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Blazing the trail: Social innovation supporting wildfire-resilient territories in Catalonia (Spain)

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ABSTRACT

Mediterranean territories have co-evolved and been shaped by fire throughout history. However, global environmental change conditions are increasing the size, intensity and severity of wildfires, which have gone from a regular natural disturbance to a serious threat for civil protection, surpassing firefighting capacities. Therefore, building resilience in fire-prone territories is an increasingly relevant policy and management objective. However, the notion of resilience has been criticized for paying insufficient attention to key social issues such as socio-political dynamics, power imbalances and societal change. At the same time, social science contributions to wildfire research are still rather limited. In this paper, we bridge social innovation theory to resilience theory in order to create a territorially embedded and socially sensitive framework for assessing socio-ecological resilience. From this perspective, we then examine how Forest Defence Groups (*ADFs,* by their Catalan acronym) have evolved from grassroots, bottom-up initiatives to well-established bottom-linked institutions and we evaluate their contributions to socio-ecological resilience in the territories where they operate. Our results show that ADFs contribute in several aspects to socio-ecological resilience and that the pave the way for opening up spaces of dialogue and collaboration through which local communities can engage with the issues that directly affect them, such as wildfires.

1. Introduction

Wildfires are an essential component of Mediterranean territories (Pausas et al., 2012). However, global change dynamics are rapidly modifying the scene, and extreme wildfires are becoming a major civil protection issue (Rego et al., 2018; Plana et al., 2018). In Mediterranean countries, this is largely driven by rural exodus and land abandonment (Frei et al., 2020), threatening socio-economic and environmental values (Wunder et al., 2021).

The traditional "zero fire policy" approach of modern welfare states, that focused on the immediate suppression of all fires (Górriz-Mifsud et al., 2019), has been shown to contribute to higher fuel loads being available for the next fire; that, in turn, increases the fire risk for both ecosystems and humans (Castellnou et al., 2019; Xanthopoulos et al., 2020)—a phenomenon known as the "wildfire paradox".[1] That, combined with the growing number of extreme wildfires that surpass firefighting capacities and the recognition of the issue as a complex, socio-ecological one (Bowman et al., 2009; Howitt, 2014; Moritz et al., 2014a), has motivated a progressive paradigm shift that departs from the full suppression paradigm and acknowledges the need for long-term prevention and preparedness (Birot, 2009; Dunn et al., 2020). In this context, understanding fire-prone territories as complex socio-ecological systems (SESs) in which human and ecological factors are closely intertwined is becoming more prominent, and building resilience arises as a major policy objective (Lelouvier et al., 2021; Leone et al., 2020).

Much of the academic literature has studied wildfires by mobilizing a

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[1] Also known as "firefighting trap", which refers to how efforts to immediately put out all fires (zero-fire policies) contribute to increased fuel load available for the next fire, and therefore increasing the fire risk for both ecosystems and humans (Castellnou et al., 2019; Fernandes et al., 2011; Otero and Nielsen, 2017; Xanthopoulos et al., 2020).

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resilience/vulnerability framework (Castellnou et al., 2019; Higuera et al., 2019; McWethy et al., 2019; Smith et al., 2016; Tedim et al., 2016). This paper builds upon this work, while taking on board some of the criticism that the resilience concept has received regarding its limited capacity to engage with ethical issues, social dynamics and power imbalances (Garrett, 2016; Kaika, 2017; Keck and Sakdapolrak, 2013; Paidakaki and Parra, 2018; Skrimizea et al., 2021). We do so by critically revisiting the notion of socio-ecological resilience from a social innovation perspective in order to put forward a more socio-centred perspective. With this, we seek to combine the well-established capacity of resilience theory for studying socio-ecological systems (SESs) and interactions therein (Cote and Nightingale, 2012; Folke, 2006) with the socially sensitive perspective of social innovation, which has been widely used for studying societal change and the role of socio-political dynamics in shaping, negotiating and governing the territories in which wildfires occur (Moulaert et al., 2019; Moulaert et al., 2013).

We apply this understanding of socio-ecological resilience to the analysis of Forest Defence Groups (ADFs, for their Catalan acronym) which are a pioneer and still uncommon type of civil society engagement in the wildfire field. Rooted in solidarity networks in rural Catalonia, ADFs are volunteer groups carrying out activities in wildfire prevention and suppression. Their institutionalization in 1986 resulted in a significant increase not only of their resources and capabilities, but also of their cooperation with the public administration. We have examined this case-study within the research carried out by the consortium of the EU H2020 SIMRA project exploring social innovation in rural areas (Górriz-Mifsud et al., 2019; Rodríguez Fernández-Blanco et al., 2019). We argue that ADFs represent an example of bottom-linked governance in the wildfire field, in which the local population self-organizes but is also consistently acting in partnership with institutions from the public sector (Moulaert et al., 2019).

The aim of this paper is twofold. Firstly, it builds a socially sensitive perspective for socio-ecological resilience to wildfires through the revision of this concept from a social innovation standpoint. From this perspective, we discuss how the social innovation initiative of the ADFs contributes to socio-ecological resilience in the territories where they operate. In doing so, we further reflect upon the socio-political dimension of resilience, while contributing to an enhanced understanding of social innovation in rural areas (Neumeier, 2012; Vercher et al., 2020; Castro-Arce et al., 2019).

2. Conceptualizing socio-ecological resilience from a social innovation perspective

2.1. Socio-ecological resilience

As the fire practice and academic community acknowledges that "zero-fire" policies are having counterproductive effects (i.e. the wildfire paradox), resilience thinking is steadily gaining ground as an approach to wildfire management (Folke et al., 2004; Rist and Moen, 2013; Scheffer et al., 2001). Defined in the field of ecology as the ability of a given ecosystem to "bounce back" to the same general structure (Holling, 1987), the concept has also been used in the social sciences field, largely following Adger's definition of social resilience as "*the ability of communities to withstand external shocks to their social infrastructure*" (2000 p. 361). Echoing Holling's understanding of ecological resilience, Adger (2000) focuses on the capacity to "endure" external shocks (Keck and Sakdapolrak, 2013) without compromising the functioning of the infrastructure sustaining community life such as health care, housing or community services (Grum, 2020). This understanding of social resilience, however, has been criticized in the literature for overlooking the role of socio-political systems (Vale, 2014) as well as the adaptive capacity of local communities through the reproduction of social innovations (Mehmood, 2016).

Despite the different types of resilience described in the literature (engineering, ecological, social, adaptive or transformative resilience, to name a few) when dealing with complex SESs, the term 'socio-ecological resilience' is most widely used. Folke et al.(2016 p.2) define socio-ecological resilience as "*the capacity to adapt or transform in the face of change in socio-ecological systems, particularly unexpected change, in ways that continue to support human well-being*" (2016 p.2). Building upon the work of the Resilience Alliance, Berkes et al. (2008) introduce the three-defining characteristics of socio-ecological resilience: (i) the amount of change the system can sustain while remaining in the same domain of attraction, (ii) the capacity of self-organization and, (iii) the capacity for learning and adaptation.

In transposing the concept to the wildfire realm, resilient territories have been described as socio-ecological systems drifting away from the "zero-fire" paradigm (Otero and Nielsen, 2017; Tedim et al., 2016) and entailing management strategies in which risk analysis and mitigation play a key role (European Forest Institute, 2019). In other words, a socio-ecological resilience approach to wildfires acknowledges that fire cannot be fully suppressed and rather focuses on maintaining an ecologically sound fire regime whilst protecting lives and assets (Schumann III et al., 2020). In this research, and by drawing upon the criticism that the resilience notion has received in the literature (Garrett, 2016; Kaika, 2017; Keck and Sakdapolrak, 2013), we critically examine the three dimensions described above and argue that socio-ecological resilience to fire is not only about individuals "surviving" a fire: it is a process that is deeply interlinked with the societal and political dynamics underlying the wildfire phenomena and the territories where they occur. Consequently, this paper makes a plea for framing the wildfire issue as a challenge anchored within wider territorial governance processes that involve those immediately concerned. From this perspective, any reflection on socio-ecological resilience to fire will imply delving into issues such as power relations as well as social and governance dynamics.

One of the main critiques to resilience thinking is its limited attention to the role of socio-political processes for social change (Cretney, 2014; Kaika, 2017; MacKinnon and Derickson, 2013), and in particular its lack of reflection on politics and power relations (Cinner and Barnes, 2019; MacKinnon and Derickson, 2013). In addition, the prominence of "resilience" as a buzzword has also raised concerns, owing to its consideration as a value-laden term, but whose value judgments often go unacknowledged, and its assumptions unquestioned (Garrett, 2016). For example, resilience is often assumed to be a desirable attribute. However, before assuming such desirability, there are three fundamental questions that need to be considered, but are often omitted: resilience of what? To what? And for whom? (Carpenter et al., 2001; Cutter, 2016). By not asking these questions, we run the risk of perpetuating unequal social structures that continue to diminish the quality of life of the most vulnerable spheres of society. Furthermore, in disaster risk management, there is an additional key question that arises: "resilience by whom", which refers to where the ultimate responsibility for building such resilience rests, or in other words, "who owns the risk" (state vs. non-state actors, including hybrid forms) (Bakema et al., 2019).

2.2. Contributions from social innovation

Social innovation refers to how social structures are modified and ethical norms revisited in order to tackle unmet needs, placing a strong emphasis on issues such as inequality, power relations and/or environmental degradation (Avelino et al., 2015; Mehmood and Parra, 2013; Vercher et al., 2020). It differs from classical innovation approaches because it aims for positive impacts that go beyond the individual level, involving the interaction among actors (Polman et al., 2017). In this paper, we build upon the work put forward by Moulaert et al. (2013) who defined social innovation as changes in social relations, political arrangements and/or governance processes that lead to improvement in a social system, identifying three main and interconnected components: satisfaction of needs, reconfiguration of social relations, and empowerment.

In this context, satisfaction of needs refers to those needs not yet or no longer fulfilled by the state or market (Moulaert et al., 2005) and can refer to basic human needs (food or shelter), non-material needs (sense of belonging, human fulfilment, equity) or to socio-ecological challenges affecting a particular area, such as environmental degradation or vulnerability to a natural hazard (Mehmood and Parra, 2013). The revelation of these needs (i.e. people becoming acutely aware of these needs and of their collective voice in addressing them) can be considered in and of itself an outcome of the social innovation process.

The second dimension refers to the reconfiguration of social relations, denoting an understanding of social innovation both as a process and as an outcome. As a process, this second dimension refers to the necessary reconfiguration of social relations and governance changes at multiple scales that enable the revelation and satisfaction of collective needs. Within this understanding of social innovation as a process, the dynamic, non-linear nature of innovation in social relations and governance is highlighted (Baker and Mehmood, 2015; Neumeier, 2012; Ray, 2006; Spijker and Parra, 2018). Also changes in actors' attitudes and/or behaviours have been flagged as relevant elements of these reconfiguration dynamics (Secco et al., 2017). This dynamic understanding of social innovation is particularly suitable for its examination from a combined socio-ecological perspective, in which the natural environment interacts with, and is embedded in, a particular social system and a specific set of governance rules and institutions (Ostrom, 2009). Social innovation as an outcome, for its part, refers to the crystallization of this process, either as material or non-material outcomes (e.g. stronger social fabric, new governance structures or new services delivered). From both perspectives, the notion of social innovation is an inherently territorialized one, operating at multiple spatial scales (Van Dyck and Van den Broeck, 2015).

The third dimension advanced by Moulaert et al. (2013) refers to the increased socio-political capability of different actors and communities, and their concomitant access to resources (Mehmood and Parra, 2013). This empowerment dimension is, therefore, linked to the capacities for political transformation and improved governance, which requires collective agency and strong cohesive relations. In regards to the role of the public sector, research shows how it plays a key role in securing favourable socio-political environments for social innovation to thrive (Klein et al., 2013; Martinelli, 2013; Spijker and Parra, 2018). In the cases in which bottom-up initiatives are incorporated into more structured and formalized systems (e.g. the public administration) or enhanced by the public sector (e.g. creation of coalitions of collaborative partnerships between SI initiatives and public agencies), we talk about "bottom-linked" governance, or "bottom-linked" social innovation (Castro-Arce and Vanclay, 2019). Empirical evidence shows how this form of governance often leads to more robust and longer-lasting citizenship engagement (Andersen et al., 2013), thus facilitating cooperation across scales and reducing conflict (Moulaert et al., 2019; Pradel Miquel et al., 2013). These two aspects—facilitating cooperation across scales and reducing conflict—have been flagged in the field of wildfires (both during the prevention and suppression phases) as areas needing attention and improvement (Buizer and Kurz, 2016; Martín et al., 2018; Paveglio et al., 2015). In addition, and since bottom-linked initiatives often operate at multiple spatial scales, they are helpful in building resilience at the multiple scales in which they operate.

2.3. Towards a socio-political understanding of socio-ecological resilience to wildfires

The socio-ecological resilience approach presents itself as quite robust for studying wildfires, owing to its consideration of the interrelations and feedback processes between the social and biophysical dimensions (Moritz et al., 2014b). However, and as discussed earlier, there is still room to further enhance the analytical power of resilience theory for understanding power dynamics and socio-political change (Folke, 2006).

In light of this, and further elaborating on the definition of socio-ecological resilience presented in section 2.1, we understand that building socio-ecological resilience to fire is a continuous process that goes beyond merely "surviving" while protecting assets and infrastructure. Resilience, in order to achieve genuine human well-being needs to be grounded on principles of social justice and equity that align with the most basic sustainability principles (Clifton, 2010). In this section, we re-examine each of the three-defining features of socio-ecological resilience described in 2.1 from the standpoint of the three social innovations dimensions described in 2.2. In doing so, we bring to light different socio-political aspects that are central to human well-being and as such, also key aspects to be incorporated into the resilience building process (Fig. 1).

The three-defining characteristics of socio-ecological resilience can also be identified with the phases of transformation introduced by Olsson et al. (2004) cited in Biggs et al., 2010). By embracing the dynamic and uncertain nature of the system, resilient SESs would "*prepare for change*" so that disturbances do not jeopardize the human well-being within the system. The resilience framework characterizes this as the "front loop" of the adaptive cycle, and it comprises features that help strengthening the existing system (Biggs et al., 2010). From a social innovation perspective, this translates into ensuring that material and non-material needs of all spheres of society are met, which assumes the acknowledgment that (uneven) vulnerability to environmental risks (e.g. wildfires) also constitutes an unmet need that requires consideration to create a socio-ecological resilient system. Perceptions and framing of the socio-ecological context play a key role, insofar as they influence social actors' interactions in the face of disturbances. Consequently, the existence of inclusive spaces for societal dialogue, collective action and questioning of the *status quo* are all necessary elements for building resilient SESs.

The idea that change is necessary for improvement ("creative destruction") appears as core both in the resilience and social innovation scholarship, and thus creates common ground for integrating these two bodies of knowledge. Once a disturbance occurs, resilient SESs can trigger processes of self-organization, in order to "*navigate the transition*" as best as possible (Biggs et al., 2010). In our understanding, a socio-ecologically resilient system would at this stage generate different societal dynamics processes directed at fulfilling multiple roles, from revealing and/or satisfying societal needs not currently met, to stirring collective reflection upon newly revealed vulnerabilities. The reproduction of social capital and renegotiation of governance arrangements across spatial scales are also key elements of these processes (Nelson et al., 2007). At this stage, it is central to include all actors immediately concerned on equal foot, if we are to avoid marginalization. Consequently, resource allocation and power dynamics are key, not only for producing tangible outcomes, but also to ensure that they respond to jointly identified needs.

In this regard, bottom-linked governance arrangements are helpful in facilitating relationships between political authorities and civil society actors, and are an essential element in processes of socio-political transformation (Moulaert et al., 2019). Specifically, we highlight the role that bottom-linked formulas may have in mobilizing resources and reinforce the role of agency in self-organization processes.

In terms of learning, this cross-fertilization exercise shows how, for a socio-ecological system to be resilient, learning needs to occur at multiple scales, and in an inclusive way. On the one hand, institutional learning requires acquiring the capacity for strategic planning in the face of uncertainty. On the other, there is a need for mainstreaming legitimate, participative approaches that explicitly consider societal needs and values as well as normative and politically sensitive issues. In the field of wildfires, the latter is of particular importance, due to the social conflict that often arises in the interaction of local communities with external bodies (e.g. firefighters) (Paveglio et al., 2015). Consequently, collective learning processes, through which different actors jointly recognize, discuss and co-construct responses to socio-ecological change

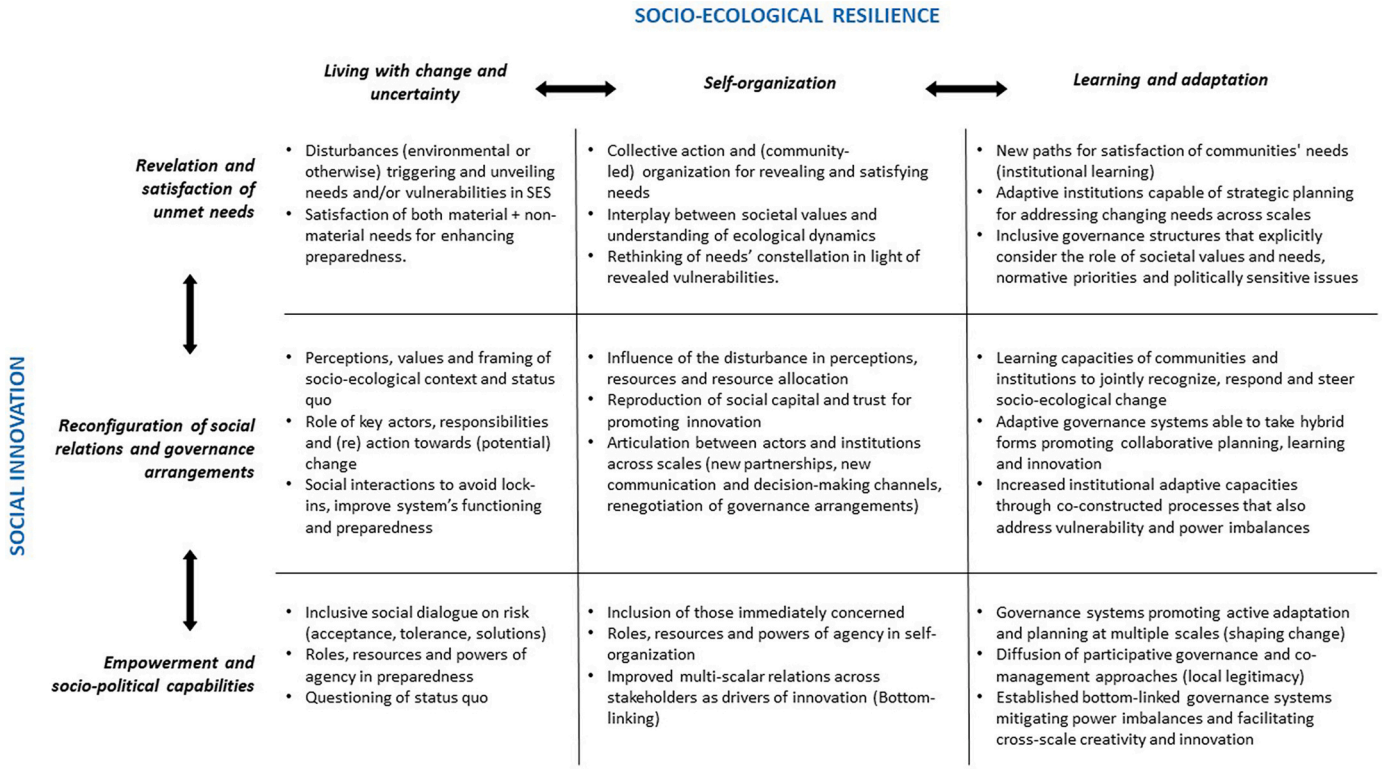


Fig. 1. Emerging elements when looking at the three-defining characteristics of socio-ecological resilience from a social innovation standpoint. Source: Authors' elaboration based on Moulaert et al. (2013) and (Berkes et al., 2008).

is crucial for socio-ecological resilience (Cinner and Barnes, 2019). The social innovation perspective highlights the importance of inclusive processes to reduce vulnerability at the social as well as the biophysical level. In this regard, adaptive institutions showing more participative governance formulas (e.g. bottom-linked) are more legitimized at the local level, and create an institutional environment that promotes creativity and innovation, thereby increasing the resilience of the SESs (Manyena et al., 2011).

Based on the cross-fertilization between the concepts of socio-ecological resilience and social innovation, we advance an understanding of socio-ecological resilience in the context of fire-prone territories as a process of collective engagement and active mobilization of citizens in unveiling vulnerabilities and mitigating risks. We consider a socially innovative social fabric that continuously questions the *status quo* and unequal power structures, to be key for avoiding lock-ins as well as for facilitate learning and adaptation (Folke et al., 2009). Additionally, we highlight the importance of inclusive governance practices as well as adaptive institutions for adapting or transforming SESs in the face of change in a way that genuinely supports the human well-being for all.

3. Methodology

3.1. Case study area

Catalonia is in the NE part of Spain; it covers an area of 32.108 km^2 and has a population of roughly 7.5 million inhabitants (IDESCAT, 2020) (Fig. 2), 42% of which are concentrated in the metropolitan area of Barcelona (AMB, 2020). Catalonia underwent a massive rural exodus over the last hundred years, resulting in heavy land abandonment and a consequent increase of forest cover (from 36% in the 1970s to 65% today, Cervera et al., 2015; IDESCAT, 2020). Seventy-three per cent of these forests are privately owned (DARP and Centre de la Propietat Forestal, 2012).

Catalonia is a highly fire-prone region (Díaz-Delgado et al., 2004a) due to its Mediterranean climate (Clavero et al., 1997; in Díaz-Delgado et al., 2004b) yet, the great diversity in average rainfall and temperature across its territory creates different wildfire regimes (Castellnou et al., 2009; Díaz-Delgado et al., 2004b). The decrease in primary sector activities has created complex landscapes for wildfire management linked to increased fuel continuity and urban sprawl leading to the expansion of the so-called "wildland-urban interface" (WUI).[2]

Administratively, Catalonia is divided into four provinces. The Catalan government is the competent authority for wildfire prevention (Ministry of Agriculture) and suppression (Ministry of Home Affairs), but municipalities are obliged to have a fire prevention plan if they are in an area of high fire risk. Municipalities are often supported by the provincial government for these tasks.

As a result of years of zero-fire policies and significant techno-managerial improvements in the firefighting services (e.g. policies being directed to suppressing all wildfires along with the inclusion of fire modelling and remote sensing techniques in fire-fighting strategies), the fire service is very efficient in quickly suppressing most fire emergencies (See annex 2). This, however, has created the so-called fire paradox (Castellnou et al., 2019), particularly evident in Table 1, in which a small number of fire events are responsible for most of the burnt area (Departament d'Agricultura, Ramaderia, 2012).

[2] The NWCG (National Wildfire Coordinating Group of the US) Glossary of Wildland Fire defines the Wildland-Urban Interface (WUI) as an area where structures and other human development meet or intermingle with undeveloped wildland or vegetation fuels. These areas are of particular concern to emergency services due to the combination of a large number of anthropogenic ignition sources and a large continuity of flammable material, thus posing high risks for both human lives and assets.

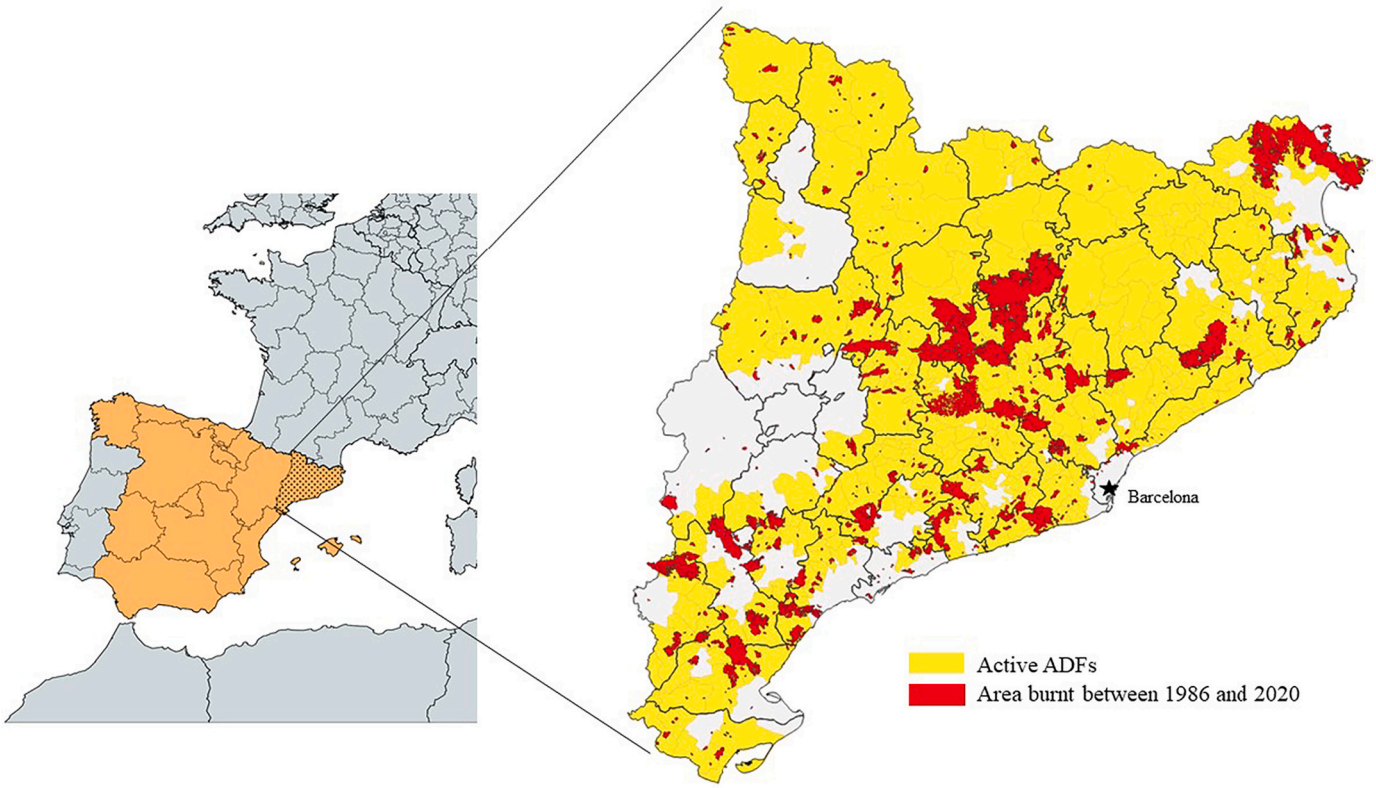


Fig. 2. Location map of Catalonia in Spain. On the right, a map of Catalonia showing the areas with active ADFs, in combination with the areas burnt between 1986 and 2020. Source: Authors' elaboration based on OpenMaps and DARP.

Table 1
Stratified fire statistics. Source: Departament d'Agricultura. Generalitat de Catalunya (2021).

Fire size (ha)	1983–1992		1993–2002		2003–2012	
	% of fires	% burnt ha	% of fires	% burnt ha	% of fires	% burnt ha
< 1	50,93%	0,54%	77,23%	0,79%	85,08%	1,89%
1–10	38,62%	4,54%	18,85%	3,12%	11,86%	5,10%
10–100	8,14%	10,05%	2,79%	5,71%	2,24%	10,77%
100–500	1,55%	13,85%	0,76%	11,11%	0,58%	19,07%
> 500	0.76%	71,02%	0,37%	79,27%	0,24%	63,17%

3.2. Data collection and analysis

This research applied a qualitative research approach grounded on social innovation and socio-ecological resilience theories. Data were collected through a combination of focus groups, semi-structured interviews and a literature review of policy documentation, scientific and grey literature, as well as local press.

Firstly, we performed a desk-based literature review identifying key stakeholders and gaining preliminary knowledge about ADFs. A summary of this review may be consulted in Górriz-Mifsud et al. (2017). Secondly, a focus group was organized in March 2018 with 4 people (a representative of the SFADF, of the first ADFs and the organization in the early years, as well as one external expert). The meeting was audio-recorded, and notes were taken by an assistant. This focus group served to reconstruct the history of the ADFs, identifying potential interviewees and finetuning the interview questions. The long existence of the ADFs affected the data collection since some key actors had either passed away or were unavailable to participate in our study.

After the focus group, and using the snowballing technique, we interviewed different stakeholders who had played a relevant role in the emergence and evolution of ADFs, including mayors, forest owners *(pagesos)*, ADF members and external experts who were knowledgeable in the subject (See annex 1). After interviewing a total of 19 informants, data saturation was reached (Patton, 2002). The types of questions asked to each interviewee varied slightly, depending on whether they had a personal role in the ADFs' emergence and/or evolution, or whether they had a wide knowledge of the ADFs from other indirect contacts. The length of the interviews ranged from 54 to 215 min. Interviews were held in both Spanish and Catalan, and were recorded, transcribed and then coded by means of thematic analysis on two rounds. The first round focused on getting a deep understanding of the empirical case study, and it was performed using the structure/agency framework proposed by Secco et al. (2017). This allowed for a cross-scale examination of the ADFs, as well an enhancing our understanding of the socio-political context in which they emerged. Afterwards, a second round of coding was performed, based on the concepts and analytical categories discussed in section 2.3 (See Fig. 1) and the knowledge acquired during the first round. In both rounds, the analysis was subject to reviews and discussions between the primary researcher and co-authors, refining the themes in light of the combined social innovation and socio-ecological resilience literature, and to cross-check for a correct interpretation of the data in light of the theoretical underpinnings.

4. The ADFs in the flow of history

4.1. Pre-existing collaborative networks for enhanced preparedness

The origins of the ADFs can be traced back to the networks of mutual help and forest owner associations operating in the territory since the 1960s and 1970s (Fig. 4) (Cerdan, 1991; Garriga, 1995; Peix et al., 1993). This type of collective action occurred largely among *pagesos* (Catalan farmers) and was particularly well-organized in Central

Catalonia, where wildfire risk is very high, although we also found evidence of similar groups in other areas nearer to Barcelona (ADF006; Rius, 1979). These networks helped local communities to put out fires affecting their properties during a time when firefighting bodies were eminently urban; and they often lacked appropriate means or training to tackle forest fires efficiently, thus regularly arriving late to the burning site (ADF005). This recurring issue had a major disrupting effect on local inhabitants living off the affected lands. In response, forest owners' associations were created, not only to help each other, but also to share the costs of fire suppression, since at the time firefighting was not provided as a public service and firefighting assistance had to be paid by forest owners themselves (ADF005; Rodriguez-Carreras et al., 2020).

In 1982, the municipality of Manresa started an environmental education project called "*Casa de la Natura*" [House of Nature, in Catalan] (NacióManresa, 2009; ADF002), which focused mainly on wildfire (ADF002; Cerdan, 1991). As evoked by one of our interviewees,

> *"In the summer of 1985, fire appeared as one of the main concerns (…). We didn't only go to supress the fire, but we also asked ourselves "What do we do now?" (ADF002).*

In light of the importance that the wildfire issue was acquiring, a wide range of local actors (*pagesos,* farmer's union representatives, local citizens, local authorities, etc.) gathered to discuss how they could tackle the situation (e.g. relationship with the public administration, risk awareness or needs for training); they did this in the *Casa de la Natura* premises, serving as a space for societal dialogue. These meetings congregated heterogeneous groups formed by forest owners, members of *Unió de Pagesos* (the main farmer's union at the time), firefighters, local inhabitants, representatives of local municipalities and *Casa de la Natura* own staff. Interviewees recall those meetings as stimulating and constructive, despite the different mentalities: "*They were from a more urban area (Manresa), so they defended more the participation of volunteers (…) but it was ok, we understood each other"* (ADF004). Eventually, these meetings caught the eye of government officials, who started to occasionally join the meetings; one of their main grievances was the lack of sufficient resources in rural areas to fight wildfires. However, and despite the lobbying efforts (particularly by *Unió de Pagesos*), it was not until 1986, when the iconic Mountain of Montserrat burnt, that the government took action (Cerdan, 1993; Cerdan, 1991).

4.2. The Montserrat wildfire as a trigger for change

1986 was a dramatic wildfire season in Catalonia. More than 6000 ha were burnt, including Montserrat, which suffered six different wildfires between 7 and 18 August. The aesthetic, environmental and religious values ascribed to this mountain by Catalan society are high, and it is considered an important symbol of Catalan identity. Consequently, the Montserrat wildfire triggered a strong response not only from the local population but also from urbanites, prompting protests against the government (Ribera, 2015). The event placed the fire issue at the top of the political agenda, and shortly afterwards, in October 1986, the Catalan Ministry of Agriculture issued an Executive Order officially creating the ADFs (Generalitat de Catalunya, 1986). The idea was to set up a new system to tackle the fires. In the words of the Catalan Minister of Agriculture of the time, "*(we) will set in motion a completely new model in the Mediterranean area (…) to create an organizational territorial system that, on the one side, guarantees as much as possible that a fire does not start (…) and on the other, that in case an ignition occurred it can be identified and suppressed as soon as possible"* (Ciència, 1986 p.42). The government's rationale was to create a new body formed by the population living in the territory, in order to reduce response times. In addition, the local population's knowledge of the locality would facilitate firefighting tasks, helping firefighters in the field during a time when GPS technology was non-existent. The Executive Order specified who could be a member of an ADF, namely: Municipalities, forest owners (or their associations), professional agrarian organizations, as well as any association devoted to nature conservation, as long as it was linked to the municipality/es in which the ADF operated (Generalitat de Catalunya, 1986).

In this vein, the *Foc Verd* programme [Green Fire, in Catalan] was prepared by the Catalan Ministry of Agriculture and approved in 1986 by the Catalan Parliament. *Foc Verd* was a fire prevention programme focused on fire prevention, detection, and rapid response with the overriding goal of tackling the existing deficiencies in the coordination and management of fire. One of its main goals was the creation of the ADFs, which were inspired by other Defence Groups and took the form of public-private partnerships in the livestock and agricultural fields (Peix et al., 1993).

Once an ADF is created, the Catalan government provides funding in order for them to carry out their activities (Generalitat de Catalunya, 1986), although nowadays they sometimes have extra funding sources such as from the provincial governments (particularly those of Girona and Barcelona). Some ADFs also have small membership fees for forest owners although respondents explained that the overall amount of these contributions remains marginal.

The 1988 Catalan Forestry Act ratified the ADFs as legal judicial entities. They also recognized their role in the firefighting system by officially regulating their interaction with the firefighting body. In particular, the Forestry Act assigned them duties in wildfire prevention, surveillance and land restoration (Garriga, 1995; Generalitat de Catalunya, 1988). Interestingly, and despite fire suppression constituting one of their main activities, this was not yet explicitly mentioned in any legal document.

After 1986, the number of burnt hectares was drastically reduced (See Annex 2). Nonetheless, the fire season of 1994, and especially the one of 1998, again hit particularly hard on the rural areas of Central Catalonia (Fig. 3).

These wildfires were perceived as a failure of the fire prevention and suppression system in place (Miró i Ardèvol, 2019; Otero et al., 2018; Plans, 2000). As one interviewee put it: "*The 1998 forest fires disavowed us*" (ADF004).

4.3. Scaling-up the wildfire governance system and its implication for the ADFs

The fires of 1994 burnt over 75,000 ha, with Central Catalonia being the most affected region (Fig. 3). The Catalan Emergency Plan for Wildfires "INFOCAT" was created as a direct consequence of these fires. The INFOCAT was crafted by the Ministry of Home Affairs, and it reasserted the role of the ADFs in the Catalan firefighting system by assigning them a specific role and position in the chain of command. Despite the renewed efforts, only four years later (in 1998), a fast moving fire surpassed firefighting capacities and destroyed more than 26,000 ha in Central Catalonia (Padró and Badia, 2017). This put wildfire management strategies again under question and triggered two major changes. Firstly, the renewal of the *Foc Verd* policy programme through the release of *Foc Verd II*. This programme, also led by the Ministry of Agriculture, kept the successful principles of the previous policy in place (by promoting the ADFs and emphasizing surveillance and first attack), as well as reinforced the role of fuel load reduction and land planning. The second major change was the in-depth reorganization of the fire department, mainly through the creation of a specialized force of firefighters within the Catalan fire service named the GRAF (Support Group for Forestry Interventions, for its Catalan acronym). The GRAF brought to the table a new discourse and a way of dealing with fire in which the notion of resilience and the use of prescribed fire were central. Otero and Nielsen (2017) explain with great detail the nature, challenges and impacts that the GRAF unit brought about, as well as the role of other Catalan institutions in disseminating their discourse (e.g. the Pau Costa Foundation or the University of Lleida).

Over time, this new discourse permeated to many other wildfire

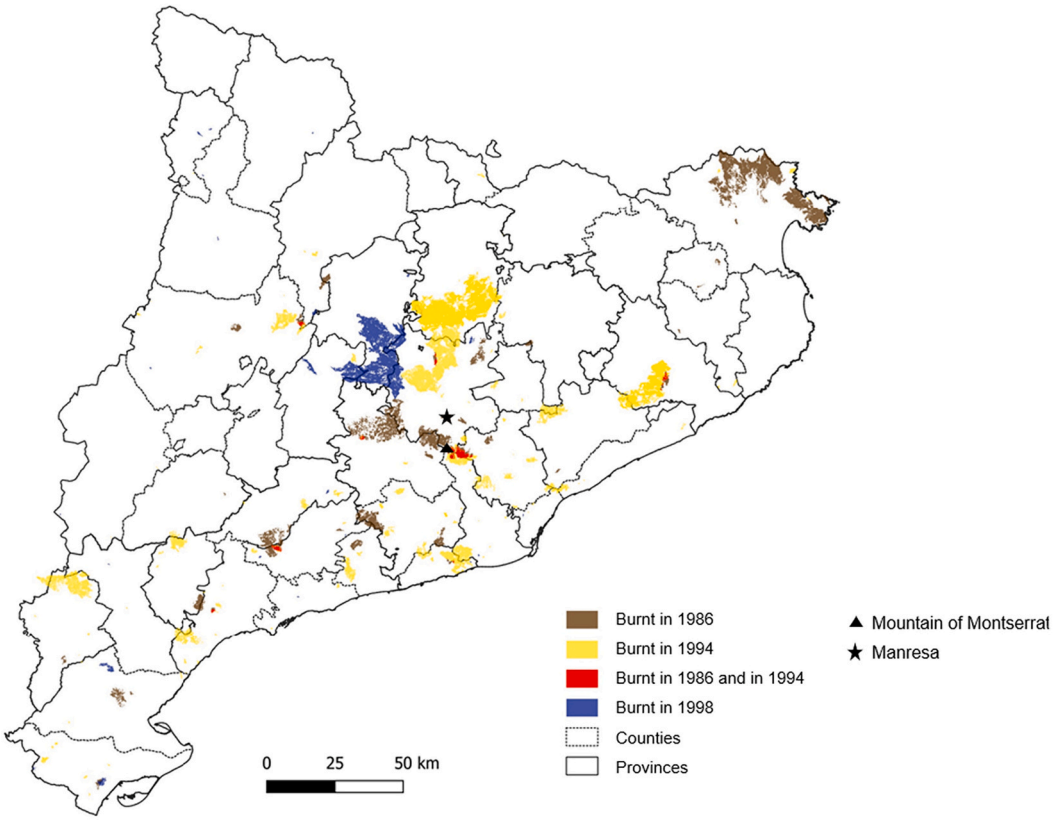


Fig. 3. Wildfires that triggered significant governance changes within the ADF history. Source: Authors' elaboration with data from Institut Cartogràfic i Geològic de Catalunya.

related agencies in Catalonia, and ADFs are no exception, as it can be seen from the quote below.

> *"Our relationship is very fluid and very good (…) we understand each other. We use the same language, the same words, the same criteria. (…). We can call them anytime, and they come" (ADF08).*

ADFs have a deep respect for the leading role of the GRAF in fire suppression and highly value their availability whenever they need something (e.g. training needs, or information on something specific). They report highly fluid interactions, both formally and informally. In terms of knowledge transfer, the GRAF unit has been actively involved since 2014–2015 in designing the training that ADFs receive from the Catalan Institute of Public Health (ISPC), which is compulsory for any ADF member wanting to participate in firefighting activities. Additionally, and because forest owners still have an important weight in ADF groups, this increased cooperation between ADF and GRAF is also regarded as an improvement in the relations between forest owners and the firefighting services (Otero and Nielsen, 2017).

Beyond the strengthened collaborative relationships inherent to the emergence and establishment of the ADFs, our research reveals that since the early days, several ADFs identified the need for better coordination among themselves (Cerdan, 1991). In some areas, such as the Bages (Central Catalonia), ADFs promoted supra-municipal bodies with coordinating functions. They were the precursors of what are today known as Federations of ADFs. These federations often operate at the county level, and their main role is to coordinate the activities of their member ADFs. In 1999, a group of federations further promoted the creation the SFADF, an umbrella association for all ADFs in Catalonia (Secretariat of ADFs; ADF018). Although it took three years for the regional government to recognize the SFADF as a valid representative, it now plays an important coordinating role, facilitating knowledge exchange and representing ADFs before the regional government.

In the over 30 years of history of the ADFs, the official role assigned to the ADFs has barely changed. However, they have certainly evolved over this time—in part, due to demographic changes (e.g. a decreasing number of forest owners and a growing number of volunteers), and in part due to the evolution of the Catalan wildfire system as whole, to which they belong. In particular, the stable collaboration with other agencies (civil protection, rural agents, or firefighters) is particularly well regarded by all parties involved.

The strong linkage of ADFs to the localities where they operate also influences the activities in which they engage, making their interaction with other local entities a common occurrence. While a comprehensive mapping of the individual initiatives of each ADF was beyond the scope of this research, during our fieldwork we came to learn about several initiatives promoted by ADFs in the areas where they operate, such as forest-based biomass cooperative (Bages county), the use of a herd of goats for fire prevention, or a solid collaboration with the local justice department to provide positions for people sentenced to community work penalties (Penedès-Garraf counties) (Górriz-Mifsud et al., 2017). Moreover, it is in fact not uncommon to find ADF volunteers that are also members of other local organizations such as the Red Cross, or Civil Protection groups.

Whereas the future of ADFs remains unknown, it is certain that they have come a long way since they first started as an informal network of scattered forest owners. Proof of the recognition they still enjoy in Catalonia is the fact that in 2018 they were awarded the *Creu of Sant Jordi*, which is the highest honour that the Catalan government has to offer (NacióManresa, 2018).

Fig. 4 depicts the life history of the ADFs, against the main wildfire events in Catalonia and relevant socio-political moments and developments at the local and supra-local levels. The combination of this with the wildfire generations described by Costa Alcubierre et al. (2011), supports the discussion in the next section.

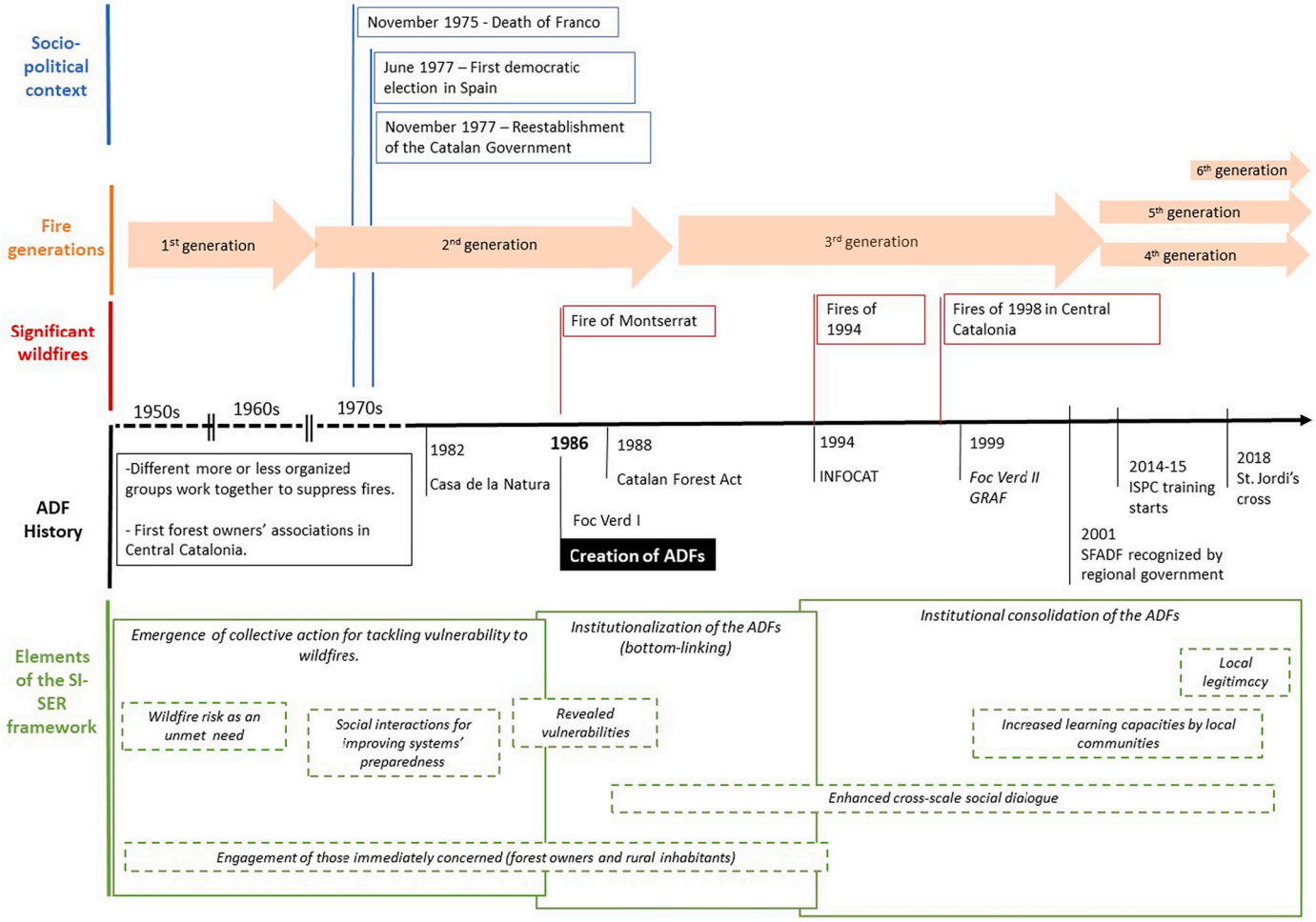


Fig. 4. Timeline of the evolution the ADF history, including at the bottom the most visible elements of our SI-SER framework for each time period. Source: Authors' elaboration.

5. The contribution of ADFs to enhanced socio-ecological resilience

5.1. The changing social and ecological needs of Catalan rural territories

In the 1970s, rural inhabitants found themselves in a situation in which wildfires were seriously disrupting their living environments, and the state's response was insufficient to tackle the problem. This vulnerability to wildfires was perceived as a shared concern among community members (collective need), and also the trigger for engaging in collective action by local inhabitants (Cerdan, 2002; Cerdan, 1991; Ciència, 1986).

> *"This organization [forest owners' association] was created as a solidarity group to organize ourselves as a first response attack, prevention work, and to share costs to pay firefighters" (ADF05).*

> *"It responded to people's needs of manage a common good, or to avoid a common bad" (ADF035).*

Such capacity for building upon pre-existing collectives or networks in order to mobilize existing resources and actively respond to environmental change is considered a characteristic of resilient systems (Cinner and Barnes, 2019). Not only can this mitigate the impact of an external shock, but it also can enhance preparedness for the future. Additionally, interviewees characterized the ADFs as responding to a need that was not only theirs but of the Catalan government—though this was not so evident in the political sphere leading up to the Montserrat wildfire in 1986.

> *"They (the Catalan Government) realised that the firefighting body is completely insufficient for tackling wildfires, and that it is important that the community (due to proximity and knowledge of the terrain) go with minimal equipment that enables them for (carrying out a) a first attack" (ADF044).*

This alignment of the needs at the local and regional level is one of the elements that paved the way for the institutionalization of the collective efforts that were already taking place in rural localities, and thus the transformation of a "bottom-up" initiative into a "bottom-linked" one in 1986.

Socio-ecological systems, however, are dynamic systems. And, in this particular context, the so-called "wildfire generations" (Costa Alcubierre et al., 2011; Rifà and Castellnou, 2007) are useful for understanding how fire behaviour, socioecological change and firefighting have co-evolved over time (Castellnou et al., 2019). In doing that, they also show the evolving needs of the Catalan SES in regards to wildfire suppression. Combining these wildfire generations with the ADF history (Fig. 4), provides with interesting insights into how the social fabric and governance systems reacted and evolved in light of the evolution of the needs revealed and generated by wildfires (Folke et al., 2009).

The first generation of fires (1950s -1960s) was a period when wildfires reached large perimeters due to increasing land abandonment. Responses to these fires were largely organized at the local level, revealing the significant power of agency for tackling existing vulnerabilities and enhancing preparedness.

During the next two decades, further land abandonment brought about the second generation of wildfires, which required a faster response and higher suppression capacities. However, these were only put in place after the Montserrat wildfire in 1986, when this need became visible for policymakers at the regional level. Thanks to the increased awareness in urban areas, and the existing and well-articulated collective efforts (e.g. *Casa de La Natura*), the regional government was forced to act. *Foc Verd I* was the political response to these needs, through which the Department of Agriculture officially established the ADFs (Generalitat de Catalunya, 1986). In doing so, a bottom-linked initiative in the wildfire realm was created, whereby the needs of the rural communities were purposefully included in the regional policy agenda.

Years of successful fire suppression policies, however, led to the "fire paradox" and to the appearance of the third generation of wildfires, which proved to be unmanageable for the existing firefighting system. The strategy put in place by *Foc Verd* I was no longer sufficient for responding to the challenges posed by these wildfires, so the public administration reacted first by releasing the INFOCAT, and eventually *Foc Verd II* and creating the GRAF unit.

In the current wildfire scenario, which poses significant threats to professional firefighters, much less non-professionals, interviewees raised concerns about what role ADFs should play:

> *"They are ok (the ADFs), but in a future (5-6 years) some things need to be reconsidered in order to keep them alive and modern, like everything else" (ADF02).*

Whereas our interviewees did not provide us with any insights about how this "future ADF" could or should look like, it seemed only a matter of time that the discussion becomes more prominent within the ADF network.

5.2. Wildfires as triggers for the reconfiguration of social relations and governance

The ADF history is one of reconfigurations of social relations across scales (the local, supra-local, and regional). At the local level, the "*Casa de la Natura*" facilitated the weaving of new social relationships and modes of collaboration among stakeholder groups previously disconnected, but for whom wildfires were a common challenge. By providing a physical space in which to meet and discuss, it significantly contributed to strengthening and improving pre-existing social relationships, while also creating new ones through the reproduction of social capital and trust. The emergence of these processes contributed to enhancing the sense of belonging and are also one key feature of socio-ecologically resilient systems.

> *"La Casa de la Natura did the job of uniting people" (ADF02).*

> *"A very important participative process was started; it was an enriching one, with an exchange of mutual motivation and reinforcement" (ADF18).*

Additionally, such dialogue served to improve systems' functioning and preparedness at the local level (due to the mutual learning processes that it fostered)—which is another element of resilient SES (Folke et al., 2009).

The Montserrat wildfire is a good example of how disturbances may contribute to shaping stakeholders' perceptions. After the Executive Order of 1986, the regional government actively promoted the creation of ADFs in areas where they had not been prompted by local communities, with the aim of covering the whole Catalan territory (ADF04) and improving the articulation between the public administration and the local level. In fact, our fieldwork shows how the institutionalization process of the ADFs generated a stronger social fabric not only among local actors, but also across spatial scales (Rodríguez Fernández-Blanco et al., 2019), which has been pointed out in the literature as a source of resilience (Nelson et al., 2007; Olsson et al., 2004).

Another important aspect is that ADFs were built upon pre-existing associations and other collectives, thus allowing them to enjoy important local legitimacy. This, combined with their close relationship to firefighting bodies, has progressively enhanced local understandings of decision-making during the wildfire emergency and has reduced conflict (similarly to what Paveglio et al., 2015 found elsewhere in the US). Nowadays, some pilot projects have been developed in order to further democratize firefighting strategies in Catalonia, which include not only ADFs but also other local actors (Otero et al., 2018), and whereas these are not yet mainstreamed, we understand them as interesting efforts for continuing the process of resilience building.

Another important element of resilient systems is learning and adaptation capacities (Barnes et al., 2017; Folke et al., 2009), which ADFs have embodied by promoting the integration of their local knowledge with the technical one held by professional firefighters, and more recently, through an even more intense cross-scale knowledge exchange, primarily through the ISPC training.

5.3. Increased socio-political capabilities for collective shaping of future wildfire scenarios

For a complete understanding of what the creation of ADFs has meant in terms of empowerment, it is important to understand the historical context (Fig. 4). Franco's dictatorship in Spain (1939–1975) was characterized by a strong centralist and nationalist government, including the censorship of most expressions of regional identity and limited freedom of association. It was against this political backdrop that the first forest owners' associations appeared. Once democracy was reinstated, most administrative powers were devolved to the autonomous communities. One of the policy-makers who motivated the creation of the ADFs aptly describes the existing socio-political environment at the time; "*Now is the time of rebuilding Catalonia, contributing voluntarily whatever is needed. The creation of the 'Defence Groups' is framed within a [Catalan] nationalist scheme of battle, in order to preserve (…)"* (Peix et al., 1993 p.128). The Catalan Minister of Agriculture of the time also recently explained in a newspaper: "*We wanted to show that the Regional Government with the transferred powers would do better than the central government"* (Miró i Ardèvol, 2019). These statements show how the identity component played an important role in the governmental support given to the ADFs, at least at the discursive level. In the interviews, this identity component appeared in the form of a strong socio-emotional bonding to the territory.

> *"… [the motivation to protect the forest]: I think you could call it love" (ADF05).*

> *"In summer, (…) it was inconceivable to leave home, go to the beach (…). Impossible because it was like (…) 'you are about to commit a mortal sin'. You are leaving the territory. How are you going to—if there is a need* (i.e. *a fire)—to get here quickly?" (ADF05).*

This strong socio-emotional bonding has been signalled as a source of resilience owing to its importance for stirring engagement of those immediately concerned with environmental stewardship (Masterson et al., 2017); it is probably one of the most obvious elements of socio-ecological resilience that emerged in this research.

One other core element of resilient SESs is the existence of inclusive governance systems able to provide new paths for addressing local communities' needs, as well as for learning and innovation (Skrimizea et al., 2021). In this regard, we understand that the bottom-linking of ADFs in 1986, and the subsequent adaptation of the Catalan political environment, has contributed to this aim, via empowerment of local communities through the provision of resources and assignment of a specific role for reshaping their local realities. It is important to acknowledge, however, that the wider wildfire management system in Catalonia nowadays largely shows a strongly hierarchical structure, as

one would expect in a for an emergency management system.

The involvement of local communities in firefighting, however, has not always been free of criticism. In fact, the question of whether fire suppression should be the responsibility of a volunteer-based organization is not new, and has also been raised for similar models elsewhere (Abrams et al., 2017). We argue that this is ultimately connected to the issue of "resilience by whom". In the wildfire context this is often translated as "Who owns the risk", and therefore, who's responsible for it. In our interviews the issue emerged sparsely, with heterogeneous approaches to it:

> *"Emergency management should be 100% public (…) managing the risk, the prevention part, that must be done by the owner" (ADF019).*

> *"What's the will of the society? As for me, if there is a need for something, then I'll come, but I think the trend is for people to rely on public services, we pay for them and they work. I think this is gaining space" (ADF02).*

The answer to this question is in any case not universal; and contrary to what is often portrayed, is not a technical one, but deeply political. Adequately addressing and resolving these issues requires a governance system that is inclusive and active in stimulating participation of the different concerned actors, in such a way that power imbalances are addressed and mitigated. This would provide opportunities to explicitly include societal values and normative issues into the wildfire conversation, as well as to appropriately address politically sensitive issues. In a scenario of increased uncertainty and extreme wildfire events, we argue that these spaces will need to become more commonplace, and that ADFs are uniquely placed for creating and facilitating this kind of dialogue and learning process within Catalan society.

Finally, it is important to highlight that whereas the bridging abilities of bottom-linked social innovations have been described as being able to exert greater influence on other institutions and increase the degree of empowerment of social groups (Castro-Arce and Vanclay, 2019), in the case at hand we have found it difficult to discern which type of influence ADFs are actually able or willing to exert over other institutions, unlike what happened in their early days, when their demands were clearly stated.

6. Conclusion

The relevance awarded to the social dimension of the wildfire issue is slowly gaining recognition within research, practice and policy-making communities. Bearing this context in mind, this article revisits the concept of socio-ecological resilience from a social innovation perspective, in order to further unravel the role of socio-political dynamics in the building of resilience in Mediterranean socio-ecological systems. We argue that resilience building is a dynamic process - rather than a final end-state – imbued with a variety of values, social subjectivities and politics. The social innovation perspective helps us advancing a critical and normative understanding of the socio-ecological processes and outcomes underlying resilience building; at the same time, social innovation offers insights into which elements can boost resilience at the societal and political levels.

In applying this combined perspective to the ADF case study, we show how a socially innovative social fabric can reveal and raise issues of concern to higher political levels, and how external shocks such as wildfires can be used as windows of opportunity for change. The bottom-linking process of the ADFs in 1986 clearly shows how environmental issues shape socio-political processes which can, in turn, also shape ecosystem dynamics. This is also true for the events of 1994 and 1998, which affected not only the ADFs, but the whole Catalan wildfire prevention and suppression system. Additionally, the ADF case portrays how bottom-linked governance arrangements can occur when there is an alignment of "unmet needs" at the local and regional level, thus reinforcing multi-scalar collective action. Through a close-up examination of their history, issues such as trust, inclusive societal dialogue and processes of knowledge and institutional co-construction come to light. These aspects, although crucial for building resilience, are often overlooked both in wildfire and forestry research.

This article critically reflects upon the social dynamics underlying the wildfire issue in a situated manner. It shows how no lone actor (nor the public administration, nor the firefighters, nor the civil society) can achieve a significant impact in the face of the extreme wildfires that Mediterranean rural areas are facing nowadays, and therefore how socially innovative, multi-scalar and multi-actors' processes are fundamental to tackle effectively the socio-ecological challenges ahead.

CRediT authorship contribution statement

CarmenRodríguez Fernández-Blanco: Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Elena Górriz-Mifsud:** Conceptualization, Methodology, Writing – review & editing, Visualization, Funding acquisition. **Irina Prokofieva:** Conceptualization, Methodology, Writing – review & editing, Project administration, Funding acquisition, Supervision. **Bart Muys:** Conceptualization, Writing – review & editing. **Constanza Parra Novoa:** Conceptualization, Writing – review & editing, Supervision.

Declaration of Competing Interest

Authors declare to having no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2022.102719.

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