Fire Ecology

ORIGINAL RESEARCH

Territories in Transition: how social contexts influence wildland fire adaptive capacity in rural Northwestern European Mediterranean areas

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Abstract

Background Rural and semi-rural areas are complex and dynamic social-ecological systems, many of which have experienced profound impacts from wildland fires, particularly this decade. Under uncertain climate change conditions, these areas require new adaptive strategies to support landscape and community resilience. While these areas vary widely, some patterns of local social context have become apparent through wildland fire research. These patterns can help decision-makers better understand what influences communities' abilities to adapt to fire. We focused our study on a northwestern European Mediterranean context, where communities are adapting to wildland fire and other climate change impacts through varied programs and policies. This area is composed of diverse landscapes, cultures, histories, languages and governance structures, but it also shares fire-based learning networks and collaborations, providing a sound indicator of shared elements of social context. Our study analyzed local social contexts in rural areas of Spain, Italy and France and assessed how these may inform adaptive capacity to wildland fire. A two-step process achieved this: (1) a targeted literature review of local social context elements as they relate to wildland fire in Mediterranean Europe; and (2) conducting semi-structured interviews with 20 key experts in rural Mediterranean areas, including fire managers, foresters, local administrators and technicians.

Results Results illustrate numerous shared patterns in rural social contexts that influence local fire adaptive capacity. Dynamic local relationships among residents, local fire knowledge and environmental movements, the role of fire managers and administrators, and embeddedness in broader sociopolitical trends all interconnect to influence local fire adaptive capacity. Some key elements of context can act as primary enablers or barriers to this process, such as the presence (or lack) of local fire knowledge, and the opportunity (or lack thereof) for sustainable local economic development. Results also demonstrate high diversity in terms of governance structures and development trajectories.

Conclusions We argue the need for deepened empirical transdisciplinary research to connect fire and land management tailored to local characteristics. Centering these local perspectives and diverse cultural values is necessary to foster long term adaptive wildland fire management strategies in rural Mediterranean communities and globally.

Keywords Local social context, Wildland fire adaptation, Mediterranean social-ecological systems, Adaptive capacity

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Resumen

Antecedentes Las áreas rurales y semi-rurales son sistemas socio-ecológicos complejos y dinámicos, muchos de los cuales han experimentado profundos impactos de los incendios forestales, especialmente en esta década. Bajo condiciones inciertas de cambio climático, estas áreas requieren de nuevas estrategias adaptativas para sostener la resiliencia comunitaria y paisajística. Aunque esas áreas varían mucho, algunos patrones de contexto social local han sido evidentes en las investigaciones de incendios forestales. Estos patrones pueden ayudar a los tomadores de decisiones a entender mejor que es lo que influye las habilidades de las comunidades para adaptarse a los incendios. Enfocamos nuestro estudio en el contexto del noroeste del Mediterráneo europeo, donde las comunidades están adaptándose a los incendios forestales y otros impactos del cambio climático a través de una variedad de programas y políticas. Esta área está compuesta de diversos paisajes, culturas, historias, idiomas y estructuras de gobernanza, pero también comparte redes de aprendizaje y de colaboración sobre los incendios, lo que provee de un indicador sólido de elementos compartidos del contexto social. Nuestro estudio analizó los contextos sociales locales en áreas rurales de España, Italia, y Francia y determinó cómo estos pueden informar sobre la capacidad adaptativa a los incendios forestales. Un proceso de dos pasos permitió alcanzar ese objetivo: (1) Mediante la revisión bibliográfica de elementos sociales locales que se relacionen con los incendios forestales en Europa Mediterránea, y (2) Realizando entrevistas semi-estructuradas con 20 expertos clave en áreas rurales del Mediterráneo, incluyendo gestores de incendios, forestales, y administradores y técnicos locales.

Resultados Los resultados ilustraron numerosos patrones compartidos en contextos sociales rurales que influyen la capacidad local adaptativa a los incendios. La dinámica de la relación social entre los residentes, el conocimiento local del fuego y los movimientos ambientales, el rol de los gestores de incendios y administradores, y el arraigo de tendencias sociopolíticas se interconectan para influir la capacidad local adaptativa al fuego. Algunos elementos clave de este contexto pueden actuar como habilitadoras primarias o barreras para este proceso, como la presencia (o falte de) conocimiento local sobre los incendios, y la oportunidad (o la falta de) para el desarrollo sostenible local. Los resultados muestran una alta diversidad en términos de estructura de gobernanza y trayectorias de desarrollo.

Conclusiones Argüimos sobre la necesidad de profundizar la investigación empírica transdisciplinar para conectar la gestión de los incendios y el paisaje, ajustándolos a las características locales. Centrarse en perspectivas locales y en valores culturales diversos es necesario para fomentar estrategias de gestión adaptativo del fuego a largo plazo tanto en comunidades rurales del Mediterráneo como a nivel global.

Background

Mediterranean fires

The fire-evolved landscapes of the Mediterranean Basin are composed of a vast diversity of ecosystems, cultures, histories, languages and governance structures. This study focuses on socioecosystems in three northwestern European Mediterranean countries (Spain, Italy and France), which we will refer to as NWMed, in the rest of the study for brevity. Wildfire regimes are intensifying due to climate and global socioeconomic changes (Brotons et al. 2013; Chergui et al. 2018; de Rigo et al. 2017). Fires are largely the result of socioecological processes such as land abandonment, as well as human negligence, and can even be sparked by disputes in land use (Aguilar and Montiel 2011; San-Miguel-Ayanz et al. 2013). Extreme events such as those in Pedrógão, Portugal (2017) and Mati, Greece (2018) have caused a large loss of human life, and they have triggered significant political tensions and changes (Aguilar and Montiel 2011; San-Miguel-Ayanz et al. 2013; Tedim et al. 2018; Vallianou et al. 2020).

Although Mediterranean fires are primarily managed using a top-down approach (Aguilar and Montiel 2011; Tedim et al. 2016), the cascading impacts of climate and social changes are often felt most at a local level. Thus, the decisions regarding wildland fire adaptations need to be considered legitimate and desirable on a local scale (Roos et al. 2016; Toman et al. 2012; Williams et al. 2012). For this, fire management and preparedness processes need to focus on local needs, values, knowledge and perceptions of fire (Brenkert-Smith et al. 2013; Gordon et al. 2010; McCaffrey 2015). This study therefore offers an examination of local social contexts in NWMed areas and how they inform adaptive capacity to wildland fire.

Shifts in Mediterranean wildfire governance

Recognizing a need for changing top-down strategies, concerted efforts aim to reverse the traditional "zero fire" policies that have shaped fire suppression in several Mediterranean areas for decades (Brotons et al. 2013). Wildfire preparedness and adaptation policies as well as Integrated Fire Management policies now proliferate in

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NWMed settings, orchestrated by national and regional administrations (such as Portugal's Agency for Integrated Management of Rural Fires), fire management and non-profit organizations like the Pau Costa Foundation (Rego et al. 2018). The European Union (EU) increasingly supports promoting these national and regional policies that reflect goals of integrating social, ecological and economic management objectives (Rego et al. 2018; Silva et al. 2010; Tedim et al. 2016). Considerable efforts are also made at local and regional levels to expand prevention strategies such as the US Firewise model (Tedim et al. 2016) and democratize wildland fire management strategies by incorporating social and ecological values into risk management (Otero et al. 2018; Otero et al. 2020). Such transformative changes require engaging with human behavior, research and innovation, emergency management, urban and land planning, biomass management, and considerations at the ecosystem, socio-economic, political and climatic scales.

Challenges in the NWMed remain in overcoming dominant policies of fire suppression, public opinion of prescribed burns (Fernandes 2013) and reducing the governance gap between communities and institutions (Wunder et al. 2021). There is a need to change from "passive expectation of institutional intervention" to local communities initiating bottom-up processes for prevention and preparedness (Tedim et al. 2016, 147). This requires confronting administrative and social challenges, such as: conflicting values and priorities among land managers, varied understandings of land use history and ecology, access to funding and technical assistance, and governance relations (Eriksen and Gill 2010; Subirós et al. 2015; Rasch and McCaffrey 2019; Wunder et al. 2021).

This shift demands significant financial input, participatory community engagement, empowering and weaving local knowledge, and increasing a sense of solidarity (Huffman 2013; Martínez-Sastre et al. 2017; Tedim et al. 2021; Wunder et al. 2021). Since fire is a transversal element, it requires creative co-management on local levels to understand local social diversity and evolution to better inform adaptive capacities and future action. By better understanding these dynamics on a local level, scientists, policymakers, local leaders and residents may be better equipped to develop desirable and flexible approaches to foster their own capacities for fire adaptation.

Adaptive capacity

To better understand local dynamics, we base our study on the conceptual frameworks of local social contexts and their influence on adaptive capacity, as developed in prior wildland fire social studies (Paveglio et al. 2009, 2012, 2019; Paveglio and Edgeley 2017). To date, all studies examining the effects of local social contexts on adaptive capacity have been conducted in the United States. Adaptive capacity can be defined as a community's capabilities, assets and resources that can be mobilized to respond to disruption, especially stressors linked to climate change (Siders 2019). While context-specific, adaptive capacities are also affected by regional, national and global processes, making scale a crucial element to consider (Vincent 2007; Wyborn et al. 2015). Fostering these capacities in the context of wildfire requires action in mitigation, preparedness, response and recovery (Moritz et al. 2014). Adaptive capacity to wildfire can be improved by diverse actors, social groups and institutions, from bottom-up grassroots efforts, governance structures and emergency managers. We understand fire adaptations as specific processes, policies or actions that are the result of adaptive capacity (Ager, Kline, and Fischer 2015; Paveglio et al. 2018).

Rural communities

Rural areas in Europe face profound shifts and therefore require careful definition. In the past, rural "communities" have been superficially equated with "...small size, territorial fixity, group homogeneity, and shared understandings and identities" (Agrawal and Gibson 1999, 640). Like Agrawal & Gibson, we contend that to understand such diverse and changing rural and semi-rural spaces, we should shift our focus to the varying interests and actors present, how these actors influence decisions, and how institutions influence political processes (1999). This understanding of "community" has also developed in wildland fire social science literature, where "community" is viewed as an emergent process beyond neighborhoods or administrative boundaries: it is a physical context in which residents interact, and where diverse relationships may exist to the surrounding area and with one another (Gordon et al. 2010; Williams et al. 2012; Paveglio et al. 2019). For the purposes of this study, we focus our analysis on rural communities as part of social-ecological systems (Ostrom 2009), as these places are socially and economically embedded in wider ecological dynamics (Iniesta-Arandia et al. 2014).

The NWMed context is marked by a process of rural abandonment. This is defined by "demographic changes, a reduction in the role played by farming and by farmers as well as by the new functions carried out by rural areas (production, residential and leisure)" (Bessaoud and Petit 2009, 6). Further, macro-economic shifts from agriculture and industry to service-based economies like tourism (that is, tertiarization processes), have profoundly shaped social and ecological dynamics for several decades (Cuadrado-Roura, Iglesias, and Heras 2003; Halfacree 2006).

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The transitions of rural spaces have important implications for fire management. Many of these NWMed rural areas lie on a spectrum of rural to semi-rural interfaces, urban fringes, and intermixes of residencies that can border upon agricultural or forestry land, or large areas of unmanaged vegetation (e.g. WUIs) (Badia et al. 2011). These present some of the most exposed spaces to wildfire, implying significant danger to vulnerable populations such as elderly residents or foreign tourists (Molina-Terrén et al. 2019; Galiana-Martin et al. 2011). Communities with many new residents, tourists or part-time residents are more vulnerable to fire risks if social networks, aid from neighbors, knowledge of local landscapes and institutional leadership are lacking (Gordon et al. 2010).

Foundational local social context research

Studies around the world show that it is necessary to incorporate the perceptions and cultural values connected to a certain place for adaptive wildland fire management (Jakes and Langer 2012; Toman et al. 2012; Subirós et al. 2015; Paveglio and Edgeley 2017). As such, fire adaptation strategies place increasing importance on the quality of social interactions, place attachment, and local knowledge about fire and the landscape in shaping a local response to wildland fire (McCaffrey 2015). New fire adaptation efforts that facilitate relationships between fire managers, community members and administrations can help to build a sense of common purpose and encourage more information exchange (Rasch and McCaffrey 2019; Tedim et al. 2021). By understanding that these social elements interact with one another, researchers can document how combinations of these characteristics can influence local capacities to adapt to wildland fire. This was named as the "interactional approach" by Paveglio et al. (2012). Such elements of local social context fall under the categories or "branches" of 1) relationships and interactions among residents and their environment; 2) local knowledge and experience with wildland fire; 3) relations with local administrations and governance bodies; and 4) structural and demographic information. Understanding local social contexts can help fire-prone landscapes adapt in ways that best reflect a community's diverse interests and needs.

Previous studies in Mediterranean areas have drawn upon elements of local social context and how these affect adaptation to wildland fire and other climate change challenges. For example, numerous studies address changing rural landscape values due to land abandonment and tertiarization. These shifts affect the retention and transmission of traditional ecological knowledge[1]

(Fernández-Giménez and Estaque 2012; Oteros-Rozas et al. 2013; Reyes-García et al. 2016; Huffman 2013; Otero et al.2013; Guadilla-Sáez et al. 2019); and affect diverse social-ecological relationships (Martínez-Sastre et al. 2017; Bidegain et al. 2020; Oliveira et al. 2017). However, a more interactive approach has yet to explore the connection between all the factors of social context and how their sum influences fire adaptive capacities on local levels.

Aims

As such, our study aims to answer the question: How do local social contexts in rural areas of Spain, Italy and France inform adaptive capacity to wildland fire? We approached this through a targeted literature review and semi-structured interviews with Mediterranean wildland fire experts. Through this process, we analyzed common elements of local social context across study areas which can affect local adaptive capacities. Furthermore, we distinguished enablers and barriers to local adaptive capacity to wildland fires in NWMed areas. Rather than focus on a single case, this research takes a novel approach to investigate common themes across several NWMed contexts. This qualitative approach allows us to address social aspects of wildland fire spanning three countries and four languages in the region.

Methods

Our methods involved a two-step process: (1) a targeted literature review of local social context elements as they relate to wildland fire in Mediterranean Europe; and (2): conducting semi-structured interviews with 20 key experts in rural Mediterranean areas, including fire managers, foresters, local administrators and technicians.

Study areas

Case study area selection of rural NWMed communities was based on the following criteria: 1) currently facing fire risks among other natural risks; and 2) previous experience with wildland fire and participation in fire knowledge exchange networks (such as projects with the Pau Costa Foundation, interregional EU projects regarding fire preparedness, Firewise communities, rural development projects, among others). Four sites meeting these criteria were identified: Tuscany, Italy; the French Eastern Pyrenees; and two locations in Catalonia, Spain—the Pallars Sobirà region and the Tordera River Basin. The distribution of these areas is represented in Fig. 1.

The common threads through these four areas include their rural to semi-rural characteristics, processes of tertiarization and rural abandonment, exposure to wildland fire and other natural risks like floods, and the implementation of innovative tools to adapt to wildland fire at the local level (Table 1). While not representative of all

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[1] "…a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al. 2000: 1252).

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Fig. 1 Map of four study areas located in Spain, France, and Italy. Case study areas do not necessarily follow administrative boundaries (ie. counties). They follow generalized areas based on fire events (Monte Pisano), watersheds (Tordera River Basin), and administrative boundaries (Pallars Sobirà, Conflent-Canigó) where distinct communities have exhibited fire adaptations

Mediterranean areas, a particularity in these study areas is the large majority of private property ownership, natural park areas, and the extreme fragmentation of land.

The rural mountain area of Monte Pisano straddles the provinces of Lucca and Pisa in Tuscany, Italy (Table 1). It was selected as it had recently experienced fires (2018) which led to significant community recovery actions. For instance, the first Firewise communities in Italy have been piloted here, and recent legislation provided the opportunity for a novel property owner organization, the Comunità del Bosco, to take root performing volunteer work to collectively organize private landowners across municipal districts for fire preparedness and awareness-raising activities (Salbitano et al. 2019). A trusting relationship was established between fire technicians, administrators, researchers and local residents. Few farmers or foresters continue in the area, and pastoralism almost disappeared by the 1960s; this shift contributed to remarkable changes in vegetation and fuel loading, key factors that increased the fire severity of the 2018 events (i.e. displacement of chestnut groves and rapid secondary succession of pines)

(Casazza et al. 2021). In Tuscany, 88% of land is in private ownership (RAF 2019). Monte Pisano is divided into over 20,000 fragmented private parcels, with many as small as one quarter hectare (Casazza et al. 2021).

The French Eastern Pyrenees were chosen as local agencies developed a prescribed burning network in response to particularly virulent fires in the late 1980s (Lambert 2010). The network has shared knowledge between local farmers and fire managers, researchers, and administrations for the last thirty years. A large network of natural parks, including Natura-2000 sites, have also proliferated for biodiversity conservation, becoming a key tourist attraction and primary motor for rural development (Roura-Pascual et al. 2005). Aside from the natural parks, most forested land is privately owned (81% in Occitania), with heavy fragmentation and many parcels often reaching 0.4 hectares (IGN 2020).

In Catalonia, Spain, two sites were selected. The Pallars Sobirà is a county also located in the Pyrenees, its development marked by several natural parks, ski stations and declining forestry and agriculture (Vaccaro and

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Table 1 Study area characteristics pertaining to wildland fire

Community	Fire experience	Ecology	History/ Land Use Transition	Primary Economy	Main fire adaptations/ policies
Monte Pisano, Tuscany, Italy: Semi-rural	Severe fire events in 2018: lead to community action	Med coastal/ mountain	Rural Abandonment New WUI areas 90% private land Protected natural areas of local interest	Tourism	Emerging Firewise programs Comunità del Bosco AIB Operational Plan 2019–2021: Fire protection strips
Pyrénées Orientales, Conflent- Canigó, France: Rural	Severe fire events in 1980 Recurring Pastoral Fires Prescribed burning	Med. Mountain (Pyrenees)	Rural Abandonment New WUI areas Over 80% private land Natural Park areas	Tourism Agriculture	Prescribed burning PPRIF (local fire hazard reduction plans) PLUi (land use/risk plans)
Tordera Basin, Catalonia, Spain: Semi-rural	Fire events in 1989, 1994, and 2003 lead to local administrative action	Med. coastal/ mountain	Rural Abandonment Private forests- 80% forest cover New WUI areas Natural park areas, Biosphere reserve	Tourism Industry Forestry (esp. cork)	Homeowner payment for risk management Law D5-2014: municipal fire protection plan
Pallars Sobirà, Catalonia, Spain: Rural	Growing fire risk & awareness Previous pastoral fires Some prescribed burns	High mountain (Pyrenees)	Rural Abandonment Much private land exproriation to natural parks	Tourism Agriculture Forestry (esp. pine)	Citizen/ administrative interest Law D5-2014: municipal fire protection plans

Beltran 2007; López-i-Gelats et al. 2009). It is the most depopulated county in Catalonia: population decreased by 75% from 1860 to 1991 (from roughly 19,000 to 5,000 inhabitants), and since has increased slightly (to 6,930 inhabitants) due to the development of tourism (Vaccaro and Beltran 2007; IDESCAT 2016). While communities here exhibit high-altitude mountain socioecological characteristics (ERDF 2021), and are not yet considered a high wildland fire risk area (GENCAT 2014), some local administrations and residents have voiced growing awareness and desire for fire preparedness action, especially as fire has played a historical role in pasture management. While some land remains in communal property structures, land ownership conflicts increased with rural abandonment and tertiarization. Private property represents only 26.8% of land as much of the communal land management institutions were expropriated by the state for massive forest repopulation in the last 50 years (Vaccaro and Beltran 2007). The Pallars Sobirà has a forest cover of 97.5% (OFC 2021).

Finally, the Tordera River Basin (on the central coast of Catalonia) has experienced infrequent, high-intensity fires as well as frequent flooding events (Mark Castellnou et al. 2009; P. Verkerk et al. 2017). It straddles the counties of Selva, Vallès Oriental, and Maresme. Some semi-rural towns have implemented homeowner payments for firebreak management around "urbanizations", or residential areas typical of Mediterranean wildland-urban interface (WUI) areas (Galiana-Martin et al. 2011), particularly after experiencing several fire events in the 1990s. Cork oak harvesting industry persists in the area, though the economy centers on tourism in several natural parks, including the Montnegre Corridor and Montseny natural parks (Broekman and Sánchez 2016). Nearly all forested property lies in private management, at above 90% across the counties (OFC 2021).

Data collection
Design
Qualitative data were collected through semi-structured interviews with key experts. These were modelled on published literature on local social contexts and adaptive capacities (Paveglio et al. 2009, 2012; Paveglio and Edgeley 2017). All interviews focused on 4 main themes or "branches" of context and their connection to fire adaptations: 1) local interactions and relationships among residents; 2) kinds of local fire knowledge and experience in the community; 3) access to scientific and technical knowledge (including fire prevention policies); and 4) structural and demographic characteristics. Twenty interviews were conducted in-person or via online video calls with both single and multiple interviewees. The number of interviews, perspectives represented, and study areas are represented in Table 2.

All conversations were recorded, then transcribed manually and analyzed through QSR NVivo 12 software. The interviews lasted between 50 min and 2.5 h and were conducted in the participants' preferred language: Spanish, Catalan, French, English or Italian. In Tuscany, a translator assisted in communicating between Italian and English.

Table 2 Description of the number of interviews, type, and study area where they were conducted

Number of Interviews	Perspectives Represented	Study Area
4	Local administrator & resident Fire manager Fire technician Forest /park manager	Conflent-Canigó, French Eastern Pyrenees (France)
5	Local administrator & resident Fire manager Fire technician	Monte Pisano, Tuscany (Italy)
5	Local administrator & resident Fire manager Forest/park manager	Pallars Sobirà, Catalonia (Spain)
6	Local administrator & resident Fire manager Fire technician Forest/park manager	Tordera Basin, Catalonia (Spain)

Interviewees were selected based on theoretical sampling (Bryman 2016), a method which seeks out individuals with specialized knowledge regarding certain topics (Charmaz 2006). This method was particularly useful during the initial phases of research, as the main author consulted with local non-profits, experienced fire managers, and government agencies to deliberate which actors could contribute diverse information to the study (Ligita et al. 2020). Each interviewee held reliable and extensive knowledge of their socio-ecosystems and had long-term experience working with diverse stakeholders in fire and land management. These actors came from fire administration and governance sectors (local and regional), forest fire and rescue services, forest and natural park management, and engaged homeowners or landowners. Published research guided this selection, as these profiles of actors possess unique knowledge on the intricacies of fire and land management (Gordon et al. 2010; Paveglio et al. 2012; Subirós et al. 2015). As opposed to other studies which have taken a more comprehensive approach by conducting interviews with many residents in a single area, the authors of this study chose to interview key experts across various regions to analyze the local adaptive capacities in different Mediterranean rural settings. The richness of this knowledge compensates for the time and resource restraints of the authors and was complemented through a targeted literature review of local social contexts.

The purpose of the targeted literature review was 1) to further explore interacting elements of local social context and their potential influence on adaptations to wildland fires; and 2) to deepen understanding of unique elements of local social context in these specific NWMed socioecological systems. This was conducted through Web of Science, Scopus and Google Scholar. The review selected social-ecological science studies specific to wildland fire (or, if lacking, other natural hazards), and on elements of local social context (resident interactions and relationships, local knowledge and experience of fire, access to scientific and technical fire knowledge, and structural or demographic information).

Analysis

After interview transcription, primary themes were coded in the form of initial topic coding, then secondary analytic coding took place regarding the aspects and opinions regarding these codes (i.e. challenges, opportunities, changes, enablers, barriers, values, and other aspects) (Saldaña 2013). The first phase of the coding process was inductive, as it explored emerging themes from the data, and the second phase was deductive as it compared data with existing frameworks of local social context. The research expands on the most notable local social context work for comparison: the 21 aspects of local social context developed by authors in the US (Paveglio et al. 2012). Overall, 135 codes were refined and interpreted across 1558 statements in the transcriptions. Finally, a selection of quotes was made to demonstrate the main surfacing themes. All quotes have been translated from their original languages to English by the first author and may lose some of their linguistic context. Each quote shares the general region of the respondent, but we avoided numbering the participants to better protect anonymity.

The literature review prioritized empirical, qualitative data when possible to better match the data which emerged from interviews. The review focused on the four case study areas. Where information was missing, the review expanded to wider areas of France, Spain, Italy and other western European Mediterranean countries (i.e. Portugal and Greece). The literature review covered published articles in English and the original languages of the study areas (French, Spanish, Catalan and Italian). This targeted review revealed 60 relevant studies focused in these 4 regions of the NWMed basin. Findings from the literature review are compared with interviews in the results and are further considered in the discussion.

Results

A broad number of interacting elements of local social context which influence adaptive capacities to wildland fire were identified in each case study area. Though the number of interviews is limited, the
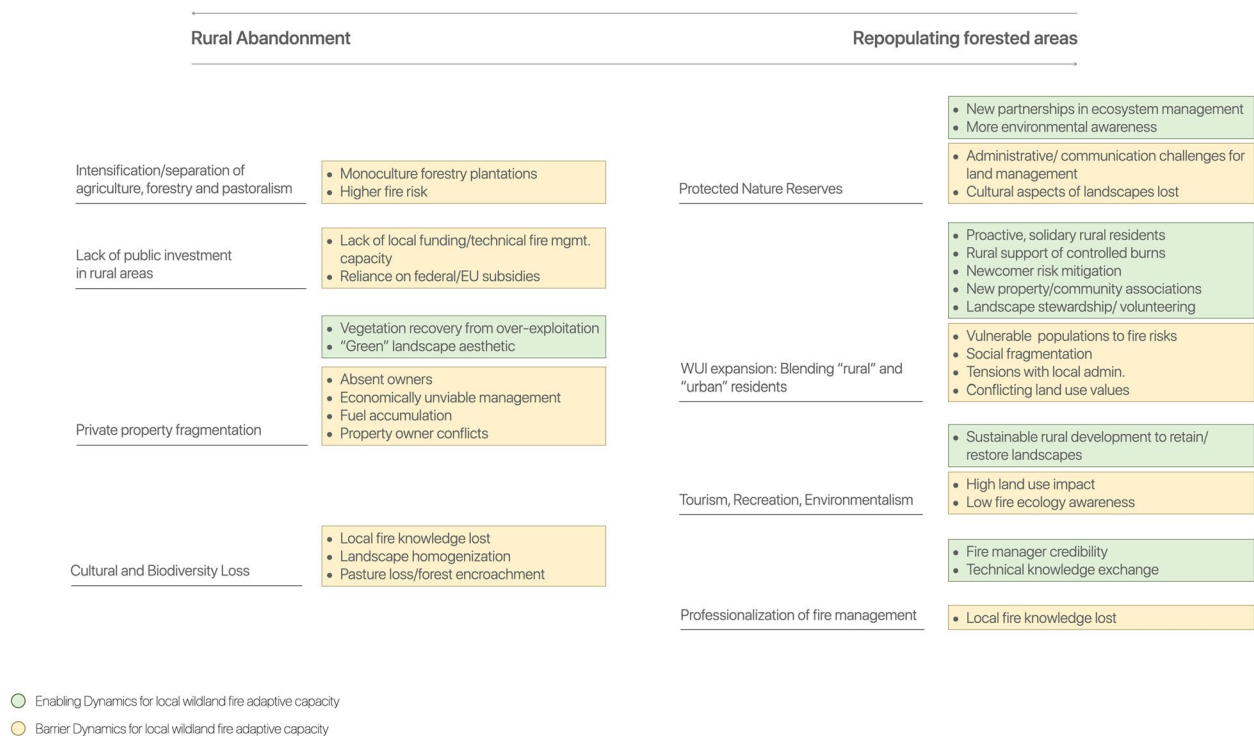
Rural Abandonment		Repopulating forested areas	
			• New partnerships in ecosystem management • More environmental awareness
Intensification/separation of agriculture, forestry and pastoralism	• Monoculture forestry plantations • Higher fire risk	Protected Nature Reserves	• Administrative/ communication challenges for land management • Cultural aspects of landscapes lost
Lack of public investment in rural areas	• Lack of local funding/technical fire mgmt. capacity • Reliance on federal/EU subsidies		• Proactive, solidary rural residents • Rural support of controlled burns • Newcomer risk mitigation • New property/community associations • Landscape stewardship/ volunteering
	• Vegetation recovery from over-exploitation • "Green" landscape aesthetic	WUI expansion: Blending "rural" and "urban" residents	• Vulnerable populations to fire risks • Social fragmentation • Tensions with local admin. • Conflicting land use values
Private property fragmentation	• Absent owners • Economically unviable management • Fuel accumulation • Property owner conflicts		• Sustainable rural development to retain/ restore landscapes
		Tourism, Recreation, Environmentalism	• High land use impact • Low fire ecology awareness
Cultural and Biodiversity Loss	• Local fire knowledge lost • Landscape homogenization • Pasture loss/forest encroachment		• Fire manager credibility • Technical knowledge exchange
		Professionalization of fire management	• Local fire knowledge lost

○ Enabling Dynamics for local wildland fire adaptive capacity

○ Barrier Dynamics for local wildland fire adaptive capacity

Fig. 2 The figure illustrates primary processes that present enablers and barriers to local fire adaptive capacity in Mediterranean rural areas, as interpreted by expert interviews across study areas. Most processes are the result of rural abandonment and tertiarization, leading to repopulation of forest areas. Notice that rural abandonment and repopulation of forest areas are simultaneous, interconnected processes. However, rural abandonment begins earlier in the 1950s-60 s, and repopulation begins later, in the 1970s-80 s

experts' perspectives provided important initial input to examining the subject. In each case study, interviewed experts distinguished several processes and patterns which can enable or hinder wildland fire adaptations, as summarized in Fig. 2. These processes, regarded as themes, are described in the following sections according to whether they were: 1) shared among Mediterranean communities; 2) providing new insights that either affirm or differ from previous studies related to local social contexts in Mediterranean areas, and; 3) considered strongly as enablers or barriers to adaptive capacity. Additional themes emerging from interviews and evaluated in the literature could not be evaluated individually due to space constraints, though they provide significant further insight to elements of local social context. They are referenced in one table per section (Tables 3, 4, 5 and 6). The following results and discussion are structured according to the four "branches" of local social context: 1) local interactions and relationships, 2) local knowledge and experience with wildland fire, 3) access to scientific and technical knowledge, and 4) structural and demographic components.

Local interactions & relationships: imprints of rural abandonment and tertiarization

Interviews and literature across study areas affirm that processes of rural abandonment and tertiarization of economies directly affect local interactions and relationships. Some primary effects include: losing relationships between neighbors, creating new land use values, and generating conflicting opinions on land management approaches (Table 3).

Most interviewees commented on distinct divisions between "urban" and "rural" social characteristics of residents:

"One citizen profile…is a person who knows the territory, who interprets it, who lives there and who has a certain balance or is relatively integrated into the territory. And on the other hand, among the communities we find another radically different profile, which would be an urban person, or an urban mentality and who does not know the territory where they are living, despite the fact that they may be in the same territory as the other. And these two people have very different behaviors." (Tordera River Basin)

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Table 3 Primary emergent themes from expert interviews and Mediterranean literature review on local interactions and relationships. These themes are interpreted as enablers or barriers to fire adaptive capacity. Blank cells in the literature column indicate that no literature was found on the subject, though it was discussed in interviews. Blank cells in the interview column demonstrate that these themes were explored in the literature, but not the interviews. We additionally include the area of literature study to illustrate the precise geographies of the findings

Enablers and Barriers to Fire Adaptive Capacity: Local Interactions & Relationships

	Interview Emergent Themes	NWMed Literature	Study Area
Enablers	Property owners manage forests for economic and cultural reasons	(Thomas, Brunette, and Leblois 2022)	France (including Occitanie)
	Sense of belonging, history, solidarity, social ties	(Piédallu et al. 2016; Bouisset et al. 2018a, b)	French Pyrenees; Atlantic Pyrenees
	Environmental/cultural values of landscape	(Ferrini 2002; Lambert 2010; Paletto et al. 2017; I. Otero et al. 2018)	Tuscany, Italy; French Eastern Pyrenees; Tuscany, Italy; Tordera River Basin, Catalonia
	Volunteer fire organizations	(Rodriguez Fernández-Blanco et al. 2022; Górriz-Mifsud et al. 2019)	Catalonia, Spain
	Generational population renewal	(Ferrini 2002; Christine Bouisset 2011)	Tuscany, Italy; French Eastern Pyrenees
	Willingness to pay for fire prevention programs	(Concu, Detotto, and Vannini 2021)	Sardinia, Italy
	Solidary reactions to hazards	None found	
	Relationships between urban residents and forest managers	None found	
	Influence of local champions	None found	
	Valued role of elder residents	None found	
	Communication networks with diverse neighbors	None found	
	Physical places for residents to gather	None found	
	Access to basic services (municipal lighting, waste pickup, water, adequate road conditions)	None found	
	Existing social/cultural networks and associations	None found	
	Trusting relationship with local administration	None found	
Barriers	Social Fragmentation. Conflicting land use values	(Vaccaro and Beltran 2007; López-i-Gelats et al. 2009; Christine Bouisset 2011; Laurent 2013; González-Hidalgo et al. 2014; Piédallu et al. 2016; Paletto et al. 2017)	Pallars Sobirà, Catalonia; Pallars Sobirà, Catalonia; French Eastern Pyrenees; French Mediterranean; Tarragona, Catalonia; French Pyrenees; Tuscany, Italy
	Aging or unrenewed populations (including fire volunteer organizations)	(López-i-Gelats et al. 2009; Lambert 2010; Coughlan 2014; Bouisset 2018a, b)	Pallars Sobirà, French Eastern Pyrenees; French Western Pyrenees; French Atlantic Pyrenees
	Lack of fire awareness from newcomers	(Clément 2005; Galiana-Martin et al. 2011; Otero et al. 2013)	Mediterranean Europe; Valencia, Spain; Tordera River Basin, Catalonia
	Blend of first and second residencies	(Galiana-Martin et al. 2011)	Valencia, Spain
	Lack of access to basic services	None found	
	Residents place too many demands on unequipped local administration	None found	

Experts often described "rural" group characteristics including proactive land and forest management, higher levels of autonomy and social solidarity. However, "rural" residents also had memories of disappeared landscapes and were critical with local administrators:

"They [rural profile] have a good memory of associationism, of working in the field… These people are the ones who put their hands to their heads, thinking, 'How can it be that [urbanites] want to go to the middle of the mountain in a residential area?' But it also must be said, and they [rural profile] are right, they are critical of the administration because we have "protected" everything they used to work on… we [public administration] told them, 'You cannot touch this, this is not done that way…' The public administration has protected natural ecological values, which is very good. It has made natural parks, but it has not taken into account social values." (Tordera River Basin)

Table 4 Primary emergent themes from expert interviews and Mediterranean literature review on local knowledge and fire experience. These themes are interpreted as enablers or barriers to fire adaptive capacity. Blank cells in the literature column indicate that no literature was found on the subject, though it was discussed in interviews. Blank cells in the interview column demonstrate that these themes were explored in the literature, but not the interviews. We additionally include the area of literature study to illustrate the precise geographies of the findings

Enablers and Barriers to Fire Adaptive Capacity: Local Knowledge & Experience

	Interview Emergent Themes	NWMed Literature	Literature Study Area
Enablers	Existing socially valued local fire knowledge	(Fernández-Giménez and Estaque 2012; Coughlan 2013; Guadilla-Sáez et al. 2019; Casazza et al. 2021)	Aragon Pyrenees, Spain; French Western Pyrenees; Cantabria, Spain; Monte Pisano, Italy
	Experience with fires in recent memory	(Concu et al. 2021)	Sardinia, Italy
	Sensitivity to other risks and local climate change	(Bouisset et al. 2018a, b)	French Atlantic Pyrenees
	Perception of landscape health as motivator for management	(Thomas et al. 2022)	France (including Occitanie)
	Understanding historic land use effect on territory (ie. rural abandonment, agriculture, animal husbandry, forestry, effect of wars, dictatorships and industrialization)	(Otero et al. 2013; Seijo et al. 2015)	Tordera River Basin, Catalonia; Central Spain;
	Understanding of current land use alliances for fire management (ie. sustainable agriculture, extensive livestock, sustainable forestry, responsible recreation/tourism, environmental activism, hunting associations, renewable energies)	(Otero et al. 2018; Aquilúe et al. 2020; Wunder et al. 2021)	Tordera River Basin, Catalonia; Catalonia, Spain; Mediterranean Europe
	Some environmentalist frameworks encourage forest management	(Castelló and Montagut 2019)	Catalonia, Spain
Barriers	Local knowledge deemed unfit with current conditions	(Agnoletti 2007; Arnould and Calugaru 2008; Lambert 2010; Ribet 2013; Coughlan 2013; Amici et al. 2015)	Tuscany, Italy; French Mediterranean; French Eastern Pyrenees, French Eastern Pyrenees; French Atlantic Pyrenees; Tuscany, Italy
	Cultural origins of landscapes ignored	(Clément 2005; Coughlan 2014; Amici et al. 2015; Agnoletti et al. 2022)	Mediterranean Europe; French Western Pyrenees; Tuscany, Italy; Tuscany, Italy
	Professionalization of fire sector sidelines local knowledge	(Ribet 2013; González-Hidalgo et al. 2014; Otero and Nielsen 2017)	French Eastern Pyrenees; Tarragona, Catalonia; Catalonia, Spain
	Biodiversity and local knowledge loss	(Huffman 2013; Amici et al. 2015; Casazza et al. 2021; Agnoletti et al. 2022)	International (including Europe); Tuscany, Italy; Monte Pisano, Tuscany; Tuscany, Italy
	Some environmentalism opposes forest management	(González-Hidalgo et al. 2014; Subirós et al. 2015; Bidegain et al. 2020)	Tarragona, Catalonia; Alta Garrotxa, Catalonia; Andalucía, Spain
	Not discussed	Some local knowledge based on large social inequalities. Need to learn from but not replicate patterns (Otero et al. 2013)	Tordera River Basin, Catalonia
	Not discussed	Women and immigrants play important but often unrecognized roles in maintaining rural agriculture socioecosystems (Laurent 2013; Fernández-Giménez et al. 2022; Farinella et al. 2017)	French Mediterranean; Spain; Italy & Greece
	Not discussed	Ownership of low value assets like woodlands and pasture do not influence fire prevention uptake (Concu et al. 2021)	Sardinia, Italy

Interviewees further shared that the disruptive and socially isolating process of rural abandonment has created some environments where rural residents experience generational conflicts with other nearby villages or landowners, creating a closed-off social environment to newcomers.

Additionally, experts considered that the influx of "urbanized" residents in most areas primarily seek leisure and privacy.

"They [urban profile] don't have this feeling of local roots, and they have transformed a second residence into a first residence. And if economically things turn around, they'll become second residences again.

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Table 5 Primary emergent themes from expert interviews and Mediterranean literature review on access to scientific and technical knowledge. These themes are interpreted as enablers or barriers to fire adaptive capacity. Blank cells in the literature column indicate that no literature was found on the subject, though it was discussed in interviews. Blank cells in the interview column demonstrate that these themes were explored in the literature, but not the interviews. We additionally include the area of literature study to illustrate the precise geographies of the findings

Enablers and Barriers to Fire Adaptive Capacity: Access to Scientific & Technical Knowledge

	Interview Emergent Themes	NWMed Literature	Literature Study Area
Enablers	Fire managers: source of trust and credibility, exhaustive engagement with communities	(Otero and Nielsen 2017)	Catalonia, Spain
	High level of collaboration and trust between volunteer fire management groups and technical managers	(Otero and Nielsen 2017)	Catalonia, Spain
	Addressing risk framed as multi-level, multi-actor approach	(Tedim et al. 2016; Otero et al. 2018; Alcasena et al. 2019; Castellnou et al. 2019)	Portugal; Tordera River Basin, Catalonia; Catalonia, Spain; Catalonia, Spain
	Resident support for contract grazing	(Varela Redondo et al. 2017)	Andalucía and Catalonia, Spain
	Prescribed fire: (in)formal knowledge networks, positive resident perception, administrative and technical resources	(Roura-Pascual et al. 2005; San-Miguel-Ayanz et al. 2013; Fernandes 2013; Ascoli and Lonati 2014; Corona et al. 2015)	French Eastern Pyrenees; European Mediterranean; Mediterranean basin; Piedmont, Italy; Italy;
	Technical knowledge exchange across regions and sectors	(Lambert 2010; Ribet 2013; Ascoli et al. 2009; Bovio et al. 2017; Held et al. 2018; Castellnou et al. 2019)	French Eastern Pyrenees; Italy; Italy; Catalonia, Spain
	Fire mitigation policies tailored to regional or local level	(Aguilar and Montiel 2011)	Mediterranean Europe
	Funding to implement local fire prevention plans	None found	
	Positive relationships between local administrations and landowner organizations	None found	
	Consistent communication between residents and local fire administrators/technicians (ie. awareness and education programs)	None found	
	Motivated local fire administrations & technicians	None found	
	Not mentioned	Democratizing fire management strategies between fire managers and local stakeholders (Otero et al. 2018; Otero et al. 2020)	Tordera River Basin, Catalonia, Spain
	Not mentioned	Large advances in fire analysis transformed fire operations. Incorporating social and ecological values in fire management (Otero and Nielsen 2017; Castellnou et al. 2019)	Tordera River Basin, Catalonia; Catalonia, Spain

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Table 5 (continued)

Enablers and Barriers to Fire Adaptive Capacity: Access to Scientific & Technical Knowledge

	Interview Emergent Themes	NWMed Literature	Literature Study Area
Barriers	Funding challenges, subsidy dependence	(Fernández-Giménez and Estaque 2012; Fernandes 2013; Castellnou et al. 2019)	Aragon Pyrenees, Spain; Mediterranean Europe; Catalonia, Spain
	Lack of awareness or bottom-up movement	(Fernandes 2013; Tedim et al. 2016)	Mediterranean Europe; Mediterranean Europe
	Administrative, legislative, political-cycle blockages to prescribed burning	(Lambert 2010; González-Hidalgo et al. 2014; Corona et al. 2015; Seijo et al. 2015; Alcasena et al. 2019)	French Eastern Pyrenees; Tarragona, Catalonia; Italy; Central Spain; Catlonia, Spain
	Local administration lack of technical capacity for territorial planning/fire management	(Galiana-Martin et al. 2011; Darques 2015; Bovio et al. 2017; Bouisset et al. 2018a, b; Wunder et al. 2021)	Valencia, Spain; Mediterranean Basin; Italy; French Atlantic Pyrenees; Mediterranean Europe
	Economic pressure on residents	(Bouisset 2011; Kocher and Butsic 2017)	French Eastern Pyrenees; California & French Mediterranean
	Professionalization sidelines local knowledge	(Arnould and Calugaru 2008; Ribet 2013; Tedim et al. 2021)	French Mediterranean; French Eastern Pyrenees; Portugal
	Reactive policies and resource traps	(Castellnou et al. 2019)	Catalonia, Spain
	Social resistance to prescribed burning	(Fernandes 2013)	Mediterranean Europe
	Resident-Administration communication challenges	Institutionalized scientific knowledge lacking for prescribed burns; leads to legal constraints and distrust (Ascoli et al. 2009; Corona et al. 2015)	Tuscany, Italy; Italy

Table 6 Primary emergent themes from expert interviews and Mediterranean literature review on structural, demographic information, and higher scale dynamics. These themes are interpreted as enablers or barriers to fire adaptive capacity. Blank cells in the literature column indicate that no literature was found on the subject, though it was discussed in interviews. Blank cells in the interview column demonstrate that these themes were explored in the literature, but not the interviews. We additionally include the area of literature study to illustrate the precise geographies of the findings

Enablers and Barriers to Fire Adaptive Capacity: Structural, Demographic Information, Higher Scale Dynamics

	Interview Emergent Themes	NWMed Literature	Literature Study Area
Enablers	Sustainable economic development: tourism, agriculture, forestry, renewable energy, territorial planning	(Roura-Pascual et al. 2005; Berthet 2012; San-Miguel-Ayanz et al. 2013; Molina and Galiana-Martin 2016; Tedim et al. 2016; Bovio et al. 2017; Otero and Nielsen 2017; Verkerk et al. 2018; Alcasena et al. 2019; Aggestam and Giurca 2021; Wunder et al. 2021)	French Eastern Pyrenees; French Eastern Pyrenees; Mediterranean Europe; Spain; Mediterranean Europe; Italy; Catalonia, Spain; Mediterranean Europe; Catalonia, Spain; European Union; Mediterranean Europe
	Cultural perception of self-responsibility (not entrusting all changes to the state)	(Tedim et al. 2016; Oliveira et al. 2017; Wunder et al. 2021)	Mediterranean Europe; Portugal; Mediterranean Europe
	Population retention without unchecked urban development	(López-i-Gelats et al. 2009)	Pallars Sobirà, Catalonia
	Broader environmental education & awareness programs	(Roura-Pascual et al. 2005; San-Miguel-Ayanz et al. 2013; Bovio et al. 2017; Oliveira et al. 2017; Castelló and Montagut 2019; Molina-Terrén et al. 2019; Tedim et al. 2021)	French Eastern Pyrenees; Mediterranean Europe; Italy; Portugal; Catalonia, Spain; Mediterranean Europe; Portugal
	Media raising awareness on climate change, fire risk and fire ecology	(Castelló and Montagut 2019)	Catalonia, Spain
	Maintaining small forest properties (methods to overcome land fragmentation issues)	None found	
	Access to public services: water, light, plumbing, internet, road conditions	None found	
	Fire infrastructure maintenance and multipurpose use of roads	None found	
	Local organization/administration access to funding	None found	
	Inter-administrative collaboration for fire management (ie. Departments of agriculture, environment, forestry, culture…)	None found	
Barriers	High private property ownership & fragmentation	(Otero et al. 2018; Alcasena et al. 2019)	Catalonia, Spain; Catalonia, Spain
	EU-level policies harming small scale farming, forestry, rural development	(Agnoletti 2007; Dedeire et al. 2013; Guadilla-Sáez et al. 2019; Bidegain et al. 2020; Agnoletti et al. 2022)	Tuscany, Italy; Mediterranean Europe; Cantabria, Spain; Andalucia, Spain; Tuscany, Italy
	Macro-scale tertiarization processes influence fire risk	(López-i-Gelats et al. 2009; Galiana-Martin et al. 2011; Dedeire et al. 2013; Kelly et al. 2015; Oliveira et al. 2017; Carlucci et al. 2019)	Pallars Sobirà, Catalonia; Valencia, Spain; Mediterranean Europe; Basilicata, Italy; Mediterranean Europe; Italy
	Low local autonomy to address fire governance issues and land use planning	(Kelly et al. 2015; Kocher and Butsic 2017; Bouisset et al. 2018a, b; Alcasena et al. 2019)	Basilicata, Italy; California & French Mediterranean; French Atlantic Pyrenees; Catalonia, Spain
	Not mentioned	Few studies on social vulnerabilities to disasters (Laurent 2013; Aguilar Cunill 2013; Frigerio and Amicis 2016; Farinella et al. 2017)	French Mediterranean; Tarragona, Catalonia; Italy; Italy & Greece

Their environment is their plot of land and the 25 meters around the plot, nothing more." (Tordera River Basin)

In a counter-trend, experts in the Tordera River Basin shared that some full-time "urbanized" residents were willing to assume the costs of fire risk management in the form of protective strips around residential areas after years of communicative efforts from the city council. While residents in this social group did not engage in proactive land management like more "rural" residents (such as forestry or farming activities), many did consider fire risk prevention as an essential public service and were willing to pay for it.

These distinct trends seem to point toward social fragmentation: interviewees reported that the economic and social diversity of full-and-part-time residents, retirees, tourists, amenity migrants and immigrant wage laborers tend toward little interaction between neighbors, leading to complications for implementing local fire adaptation plans. One respondent believed:

"This here is very different from the USA, where 'communities' exist. Here they don't exist. People don't feel that they belong to a community in an urbanization [residential area], for example. And that's what makes things difficult for people to take care of their own property. First you have to create community and then work among everybody. And that collaborative work just doesn't work here." (Tordera River Basin)

Indeed, while some social fragmentation seems to exist, interviewees simultaneously shared that they had most success with wildland fire adaptation strategies in places that were already "alive" with formal and informal associations or activities related to landscape management and cultural events. Frequently mentioned groups that helped promote fire awareness and adaptive strategies included volunteer firefighters, farmer associations, hunters, scouts, sustainable agriculture initiatives, volunteer forest management organizations, some environmental organizations, and landowner associations.

Prior studies in these areas closely resemble these findings on local interactions and relationships.. Due to the tertiarization of economies and subsequent "naturbanization"[2] of these areas (Badia et al. 2011), dynamics such as

an ageing population, outmigration, and immigration all affect local relationships, generating greater complexity and conflict between different population group values (Lópezi-Gelats et al.2009; González-Hidalgo et al. 2014; Piédallu et al. 2016; Paletto et al.2017). This was a consistent finding across the literature in Catalonia, French Eastern Pyrenees and Tuscany.

A study in Catalonia found that new inhabitants in rural areas are often considered "spectators", though not participants in shaping their landscape (Otero 2013). This sentiment ties to findings in Tuscany where designated natural areas often protect ecosystems, but they fail to recognize the cultural origins of many landscapes by prohibiting many agro-silvo-pastoral activities within these spaces (Agnoletti 2014; Agnoletti et al. 2022). A concern about the lack of fire awareness in "newcomer" populations is shared in studies in Valencia, Spain and the wider European Mediterranean basin (Clément 2005; Galiana-Martin et al. 2011).

At the same time, our varied findings on the role of "urbanized" populations also fit with descriptions of residents who have an affinity for natural-looking or green areas and recreational activities around them, which could help with developing more local service-based economies and some low-intensity forest management as determined in Tuscany by Ferrini (2002) and Paletto et al. (2017).

Local knowledge: Implications of fire ecology in traditional knowledge and environmental awareness

A recurring theme across study areas is the acute presence or lack of local traditional fire knowledge and its effects on local fire adaptation processes (Table 4). For example, a prescribed fire manager in the Catalan Pyrenees of Pallars Sobirà reflected on how local farmers and shepherds react positively to reintegrating fire in the landscape:

"It hurts their [shepherds'] eyes to see the territory in its current form [of lack of management]. And so when they see a group of firefighters or rural agents who do a [prescribed] burn in the neighboring valley, they say, 'Well wow, I want that too!' So that's the main kind of supporter [for prescribed burns] we have in the territory" (Pallars Sobirà)

In some rural areas, prescribed burns are in higher demand than supply:

"In the Catalan Pyrenees, we haven't had any problems. I know that in many parts of Catalonia there are environmental movements [against prescribed burning], but what happens here is I believe the introduction of fire has been done well, more or less, in the Pyrenees sector, and they

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[2] Naturbanization occurs when the perceived quality of landscape and environmental values are the main mechanisms attracting urban populations to move to rural areas. While similar to amenity migration dynamics in the western United Sates, we separate the concepts because "post-capitalist effects in north-European rurality have been specifically linked with rural restructuring processes that have taken a particular form- and could not do otherwise- according to the specificities of each context and its geo-historical, sociocultural, political and economic facets" (Pallarès et al. 2014).

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[locals] see that this is an ancestral dynamic for them. They do not see it in a negative way. Quite the contrary." (Pallars Sobirà)

However, many interviewees also converged on how much of the remaining traditional fire knowledge in NWMed areas was considered "out of touch" with a landscape that has radically changed in the last half century:

"There's a culture of fire, yes, but then fire as, let's say, a technical tool? No. They [farmers] burn without any criteria because they've done it like that their whole lives." (Pallars Sobirà)

At the crossroads between losing remaining elders' fire knowledge and completely professionalizing prescribed burns, opportunities still exist to integrate knowledge systems. As one respondent reflected:

"It would be good for the topic of prescribed burning… that in some way people could participate more, right? Because now they [burns] are done with highly specialized personnel, but in some way, they [fire managers] left the shepherds on the sidelines. And maybe it would be good to think, if someone from the town would like to participate in the burns in a safe way, so that they feel it's more their own, right? That it's not so much the administration that does it and that's it, right? Because before they [farmers] used to do it. And now it's like, we ignore your knowledge and we go down there because we're professionals. Here, I think we need to think of something." (Pallars Sobirà)

Across locations, interviewees also mentioned growing environmental awareness as both a source of enabling or hindering local fire adaptation efforts. For example, interviewees noticed an awareness in residents who valued consuming local products, recovering community gardens, and tending forests for ecosystem services, who were also keen to involve their communities in adapting to wildland fire:

"Surely, the same areas that in the '80s got together to defend the territory, the little that was left… those are the same that have formed, say, environmentalist groups and they're the same that are trying to promote kilometer-0 products [local products] or trying to install biomass heaters. And so, where there is already a tradition, because there were capable people who had turnover between activists, where they've been maintaining these spaces, you can now promote new things [like fire management actions]." (Tordera River Basin)

However, other environmental groups that may be unaware of local fire ecology dynamics seem to oppose vegetation management. As one fire administrator in France shared:

"There's a consciousness rising that we are in the middle of massacring nature. So suddenly, we put it in a sanctuary and, how do I say? The population tends to freeze the space that's closest to them. 'Do what you want elsewhere, but not in my backyard. Where I live, it's sacred, don't touch it.' So, when we make a new fire road, it's a hassle." (French Eastern Pyrenees)

The literature gives further context for these contradictory dynamics behind local fire knowledges. Economic sanctions, incarceration and scapegoating by the media in previous decades for lighting pastoral fires triggered more clandestine and high-risk burns (Clément 2005; Arnould and Calugaru 2008). Due to radical socioeconomic shifts, traditional fire knowledge is declining more rapidly in Europe than anywhere else in the world (Huffman 2013; Otero 2013; Oliveira et al. 2017). In part, this may be because the very notion of "rurality" is in dispute in many parts of Europe, and this complexity also leads to increasing conflicts in values, priorities and knowledge in land management (López-i-Gelats 2009). Today, prescribed burns are delegated strictly to fire managers and rural agents. Rural abandonment is one of the processes that directly contributed to the evolving complexity and severity of "generations" of fire regimes in Mediterranean areas, thus requiring more technical knowledge to manage them (Castellnou et al. 2019). Today, fire managers, locals and researchers recognize that the total professionalization of fire knowledge risks sidelining and undervaluing local knowledge in the study areas (Arnould and Calugaru 2008; Coughlan 2013; Ribet 2013; González-Hidalgo et al. 2014; Seijo et al. 2015). However, local fire knowledge holders still lack institutional, judicial and social support (Ribet 2013). Such political and economic power imbalances in the territory are felt acutely when it comes to fire management (Seijo 2007; González-Hidalgo et al. 2014; Seijo et al. 2015). Networks like the 30-year-old Prescribed Burning Network in the French Eastern Pyrenees aim to address this, connecting pastoral burns with technical fire management networks (Lambert 2010).Literature sources also confirm interviewee sentiments on how traditional fire knowledges must be met with caution and complemented with technical knowledge, given the radical changes in landscapes (Clément 2005; Lambert 2010).

Mediterranean literature expands on how local fire knowledge can positively impact fire adaptive capacities in various ways. This knowledge is often deeply embedded in managing agro-silvo-pastoral systems and can help maintain diverse economic and cultural activities,

shaping landscape "mosaics" in rural areas,[3] as found in Tuscany, the French Eastern Pyrenees and parts of Spain (Vaccaro and Beltran 2007; Lambert 2010; Ribet 2013; Coughlan 2014; Amici et al. 2015; Seijo et al. 2018; Guadilla-Sáez et al. 2019). Its presence can also lead to wider social acceptance of prescribed fire, helping to facilitate trust and deepen networks between land management sectors (Ribet 2013).

As mentioned in the interviews, environmentalist movements present both enablers and barriers to fire adaptation efforts. Some international environmentalist organizations have widely consulted fire ecology research are in favor of vegetation management in their territories through ecological means, which aids broader public messaging around the positive role of fire in the Mediterranean ecosystem (Greenpeace 2020; Hernandez 2019; Castelló and Montagut 2019).

At once, this messaging creates friction with traditional conservation paradigms. Studies in Spain and Tuscany have found that desires for "wilder" landscapes can influence how forests are managed, with often little consideration for how those landscapes were generated in the first place through cultural agro-silvo-pastoral practices (Cebrián-Piqueras et al. 2020; Agnoletti 2014). Ongoing afforestation in Mediterranean areas can lead to biodiversity loss (Pausas and Keeley 2019), while active cultural landscape management could help maintain heterogeneity. Placing additional constraints on traditional human activities in such protected areas, as studied in Tuscany and Catalonia, could have harmful effects on biocultural diversity (Amici et al. 2015; Aquilué et al. 2020; Agnoletti et al. 2022).

Scientific & technical knowledge: fire managers and administrative limits

The way in which scientific and technical fire knowledge is implemented in all case study areas also influences local adaptive capacities to fire (Table 5).

One significant element of technical knowledge that can enable local adaptive capacity is the role that professional and volunteer firefighters play in their communities. A prescribed fire manager in Italy described their role as vegetation managers and public communicators:

> "It is the same level of work [vegetation management and communication]. Good work, but good communication. The result is a mix of those two aspects." (Tuscany)

Volunteer and professional firefighters in Catalonia tend to have high generational turnover across case studies, which also serves to build a connective narrative about trustworthy figures who are familiar with local issues and lived experiences of fire:

> "Within Firefighters, this oral transmission has happened, for better or worse, and then it's like a narrative that makes sense when you're talking to an old person from Cap de Creus, who remembers [a fire event in 1996]… and even though I was eleven in '96, I can tell you about the experiences of the firefighters who lived this, and then we connect, you know? And here it starts, from the beginning of our chat, that credibility and trust." (Tordera River Basin)

In France, commitment and effective leadership helped build a wide network of prescribed burning over time, and respondents pointed to the quality of social relationships in the network.

> "… I also think it's this good coordination and this good conciliation between the world of prevention and the world of livestock, but it's a matter of men, humans, relationships and transmission as well, [our predecessors] who passed on to us a generation of technicians and so on." (French Eastern Pyrenees)

Meanwhile, significant barriers to integrating scientific and technical knowledge in case study areas include: 1) a lack of funding and technical capacity on local levels to implement fire adaptive policies and 2) confronting conservation paradigms in other administrations.

In all study areas, municipal administrators and fire technicians particularly felt the burden of risk management. Local champions and municipal leaders felt that the responsibility of mitigating fire risk should fall on higher levels of governance, since they did not have the technical capacity or funds to enact needed changes in their communities, and since fire behaves on a broader territory scale regardless of measures like fire protection strips created around small towns. At the same time, several fire technicians and administrators believed that residents and local municipalities needed to take a more active role in managing their landscapes.

> "I mean, 'mom and dad' administration can't save you. We need to work on that perception a lot. Risk awareness, the reality of where you live, the reality of the changing landscape." (Tordera River Basin)

Current fire mitigation plans conflicted with other administrations throughout study areas (i.e. cultural or environmental) that aim to preserve landscapes. Across case study areas, this approach to land management was institutionalized in various administrations and was challenging to

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[3] Mediterranean landscape mosaics can be understood as culturally generated landscapes that serve multi-functional human and ecological purposes, maintaining biodiversity and ecosystem services.

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confront both in terms of communication and paperwork. This challenge was particularly evident for implementing prescribed burns. Fire managers described the challenges in changing other administrators' minds regarding the benefits of prescribed burning for habitat conservation:

> *"What's more important? Conserving every member of an endangered population, or managing their habitat so it can ensure healthy populations in the future?" (Tordera River Basin)*

Even the long-established prescribed burn network of the French Eastern Pyrenees faced increasing restrictions due to smoke concerns and environmental impacts. According to the experience of a key expert, "new residents" with traditional ideas of landscape preservation began obtaining more power in city councils and opposed prescribed burning. Some current effects of this included increasing paperwork and expenses for prescribed burning, and severely limited the size of management actions. These administrative and economic burdens have become too prohibitive for many farmers to continue burning their pastures for maintenance. Another respondent commented:

> *"In the end, it's the economic impact. It's no longer bearable. It's [burning] just for grass, let's not forget!" (French Eastern Pyrenees)*

Tuscany was the first region in Italy to implement prescribed burns, and respondents felt they lacked technical resources and references to implement more burning needed in the territory.

> *"We need help from a tradition that we don't have. We are building the tradition in this sector, and from the proof, approval, of the people, the institutions..." (Tuscany)*

Throughout the literature, the enabling dynamics of firefighter credibility and technical knowledge exchanges in European Mediterranean areas have been echoed.. Certain groups of fire managers, fire ecology organizations and prescribed burning knowledge networks across study areas have been able to establish a "community of practical experience" (Ribet 2013; Held et al. 2018). By leveraging knowledge exchange networks and trainings across borders and governance structures, these networks can challenge strict administrative barriers and increase more integrated fire management strategies (Otero and Nielsen 2017; Iago Otero et al. 2020).

However, in all study areas, municipal administrators and fire technicians felt the burden of risk management. This echoed other studies in NWMed settings which found that rural municipalities often lacked the technical fire services or capacities to implement land management

plans and ensure community safety (Bouisset 2011; Bovio et al. 2017; Bouisset et al. 2018a, b).

Furthermore, in each case study area, legislation was either absent or prohibitive for prescribed burning, and various cultural and environmental administrations continued to misunderstand the role of fire ecology in the ecosystem (Lambert 2010; Ascoli et al. 2009; Corona et al. 2015; Bovio et al. 2017; Alcasena et al. 2019).

These findings point to a governance gap between rural communities and higher institutions in European Mediterranean areas. Both expert interviews and consulted literature called for more bottom-up processes to encourage community engagement and empower local knowledge about landscape dynamics, as these are necessary components to positively influence local fire adaptation (Kocher and Butsic 2017; Oliveira et al. 2017; Otero et al. 2018; Tedim et al. 2021; Wunder et al. 2021).

Structure & demographics, and higher scale dynamics: fragmented opportunities

While not a statistical measurement of change, interviewees' perspectives on socio-demographic changes such as shifts in local economies and property ownership, also help inform the analysis of local social context. This information can identify perceived needs and trends in these communities regarding fire adaptive capacity. Across study areas, considerable opportunities in sustainable and localized models of diversified agriculture, forestry and tourism can provide creative and longer-term solutions for mitigating wildland fire risk on a local level (Table 6). Interviewees shared sentiments of high economic potential for more localized and diversified agricultural production, more humane and high-quality meat and dairy production under extensive grazing models, restoration of traditional crops to recuperate landscape heritage, small-scale wood production and public biomass infrastructure for municipal heating, among other sustainable bioeconomy[4] activities (European Commission 2018).

> *"It is a bit of a paradox because we want to consume local, we want to consume sustainable energies and sustainable materials, but people are offended when they see that we are cutting trees..." (French Eastern Pyrenees)*
> *"...It seems to me an aberration that much of this energy that we have is transported, is transferred to [another county] and that maybe from there it goes to Italy [from Catalonia]. Many of the fires that we've had, after the trees that burned have been cut down,*

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[4] Bioeconomy: includes all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles that use and produce biological resources (European Commission 2018).

basically could be used to generate biomass… and we can promote many positive dynamics at the territorial level to favor landscape management." (Pallars Sobirà)

Moreover, several forest owners' associations (such as the *Propietaris de Montnegre Corredor* in Catalonia, *Association syndicale de la suberaie* in the French Eastern Pyrenees, and *the Comunità del Bosco* in Tuscany), were keen on helping manage larger pieces of private land. These organizations are particularly salient in the NWMed context, as so much of the territory lies in fragmented private property. Promoting forest ecosystem services and sustainable tourism, such as biodiversity observatories, can also contribute to these initiatives.

Two key barriers also emerge in tandem with these opportunities for local development: 1) extreme fragmentation of private properties; and 2) embeddedness in higher-scale economic and policy dynamics at national and EU levels.

When implementing fire prevention plans, interviewees shared the difficulty in contacting such large numbers of property owners on small scales, where official land registries can be inaccurate or missing, and where current owners may be the unwitting descendants of property owners several generations prior.

"People go walking, but they forget each time that they are crossing extremely fragmented private properties. The size of properties is less than half a hectare. This means that as soon as we do work there are plenty of owners, we build a bit of fire road, we have to make easements…We have to consult the town hall, look for the owners, look for descendants. It reveals people who are in Malta or in Madagascar. It's mind-blowing!" (French Eastern Pyrenees)

This process of fragmentation also speaks to the challenge of sheer density of human development in Mediterranean European areas, where humans have profoundly reshaped their surroundings for millennia.

"You can't go 10 km without finding a house here. On the other hand, over there [in the USA], you can go hundreds and hundreds [of kilometers], and you don't find anything." (French Eastern Pyrenees)

The economic unviability of managing these small private parcels presents a primary challenge for new forms of land management and localized economies that could assist in fire adaptations.

Interviewees also pointed to broader social processes that could aid in overcoming higher-scale political embeddedness. One such effort is focusing on environmental education in primary school curricula in high fire risk areas. While this process develops on a longer time scale, it is essential to promote broader cultural shifts in land management:

"I mean, when I see the ecology as it is I see it as a cultural challenge of utmost magnitude. Only with more laws, the only thing you'll do is make fines and fill more jails, only with laws…I say fewer laws and more culture. And culture not in the literary sense, that I've read more than you. But rather culture in its original Latin sense, which is that relationship with nature, with cultivating nature." (Pallars Sobirà)

Mediterranean literature also mentions "endogenous development" opportunities as an enabling factor which could help develop more private and public investments in sustainable, integrated forest and fire management (Verkerk et al. 2018; Kramer et al. 2022). Such initiatives include more sustainable rural tourism, agriculture, forestry, renewable energy, and integrated territorial planning (Roura-Pascual et al. 2005; Berthet 2012; San-Miguel-Ayanz et al. 2013; Molina and Galiana-Martín 2016; Tedim et al. 2016; Bovio et al. 2017; Otero and Nielsen 2017; Alcasena et al. 2019; Aggestam and Giurca 2021). These initiatives could further help mend some of the landscape management rifts between abandonment, intensification, and clashes between rural and urban landscape population values while also mitigating fire risk more sustainably (Otero and Nielsen 2017; Aquilué et al. 2020; Wunder et al. 2021).

On the other hand, other European Mediterranean studies have found it impossible to disentangle heavy state-level influence on local land use planning, as found in a comparative study between policies in California and France (Kocher and Butsic 2017). Across study areas, development patterns are perceived to have low local autonomy, in part due to EU level framework regulations in agriculture, forestry and biodiversity goals (Kelly et al. 2015; Kocher and Butsic 2017; Bouisset et al. 2018a, b; Alcasena et al. 2019). Furthermore, entrenched political habits and institutional traditions in some Mediterranean governance systems often impose objectives without debate. This creates a situation where: "broad and deeply rooted social participation in policy-making is less frequent in Mediterranean countries than in other EU member states" (Tedim et al. 2016; Aguilar and Montiel 2011, 634).

Discussion

While each case study area is unique, results from interviews and literature review demonstrate significant similarities in local context across NMed territories. We discuss how findings from different "branches" of context

across case study areas interact and can inform local fire adaptive capacity.

Local interactions

The growing heterogeneity of land use values combined with limited social cohesion has real implications for fire adaptation; this can lead to scarce territorial connection, misunderstandings of landscape origins, and diverging opinions on what kind of land use and fire management is needed to adapt to future climate change and who is responsible for risk reduction (Clément 2005; Christine Bouisset 2011; Galiana-Martin et al. 2011; Otero 2011). Additionally, strong differences in resident values can create environments that are "far from the myth of cohesive communities who know each other, work together, or communicate" (Tedim et al. 2016, 148). This diminishing community capacity can directly influence how populations prepare for wildland fire (Concu et al. 2021). This dynamic has important implications for promoting fire adaptive capacities in our study area because fire managers, policy makers and local leaders must navigate these complex manifestations of social fragmentation and encourage active participation from residents. At the same time, the views expressed by experts and the literature on the lack of community cohesion may not fully represent the views of residents themselves. For this, we encourage further in-depth case studies.

Local knowledge

Several rural populations in our study area demonstrated more generational familiarity with fire in the landscape, and strong indications suggest they would accept its controlled reintegration enthusiastically. In NWMed contexts in Spain, France and Italy, TEK systems are still relevant for land stewardship and resource management, as they; mirror institutionalized scientific findings on ecosystem dynamics, provide valuable diverse sources of information on historical processes, help monitor changes, and foster local empowerment (Fernández-Giménez and Estaque 2012; Oteros-Rozas et al. 2013; Reyes-García et al. 2016; Oliveira et al. 2017; Guadilla-Sáez et al. 2019).

On the other hand, the lack of local knowledge integration has led to processes of local disempowerment and increased distrust of professional land and fire managers. Mending these relationships and encouraging much needed local knowledges to take a more active role would require facilitation and co-productive knowledge exchanges.

The concurrently enabling and hindering force of environmental values in different populations can also be considered as symptoms of the ongoing social transitions of more "urban" and "rural" values in the studied territories. This lack of consensus on land management priorities could shape the success or failures of future fire adaptation strategies (Subirós et al. 2015). Local knowledge and environmental awareness are also linked to the kinds of social interactions and relationships playing out in different Mediterranean territories.

Scientific/Technical knowledge

Exhaustive communication efforts in every study area have helped to build trust between local fire managers, administrators and residents along the "urban" and "rural" social spectrum. This can have a positive effect on local adaptation such as vegetation management and prescribed burning.

Legacies of distrust and sanctions on local populations still exist, as discussed in the local knowledge section. Mending these dynamics requires more concerted efforts and resources for dialogue in the long term.

Both expert interviews and consulted literature call for more bottom-up processes, community engagement and empowering local knowledge about landscape dynamics to influence local fire adaptation (Kocher and Butsic 2017; Oliveira et al. 2017; Tedim et al. 2021; Wunder et al. 2021).

Structure & demographics, higher scale dynamics

While enablers for sustainable local development are cited in each territory, these do not exist in a vacuum: macro-scalar sociopolitical processes in the EU influence the autonomy of local communities to address land use and abandonment, which in turn affects adaptive capacity for wildland fire (Kelly et al. 2015; Otero et al. 2018; Carlucci et al. 2019). The Common Agricultural Policy is frequently cited as one of the main drivers of changing social, environmental and economic dynamics in rural areas through the intensification of agribusiness and declining landscape heterogeneity (Guadilla-Sáez et al. 2019; Bidegain et al. 2020). Individual communities may lack the capacity to confront these challenges and would require assistance from regional and national governments for access to financial aid. However, new EU legislation through the Green New Deal and Next Generation Funds looks to address these issues (Aggestam and Giurca 2021). Results from these new policies and their impacts at local levels are yet to be widely documented in the literature.

Interactions of enablers & barriers across branches of context

As explored in prior studies in the US, each branch of local social context does not exist in isolation. Rather, they interact and inform local adaptations to fire (Paveglio et al. 2016). Our findings support the premise that local

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adaptive capacity is a sum of all of its influences. Further, we argue that certain enablers and barriers to fire adaptation can leverage effects across different branches of context.

For example, the presence of local traditional fire knowledge across our study areas in Spain, France and Italy can affect adaptive capacity positively in multiple ways. According to findings from the interviews and literature, recognizing and providing support for remaining local knowledge while also expanding general knowledge of fire ecology can lead to: a sense of rural community empowerment, restoring agro-silvo-pastoral management and increasing biodiversity, building trust between professional fire managers and locals, orienting environmental and conservation movements in the context of fire ecology, and fostering more socially appropriate, localized land use policies.

Conversely, dynamics of development at higher governance scales can significantly hinder adaptive capacities across local context spheres. The lack of opportunities for sustainable endogenous socioeconomic development has presented a primary barrier for local fire adaptive capacities. This dynamic perpetuates a loss of local knowledge, pushes residents to leave rural areas, and creates a relational gap when newcomers repopulate these landscapes. This in turn can lead to social fragmentation in these geographic areas.

The far-reaching influence of these enablers and barriers can help orient feasible action-research steps to bolster adaptive capacity across multiple branches of local context. These interconnected influences are represented in Fig. 3.

Limits to the study

Findings on local social contexts have built upon numerous case studies over time in other areas of the world. For example, other local social context studies have conducted over 60 interviews with experts and residents in the same county (Paveglio and Edgeley 2017). While this study was limited to a small sample of key experts across four areas, the results demonstrated emerging themes shared across NWMed rural contexts. This study presents a first step for more qualitative, empirical research needed to develop further research in the region. Additionally, the targeted literature
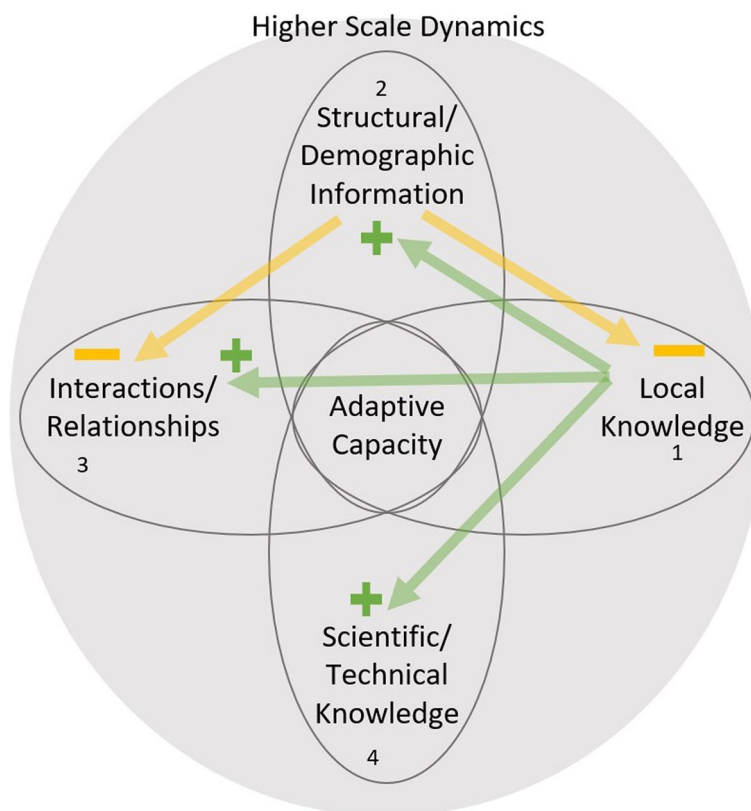

Fig. 3 Enablers and barriers that influence multiple branches of adaptive capacity. Yellow arrows indicate barriers and green arrows indicate enablers. Local fire knowledges (1) can act as a beneficial multiplier across all branches: restoring agro-silvo-pastoral biodiversity (2); strengthening local empowerment (3); and building trust between technical and traditional fire managers (4). Lack of sustainable development initiatives (2) can negatively affect several branches: it can lead to loss of local knowledge of the landscape (1); and push residents out of rural areas and increase social fragmentation, (3)

review may have missed some aspects of local social contexts in these areas, as social science terminology and language fluctuate across countries and some literature related to other aspects of land management (not specific to wildland fire). However, to our knowledge, there has been no prior effort to synthesize the interaction of such elements and their effect on adaptive capacity in Mediterranean fire social science literature. Our literature search did reach content saturation in many aspects of local context while also illustrating several gaps that emerged in the interviews but not the literature, helping to create a strong reference base on research needed for future studies on Mediterranean local social context and fire adaptive capacities. More critical social engagement is also needed to better understand and represent social diversity in each study area. For instance, few studies or interviews explored the linkage between social vulnerabilities and fire adaptive capacity, such as the social exclusion that immigrant labor populations from Northern Africa and the Middle East experience in rural NWMed areas (Aguilar Cunill 2013; Laurent 2013; Frigerio and Amicis 2016; Farinella et al. 2017). This focus only on key experts dispersed across NWMed areas may have limited the scope of the results, as experts are also prone to their own assumptions and biases, though it did provide significant insights into common trends across territories that merit further inquiry. While this study provides initial insight into NWMed local social contexts from experts, we recommend future research to test these perceptions by engaging with larger, more diverse samples of local landowners and residents. Additionally, this study has revealed important connections between local social contexts and fire governance institutions that vary dramatically between countries, regions and even counties: we encourage a thorough analysis of how these institutions influence fire adaptive capacity at the local level for researchers in policy and governance.

Conclusion

This study has investigated how the local social contexts of rural NWMed areas influence adaptive capacity to wildland fires, generating new insights to international wildland fire sciences. The information synthesized from key expert interviews and literature across four study areas has begun to describe patterns across rural contexts in Spain, France and Italy. These overarching patterns of context manifest differently in each socioecosystem, and communities are adapting to fire through diverse approaches.

We have found that the way these context elements interact can act as enablers or barriers to adaptive capacity at a local level. For example, local interactions and relationships related to community identity, communication networks and associations can greatly shape local adaptive capacity; these elements connect directly with local knowledge and experience with fire, perceptions of landscape health, and experience with other risks; in turn, this can influence trust in local fire management agencies and governance institutions, and; these interactions are influenced by drivers of economic development and private property ownership. Our research affirms previous findings documented in the literature: there is no one set of characteristics that determines adaptive capacity to wildland fire, though key elements interconnect with one another to influence adaptive capacity.

Other context elements seem unique to rural NWMed settings. For example, local social context is deeply embedded in higher scales of decision-making, culture and governance. Agriculture and forestry are heavily subsidized at the EU level, macro-processes of rural abandonment and tertiarization affect all study areas, and top-down governance approaches continue to influence fire mitigation strategies. These patterns became clear through the interviews and they were also reflected in the literature. At the same time, this context also provides specific opportunities to promote more sustainable and localized rural development initiatives that advocate for circular bioeconomies, revaluing local knowledge, and growing environmental awareness centered in fire ecology.

Understanding the distinct manifestations of these processes in each place can contribute to more relevant and well-rounded strategies when developing appropriate "pathways" to fire adaptation. Deepening stakeholder participation, empowerment and ownership of these strategies paves the way for more long-term adaptive co-management of landscapes and risks. These essential building blocks can help improve resilience to wildland fire and climate change uncertainties in Mediterranean areas and should be examined locally and internationally.

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Design of study. Manuscript structure and revision. CK Design of study. Manuscript structure and revision. ERL Design of study and fieldwork. Interpretation of results and discussion. Manuscript revision. The authors read and approved the final manuscript.

Availability of data and materials
The data generated and analyzed during the current study are not publicly available due to participant privacy. Anonymized transcripts are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval of this research was obtained at Wageningen University through a proposal review committee in 2021. Participants were provided with informed consent forms compliant with GDPR guidelines, outlined by the Ethics Committee of the PyroLife Innovative Training Network. Forms were signed in person with the author conducting fieldwork. Interview transcripts were provided to individual participants upon request. All personal data has been kept anonymous.

Consent for publication
Not applicable. No personal data is used in this publication.

Competing interests
The authors declare that they have no competing interests.

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