

# **ADVANCES IN FOREST FIRE RESEARCH**

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## Distinguishing between mitigation and adaptation as wildfire prevention actions

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### Abstract

There is actually a broad consensus over the need to shift from fire suppression to fire prevention strategies. To inform policies that effectively promote this shift, we distinguish between actions aimed at more fire-resilient landscapes and those focused on the protection of people, i.e., wildfire mitigation and adaptation (WM&A), respectively.

With the goal of discussing the usefulness of this distinction and identifying local factors and external resources that promote preventive actions, we developed an analysis of collective WM&A actions across 116 parishes in a wildfire-prone region in Portugal, Pinhal Interior. Two principal component analyses were used to explore relationships between variables expressing collective WM&A actions. Random forest was used to model how those actions are related to local factors (land use/land cover, population, institutions) and external resources for wildfire prevention.

Our results showed that collective mitigation and adaptation responses to wildfire are independent, in coherence with their distinct goals, actors involved, and policy domains. Mitigation through owners' collaboration proved to be strongly related to policy funding, local economic dynamism, and demographic vitality, unlike community adaptation. In fact, adaptation responses from the local governments and the very few existing residents' collaboratives are very incipient. We conclude, on one hand, that mitigation and adaptation actions are currently supported by two unequally consolidated policy domains and, on the other hand, that both domains are equally underfunded, namely because of the difficulties in expanding owner collaboratives beyond favorable local conditions, i.e., in socioeconomically depressed regions.

## 1. Introduction

The shift from fire suppression to fire management through prevention has been increasingly discussed in the scientific and policy communities (Ager et al., 2018; EC, 2018; Leone and Tedim, 2020; Moreira et al., 2020; Fernandes et al., 2020). Within preventive actions we distinguish between mitigation and adaptation, taking into consideration the action itself, its objectives, and the actors involved, in line with the need to identify the policy recipients. Mitigation actions are primarily designed to reduce the susceptibility of the landscape to wildfire,

while protecting forest assets. Adaptation actions mainly seek to safeguard people and goods through reducing their exposure and vulnerability. Mitigation includes actions taken by landowners to reduce the amount or modify the kind and arrangement of fuel loads in forest and agricultural areas, thereby contributing to reduce wildfire hazard (Fernandes et al., 2014; Martins et al., 2021; Oliveira et al., 2013). Adaptation actions are taken by residents, homeowners, or communities to create defensible space on their properties and territories (Alcasena et al., 2019; Bihari and Ryan, 2012; Stidham et al., 2014) or to get insurance policies that allow a quicker recovery after a damaging event (Gan et al., 2015). Adaptation includes actions such as fuel treatments and protection strips in the surroundings of rural settlements and infrastructure, escape strategies, and shelters (Everett and Fuller, 2011).

These wildfire mitigation and adaptation (hereafter WM&A) actions can be carried out at different levels (Busenberg, 2004; Gill, 2005). This study is focused on the WM&A actions at a collective level (private owner groups, local communities, and local governments), unlike most empirical studies, which mainly address the individual responses (e.g., Fischer, 2011; Rodríguez-Carreras et al., 2020, Brenkert-Smith et al., 2012; Martin et al., 2009; McCaffrey et al., 2011; McGee et al., 2009; Olsen et al., 2017). The collective level is relevant because, to be effective, WM&A actions need to be coherently executed at a scale larger than the individual.

This study also aims to inform an effective paradigm shift from suppression to prevention by analysing collective WM&A actions within a wildfire-prone Portuguese region: Pinhal Interior. The WM&A actions are included in the same analysis, resorting to the same explanatory factors, but clearly distinguishing between mitigation and adaptation based on their different nature and goals and the actors involved in their implementation. We seek to define relationships between WM&A actions and both local factors (natural resources, population, and institutions) and external resources (access to policy funding) that favour or hinder mitigation and adaptation. The main goal of this study is to explore the usefulness of distinguishing mitigation and adaptation, and to identify local factors and external resources that promote each of them.

## **2. Data and methods**

Data collection and analysis were executed at a parish level from primary and secondary data. A survey was applied to the presidents of Parish Councils to identify WM&A actions during the 2015-2020 period. These correspond to a set of 14 actions related to investments in firefighting, awareness and protection, land clearing, grazing and plantations. Five of the 121 parishes were excluded for non-answer reasons. Secondary data includes Forest Intervention Zones (FIZ), land use/land cover (LULC), population, institutions, public funding, or burnt areas.

A principal component analysis (PCA) was applied to the 116 parishes to understand the relationship between mitigation and adaptation. Four variables were used in the PCA: 1) number of adaptation actions (Numb\_actions); 2) existence of an approved Forest Management Plan (FMP\_approved); 3) proportion of the parish covered by FIZ (FIZ\_extent); and 4) age of FIZ (FIZ\_age). The last three variables express the FIZ's success in the implementation of collective mitigation actions. The principal components (PC) with eigenvalues greater than 1 were extracted.

Random forest modelling was used to determine relationships between PC scores (dependent variables) and a set of 51 independent variables, which were grouped in five dimensions: 1) LULC or resource system characteristics; 2) people and their relationships; 3) institutions; 4) external resources; and 5) wildfires. Mean squared error (MSE) was used to measure the effect of each independent variable in the models.

## **3. Results and discussion**

### **3.1. Collective mitigation progression and adaptation effort display two locally independent dynamics**

Two PC were extracted from the PCA, retaining together 88% of the total variance (table 1). PC1 (mitigation under FIZ) collects 64% of the variance and is associated with FMP\_approved, FIZ\_extent and FIZ\_age. PC2 (community adaptation) represents 24% of the variance and is only associated with Numb\_actions. These PC can be considered as orthogonal because all variables related to mitigation only contribute to PC1 and the

variable related to adaptation only contributes to PC2. Therefore, these PC are independent and not spatially related, which means that there is no association between progression of mitigation and adaptation effort.

It was possible to achieve this innovative result by comparing both responses to wildfire (actions for landscape protection and people's protection) across different territorial units for the first time. In fact, research on collective responses to wildfires are mostly confined to single territorial contexts and case studies (Danley et al., 2021). On the other hand, landowners' mitigation and residents' adaptation are either analysed separately or just assimilated (Everett and Fuller, 2011; Górriz-Mifsud et al., 2019; McLennan and Birch, 2005).

**Table 1- Unrotated component matrix extracted from the PCA.**

Acronym	Variable	Component	
		Mitigation under FIZ (PC1)	Community adaptation (PC2)
<i>Numb_actions</i>	Number of WM&A actions	-0.264	0.964
<i>FMP_approved</i>	Forest Management Plan approved	0.915	0.151
<i>FIZ_extent</i>	Proportion of the parish covered by FIZ	0.910	0.085
<i>FIZ_age</i>	Age of FIZ	0.909	0.042

### 3.2. Socioeconomic vitality, ownership structure, and leadership are key factors for WM&A action, unlike wildfire experience

Random forest models (figure 1) showed a much better fit for PC1 than for PC2 (58.5% vs. 6.8% of variance explained). This can be partly explained by the different territorial levels between actions and local and external resources. Data for some of the variables were only available at the municipal level, not allowing to fully capture the reality in each parish of the same municipality.

The highest scores of PC1 were obtained for parishes with higher values of built-up areas (*Built\_up*), population densities (*PopDens*), agriculture areas (*Agricult* and *AgricBuff*), landscape heterogeneity (*Shannon*), younger people (*Young*), livestock (*LivStock*), tourism (*AccomCap* and *NightSty*), properties' dimension (*AvgUAA*), and capacity to raise public funding (*ForFund*). The propensity for landowners' collective mitigation under FIZ occur in parishes with more heterogeneous landscapes, larger built-up and agricultural areas, higher social dynamism, larger properties, higher amounts of money from public funding, and recent wildfires. On the contrary, there are no FIZ in parishes where people are older (and more vulnerable), landscape is more homogeneous, eucalyptus prevails, properties are smaller, and there have been fewer recent fires.

The PC2 model shows that only land registry (*LandReg*) stands out in variable importance (figure 1). The active role played by local governments in the promotion of land registry suggests that community adaptation depends on stronger leadership by local governments (Harris et al. 2011; Labossière & McGee, 2017). The PC2 scores are not clearly related to the other considered variables.

Historic and recent fires, namely the catastrophic years of 2003, 2005 and 2017, did not have significant effects on local collective mitigation or adaptation actions. This means that wildfire experience and awareness at the local level may not represent an effective trigger of collective mitigation and adaptation action, unlike what has been suggested in other studies (Jakes and Sturtevant, 2013; Mockrin et al. 2018; Muller and Schulte, 2011; Steelman and Kunkel, 2004).

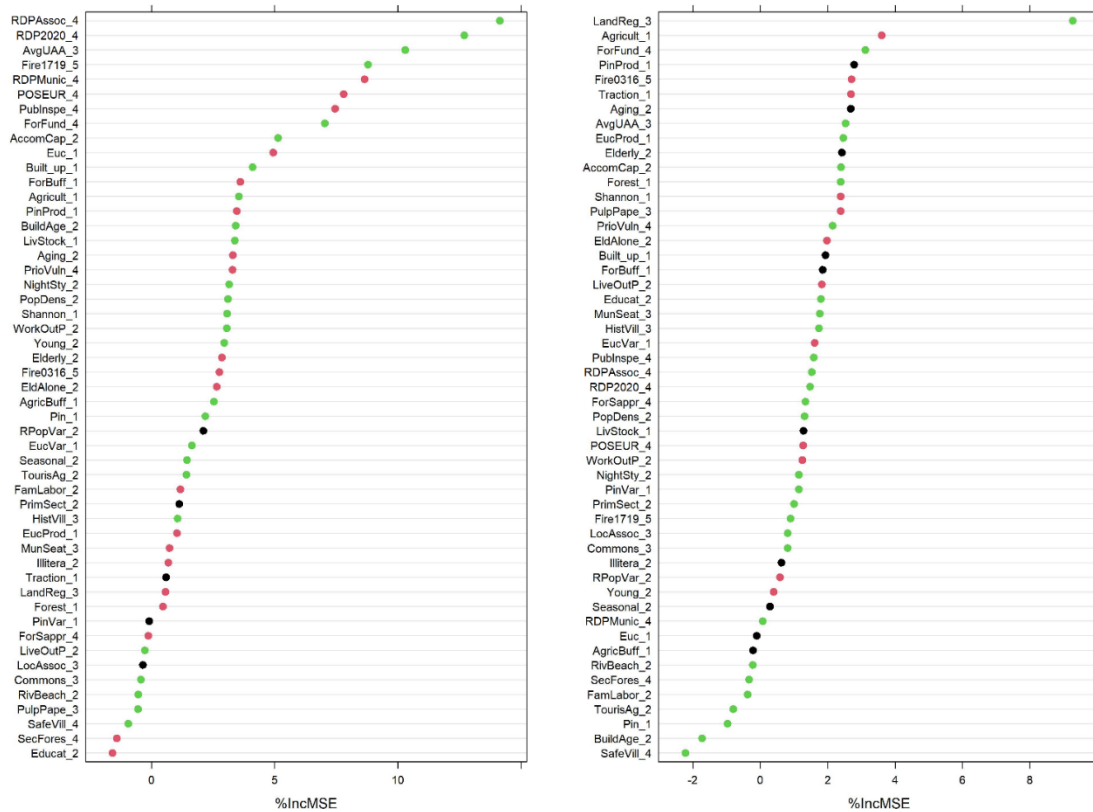


Figure 1- Variable importance for the random forest models for PC1 (left) and PC2 (right). Green, red, and black dots identify positive, negative, or unclear marginal effects of the variable on the scores of the PCs, respectively. Numbers following variable names refer to the corresponding dimension (see data and methods section).

### 3.3. Mitigation and adaption: a distinction supported by different policy domains

Most of the top variables in the PC1 model are included in the external resources dimension, demonstrating the vital role of public funding for collective mitigation progression (Canadas et al., 2016; OECD, 2013). This association is positive for public funding aimed at mitigation and negative for programmes aimed at adaptation. These associations reinforce the usefulness of distinguishing the two action spheres that are also supported by two distinct policy domains (OECD, 2016). Mitigation under FIZ is positively associated with landscape protection, agricultural and rural development policies.

Mitigation and adaptation actions on the ground are related to distinct policy domains, which are promoted by different policy actors and tend to protect different interests (table 2). However, these two policy domains seem to be unequally consolidated. The mitigation domain is supported by a set of well-established public and private agencies, policy measures and funding allocation already in place. The adaptation domain is more recent and less established, unlike what happens in the Anglo-Saxon countries (Everett and Fuller, 2011; McLennan and Birch, 2005).

Table 2- Programmes, entities, and policy domains supporting collective WM&A actions.

Programme	Executing/funding entities	Policy domain
“Secure Forests” Operation	National Republican Guard (Ministry of Internal Administration and Ministry of National Defence)	Adaptation
“Safe Village, Safe People” Programme	National Emergency and Civil Protection Authority (Ministry of Internal Administration), National Associations of Municipalities and Parishes	Adaptation
Rural Development Programme 2014-2020 (RDP 2020)	Ministry of Agriculture Co-financed by the European Agricultural Fund for Rural Development (EAFRD) and the Portuguese State Budget	Predominantly Mitigation
Permanent Forest Fund	National Forest Authority	Mitigation
Programme for Sustainability and Efficient Use of Resources [POSEUR]	Ministry of Environment Financed by the European Commission’s Cohesion Fund	Predominantly Adaptation

Nevertheless, several drawbacks affect both action spheres and policy domains. Underfunding is among the main drawbacks pointed to mitigation policies (Santos et al., 2021). In fact, as in other countries, fire suppression has repeatedly attracted most public funds related to wildfires, thus limiting the resources for prevention (Calkin et al., 2011; Fernandes et al., 2020; North et al., 2015). The average investment in suppression in Portugal during the 2007-2016 period was three times higher when compared to prevention (Beighley and Hyde, 2018; Viegas et al., 2017). On the other hand, the results have demonstrated that the adaptation effort on the ground does not have a strong association with any funding or policy priority.

#### **4. Conclusions**

The proposed distinction between mitigation and adaptation has enabled us to reveal that, on the one hand, collective mitigation and adaptation are independent, i.e., mitigation action does not go along with adaptation action, and, on the other hand, WM&A are associated to different territorial variables and policy domains. The visibility given to the unequal consolidation levels between the two policy domains is an important outcome of that distinction.

The results suggest the local context, namely the economic and social vitality, ownership structure, and leadership by local governments, as the key factors to explain the different involvement of the territories in collective WM&A action. Unlike what is dominantly assumed in the literature the wildfire experience seems to play a minor role. Therefore, awareness campaigns targeted at landowners and local communities may prove insufficient to promote the desired WM&A action.

Although territorial differences are recognized in the wildfire literature, the consequences of those differences have not yet been fully explored, namely concerning the role of local government versus self-organization for collective WM&A actions. In the study area, owners' collaboration for mitigation has developed in parishes with higher demographic vitality and economic dynamism and resident collaboration for collective adaptation is almost absent. High levels of aging, low profitability of land-using activities and land management abandonment hinder both WM&A on strictly self-organization grounds. In fact, self-organization unlikely arises and thrives in similar regions, where local socioeconomic conditions markedly differ from those reported in the WUI literature.

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