Environ. Plann. Manage. 53 (6), 681–699.
Busby, G., Albers, H., 2010. Wildfire risk management on a landscape with public and private ownership: who pays for protection? Environ. Manage. 45, 296–310.
Canadas, M.J., Novais, A., 2014. Bringing local socioeconomic context to the analysis of forest owners' management. Land Use Policy 41, 397–407.
Canadas, M.J., Novais, A., Marques, M., 2014. Proprietários florestais, políticas e territórios: incêndios e a gestão do espaço rural. Lisboa, ANIMAR.
Collins, R., Neufville, R., Claro, J., Oliveira, T., Pacheco, A., 2013. Forest fire management to avoid unintended consequences: a case study of Portugal using system dynamics. J. Environ. Manage. 130, 1–9.
Crowley, C., Malik, A., Amacher, G., Haight, R., 2009. Adjacency externalities and forest fire prevention. Land Econ. 85 (1), 162–185.
DGRF, 2006. Estratégia Nacional para as Florestas, Lisboa,D irecção Geral de Recursos Florestais.
Deus, E., 2010. A implementação do conceito Zona de Intervenção Florestal em Portugal: o caso do concelho de Mação, Coimbra, Faculdade de Letras, Universidade de Coimbra.
Doss, C., Meinzen-Dick, R., 2015. Collective action within the household: insights from natural resource management. World Dev. 74, 171–183.
Fabra-Crespo, M., Rojas-Briales, E., 2015. Comparative analysis on the communication strategies of the owners' associations in Europe. For. Policy Econ. 50, 20–30.
Feliciano, D., Mendes, A., 2011. Forest owners' organizations in North and Central Portugal: an assessment of success. South-East Eur. For., 1–11.
Fernandes, P., Rego, F., Rigolot, E., 2011. The fire paradox project: towards science-based fire management in Europe. For. Ecol. Manage. 261, 2177–2178.
Fernandes, P., Loureiro, C., Guiomar, N., Pezzatti, G., Guiomar, N., Manso, F., Lopes, L., 2014. The dynamics and drivers of fuel and fire in the Portuguese public forest. J. Environ. Manage. 146, 373–382.
Fernandes, P., 2013. Fire-smart management of forest landscapes in the Mediterranean basin under global change. Landscape Urban Plann. 110, 175–182.
Finley, A., Kittredge, D., Stevens, T., Schweik, C., Dennis, D., 2006. Interest in cross-boundary cooperation: identification of distinct types of private forest-owners. For. Sci. 52 (1), 10–22.
Fischer, P., Charnley, S., 2012. Risk and cooperation: managing hazarduous fuel in mixed ownership landscapes. Environ. Manage. 49, 1192–1207.
Fischer, P., 2012. Identifying policy target groups with qualitative and quantitative methods: the case of wildfire risk on nonindustrial private forest lands. For. Policy Econ. 25, 62–71.
Galiana, L., Aguilar, S., Lázaro, A., 2013. An assessment of the effects of forest-related policies upon wildland fires in the European Union: applying the subsidiarity principle. For. Pol. Econ. 29, 36–44.
Gass, R., Rickenbach, M., Schulte, L., Zeuli, K., 2009. Cross-boundary coordination on forested landscapes: investigating alternatives for implementation. Environ. Manage. 43, 107–117.
Hartsough, B., Abrams, S., Barbour, R., Drews, E., McIver, J., Moghaddas, J., Schwilk, D., Stephens, S., 2008. The economics of alternative fuel reduction treatments in western US dry forests. For. Policy Econ. 10, 344–354.
ICNF, 2013. IFN6–Áreas dos usos do solo e das espécies florestais de Portugal continental em 1995, 2005 e 2010 (resultados preliminares), Lisboa, MAMAOT.
Ishiara, H., Pascual, U., 2009. Social capital in community level environmental governance: a critique. Ecol. Econ. 68, 1549–1562.
Jarret, A., Gan, J., Johnson, C., Munn, I., 2009. Landowner awareness and adoption of wildfire programs in the Southern US. J. For., 113–118 (April/May).
Kittredge, D., 2005. The cooperation of private forest owners on scales larger than one individual property: international examples and potential application in the United States. For. Policy Econ. 7, 671–688.
Klosowski, R., Stevens, T., Kittredge, D., Dennis, D., 2001. Economic incentives for coordinated management of forest land: a case study of southern New England. For. Policy Econ. 2, 29–38.

Kollock, P., 1998. Social dilemmas: the anatomy of cooperation. Ann. Rev. Sociol. 24, 183–214.
López-Gunn, E., 2012. Groundwater governance and social capital. Geoforum 43, 1140–1151.
MCPFE, 2010. Assessment of forest fire risks and innovative strategies for fire prevention. Ministerial Conference on the Protection of Forests in Europe.
Madureira, L., Santos, J.L., Ferreira, A., Guimarães, H., 2013, Feasibility study on the valuation of public goods and externalities in EU agriculture, JRC Scientific and Policy Reports, European Commission.
Martins, H., Borges, J., 2007. Addressing collaborative planning methods and tools in forest management. For. Policy Econ. 248, 107–118.
Meinzen-Dick, R., Di-Gregorio, M., McCarthy, N., 2004. Methods for studying collective action in rural development. Agric. Syst. 82, 197–214.
Mendes, A., 2011. Institutional innovation in European private forestry: the emergence of forest owners' organizations. In: Weiss, G., Pettenella, D., Ollonqvist, P., Slee, B. (Eds.), Innovation in Forestry: Territorial and Value Chain Relationships. CABI, Oxfordshire.
Mondal, P., Buttler, B., Kittredge, D., Moser, W., 2013. How are America's private forests changing? Land Use Policy 32, 230–238.
Montiel, C., 2013. Comparative assessment of wildland fire legislation and policies in the European Union: towards a fire framework directive. For. Policy Econ. 29, 1–6.
Moreira, F., Viedma, O., Arianoustsou, M., Curt, T., Koutsias, N., Rigolot, E., Barbati, A., Corona, P., Vaz, P., Xanthoupoulus, G., Mouillot, F., Bilgili, E., 2011. Landscape-wildfire interactions in Southern Europe: implications for landscape management. J. Environ. Manage. 92, 2389–2402.
Mourão, P., Martinho, V., 2014. The choices of the fire: debating socioeconomic determinants of fires observed at Portuguese municipalities. For. Policy Econ. 29, 1–6.
Novais, A., Canadas, M.J., 2010. Understanding the management logic of private forest owners: a new approach. For. Policy Econ. 12, 173–180.
Nunes, A., 2012. Regional variability and driving forces behind forest fires in Portugal: an overview of the last three decades (1980–2009). Appl. Geogr. 34, 576–586.
OECD, 2013. Providing Agri-Environmental Public Goods Through Collective Action. Organisation for Economic Co-operation and Development, Paris.
Olson, M., 1971. The Logic of Collective Action: Public Goods and the Theory of Groups. Harvard University Press, London.
Ostrom, E., 2003. How types of goods and property rights jointly affect collective action. J. Theor. Pol. 15 (3), 239–270.
Ostrom, E., 2011. Background on institutional analysis and development framework. Policy Stud. J. 39 (1), 7–27.
Padgee, A., Kim, Y., Daugherty, P., 2006. What makes community management successful: a meta-study from community forests throughout the world. Soc. Nat. Resour. 19, 33–52.
Pereira, J.M., Carreiras, J., Silva, J., Vasconcelos, M., 2006. In: Santos-Pereira, J., Rêgo, F., Silva, J., Silva, T., Pereira, J.M., Carreiras, J., Silva, J., Vasconcelos, M. (Eds.), Incêndios Florestais Em Portugal. ISA, Lisboa, pp. 133–155.
Pinho, J., Santos, C., 2012. Caracterização Das Zonas De Intervenção Florestal: 3° Relatório De Progresso. ICNF, Lisboa.
Place, F., Kariuki, G., Wangila, J., Kristjanson, P., Makauki, A., Ndubi, J., 2004. Assessing the factors underlying differences in achievements of farmer groups: methodological issues and empirical findings from the highlands of Central Kenya. Agric. Syst. 82, 257–272.
Poteete, A., Ostrom, E., 2008. Fifteen years of empirical research on collective action in natural resource management: struggling to build large-N databases based on qualitative research. World Dev. 36 (1), 176–195.
Prante, T., Little, J.M., Jones, M., McKeed, M., Berrens, R., 2011. Inducing private wildfire risk mitigation: experimental investigation of measures on adjacent public lands. J. For. Econ. 17, 415–431.
Pulla, P., Schuck, A., Verkerk, P., Lassere, B., Marchetti, M., Green, T., 2013. Mapping the Distribution of Forest Ownership in Europe. European Forest Institut, Joensuu.
Radich, M.C., Baptista, F.O., 2005. Floresta e sociedade: um percurso (1875–2005). Silva Lusitana 13 (2), 143–157.
Ratner, B., Meinzen-Dick, R., May, C., Haglund, E., 2013. Resource conflict, collective action, and resilience: an analytical framework. Int. J. Commons 7 (1), 182–208.
Rego, F., Catry, F., Montiel, C., Karlsson, O., 2013. Influence of territorial variables on the performance of wildfire detection systems in the Iberian Peninsula. For, Policy Econ. 29, 26–35.
Rickenbach, M., Bliss, J., Reed, A.S., 2004. Collaboratives, cooperation, and private ownership patterns: implications for voluntary protection of biological diversity. Small-Scale For. Econ. Manage. Policy 3 (1), 69–83.
Rickenbach, M., 2009. Serving members and reaching others: the performance and social networks of a landowner cooperative. For. Policy Econ. 11, 593–599.
Rolo, J., Cordovil, F., 2014. Rural, Agriculturas E Políticas. ANIMAR, Lisboa.
Santos-Pereira, J., Rêgo, F., Silva, J., Silva, T., 2006. Incêndios Florestais Em Portugal. ISA, Lisboa.
Sapkota, L., Shrestha, R., Jourdain, D., Shivakoti, G., 2015. Factors affecting collective action for forest fire management: a comparative study of community forest user groups in Central Siwalik. Environ. Manage. 55, 171–186.
Schulte, L., Rickenbach, M., Merrick, L., 2008. Ecological and economic benefits of cross-boundary coordination among private forest landowners. Landscape Ecol. 23, 481–496.
Serbruyns, I., Luyssaert, S., 2006. Acceptance of sticks, carrots and sermons as policy instruments for directing private forest management. For. Policy Econ. 9, 285–296.
Slee, B., 2006. The scope for reconciling public good and private forestry in the United Kingdon. Small-Scale For. Econ. Manage. Policy 5 (1), 1–18.
Stevens, T., Dennis, D., Kittredge, D., Rickenbach, M., 1999. Attitudes and preferences toward co-operative agreements for management of private forestlands in the north-eastern United States. J. Environ. Manage. 55, 81–90.
Torres-Manso, F., Fernandes, P., Pinto, R., Botelho, H., Monzon, A., 2014. Regional livestock grazing, human demography and fire incidence in the Portuguese landscape. For. Syst. 23 (1), 15–21.
Van-Gossum, P., De-Mayer, W., 2006. Performance of forest groups in achieving multifunctional forestry in Flanders. Small-Scale For. Econ. Manage. Policy 5 (1), 19–36.
Verde, J.C., Zêzere, J.L., 2010. Assessment and validation of wildfire susceptibility and hazard in Portugal. Nat. Hazards Earth Syst. Sci. 10, 485–497.
Vokoun, M., Amacher, G., Sullivan, J., Wear, D., 2010. Examining incentives for adjacent non-industrial private forest landowners to cooperate. For. Policy Econ. 12, 104–110.
Williams, E., Ellefson, P., 1996. Natural Resource Partnerships: Factors Leading to Cooperative Success in the Management of Landscape-level Ecosystems Involving Mixed Ownership. Department of Forest Resources, University of Minnesota.
Wolf, S., Hufnagl-Eichiner, S., 2007. External resources and development of forest landowner collaboratives. Soc. Nat. Res. 20, 675–688.
Wyman, M., Malone, S., Stein, T., Johnson, C., 2012. Race and wildfire risk perceptions among rural forestland owners in North-Central Florida. Soc. Nat. Resour.: Int. J. 25 (12), 1293–1307.