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Multi-scale governance analysis of Integrated Fire Management in Southeastern France

Supervisors

Dr. Imma Oliveras Menor, IRD France

Dr. Sergio de Miguel, University of Lleida

Milena Pereira Kozlowski

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University of Lleida

School of Agrifood and Forestry Engineering and Veterinary Medicine

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Dr. Imma Oliveras Menor, IRD France

Dr. Sergio de Miguel, University of Lleida

Submitted by

Milena Pereira Kozlowski

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Acronyms Index

BA – burned area

DFCI – defense of forests against wildfires (French: *défense des forêts contre les incendies*)

ES – ecosystem services

IFM – integrated fire management

I(N) – interviewee (interviewee code)

OLD – households' legal vegetation clearing obligations (French: *obligations légales de débroussaillement*)

PB – prescribed burning

SES – socio-ecological system

WUI – wildland-urban interface

Abstract

Fire has long shaped Mediterranean landscapes, influencing both ecological and social processes in socio-ecological systems (SES), with many plant species having evolved to adapt to frequent fires. However, climate change has intensified uncontrolled extreme wildfires events, with significant human and ecological damage, challenging the adaptive capacities of species and human communities. This highlights the need for integrated fire management (IFM), combining fire suppression activities with prevention, recovery, and the restoration of historical fire regimes. Social processes, driven by decision-making and resource allocation, are key to implementing IFM. This study explores these social processes in the Occitanie region in Southeastern France, in a Mediterranean landscape, historically affected by wildfires. It examines the socio-ecological context, policy effectiveness, stakeholders' relations and activities, and stakeholder valuation of ecosystem services (ES) before and after wildfires. This was done through semi-structured interviews with key stakeholders and a network analysis. Results revealed that stakeholders view France's fire suppression policies as effective, mainly by reduced burned area over time, despite increased wildfire risks from urbanization and fuel accumulation. Fuel management is the main strategy and is critical for reducing wildfire risk but faces challenges, including (1) insufficient enforcement of households' vegetation clearings in wildland-urban interfaces (WUI); (2) fragmentation and ownership issues limiting the development of larger fuel breaks; (3) lack of economic interest for private forest management; and (4) socio-economical barriers to promoting grazing and prescribed fires for fuel management. Long-term wildfire management requires cultural shifts and collaboration, with potential strategies including awareness raising on households' vegetation clearings, improving administrative coordination with private forest owners, promoting socio-ecological ES and grazing through economic mechanisms, and testing prescribed fires while educating decision-makers on their benefits. This study brings light to the current context of IFM in one region in Southeastern France, with information regarding socio-ecological and governance challenges as well as opportunities for IFM.

Keywords: wildfire management; fire governance; network governance; ecosystem services; wildfire policy.

1. Introduction

Natural fires in Mediterranean ecosystems are an intrinsic disturbance which maintain certain ecological functions and processes (Alló & Loureiro, 2020; Fournier et al., 2020; Szymczak et al., 2020). Anthropogenic fires have been used in the region for millennia for activities that generates humans' benefits, such as land clearing and grazing (Martín-López et al., 2012; Moritz et al., 2014; Connor et al., 2019; Pausas & Keeley, 2019; Moreno et al., 2021; Pereira et al., 2021). These natural and human interplay have resulted in "fire regimes", related to climate conditions, fuel type (vegetation) and fire activity (size, season, frequence, intensity and severity) (Moritz et al., 2014). Because of Mediterranean's cold wet winters and dry hot summers, promoting first vegetation growth and further dryness and increasing flammability, summer wildfires are common in the region. Some vegetation is adapted to the region's historical fire regime (Depietri & Orenstein, 2019; Pereira et al., 2017; Lestienne et al., 2019; Moreira et al., 2020; Duane et al., 2021) developing traits such as serotiny, bark thickness, and others (Romero & Ganteaume, 2020). Yet, recent human alterations to landscapes and climate have dramatically changed fire regimes and their socio-ecological effects, creating "anthropogenic fire regimes", which may not be ecologically viable to species adapted to historical fire regimes (Rego et al., 2010; Lestienne et al., 2019; Pausas & Keeley, 2019; Moreira et al., 2020; Romero & Ganteaume, 2020; Fernandez-Guisuraga et al., 2023; Pandey et al., 2023).

Nature and society are interconnected and interdependent in a socio-ecological system (SES), where social and natural elements are constantly influencing one another, and fire is one natural element of this system (Moritz et al., 2014; Brenkert-Smith et al., 2017; Hamilton et al., 2019; Lestienne et al., 2019; Pacheco & Claro, 2020; Skrimizea et al., 2021; Tedim et al., 2016; Vigna, 2022). This means that social activities impact nature, but nature "activities" also impact society in continuous feedback. It becomes, therefore, important to study how social processes and decisions, mainly in terms of policies, affect the ecological system (Andriollo et al., 2021; Fischer, 2018; Pausas & Keeley, 2019; Kirchner et al., 2024).

Today's Mediterranean landscape has been long shaped by humans and by fire (Aguilar & Montiel, 2011; Rego et al., 2010; Connor et al., 2019; Moreno et al., 2021). This landscape has a complex dynamic shaped through history with the interplay between past, present and future decisions in land management, together with environmental conditions (Fischer, 2018; Connor et al., 2019;

Kirschner et al., 2024). Decisions are made by stakeholders that interact within social networks, shaped by cultural and historical narratives, creating rules and relational patterns that influence land management. They continuously shape the development pathways by reproducing, reworking, contesting, and renegotiating established rules (Shapiro-Garza et al., 2019; Kirschner et al., 2024). Disturbances to the historically established and developed fire regimes can impact ecosystem's natural functions and processes (Moritz et al., 2014; Fischer, 2018; Pausas & Keeley, 2019), such as a fire exclusion policy taking fire completely out of the landscape or a lack of fuel management that can increase the frequency and/or intensity of extreme wildfire events.

Fire has been a topic of much public discussion and a recurring source of paradoxes due to its controlled application in daily life and the risks it poses to people and property when with extreme uncontrolled wildfire events (Rego et al., 2010). Not all fires are the same and have the same consequences, so it is important to differ fires from extreme wildfire events and megafires. Fire can be used as a tool for human activities, usually with low intensity and frequency. Extreme wildfire events are fires with high speed, intensity and extension, with erratic and unpredictable fire behavior and spread, being characterized by their behavior and control capacities rather than by their size, although often being large, challenging knowledge about historical fire regimes, even in fire-prone areas (Duane et al., 2021). Megafires, mostly defined by its size, are fires of more than 10.000 hectares in area, arising from single or multiple ignitions (Linley et al., 2022), creating fire clusters enabled by critical weather conditions. Because of simultaneous fire ignitions and rapid fire spread, initial fire attacks supported by firefighting means are rapidly overwhelmed and not reliable under extreme weather conditions (San Miguel Ayanz et al., 2013).

Main issues present in today's Mediterranean landscapes are that, because of climate change with its longer drought periods and higher temperatures (Varela et al., 2018), particularly in southern Europe (Rego et al., 2010), not only the likelihood of wildfires may increase, but also its frequency (Ruffault et al., 2018; Romero & Ganteaume, 2020; Huidobro et al., 2024), severity (Santos et al., 2021), intensity (Pereira et al., 2017; Lecina-Diaz et al., 2023), extent (Fernández-Blanco et al., 2022) and with a longer fire-prone period (Cardill et al., 2019; Lestienne et al., 2019). These climate conditions, coupled with a peri-urban population growth in fire-prone areas, known as the wildland-urban interface (WUI), increases human vulnerability to extreme wildfire events and reduces existing preventive and suppression measures effectiveness (Lestienne et al., 2020; Pandey et al., 2023). With this, the region is experiencing a shift from small, manageable fires to extreme

wildfire events and megafires (Górriz-Mifsud et al., 2019; Pausas & Keeley, 2019; Alló & Loureiro, 2020; Moreira et al., 2020; Wunder et al., 2021; Fernández-Blanco et al., 2022).

Not only urban areas are concerned, but also rural ones, as land and agricultural abandonment also changes the landscape (Moritz et al., 2014). With previous, current and future land abandonment, there is shrubby vegetation regeneration, developing a highly flammable biomass volume (Alló & Loureiro, 2020; Nuss-Girona et al., 2022; Lecina-Diaz et al., 2023; Vigna et al., 2024). This process is called "fuel build up", which makes that, if there is a source of ignition, this fuel can be rapidly consumed by fire, risking becoming an uncontrolled wildfire. Another process promoting fuel build up is the extensive fire suppression policy taken in recent decades, mostly aimed to protect people and properties, as fires started expanding in the WUI (Hamilton et al., 2019; Huber-Stearns et al., 2021). Taking out fire of a landscape and vegetation that adapted to its presence promoting a "fire deficit" may change vegetation structure and composition, reducing diversity in fire-dependent plant communities (Schmerbeck et al., 2015; Fournier et al., 2020), also promoting a landscape for more intense and severe wildfires as there is more fuel available for consumption (Huber-Stearns et al., 2021). The increase in the probability of extreme wildfire events impacts the cultural use of fire, for instance, in the French Pyrenees's Mountain areas, fire has been used for millennia as a cultural practice to regenerate vegetation for grazing (Aguilar & Montiel, 2011), now being regulated to certain specific dates to decrease the probability of cultural fires becoming uncontrolled wildfires.

As fire distribution is usually determined by human activities and settlements and the location of the largest fires is influenced by the continuity and type of fuels (Ruffault & Mouillot, 2017), understanding the role of fire in the SES and avoiding uncontrolled fires and extreme wildfire events is essential. The Integrated Fire Management (IFM) comes as a framework to address the root causes of extreme wildfire events (Wunder et al., 2021). IFM seeks to reduce the negative impacts of fires and increase its benefits, by incorporating assessments of social, economic, cultural (Shlisky et al., 2007), and ecological aspects (Aguilar & Montiel, 2011). It means that, because of changing climate and social conditions, with an increased wildfire risk, people will need to remember a time where humans lived with fire and it was a present and natural element of the landscape, instead of intensively trying to completely exclude it. IFM promotes a combination of preventive measures and land management (e.g. promoting sustainable logging, grazing, and firebreaks) to reduce fire intensity and protect biodiversity, alongside designing and implementing

policies that integrate fire into urban planning, resource extraction, and infrastructure development (Shlisky et al., 2007; Badeau et al., 2024). In the context of Integrated Fire Management (IFM), identifying current stakeholders and assessing their capacity to engage in planning is crucial for listing the variables that influence each fire-related context and for providing effective governance structures tailored to the opportunities and constraints specific to the area studied (Aguilar & Montiel, 2011).

Scientific discourse is bringing more and more the shift from passive behavior, moving away from the complete fire suppression paradigm, to a more active behavior, learning to "live with" (Górriz-Mifsud et al., 2019) and "adapt to" wildfire risk (Brenkert-Smith et al., 2017; Kirscher et al., 2024), or "coexist with fires" (Moritz et al., 2014; Tedim et al., 2016), learning to use fire and allowing it to have its ecological role. A new perspective, with a deeper understanding of the intricate relationships that exist between fire, landscape, climate, communities, and society will need to be promoted to help communities reimage the role of fire in the landscape, understanding its place and that it may be tolerated in the landscape, where and when appropriate, where the goal is to deliver the right amount of fire at the right place, time, and cost (Brenkert-Smith et al., 2017; Kete, 2023). The impact of fires on populations is shaped by the objectives of fire management organizations, which in turn are influenced by the social, economic, and political institutions governing them (Huidobro et al., 2024).

It is acknowledged that the issue won't be fixed unless the causes of the growing wildfire risk are addressed and its socioeconomic foundations investigated (Tedim et al., 2016). However, human processes, components, and aspects are given much less attention than physical ones in wildfire research, with very few social sciences and qualitative research and/or authors advocating for its importance (Moritz et al., 2014; Tedim et al., 2016; Górriz-Mifsud et al., 2019; Pacheco & Claro, 2020; Huber-Stearns et al., 2021; Wunder et al., 2021). This scarcity of social science insights limits the understanding of the role policies play in either mitigating or exacerbating wildfire risks (Huidobro et al., 2024). The many responsibilities that various actors play within network governance have not received much attention in the literature so far, needing more research to fill in knowledge and practice gaps (Huber-Stearns et al., 2021).

Governance encompasses the rules, structures, processes, and traditions guiding decision-making, power-sharing, and accountability (Andriollo et al., 2021; Kirchner et al., 2024). It can also be the mechanisms and tools used to shape societal change in predetermined directions (Aguilar &

Montiel, 2011), such as policy development, legislation, law enforcement, decision-making structures, property rights management, and market-based distributions, often complemented by public-private partnerships (Moritz et al., 2014; Metzger et al., 2021). It typically involves multi-actor and multi-level processes characterized by diverse interests, perspectives, needs, knowledge, and resources, which can lead to conflicts but also opportunities for collaboration (Andriollo et al., 2021). One characteristic of environmental governance is that it usually features multiple semi-autonomous decision-making processes (Hamilton et al., 2019), with wildfire management remaining complex due to the diversity of actors involved, the uncertainty of outcomes, and trade-offs between short-term and long-term impacts (Huidobro et al., 2024).

Forest policy design, organization and implementation varies across nations due to institutional traditions, political customs (Aguilar & Montiel, 2011), available resources, social structures, governance processes, and cultural factors (Skrimizea et al., 2021). As institutions can shape behavior through rules, conventions, and incentives (Arts et al., 2014; Kirchner et al., 2024), this study focusses on analyzing institutions, the roles they play, and how they collaborate to better understand the scope of their actions (Huber-Stearns et al., 2021), similar as Kirchner et al. (2024) did in Italy and González & Ghermandi (2024) did comparing several countries. Recognizing institutional players, the many roles they play, and how they collaborate can bring light on the variety of abilities and know-how required to design and implement more adapted and effective policies (Arnouts et al., 2012; Huber-Stearns et al., 2021).

Social capital, which includes social norms, shared values, and networks, plays a crucial role in wildfire management (Górriz-Mifsud et al., 2019). Integrating social and cultural values into environmental policies could improve fire risk assessment and management (Palaiologou et al., 2021). This also includes, for example, how stakeholders see and value the nature surrounding them, which can be expressed in the ecosystem services (ES) nature deliver. Ecosystem services (ES) are here understood as "the benefits people obtain from ecosystems. These include *provisioning services*, such as food and water; *regulating services* such as flood and disease control; *cultural services* such as spiritual, recreational and cultural benefits; and *supporting services*, such as nutrient cycling, that maintain the conditions for life on Earth." (Millennium Assessment, p.1, 2005). Studying how stakeholders value ES and their dynamics before and after extreme wildfire events can help to understand which ES could be favored (or not) in decision-making. The evolving nature of hazards and disasters, characterized by increasing complexity and

uncertainty, calls out for research that fully engages with the intricate relationships between social and ecological systems (Skrimizea et al., 2021).

France is the fourth Mediterranean country with more wildfire research (Pacheco & Claro, 2020), having knowledge gaps yet to fill. As most wildfire-related studies usually focus on a specific place (e.g. natural park) and some compare experiences among sites and countries (Pacheco & Claro, 2020), this study was carried out in the administrative region of Occitanie, in Southeastern France, working with several administrative scales, from national to inter-municipalities level. The Occitanie region is composed of three main climate zones: warm temperate dry (Mediterranean) on the east, warm temperate moist on the west and cool temperate moist on the south (Joint Research Center, n.d.). South-Eastern France is particularly vulnerable to wildfires due to several factors: the Mediterranean climate with prolonged summer droughts and frequent strong winds, high population density leading to numerous ignition sources, and extensive connected stands of flammable forests and shrublands (Lahaye et al., 2014; Moritz et al., 2014; Chappaz & Ganteaume, 2022). Occitanie was specifically chosen because of its Mediterranean area being historically affected by wildfires although rarely considered in scientific studies, with nevertheless an increasing wildfire risk towards its non-Mediterranean areas. These areas not historically concerned by wildfires are in the beginning of the process to adapt their prevention and firefighting systems to this increased wildfire risk. Considering that part of the region has a historical risk with an adapted established system while others not yet, studying how this historical system is organized, and the main activities and actors involved can bring light to develop similar systems elsewhere, tailoring it to local contexts.

Taking all of this into account, the current study explores the current socio-ecological context, as well as the governance structure (policy effectiveness, stakeholders' relationships and activities) and ES valuation dynamics in an IFM context in one administrative region in Southeastern France. By doing so, it aims to highlight the main current challenges, activities and opportunities to better dealing with extreme wildfire events and megafires, promoting an Integrated Fire Management (IFM), while still recognizing the ecological role of fire in this Mediterranean landscape.

1.1. Research Objectives

1. To explore the current policy framework concerning wildfires across different administrative levels (national, regional, departmental, municipality) and types of public policy instruments

(regulations, programs, plans, etc.), identifying the main public policies designed, implemented, and applied regarding IFM.

2. To understand the overall governance framework in relation to IFM, but not evaluating it. Also, to assess, through stakeholders' points of view, the effectiveness of implemented public policies, the stakeholder's relations and activities, as well as identifying main barriers to implement and opportunities to promote IFM activities.
3. To explore stakeholder's perceptions and valuations of ecosystem services (ES) within an IFM context, considering associated social, economic, and ecological reasons to identify the most relevant ES before and after an extreme wildfire event.

2. Methods

This study has a qualitative approach as it is a methodology commonly used in socio-ecological studies regarding wildfires (Vigna, 2022; Kirchner et al., 2024). Data collection regarded the identification and further interviewing of previously identified stakeholders, as well as policy and governance analysis based on the results obtained from the interviews. Moreover, triangulation of data was done with scientific literature and policy documents (laws, regulations, programs, plans). This research also examined the non-monetary values of ecosystem services and disservices by stakeholders, such as perceptions, uses, and dynamics (Dendoncker et al., 2018; Orenstein & Groner, 2014). Interviews were semi-structured, with an interview guide (Appendix 1) composed by open-ended questions, allowing the interviewees to freely express themselves, without introducing predefined concepts or limits, to reduce potential research bias (Scholte et al., 2015; Dendoncker et al., 2018). Interviews were made following the ethics requirements of IRD after few remarks from the ethics committee. The free and informed consent of interviewees were obtained to participate and record the interview, also respecting interviewees anonymity.

2.1. Study area

The study was done in the Occitanie region, in Mediterranean France. The region is in a Mediterranean ecosystem with recurrent fires, with some extreme wildfire events and megafires in a small proportion. Other regions in Mediterranean France, such as Provence-Alpes-Côtes d'Azur and Corsica are the main affected and thus studied regions, with studies on pyroregions, wildfire historical and current characteristics and species response to wildfires (Ruffault et al., 2018; Ganteaume & Barbero , 2019; Lestienne et al., 2020; Romero & Ganteaume, 2020; Szymczak et

al., 2020; Bountzouklis et al., 2022; Lestienne et al., 2022; Badeau et al., 2024). Despite being a region also historically affected by wildfires, Occitanie is rarely studied and, when done so, only the eastern part of the region, with a Mediterranean ecosystem, is the subject of study (Curt et al., 2014; Guion et al., 2021). Occitanie is also an interesting study area because of a new administrative rearrangement of France's regions in 2016, where two territories were jointed and became the Occitanie region, namely **Languedoc-Roussillon** (LR) (right side of the first figure in Fig. 1), with departments Aude, Gard, Hérault and Pyrénées-Orientales, and **Midi-Pyrénées** (MP) (left side of the first figure in Fig. 1), composed of departments Ariège, Aveyron, Gers, Haute-Garonne, Hautes-Pyrénées, Lot, Tarn, and Tarn-et-Garonne. This administrative change made that the region has now distinct patterns of climate and fire activity, from highly fire-prone Mediterranean plains and foothills to cooler peri-Mediterranean mountains (Curt et al., 2014). In the previous LR territory in a Mediterranean climate, fire has been present in the landscape for millennia and departments are considered "historical territories", with an established and historical IFM organization put in place. Meanwhile, the MP territory is now becoming more and more concerned by wildfire risk and is starting to develop its structures.

The primary goal of the study was to focus on the Occitanie region, however, during interviews, stakeholders heavily cited institutions that worked on other geographical scales (Mediterranean France, individual departments, inter-departments and inter-municipalities). Since some of these institutions were considered by stakeholders as the main ones in the implementation of IFM, the scope of the study had to be expanded to also include these other scales. Actors in the Hérault department were chosen to represent the departmental scale, considering that the department is historically affected by wildfires and one of the most affected in terms of burned area (BA) and number of starting fires in 2023, with a historical IFM structure established.

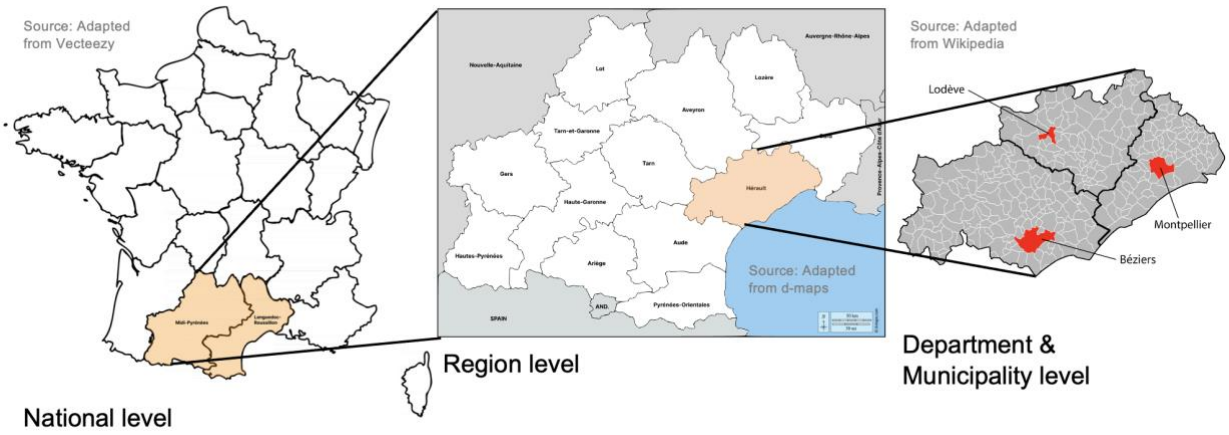

Figure 1: Geographical and administrative scales. In the right-handed side of the scheme, red-colored municipalities are the capital of the territories within the department, this does not mean that they were the ones interviewed. Source: The author (2024).

Wildfire data is important to understand main fire causes and when fire happens (fire season) helping to tailor surveillance and suppression systems. Only one year (2023 here presented) cannot be taken as representative of the wildfire context, with its high level of variability and randomness, but it helps to have an overview of the wildfires scale and context in the region.

The whole burned area (BA) in Occitanie in 2023 was almost 2.6 thousand hectares, with 601 starting fires. They were concentrated in the historical departments (in the previous Languedoc Roussillon) and located in Mediterranean coastlines, prone to dry winds and high temperatures (Evin et al., 2018). The greatest number of fires happened in the departments of Aude (31% of all fires starting in the region) and Hérault (23%) (Fig. 2). The BA distribution is highly skewed, with many small fires and few large ones. In France, large fires are considered those of more than 100 hectares (Lahaye et al., 2014), which are increasingly frequent in southern Europe due to climatic and landscape changes (Evin et al., 2018). Larger BA in 2023 happened on Pyrénées-Orientales (49% of the whole BA in the region) and Hérault (19%).

Human factors (accidents, negligence, and arson) primarily drive fire ignition in the Mediterranean region (Pereira et al., 2017). This is supported by the fact that in Occitanie in 2023, 97% of fires were anthropogenic, 35% being on purpose, with arson mostly present in Hérault and Pyrénées-Orientales, and 25% fires resulting from accidents related to forestry, agriculture and construction works. Almost half of BA (47%) is of shrublands and 27% in forest areas, according to the vegetation definitions given by the Database of forest fires in France (*Base de Données sur les Incendies de Forêts en France* - BDIFF). Most ignitions happen in summer (Rego et al., 2010;

Pereira et al., 2017) during July and August (33% of all year ignitions), with 12% and 11% happening during February and April, mostly related to agropastoral fires in Pyrenees mountains.

Figure 2: Number of fires in the Occitanie region in 2023. Source: Base de Données sur les Incendies de Forêts en France (BDIFF), 2023.

2.2. Data collection

The identification of key stakeholders was done first listing those mentioned in public policies, such as the Forest Code. With a purpose sampling, the focus was to select participants with expertise and experience in wildfires and/or involved in the governance processes (Brenkert-Smith et al., 2017; Frei et al., 2020; Skrimizea et al., 2021; Kirschner et al., 2024). In a second phase, additional stakeholders were identified through snowball sampling, meaning that all stakeholders were asked to list other relevant actors to include in the research. Both stakeholder identification and snowball sampling are widely used methodologies in similar studies (Frei et al., 2020; Lamarque et al., 2011; Vigna et al., 2024), as well as semi-structured interviews (Kalabokidis et al., 2008; Cocking et al., 2012; Hamilton et al., 2019; McGee & Langer, 2019; Huber-Stearns et al., 2021; Karemaker et al., 2021; Tebbutt et al., 2021; Baratella et al., 2023).

Since the study area was in France, interviews were made in French to 1) increase interviewee's willingness to participate; and 2) to make interviewees more comfortable to express themselves in

their native language, which is fluently spoken by the interviewer. Following similar studies, the interviews were recorded to foster better synergy between the interviewer and the interviewee. The location and mode of the interviews depended on the interviewee's time and place availability, with options including telephone, video calls, or in-person meetings. For those based outside Montpellier and its surrounding areas, priority was given to online interviews (by telephone or video calls).

All the interviews were done by the same interviewer, following an interview protocol (Appendix 01). The interview protocol consisted of four core sections with questions about: 1) the institutional role and fire context in the region; 2) the relationship among stakeholders, inspired by Hamilton et al. (2019); 3) the policy effectiveness and improvement points; 4) ecosystem services (ES) valuation before and after a wildfire event; and 5) snowball sampling and additional comments. Moreover, while other studies have opted sending the interview guide in advance to allow interviewees to gather information beforehand, like Kalabokidis et al. (2008), here it was chosen not to do so to promote more spontaneous responses. Aiming to keep the fluidity of the interview, the interviewer did not follow a strict order of the questions neither explicitly asked all of them, as sometimes interviewees replied several questions in only one answer. Data were later organized in the corresponding question. Sometimes some questions were not asked (mainly the ecosystem services one) because of time constraints or because the interviewee was not concerned by the subject.

For the snowball sampling question "*Are there other institutions or people you consider important to add into this research?*", interviewees were let free to cite how many stakeholders they wanted, not having a pre-established limit (Langemeyer et al., 2018). Overall, the most cited actors were all interviewed. Nonetheless, the stakeholders' list does not aim to be exhaustive, as some actors may still be lacking, but it is considered that the interviewed participants represent the IFM context in the studied geographical scale.

Regarding the ecosystem services (ES) valuation questions, many authors highlighted that the concept of ES may not widely understood by all stakeholders (Juerges et al., 2021; Oteros-Rozas et al., 2014; Tovar Tique et al., 2021). In this context, the term "ecosystem services" was avoided, as the objective was also to understand how various stakeholders perceive these concepts without any prior influence (Lamarque et al., 2011). Therefore, instead of asking, "*What ecosystem services*

do you value the most?", it was asked, "*What are the most valuable things that nature, in Occitanie, gives to local citizens?*". Another precaution taken is to clarify at every stage of communication, as well as before and during the interview, that the interviewee should respond from an institutional rather than a personal perspective (Lamarque et al., 2011).

2.3. Data analysis

Interviews were all recorded, and they were transcribed with an AI tool (Tactiq.io), transcriptions generated by AI were later verified with the original audio recordings to guarantee precision. Translation was done from French to English, checking technical terms in the Larousse online dictionary, and put into a Microsoft Excel sheet for analysis.

The qualitative analysis focused on interpreting words and their meanings in relation to the research questions (Frei et al., 2020), using an interpretive methodology, specifically through thematic analysis and coding derived from interviews to identify main issues, actors, dynamics and interactions (Lamarque et al., 2011; Miles et al., 2019; Vigna, 2022). Coding is an iterative process that facilitates analysis when dealing with a considerate number of text transcripts (Miles et al., 2019; Frei et al., 2020), as it was the case. The first round of coding took information from transcripts and removed phrase connectors, such as "so", "in this way", and so on, trying to focus on keeping the main key words used. Nevertheless, codes were still long, so a second coding round was done, focusing solely on transforming phrases (1st round coding) into key words (2nd round coding), preferring nouns and avoiding verbs. For instance, if the quote was "*there is an increase in the stakes, but above all there is an increase in the consideration of this risk*", in the first round it was coded "*increase in the stakes and in consideration of the risk*", whereas in the second round it was coded and split in two codes as "*stake increase*", and "*risk consideration*". Here, each interviewee's code received a different color to not lose the origin of codes when grouping similar codes into themes. While analyzing the results, a lot of back-and-forth between codes and quotes were made to identify the best quotes that represented the codes and themes. Quotes were added only to enhance reading, never changing meaning, and any omission is presented with ellipses, as in Brenkert-Smith et al. (2017).

Themes were made considering the structure of the interviews, but some were joined for more cohesive analysis since they presented similar codes. The interviews had the following sections: 1) institutional role and fire context; 2) stakeholders' relationships; 3) policy effectiveness; 4)

ecosystem services (ES) valuation and identification. Codes were grouped into five categories: 1) fire context; 2) stakeholders' relation; 3) Integrated Fire Management (IFM) activities; 4) policy evaluation; 5) ES valuation and identification. A word cloud was made with the most cited codes (max. 50), using the online tool WordArt.

As semi-structured interviews allow the interviewee to explore subjects within an established framework, it also allows the researcher to identify what themes are being constantly brought and developed (Brenkert-Smith et al., 2017). Codes from interviews considered keywords used in answers and were grouped into themes (Table 2, partially represented, full version in https://bit.ly/kozlowski-pol-gov-data).

Table 1: Codes organization within themes and subthemes. Each color represents one stakeholder. Source: The Author (2024).

Themes	**Subtheme**	**Codes**			
Governance	Partners	close partnership	collaboration	collaboration	complete approach
	Human Resources	1993	2000	2021	2021
	Administration	department highly involved	local level low involved	municipalities disinterest	department optional competence
Policy Evaluation	Policy	awareness raising post-2022	confinement	increased concern post-2022	new regulations
	Instruments	fire risk maps	forestry works decree	hazard maps	interministerial report
	Policy effectiveness	burned area reduction	burned area reduction	burned area reduction	complicated to evaluate
	Challenges	few human resources	fuel cut underdeveloped	funding	human resources
	Improvements	advice forest owner	advice forest owner post-fire	agricultural & livestock return	anti-wildfire devices

Data anonymization was carried out immediately after transcription and before any analysis, replacing institutions' names with a code. This ensured that both qualitative and quantitative analyses was conducted on anonymized data, thereby eliminating the risk of personal information disclosure. Stakeholders were identified according to the order they were interviewed, so I1 was the first interviewee and I19 the last. Stakeholders not interviewed were considered external to the analysis, named as E. Those who could not be included in the research, but considered important in IFM were working in 1) fire and weather forecasting at national and sub-national level; 2) departmental summer patrolling and resource allocation; and 3) municipalities and inter-municipalities summer patrolling volunteers.

Stakeholders' activities were classified according to United Nations Environment Programme (UNEP) (2022), as it is a framework that includes policy-related actions, not found in other IFM frameworks (Huidobro et al., 2024). In UNEP's framework, activities are divided in five categories that are linked and overlaps among them: review and analysis, risk reduction, readiness, response, and recovery; also known as PPPRR (planning and prevention, preparedness, response, and recovery) (UNEP, 2022). Relationships among stakeholders were analyzed through network analysis, considered useful for studying governance networks in natural resource management (Borg et al., 2015; O'Brien, 2015). They understand actors based on their interconnections rather than their individual attributes, focusing on their roles within the network. It examines relationships between several organizations (*nodes*) defined by the arrows (*edges*) that connects the actors and construct the network (O'Brien, 2015). The edges represent the direction of relationships, coming from a *source* and achieving a *target*. Despite their usefulness, network analyses are still not often found in fire governance studies, with similar studies found in Hamilton et al. (2019), Tebbutt et al. (2021), with network governance found in Huber-Stearns et al. (2021), and network analysis found in other natural resources studies, such as river basin (Reyhani & Grundmann, 2021). This approach can be used to find relationships and structures between the entities that the nodes represent, indicating suggestions that can be made to increase the efficacy of environmental interventions (Andriollo et al., 2023).

To do the network analysis, the software Gephi 0.10.1 was used, with previous versions being used by O'Brien (2015) and Reyhani & Grundmann (2021). The Fruchterman Reingold layout was the one used for enhanced visualization. Nodes were classified by their in-degree (receiving citations),

with directed edges (arrows), meaning that citations were not reciprocal. If edges were undirected, this would mean reciprocal citations.

Nodes are the organizations and the arrows between them represent three things: 1) the number of times, the order and by who they were cited in the snowball sampling question: "*Are there other institutions or people you consider important to add into this research*?"; 2) the number of times, the order and by who they were cited in the question "*How would you describe the contact and communication with them*?". The number of citations was used as a proxy according to the order they were cited (actors cited first had a higher weight than those cited last), meaning they were on the top of the mind of stakeholders as, sometimes, people tend to better remember actors who they work with or that are overall more active or more important.

Finally, interviews' data were triangulated with existing secondary data, including official policies, scientific literature, and press articles. As for the ES valuation, emerging codes from interviews were categorized within the Common International Classification of Ecosystem Services (CICES) V5.2 framework.

3. Results

3.1. Interviews' quantitative results

In total, 19 interviews were done, with 22 people interviewed (3 interviews had two participants) (Table 01). Most interviews were carried out in Spring 2024, with a minimum duration of 10 minutes, average of 40 minutes and maximum of 90 minutes. The faster interview happened with an organization who was heavily cited by other stakeholders as the institution represents a relevant stakeholder group, but the responsible for the subject had started the job a few months before the interview and was not able to answer all questions. The maximum duration was with one of the main actors involved (according to other stakeholders), thus having a bigger amount of information to share. According to interviewee's availability and location, interviews were done either by virtual meeting's platforms (60%, 11 out of 19), by telephone (26%; 5), and few were made in person (16%; 3).

In terms of geographical scale, other research classified stakeholders on national, regional and local scale (Brenkert-Smith et al., 2017; Huber-Stearns et al., 2021). It is important to notice that the scale here is only related to the interviewees, as many organizations have national, regional and

departmental or local offices, but it is related to the scale the interviewee worked. Interviewees worked on the national level (5%; 1 organization), 21% (4) worked in the French Mediterranean scale, 26% (5) involved in the Occitanie region, 26% (5) worked with more than one department within Occitanie, 16% (3) involved in only one department in Occitanie and 5% (1) involved in an intermunicipal scale.

The stakeholders interviewed included individuals from associations, Ministries, governmental agencies (protected areas, firefighters, wildfire prevention, and others) and from the private sector. The sample cannot be considered statistically representative (E. Pereira et al., 2005), which is normal when working with qualitative data. The goal is to have in-depth information with main and diverse stakeholders, not only considering the number of stakeholders interviewed. More importance is given to stakeholders' involvement with the subject and the diversity of the group to guarantee representation and information accuracy rather than the amount of interviews done.

Table 2: Interviewees' characteristics, geographical scale and interview type. Source: The Author (2024).

Interviewees	**Geographical Scale**	**N**	**%**
Environmental association	National level	1	5%
Firefighters	French Mediterranean	4	21%
Forestry sector	Region	5	26%
Governmental agency (protected areas; firefighting education; land and urban planning; private forests; and wildfire prevention)	Interdepartments	5	26%
Ministries (Agriculture and Environment)	Department	3	16%
Municipalities representatives	Intermunicipalities	1	5%
Private company		19	1
Private forest owners' representatives	**Interview type**		
Public forests management	In person	3	16%
N = 19 interviews	Online	11	58%
22 people interviewed, 3 interviews with 2 participants	Telephone	5	26%
		19	1

The main keyword, cited by 9 organizations, was "new territories", six cited "burned area reduction" and "July law", five "trainings", and four talked about "awareness raising", "communication", "OLD" (legal clearings obligation; *obligations légales de débroussaillement*), "risk consideration" and "summer patrolling". The total word counting was 482, with the illustration limited to 50 keywords (Fig. 3) for improved observation. There is a specific case for

"OLD", which was directly cited four times, but it was cited more times with other implications, such as "OLD weak implementation", or "OLD prefectural decree", thus being a relevant subject but not appearing in the word cloud. "DFCI" is for defense of forests against wildfires (*défense des forêts contre les incendies*), which is the term used in France for wildfire-related activities (prevention, response, and recovery).

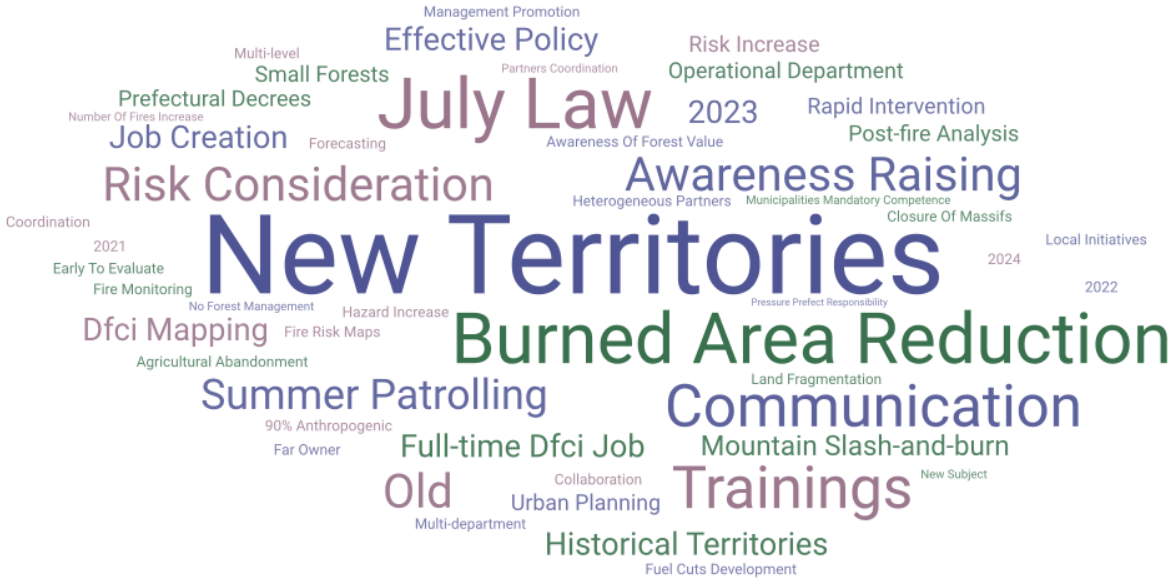

Figure 3: World Cloud with main codes said by interviewed stakeholders. The size of the code is proportional to the number of times it was cited by stakeholders. Source: The Author (2024).

3.2. Socio-ecological system (SES) context

Codes that arose when talking about the wildfire context were grouped into the subthemes "fire-adapted ecosystem", "fire history", "socio-ecological factors", "fire characteristics", and "risk evolution". Considering the varied actions' extent of interviewed stakeholders, some gave answers related to national, regional, and departmental context.

A subject that emerged from some stakeholders was the fact that Occitanie is a region partly located in a Mediterranean climate (previous Languedoc Roussillon - LR), with frequent summer fires and a millennial anthropogenic fire use.

"*We often forget that we are in a region, regardless of climate change, which experiences hot and dry summers, with fires which are very, very predominantly of anthropogenic origin. And it doesn't come from today, it comes from the time of the Romans and the Greeks*" [I4].

Brought by three stakeholders, anthropogenic fires are still the most frequent in the region, representing roughly 90% of all emerging fires, where 50% are malicious and 50% are done by accident and lack of attention (BDIFF, 2024). Fires are very random in terms of number, BA and location with yearly fluctuations. A burned area (BA) reduction was perceived, although with an increase in the number of starting fires, meaning that most fires have a small BA, and most of total BA is consequence of few large fires.

Other fire ignition causes cited were related to professional activities, such as cereal and wood harvesting machines, as well as trains' intense breaking, that could cause non-intentioned sparks and ignitions. Sparks in these cases may happen by friction between cutting elements on harvesting machines and a rock on the field, or related to trains, if they need to do an emergency breaking, a spark may be caused by the intense friction between the train's breaking structure and its rails. The two land use activities (cereal harvesting and forestry works) are regulated by departmental prefectural decrees stating that these activities must have an increased attention and be equipped with fire extinction equipment during the wildfire season (in Hérault, from June 15th to September 15th), with the activity being suspended by a supplementary regulation in some day(s) of extreme wildfire risk. Leisure activities cited as starting ignitions are those regarding the incorrect disposal of cigarettes, and lack of responsibility when doing barbecues. One stakeholder, for instance, cited that 80% of the 90% of anthropogenic fires begin in roadsides, thus highly correlated with human activity. Meanwhile, spring and winter fires are more common in Pyrenees mountainous regions, caused by slash-and-burn practices to renew pasture and with an increasing concern by stakeholders, this activity is also regulated by departmental prefectural decrees but lack enforcement. Another type of fire was also brought into attention, the so-called "vegetation fire" (*feux d'espaces naturels*), happening mainly in fallow areas and WUI. One stakeholder strongly highlighted that this type of fire happens in a proportion 10 times bigger than forest fires and that this is their current main issue.

In Occitanie, stakeholders perceived that the risk is spreading through northern and western areas of the region. This includes the territory of Midi-Pyrénées (MP) which was not highly concerned before, with stakeholders briefly commenting about some wildfires happening in the area in recent years. This results that these "new territories" will have to base their Integrated Fire Management (IFM) strategy on the so called "historical territories" (the previous LR), that are dealing with wildfires for a longer time and with a more experienced organization and structure put in place.

According to stakeholders, the awareness about the wildfire risk increased exponentially after the "2022 major fires season" in the French territory, with the highest burned area since 2010 (Institut National de l'Information Géographique et Forestière, 2023). This season culminated in the promulgation of the law of July 10th of 2023, reinforcing wildfire prevention in the national territory. With wildfires going way beyond the historical territories, this law establishes rules for new territories to start developing wildfire prevention and suppression planning documents and activities or, at least, reflect on their current structures. Regarding this, the governmental agency responsible for public forests management has a specific wildfire prevention agency, receiving an additional funding for wildfire-related activities (e.g. fuel treatment in public forests and summer patrolling), and is giving technical support through trainings to other departments and regions of the national territory.

In terms of the risk increase, one stakeholder highlighted changes in the risk calculation method while other said not to have perceived a fire activity increase in the last 5 years. Some talked not about a risk increase, but a *hazard* and *stake* increase. Here it is important to define three words used by stakeholders: risk (*risque*), hazard (*aléa*) and stake (*enjeu*).

"*The **hazard** is the event, whether natural or anthropogenic, which will occur suddenly and which will impact a stake, so a natural hazard is a forest fire, a flood, snow, an earthquake, a volcano and which will impact a stake. A **stake** is a property or a person who is threatened by a hazard, so a building, a city, a Seveso factory, a road. The **risk** is the hazard times the stake. When the hazard affects a stake, it generates a risk. We talk about a major risk when the issue is major, if it is an isolated habitat which is affected by a flood, it is a risk, [but] if it is an entire village or neighborhood, it is a major risk*." [I14].

Socio-economical and biophysical conditions in the region that could be causing the risk to increase are climate change, land abandonment, agricultural and grazing activities decline, forest area increase, low to no forest value and management, forest ownership fragmentation and absentee forest owners.

All these are interconnected subjects, some being causes and other consequences of socio-economical activities, or the lack of them. For instance, agricultural and grazing activities decline promotes the redevelopment of vegetation, which could turn into a shrubland or a forest, thus forest increased area could be a result of this decline, which was maybe exponentiated by climate change,

all this increasing wildfire risk. The issue of forest ownership and forest management is that, because of the inheritance system put in place after the French Revolution that equally divided the land for heirs, reducing the size of land inherited at every generation, the current average forest area per owner is a barrier for forest management.

"*An average owner in Hérault owns 1 hectare, it's very small. We can't manage 1 hectare; to manage our forests, the forest must be at least 10 hectares to have a semblance of management on all the plots. So, these forests are not managed, [and] the owners are also not interested.*" [I12]".

Moreover, brought by stakeholders, most forest owners have inherited a forest area but, most of them do not actually live off the forest nor live nearby their forest, with low to no interest in managing them. Not only that, but also the fact that Mediterranean forests, despite its high ecological and social values, lack an economic valorization which also discourage owners to invest in their forests as they may bring low to no economic return. Because of the inheritance system, which reduced the size of land, coupled with the low economic value of Mediterranean forests, the non-management increases fuel build up, therefore increasing wildfire risk.

Although some practices may be done in other parts of the French territory (e.g. grazing), according to interviewees these are practices considered interesting to be developed in Occitanie or in Hérault for fuel management and wildfire risk reduction. It is noteworthy that some subjects and practices may be here underrepresented because of lack of participation of certain organizations that could bring them into discussion.

3.3. Governance

Relevant sections to explain the governance framework were three: stakeholders' relation, IFM activities and policy evaluation. In France, there is a current strategy called the "defense of forests against wildfires" (*défense des forêts contre les incendies* in French - DFCI). The DFCI term was highly cited by stakeholders and involves activities such as public forest management for fuel reduction, as well as managing so-called DFCI equipment (creating and maintaining firefighting roads, water points, watch towers, and fuel breaks). It remains a question if DFCI activities are equivalent to Integrated Fire Management (IFM) ones, which may vary according to the framework adopted. Here, DFCI activities cited by stakeholders were accommodated into the UNEP (2022) IFM framework.

3.3.1. Stakeholders' relation

Key actors were asked to list other stakeholders they considered relevant to include in the research and to detail their collaborative connections with other stakeholders. From these, subthemes grouped here are related to "partners", "human resources", and "roles". All stakeholders replied to the first question, but it was not the case for the second, as the response rate was lower (or absent) from some groups. This may have biased the collected information that could reflect the experiences of more active organizations (Borg et al., 2015). As the number of answers were not the same, a comparison between the two generated networks is not possible. Nevertheless, a cursory and visual comparison still confirms the main actors involved in IFM. Although providing valuable insights into the general structure and dynamics of the collaborative network, highlighting the potential of network analyses to enhance the understanding of collaborative governance in wildfire governance (Borg et al., 2015), the findings here may not be transferable to other networks.

In total, 38 stakeholders were cited by the 19 interviewees, with an average of 5 cited organizations per stakeholder. Fourteen stakeholders were cited more than once. Main stakeholders cited were I4 (cited 15 times), I9 (14) and I13 (13). All of them work in at least one department in the region, with the department scale being considered by stakeholders as the operational one. Other stakeholders were cited six times or less. Therefore, these three stakeholders were considered the main actors in IFM.

Stakeholders' awareness about other actors are related to actors where arrows go from who cited towards the cited stakeholder (Fig. 4) and the color represents the geographical scale of the citing organization. Stakeholders external to this research, but still cited, are represented in grey. The interest in analyzing who is cited and by whom is to understand 1) which actors are most known thus considered more important, and 2) which are the institutions and their scale who know more actors. In this way, it is possible to see who knows each other within IFM, also showing the main actors and those who may be more on the margins of the subject. This allows to reflect stakeholders' involvement on the subject. Also reflecting if it would be strategic to involve more of them, how to do so and promoted by whom. Those who cited most stakeholders operates either in the national, French Mediterranean or regional scale, thus probably having a broader view of the subject (Brenkert-Smith et al., 2017). It is important to highlight that, in this case, arrows do not mean collaboration, it just means that the stakeholder know the existence of and cited other stakeholders.

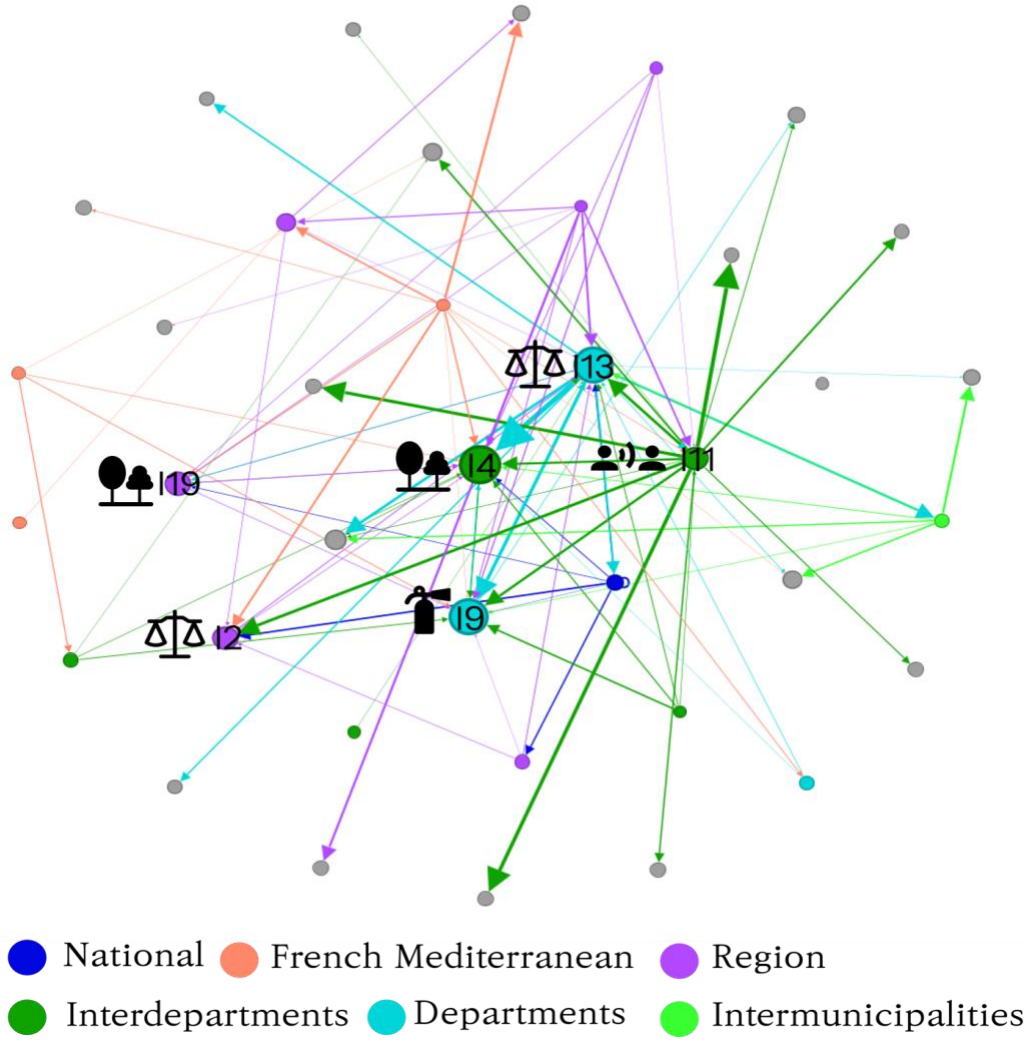

Figure 4: Network analysis of the snowball sampling question: "Which other organizations should I include in this research?". Source: The Author (2024).

As for collaborations (Fig. 5), they happened mainly in broader geographical scales, from the national level (dark blue) to French Mediterranean (orange) to inter-departments level (dark green). Again, the same three institutions appear strongly (I4, I9, I13), being more cited with other organizations collaborating with them than citing collaborations they themselves have. Besides, collaborations varied among stakeholders on types (funding, meetings, technical and regulatory support, common projects and actions, etc.) and frequency (number of times they contact each other). For instance, the three main stakeholders, together with other two not interviewed, such as E16, are in contact almost daily, mainly during summer, to plan and set up summer patrols. Meanwhile, others are in contact several times per year to organize technical meetings and/or

trainings on specific subjects, such as the legal vegetation clearings obligation (OLD) implementation and enforcement.

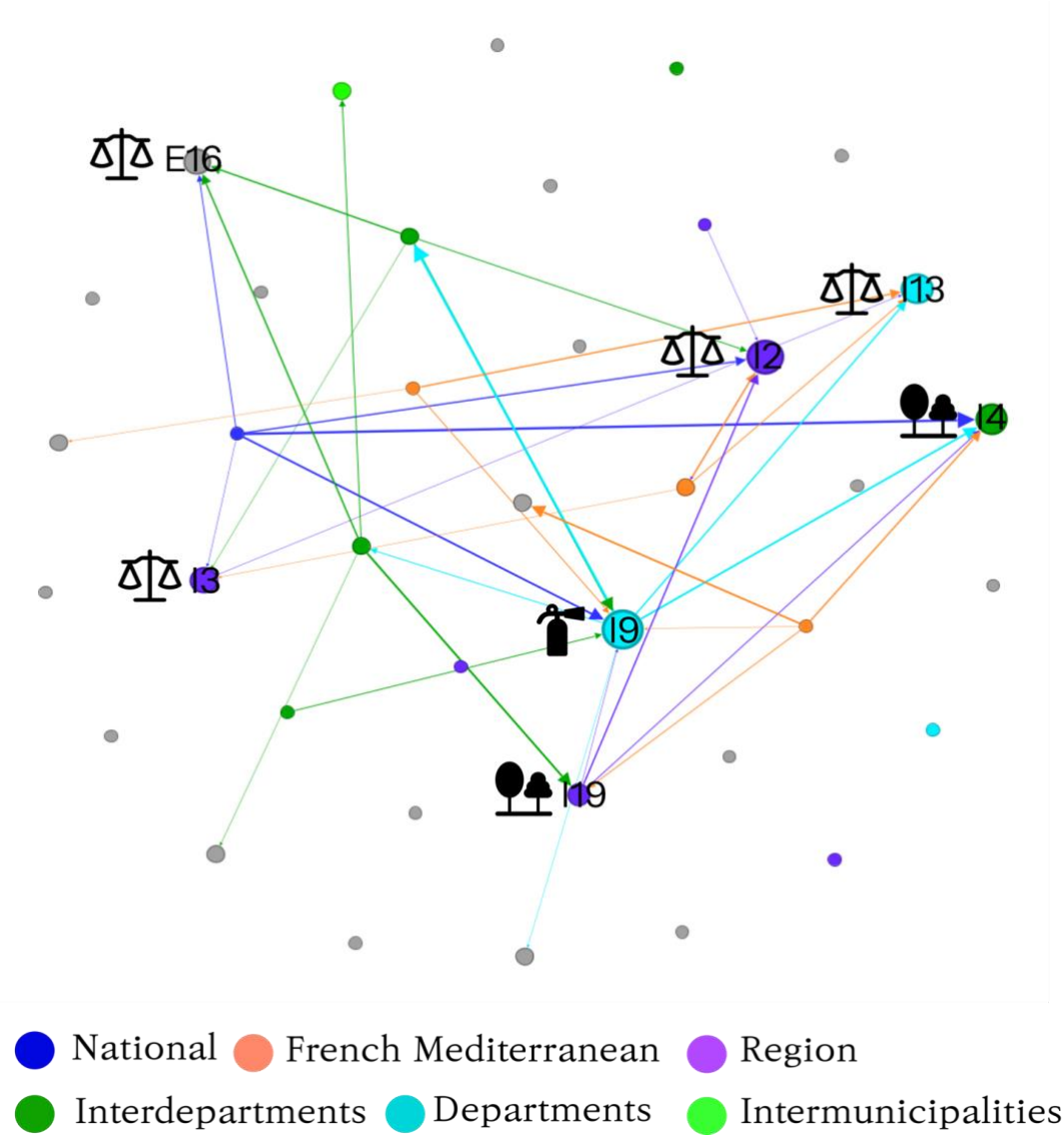

Figure 5: Network analysis of the collaboration among stakeholders' question. Source: The Author (2024).

Several stakeholders used positive words regarding actors' collaborations, such as "coordination", "collaboration", "synergy", "partnerships", stating it is a working system, because of defined roles and willingness of stakeholders to collaborate and tackle the issue together.

"*Each one has its role and has its range of intervention and that's why it works, it's that the roles are clearly defined*. […] *What I can guarantee you in Hérault is that each of the actors has its structure and its missions, but it works together; we all work together, we have a common destination, and each brings their little bit of added value that they can bring to this search to avoid*

the catastrophe and to this cooperation." [I14]; "*We listen to each other between partners to try to build a policy and actions that seem to us to be the most optimal in relation to what is happening on the territory*" [I1]; "*It's truly multi-partner and that's the strength of our system in the department*" [I9].

However, some of them talked about "small tensions", and "sources of incomprehension". These was further detailed when stakeholders stated that in some departments there may have duplicate meetings and some sources of incomprehension and rivalry because of a proactive approach from one institution and a sort of inaction from the ones that should be at the origin of the meetings.

The human resources subject appeared because of the number of hours dedicated to wildfire-related activities in people's jobs. Although not all people expressed the amount of time dedicated to wildfire-related activities on their contracts or their historical relation with the subject, those who did have a full-time wildfire-related role (3) and others a part-time wildfire-related role (2 stakeholders), with three of them being a position created in the last years. In terms of how long they were working with the subject, the person who have been working with wildfires for the longest time works with it since 1993, other few varied from 2000, 2010, and most part of those who informed their seniority in the subject started in 2021 (3), 2022 (2), 2023 (3) and 2024 (2). Important to notice these results reflect the seniority of the interviewee working on the subject, but not about the seniority of the organization's activities. Even though some organizations work with the subject for a longer time, it was not the case for the interviewee. This reflects on the disparity of information depth received, while experts working on the subject for a long time and in different organization types could provide more details about the actors involved and their roles, as well as the history of the IFM in the region, others recently started their positions and still lack feedback on the subject.

3.3.2. Stakeholders' activities

In France, stakeholders' activities are under the policy of defense of forests against wildfires (*défense des forêts contre les incendies* - DFCI), no reference being made to IFM, with a strong prevention and suppression approach. Considering stakeholders' roles, the main roles identified are communication about regulatory issues and risk information with hazard maps; awareness raising for mayors and public; technical and regulatory support for private owners and forestry works companies; stakeholders' representation on several instances; promotion of dialogue

regarding Mediterranean forests and their management; subscribing forest owners in an insurance system (sometimes covering wildfire-related losses); governance coordination among main stakeholders; regulation implementation and enforcement; policy monitoring and policy communication; firefighting trainings and other types of capacity building. It is noteworthy that activities brought by participants may not completely reflect all their activities (Brenkert-Smith et al., 2017; Huber-Stearns et al., 2021), as they might have forgotten some or thought it was not relevant to bring up.

One subject brought many times is the operational responsibility, which falls under municipalities mandatory competences, while it can be an additional competence for departments' administration. Focusing on working in a local scale, municipalities are thus responsible for planning, funding and carrying out IFM works, such as creating and managing IFM equipment (firefighting roads, water points, watch towers, fuel breaks) in their municipal forests and do regulations enforcement, such as the households' legal vegetation clearing obligations (*obligations légales de débroussaillement* - OLD). To adapt regulations to each territory, the department is the one issuing the official regulations through prefectural decrees, which must be implemented and followed by municipalities, regarding 1) the use of fire; 2) OLD rules; 3) forestry works regulation; and 4) access to forests (mainly in summer). However, one stakeholder brought the subject that, specifically for the OLD enforcement, the department prepare and mandate OLD checks in municipalities at higher wildfire risk to ensure that they are complying with the regulation, despite not being their mandatory responsibility to do so. This increases their workload and show a disparity between what is regulatory and written (municipalities with the mandatory competence) and the practice of what actually happen. It is necessary to highlight that this situation may represent solely what happen in this specific department.

In Hérault, the departmental council took the decision to be the main responsible for financing and carrying out IFM activities, bringing both advantages and disadvantages. The advantages are that they have more financial and human resources to maintain all IFM equipment (firefighting roads, water points, watch towers, fuel breaks) in a similar condition, which helps firefighters since they know the equipment will be homogeneous in the whole department. But the disadvantage is that since the department is highly involved, municipalities are less involved, even though having the mandatory competence to do so, but since IFM involves funding and people, they prefer to focus on other subjects since this subject is already taken into account by the departmental council. The

situation is highly diverse in a neighboring department (Gard), where municipalities kept their mandatory competence of implementing IFM activities since the department chose not to. Here, municipalities concerned by wildfire risk joined forces and resources (equipment, personnel, and funding) to organize themselves into mixed associations and develop IFM activities in their territories. This also brings advantages and disadvantages. The advantages being that municipalities are complying with their mandatory competence, but disadvantages are related to the heterogeneity of the IFM equipment across the territory and that they may have less funds to finance IFM activities.

When asked about their main activities, some stakeholders started to explain third party activities, making it interesting to see that actors are aware of what others are doing. Also, some stakeholders may have actions regarding more than one category of the IFM framework from UNEP (2022), as one actor may have multiple roles (Huber-Stearns et al., 2021).

Activities done by most stakeholders are related to risk reduction, mainly regarding awareness raising in several geographical levels, fuel management and land use planning. Most activities regarding policy design and the distribution of financial funds happen at the regional level, meaning that regional authorities share the financial resources among departments according to their demands. Operational actions (e.g. vegetation clearing in public forests and enforcement of households' legal vegetation clearings obligation) are carried out in the inter-departments and department level, with the latter being done in inter-municipality level in other departments. Fuel management in municipal forests and summer patrolling volunteers were both done in the municipal and inter-municipal scale. Sometimes, fuel management in municipal forests can be done in the inter-departments scale if the municipality mandates a contract for the State agency responsible for that.

Several stakeholders stated that the department is the responsible for operationalizing IFM activities, mainly regulatory, IFM equipment management and summer patrolling. It is important to distinguish the considered prevention actions, as they may vary from actor to actor, those cited by one stakeholder were awareness raising campaigns, OLD implementation, summer patrolling, regulatory enforcement, IFM equipment (firefighting roads, water points, watch towers, fuel breaks) and grazing. To avoid these heterogeneities, the UNEP (2022) IFM framework (Table 3) was used to organize stakeholders' activities in an attempt to homogenize wildfire-related activities within only one framework.

Table 3: Integrated Fire Management activities within UNEP (2022) themes and categorized by stakeholders. Source: The Author (2024).

Theme	Actions	Concepts related to the action	Stakeholders
Review and analysis	Collection of data and information	Development of fire behavior models; Post-fire assessment and analysis; Identify critical areas where intervention and investment are needed to support risk reduction	
	Review of policies, procedures, and approaches to IFM	Integrate fire management	
	Analysis of data and stakeholder engagement	Development of integrated fire management plans	
Risk reduction	Awareness and education	Ignition avoidance/restriction of high-risk activity; Personal evacuation plans; Asset protection; Training	
	Landscape management	Fuel management (hazard reduction; indigenous/traditional approaches; grazing/mowing; support ecological needs); Firebreak creation and maintenance; Land use planning; Fire regime restoration and management	
	Fire use laws and enforcement	Building codes; Regulate fire use; Ignition reduction strategies	
	Community based fired management	Promote the safe management of fire through education; Homeowner actions	
Readiness	Adaptive suppression	Safe; Adequate (rapid initial attack); Appropriate (right resource mix); Effective (contained and control, if possible)	
	Suppression resource	Capacity maintenance; Resource sharing/requests	
	Community health and safety	Evacuation (emergency food, water, and shelter; emergency health care); Support mobilization	
	Post-fire impact planning	Recovery assistance plans; Loss assessment tools	

Recovery	Community aid	Emergency housing; Finance; Longer term recovery assistance plans	
	Environment	Wildlife rescue; Environmental restoration; Fire regime restoration	
	Infrastructure	Loss assessment; Repair	

3.3.3. Policy evaluation

The governance system also includes the policy framework and its effectiveness, seeking for implementation and enforcement barriers and challenges, as well as improvement points to be considered when designing future policies. Here, main themes were related to "policy", "instruments", "policy evaluation", "challenges and barriers", and "future activities and improvements".

As stated by two stakeholders, the "2022 major fires season" increased awareness and caused policy movements concerning wildfire prevention and response in the French territory. Overall, the French strategy for dealing with wildfires is focused on "rapid intervention" of starting fires, brought by three stakeholders, together with preventive vegetation clearing to protect people and houses and confinement. Prevention activities are done through fuel management, mainly in public forests and in wildland-urban interface (WUI) households, as well as with yearly inter-ministerial awareness raising campaigns.

"*The French strategy […] is different from the majority of other European countries. Since the end of the 1980s and beginning of the 1990s, the strategy that has been developed in France has been the massive attack on emerging fires.*" [INT4]; "*The doctrine of the firefighters, theoretically of the State, is to confine people in the houses and not to evacuate them, because someone who is in a house endures less risk than if the person is on the road evacuating. And as the fire takes ten minutes to pass, you have a house, the fire arrives, after ten minutes, it is passed, it is over. So, the person who is in the house will be able to go out, will be able to put out what will continue to burn: the garden chairs, the pipes, etc. Whereas if the person is not there, everything will continue to burn and the house will be destroyed.*" [I12].

Starting in the national scale, the 2022 major fires season brought "new regulations", such as the "July law" (cited by six stakeholders), promulgated on July 10th 2023, aiming at reinforcing the protection of forests against wildfires. This includes the "risk consideration" in planning documents, with 1) the creation of a first generation of planning documents and regulations for the new territories not previously concerned; and 2) the update of these documents for the historical territories already previously concerned. The documents that enforce the law are the departmental "prefectural decrees" (*arrêtés préféctoraux*) and were cited by several stakeholders. These decrees are made for the households' legal vegetation clearing obligations (*obligations légales de débroussaillement* - OLD), the access to forest massifs (mainly in summer), the forestry works and the use of fire. One characteristic of these decrees is their differences among departments, whether in the number of meters to clear vegetation under OLD or on the dates allowing to use fire, and so on. Some decrees, such as the access to forest massifs and the forestry works, are based under daily summer fire risk maps, cited by four stakeholders. Based on this risk maps, additional regulations are put in place to limit the access to forest massifs only to authorized people and if forestry works need to have additional attention or even be restricted. The OLD was considered a strong axis of the French wildfire policy, being highlighted by several stakeholders, also being heavily presented in public communication campaigns. It consists of an obligation to clear vegetation on a private land and/or construction nearby forests (<250 meters) to reduce fuel vertical continuity and wildfire risk, working as a passive protection.

One of the interviewees who worked in wildfires for more than 30 years explained the history of this obligation in France, dating from 1985 but still lacking complete implementation. This lack of implementation was brought by several stakeholders as a main current policy challenge. Reasons for that will be further discussed.

Other subjects cited were the financing of IFM activities and differences in interest of Ministries.

"*The DFCI is financed by the Ministry of Agriculture. The Ministry of Ecology is based more on major risks, and everything related to human resources. In the DFCI [related to public forests], the Ministry of Agriculture is more interested in the defense of forests and houses that can burn, the Ministry of Ecology is more interested in the house that can be burned and everything that is around.*" [I4].

In France, the responsibility for wildfire policy is divided among several ministries: the Ministry of Agriculture oversees and finances most part of wildfire prevention, while the Ministry of Interior plans suppression efforts and aerial detection. The former works in tandem with the Ministry of Ecology (Aguilar & Montiel, 2011). In terms of laws, wildfire prevention is mostly under the forest code, with planning documents being the "departmental plan of protection of forests against wildfires" (PDPFCI), the "plan of protection of forests against wildfires" (not in the departmental level) (PPFCI), and in the private sphere the "simple sustainable management plan" (PSG). Under the urban code and in urban planning, for construction allowance or restriction, there are the "municipal protection plans" (PCS) or "inter-municipal protection plans" (PICS). The environmental code regards mostly protected areas. In a lesser extent, the interior security code regards firefighters' organization and the penal code deal with fines.

For the policy evaluation, stakeholders' answers can be divided into two groups of stakeholders: those not still available to measure an effectiveness of the policy, stating it was too early (two stakeholders), probably thinking about the changes brought by the recently established law of July 10th in 2023, and those saying that it was "generally effective" and a "working system" (three stakeholders). Others said that there is specifically an "effective response", and some expressed an unsatisfaction with regulations (prefectoral decrees) usually being systematic with fixed limiting dates instead of considering the actual seasonality and weather conditions. Although stakeholders consider the policy effective, there was worry for its implementation and enforcement.

"*We are happy to see a law coming […] and that there has at least been movement at the legislative level. It's been a long time since we've seen a law on forest fires. So, we're not going to say that we're disappointed. It still made it possible to bring together the three ministries on this issue. […] Afterwards, everything is also played out in implementing the texts, everything is played out in the decrees, […] but sometimes [the law] may not have any effect because, quite simply, we don't write the texts to implement it. […] We really need to distinguish between the law and the decrees, instructions, which, in fact, activate the law*." [I7]

"*We have reduced the number of burned areas significantly over the last 30 to 40 years in the French Mediterranean region. The number of fires has decreased a little, but much less quickly than the number of burned area. […] Afterwards, I think that there is no reason to question this strategy*." [I4].

Results considered to "prove" the policy effectiveness were mostly the reduction in burned area (BA) over time, cited by six stakeholders which considered that the policy was able to reduce BA even with an increasing risk driven by climate change, expanding WUI and fuel accumulation.

3.4. Ecosystem Services (ES) identification and valuation

An ecosystem services (ES) identification and non-monetary valuation was done. The term "ecosystem services" was avoided during the interviews, as sometimes not all stakeholders are acquainted with the concept. To do that, interviewees were asked "*What are the most valuable things that nature, in Occitanie, gives to local citizens*?", "*Which of these could be the most negatively/positively impacted by wildfires*?". This question was the one that stakeholders had the most difficulty to understand and answer, as stated by one interviewee, "*it is a question that raises questions*" [I18], mainly because the person did not feel able of answering it and suggested to contact other, more specialized professionals. People also highlighted that it was difficult to generalize "nature" throughout the whole Occitanie region, because of ecosystem's diversity and its related ES. Others stated it was a very personal view, not being sure if it was shared in a bigger scale, which could be further explored in a quantitative survey.

ES were classified according to Common International Classification of Ecosystem Services (CICES) V5.2 framework. The main ES cited were 1) provisioning services: wood production (1.1.1.2); 2) regulating services: biodiversity conservation (2.3.2.1; 2.3.2.2; 2.3.2.3; 2.3.2.4; 2.3.2.5), carbon sequestration (2.3.6.1), natural risks reduction (2.2.3.1), soil conservation (2.2.1.1; 2.3.4.3), water management (2.3.5.1), climate stability (2.3.6.2); and 3) cultural services: recreation (3.1.1.1; 3.1.1.2), and landscape aesthetics (3.2.1.4).

From the 19 interviews, eight interviewees answered the question identifying ES. Here, stakeholders brough economic values first (4 stakeholders), usually followed by ecological and social values. Ecological value was first cited in three interviews, and only one cited the social importance first. As for specific ES categories, wood production was the most cited first, reinforcing the economic value put at first place, followed by biodiversity conservation and recreation, showing that provisioning services were first, followed by regulating and social. Although wood production is the most cited first, recreation is the most cited ES overall. Other ES were related to natural risk reduction (mainly landslides), soil conservation and erosion control, carbon sequestration, air quality, water management, climate stability and landscape aesthetics.

For the questions regarding the ES most impacted by wildfires, seven stakeholders from 19 answered it. Most stakeholders talked first about the ecological value of forests that would be the most impacted (4 stakeholders). Two talked about the social value, in terms of recreation and landscape aesthetics, and one stated the economic value to be the most impacted. As for ES categories, landscape aesthetics was the most cited first (3), followed by natural risk reduction related to risks following a wildfire, such as landslides and soil runoff. Recreation appears again as the most cited overall (4) although not being the first cited. Here cultural ES are seen as most negatively impacted, followed by regulating services. Other ES were the impact on wood production, biodiversity conservation, soil conservation, cultural heritage, air quality, soil conservation and carbon sequestration.

Unfortunately, ES identification cannot be compared with the ES valuation as not the same stakeholders replied to both questions. In general, most stakeholders considered that ES are negatively impacted by wildfires, with three stakeholders talking about the positive effects of fires.

"*Fire contributes to a mosaic of environments and the expression of biodiversity. We cannot say that, overall, it is bad for nature. It's been around for millennia. And the Mediterranean region is a biodiversity hotspot. So, to say that fire is a disaster for biodiversity, in the long term, no. If, on the other hand, we have a fire that burns 200,000 hectares, an entire region, yes. But that is not the case today. It's a human catastrophe. In relation to the landscape, to the collective unconscious, it's a catastrophe because we go from something green to black. Everything we have known, in which we are used to live, disappeared overnight, it's shocking. But for animals, they adapt faster than us, often faster*." [I4].

"*Well, the fire does not completely destroy nature. Sometimes, it passes very slowly, burns all the trees, destroys the soil, but often, there is still life. And we realize more and more that we must not rush to want to clean everything, to reforest everything. We need to remove dangerous trees, we need to organize this protection to prevent water from causing erosion, but let's trust nature and wait for the Aleppo pine seeds to germinate, for example, or for the holm oak stumps to sprout, or for what we call the soil seed bank to express itself with vegetation that starts growing again. So, let's not rush and wait to see what the natural reaction is to act and start its work."* [I15].

4. Discussion

Similar themes, such as biophysical and societal factors affecting fire hazards, reflections on existing fire policies, and public participation in risk mitigation were found by Kalabokidis et al. (2008) interviewing stakeholders in Greece. Kirschner et al. (2024) did a similar study on institution's roles in Italy and González & Ghermandi (2022) briefly analyzed France's policy, comparing with other countries. The number of interviews (19) aimed to represent the maximum points of views, including stakeholders from several geographical scope and diverse activities, being within boundaries in similar studies (Arnouts et al., 2012; Brenkert-Smith et al., 2017; McGee & Langer, 2019; Frei et al., 2020; Huber-Stearns et al., 2021; Skrimizea et al., 2021). It is noteworthy that themes brought may be subjected to the scale the interviewee works (Brenkert-Smith et al., 2017).

4.1. Socio-ecological system (SES) context

Socio, economic and environmental contexts were identified according to interviews' themes and codes (Table 4), also identifying current solutions and its challenges, together with improvement points brought by stakeholders.

Table 4: Socio-ecological context, causes, consequences, current solutions, challenges and solutions for the wildfire context in Southern France. Source: The Author (2024).

		Consequences	**Current solutions**	**Challenges**	**Solutions strategies**
Socio-ecological causes	**Agricultural abandonment**	Fuel build up and more WUI fires	Households' legal vegetation clearings obligation	Lack of implementation	Increase mayors' awareness raising for citizen education and enforcement
				High costs (individual and municipality)	Collective management to reduce costs
		Fuel build up and increase in vegetation fires	Vegetation clearing, grazing	Grazing decline	Grazing promotion through local initiatives
			Partial fuel breaks	Land ownership fragmentation	Work in the intermunicipality level
	Low forest economic value	Lack of forest management	Research of alternative and less flammable wood species and uses	No management interest	Forestry grouping
					Financial support from State for management
			Promotion of social and environmental value	Forest ownership fragmentation	Raising awareness (and financing) about other forest values

	Climate change and risk increase	New territories concerned	Creating and/or updating regulations	Different socio-ecological contexts and financial means	Exchanges with historical departments
		Major fires of 2022	Law of July 10th 2023 and departmental prefectural decrees	Lack of implementation	Documents harmonization
				Fixed periods of prefectural decrees	Consideration of real seasonal and daily weather variation
	Policy fire suppression history	Human resources capacity on prevention activities	Trainings and exchanges of new employees	Difficulties in recruiting with few to no applicants	Promoting the importance of the forest sector and wildfire-related jobs
		No to low wildfire risk citizen awareness	Yearly interministerial national campaign	Tailor communication to regional and local contexts	National communication campaign adapted at local scale
		Disparities in funding	National, regional and municipal funds	Variety depending on socio-economic characteristics of municipalities	Promoting bridging institutions to pool resources

4.1.1. Agricultural abandonment

In the second half of the XX century, land abandonment happened with the increase of rural exodus and people's concentration in urban centers (Brenkert-Smith et al., 2017; Tedim et al., 2016; Kirchner et al., 2024). This event has impacted both rural and the urban areas, bringing consequences for wildfire risk.

On one side, in rural areas vegetation regeneration was promoted, increasing available flammable biomass, because of a decline in agricultural activities, where previous grazing and controlled burns traditionally managed fuel accumulation and kept open landscapes in mountain scrublands and forests (Balzan et al., 2019; Alló & Loureiro, 2020; Kirchner et al., 2024; Vigna et al., 2024). On the other side, driven by land abandonment, people started building in fire-prone areas near urban centers (Tedim et al., 2016; Ghasemi et al., 2020; Moreira et al., 2020; Pandey et al., 2023), in the so-called wildland-urban interface (WUI), being exposed to wildfire risk usually because of vegetation around their homes. This dynamic of fuel accumulation in rural areas and people concentration in fire-prone areas with non-managed fuel show that fuel concentration and lack of management is a current challenge.

In rural areas, fuel management can be done in smaller scales (property area) or in bigger scales (with fuel breaks involving several properties). This can be done through manual and/or mechanical techniques with thinning and pruning; agroforestry and grazing activities; and using low intensity and low severity fire (Varela et al., 2018; Depietri & Orenstein, 2019; Nuss-Girona et al., 2022; Lecina-Diaz et al., 2023; Kirchner et al., 2024). Manual or mechanical techniques can become very costly as they depend on human resources and equipment (Varela et al., 2018). Agroforestry and extensive grazing can be used to reduce surface fuels, having a low impact on the forest landscape and being mostly accepted by stakeholders, also promoting an income activity. However, these strategies must be carefully managed to avoid excessive interventions, such as overgrazing (Depietri & Orenstein, 2019). The use of fire, usually through prescribed fires, has a social and ecological component (Lecina-Diaz et al., 2023; Kirscher et al., 2024). It is social because it brings back the fire culture in the region, and it is ecological because fire is reintroduced in the system, making a mimic of natural fire disturbances and ensuring its role of fuel regulation and other ecological processes (Aguilar & Montiel, 2011; Depietri & Orenstein, 2019). Prescribed fires are intentionally planned and executed by experts under controlled weather conditions to reduce fuel loads and minimize potential future wildfire behavior (Moritz et al., 2014; Huidobro et al., 2024).

This technique surely has its drawbacks, mainly with smoke release, nevertheless it is still less impactful on biodiversity than wildfires (Pereira et al., 2021). Moreover, with the Earth getting warmer and dryer, it is becoming even more important to actively shape fire regimes (Pausas & Keeley, 2019; Badeau et al., 2024).

The creation and development of fuel breaks was brought by stakeholders, with some partial fuel breaks already done in the department. Nevertheless, effective fuel breaks need a large area with several properties and owners. Involving private forest owners in fuel management can promote a more collaborative framework with community involvement (Kete, 2023), although here being challenged by forest ownership issues, with small and fragmented areas (Rego et al., 2010; Kirchner et al., 2024) and absentee owners (Wunder et al., 2021). Larger scales are crucial for implementing fire prevention infrastructure, but small landowners struggle to achieve it alone (Canadas et al., 2016), usually because fuel management activities may not be compatible with their main activity, or it is costly or they are simply not interested to do so. Cost-effective fuel management where inactive owners dominate, which is the current case, could be promoted by governments or third-party entities that could buy management or property rights from owners, building networks of fuel breaks, without relying on individual owner consent and ensuring technical effectiveness (Santos et al., 2021). Grouping and cost-sharing with the collective management of large, contiguous areas involving multiple landowners, governed by a unified management plan, encourages collaboration and should be promoted (Canadas et al., 2016). However, one stakeholder highlighted that this was not possible to be done at the department level as it involves a multitude of owners, and it would be better done in the inter-municipalities scale. These barriers may be surpassed by strengthening institutional relationships to allow fuel breaks to be done on private land, of course needing a strong communication and collaboration of bridging institutions to contact these owners.

Participants highlighted that the promotion of grazing would be interesting, as it affects shrub biomass, vegetation cover, landscape quality, biodiversity, and wildfire prevention (Bernués et al., 2014), instead of creating fuel breaks with vineyards, for instance, which is an activity not compatible with forests since the forest is replaced by vineyards. Barriers for implementing grazing are related to the loss of cultural heritage of this activity, coupled with landscape characteristics and vegetation type in lowlands (Bartolomé et al., 2020), where wildfires are more common than in mountain areas, where grazing actually occurs. Agri-environmental policy should give priority

to grazing methods since they help avoid wildfires, which have emerged as one of the Mediterranean region's largest socio-ecological issues in recent decades (Rodríguez-Ortega et al., 2018). Grazing activity can also be promoted through payment for ecosystem services (PES) schemes, as done in specific parts of Spain (Varela et al., 2018; Nuss-Girona et al., 2022).

Using fire to reduce wildfire risk through prescribed burnings (PB) with a clear objective of reducing fuel is a way to mimic fire as a natural disturbance, as fire creates short-lived conditions that can limit future fires (Duane et al., 2019; Badeau et al., 2024). Although not brought by any stakeholder, prescribed burnings (PB) are done in France, being established in the 1980s (Rego et al., 2010) with the Forest Fire Prevention Unit. They tested the viability of PB in the Mediterranean region, integrating it with other fuel management activities (Aguilar & Montiel, 2011). Departments in the French Mediterranean have set up an operational PB network that has executed PBs since 1990 (Aguilar & Montiel, 2011), one being done in Occitanie in 2023 to reduce fuel and acquaint stakeholders with the practice (Chambre d'Agriculture d'Hérault, 2024), promoting knowledge transfer, experience sharing, training, and encouraging this practice amongst various stakeholders (Aguilar & Montiel, 2011). The possibility of increasing PBs can be studied, as interest seems to be growing. However, this method presents a social, political, and technological challenge: cooperation amongst various stakeholders, bureaucratic challenges (Moreira et al., 2020), lacking policy or funding support (Huber-Stearns et al., 2021), usually with low social acceptance and cultural resistance (Moreira et al., 2020), understanding and risk aversion (Huber-Stearns et al., 2021). As for now, the extensive and historical fire suppression culture also have painted a picture on people's minds on the place of fire in the landscape, being viewed as a negative aspect with little thought given to its positive ecological role (Tedim et al., 2016; Brenkert-Smith et al., 2017). A strong public awareness campaign should be done to explain the ecological role of fire (Bihari & Ryan, 2012; Schmerbeck et al., 2015), as already done in some places by engaging communities with research on fire history and post-fire ecosystem dynamics (Higuera et al., 2019).

On the other side, in urban areas, fuel reduction efforts are mostly localized near roads and urban interfaces, where ignitions are more likely (Curt & Frejaville, 2017). Also, people build in fire-prone areas without fully understanding the local disturbance regime, and their actions can unintentionally increase the severity and frequency of wildfires (Fischer, 2018) with firefighters emphasizing that pre-fire mitigation activities are crucial (Kolden & Henson, 2019) and households are expected to, at least, engage in risk reduction behavior, like clearing vegetation around houses

(Moritz et al., 2014; Brenkert-Smith et al., 2017). This is why in peri-urban fuel management is prioritized and became a citizen obligation in some zones in France, with possible fines for non-compliance and being regulated by the households' legal vegetation clearing obligations (*obligations légales de débroussaillement*, OLD). Debate exists on whether home protection and safety in wildfire-prone areas should be primarily the responsibility of residents (Kolden & Henson, 2019). On the other side, recognizing private citizens' responsibility in managing wildfire risk can be one way of community inclusion and a form of raising awareness about the wildfire risk (Górriz-Mifsud et al., 2019). This can also promote a gradual shift away from the passive expectation of institutional intervention to one in which local communities take the lead in bottom-up initiatives pertaining to prevention, readiness, and quick suppression (Tedim et al., 2016), this last made through volunteering groups. The absence of genuine stakeholder participation is a prevalent flaw in related legislation, planning documents, and in the political process (Aguilar & Montiel, 2011). Even for OLD, for instance, the citizen is imposed this obligation, not having a space for discussion or flexibility as the compliance levels are defined by the departmental prefectural decree.

Promoting citizen cooperation can be done through non-mandatory financial incentives, and/or regulatory measures. Both can drive compliance with fire prevention efforts and can encourage adherence to fuel treatment plans (Canadas et al., 2016), financial incentives can pay those who do a management activity, while regulatory measures can put sanctions on those not complying. Currently, the households' legal vegetation clearings obligation (OLD) is considered, by many stakeholders, as the main strategy in France for WUI fuel management. Although the OLD regulation has been enforced in previous decades by some State authorities, there is still a lack of implementation of this policy. Stakeholders stated that, to better enforce this regulation, awareness raising activities will be prioritized for the following 3 to 5 years before a strong enforcement comes, with sanctions and fines for non-compliance (Forest Code, n.d.).

According to stakeholders, this lack of implementation happens because 1) vegetation must not be cleared only once, but constructions nearby forested areas must be continuously kept in a so-called "cleaned state", involving long-term investments and increasing its cost (Santos et al., 2021); and 2) inhabitants dynamic changes with newcomers that do not have the awareness of living in a fire-prone area (Brenkert-Smith et al., 2017), thus not complying with the OLD regulation. For the cost part, some solutions are appearing for municipalities to do a collective fuel management, as an

increased scale lowers per-unit costs of fire mitigation (Canadas et al., 2016). Residents often resist treating fuels around their homes due to perceived benefits like aesthetics, privacy, and sound reduction (Moreira et al., 2020) and by people's confidence in the public administration's response as they may feel comfortable and do not see the need to take action (Tedim et al., 2016; Alló & Loureiro, 2020; Kirchner et al., 2024), although firefighters have noted that defensible space around homes makes it safer for them to operate without fear of entrapment (Kolden & Henson, 2019). Thus, community partnerships between agencies and residents could be essential for implementing OLD, together with awareness raising campaigns. Gathering and disseminating knowledge about strategies to mitigate wildfire risks can include attending wildfire meetings and educating friends and neighbors about methods of lowering fire hazard (Bihari & Ryan, 2012; Kolden & Henson, 2019).

The households' legal vegetation clearings obligation (OLD) and fuel breaks techniques were strongly considered by stakeholders as a game changer for risk reduction in WUI and forested areas. Although given a great importance, both were also heavily criticized for lack of implementation. One challenge brought to implement the OLD is the lack of technical mapping resources of small municipalities for preparing communal clearing plots and assess compliance, whereas some departments may have cartography associations which they join for the association to do this work. Fuel management tools, such as household vegetation clearing, grazing and prescribed burnings (PB) need to be adapted to local social and cultural conditions, engaging with and informing local and regional communities (Huber-Stearns et al., 2021). This can be done by local governments and planners that can use place attachment in public communications to facilitate collaborative management, motivating neighbors to collaborate on wildfire preparedness activities, which should also be promoted among recent arrivals and long-term residents (Bihari & Ryan, 2012; Ghasemi et al., 2020).

Overall, grazing and prescribed burnings (PB) are cost-effective fuel treatments with proven success in hazard reduction, fire suppression, and achieving ecological goals and should be encouraged, together with biomass for energy to promote fuel reduction management activities in rural areas and forests (Varela et al., 2018; Moreira et al., 2020; Nuss-Girona et al., 2022).

4.1.2. Low forest economic value

Mediterranean forests are generally mostly valued by their ecological and social features (Varela et al., 2020; Wunder et al., 2021). In these forests, non-wood products may become more important than traditional wood-based goods due to their income potential and societal benefits (Varela et al., 2020). Forest managers are discouraged from engaging in active forestry without sufficient support (Wunder et al., 2021; Kirchner et al., 2024), with the low profitability of many non-wood forest products calling for an improved policy support and/or market recognition (Canadas et al., 2016).

Brought by one stakeholder, this lack of interest in management is also derived from the French inheritance system, which divided forest areas per generation. Because of the small areas and lack of economic interest, forest owners usually live far from their forests and are not interested in managing the forest, which increases un-managed fuel accumulation. In addition, these absentee owners do not directly experience the impact of wildfires, also reducing their interest in engaging in fuel management or forest management activities due to transactional costs (Wunder et al., 2021). The main issue in these areas is that there is a lack not only of forest management, but also a lack of fuel management (e.g. clearing understory vegetation to reduce fire severity and intensity and have a more uniform fire behavior) (Casals et al., 2016; Piqué & Domenèch, 2018; Viedma et al., 2020). These dynamics have been responsible for the creation of extremely flammable landscapes and dangerous fire environments, where the historic mosaic of farmlands and forest patches was replaced by highly connected, continuous, less intensively used, and flammable wildland (Tedim et al., 2016). Without proper management, new forests with highly flammable biomass content increase wildfire risk, particularly as climate change exacerbates the frequency and severity of fires, with a clear link between active forest management and lower wildfire risks (Rego et al., 2010; Varela et al., 2020; Pacheco, 2022; Vigna et al., 2024).

One part of motivating management is to promote Mediterranean products, with some work being done by two stakeholders regarding that. One was studying the feasibility of using Mediterranean tree species in wood construction, which could also focus on using less flammable species (Pedrotta et al., 2021) and the other working with discussions about Mediterranean forests and carbon, water, grazing and other services. Due to the forest ownership and area fragmentation, private owners' associations in the region aim to group owners to increase the manageable forest area and do a joint forest management, which should be further developed throughout the years. This type of collective action can be fostered in areas with fragmented ownership, with management practices relatively

uniform and easier to scale as dealing with more than one owner (Canadas et al., 2016; Santos et al., 2021). An active forest management can also be promoted through incentives, such as tax benefits (Shlisky et al., 2007), and payment for ecosystem services (PES) (Varela et al., 2018; Nuss-Gironae t al., 2022), focusing on new, developing and developed markets, and/or disincentives aimed at changing behaviors (Wunder et al., 2021).

For instance, forest management with species selected based on flammability (Moreira et al., 2020; Pedrotta et al., 2021) fostering heterogeneity in vegetation types (Moritz et al., 2014), the promotion of ecotourism activities (Kete, 2023), the bioenergy market (Rego et al., 2010), and restoration activities with local less flammable species (Shlisky et al., 2007). On the other side, fuel reduction activities could also be promoted, for instance, when owners thin their forests, or where owners make part of their land available for developing fuel breaks and are economically compensated for that (Santos et al., 2021). Active forest owners are more likely to participate in contracts for fuel management if they include actions like shrub clearing but require higher payments to set aside land for fuel breaks. Conversely, nonactive owners, who constitute the majority in this case, are more likely to opt for delivering land for fuel breaks rather than bearing the ongoing costs of shrub clearing (Santos et al., 2021). This type of information could be further studied in the region to understand owners' openness to adhere a similar program, helping to tailor future policies.

Moreover, forest owners most of times make their land available, mainly for recreational activities, not receiving or receiving little compensation for the use of their lands, unless they incorporate other economic activities into their management strategies (Juerges et al., 2021). As forest owners bear the costs of fuel management actions without receiving benefits (Santos et al., 2021), there is increasing advocacy for public cost-sharing policies that would compensate forest owners for the ecosystem services (ES) provided by fuel management, with public funds helping to offset the costs for forest owners (Rego et al., 2010; Varela et al., 2018; Santos et al., 2021; Lecina-Diaz et al., 2023).

Although not cited by any stakeholder, Payment for Ecosystem Services (PES) could be a way to promote grazing and forest management activities, which were demands brought by stakeholders. PES schemes are used to incentivize behavior changes through economic means, complementing regulatory approaches (Varela et al., 2018), aiming to bridge the gap between public demand for ecosystem services (ES) and private landowners' incentives to manage these services (Shapiro-

Garza et al., 2019), presenting a viable option to encourage active forest management while addressing societal needs, if well designed, implemented and monitored (Górriz-Mifsud et al., 2016; Lecina-Diaz et al., 2023). The model assumes that non-industrial private forest owners respond to financial incentives by attempting to maximize their utility, while ES beneficiaries are willing to pay for increased ES (Górriz-Mifsud et al., 2016). Some examples are a carbon fee to support efforts related to fire management and forest regeneration (Pacheco, 2022). The involvement of other agricultural activities and ecotourism, such as cultivating fragrant and medicinal plants as well as forest fruits, could enhance forest owners' willingness to adopt such actions and provide the forest with a higher economic worth (Pacheco, 2022). Fire prevention management scenarios could include reducing tree cover, as well as vertical and horizontal canopy continuity. Current subsidies do not cover the costs involved, and forest owners are still unlikely to adopt these practices without significant financial support (Górriz-Mifsud et al., 2016).

Research reveals that society's willingness to pay (WTP) for enhanced ES, such as biodiversity improvement and fire prevention, exceeds the costs of providing these services, indicating a potential for a well-designed PES scheme. In a study in Spain, proposed contracts for forest owners offer two payment options: €30/ha/year or €120/ha/year, which would require an annual tax of €1.02 to €4.9 per citizen, plus transaction costs (Górriz-Mifsud et al., 2016). Still in Spain, Bernués et al. (2014) found that the most valued ES WTP was wildfire prevention (53.2% of total economic value), seen by the general population as a crucial ecosystem service (ES) provided by agroecosystems.

Two initiatives were found using grazing for reducing fuel and wildfire risk. One in Catalonia in northeastern Spain (Nuss-Girona et al., 2022), and one in Andalusia in the Southern Spain (Varela et al., 2018) where shepherds receive payments based on the amount of biomass reduced. Payments are structured to include a fixed bonus and a variable rate depending on grazing conditions, integrated with the regional fire protection plan and coordinated with fire prevention services to ensure grazing activities complement mechanical clearance efforts (Varela et al., 2018). This brought several benefits, such as the creation of a new institution advocating for extensive grazing, also with grazing activities estimated to save 75% of the costs of fuel management compared to mechanical clearance alone, also contributing to ecological recovery, early wildfire detection and reduced arson (Varela et al., 2018). Nevertheless, shepherds report that payments do not fully cover their costs, but they participate for community involvement, improved relations with forest

administrators, and recognition (Varela et al., 2018). PES schemes and financial incentives or disincentives can be thought to motivate or punish fuel management and forest management, but should be carefully designed considering local social and cultural aspects for their acceptance and adoption.

4.1.3. Climate change and risk increase

Because of climate change, increasing temperatures and drought periods, wildfire risk is spreading to the north and western part of Southern Europe (Vigna et al., 2021), which is also the case in Occitanie as reported by stakeholders. The main keywords of this theme are related to an increase and spread of the fire risk and hazard to new territories and areas that were not concerned before, as showed by climate predictions (Fig 6. and 7). This risk spread was seen in the 2022 fire season with the presence of major fires, showing that the whole national territory is and could be even more concerned by wildfires.

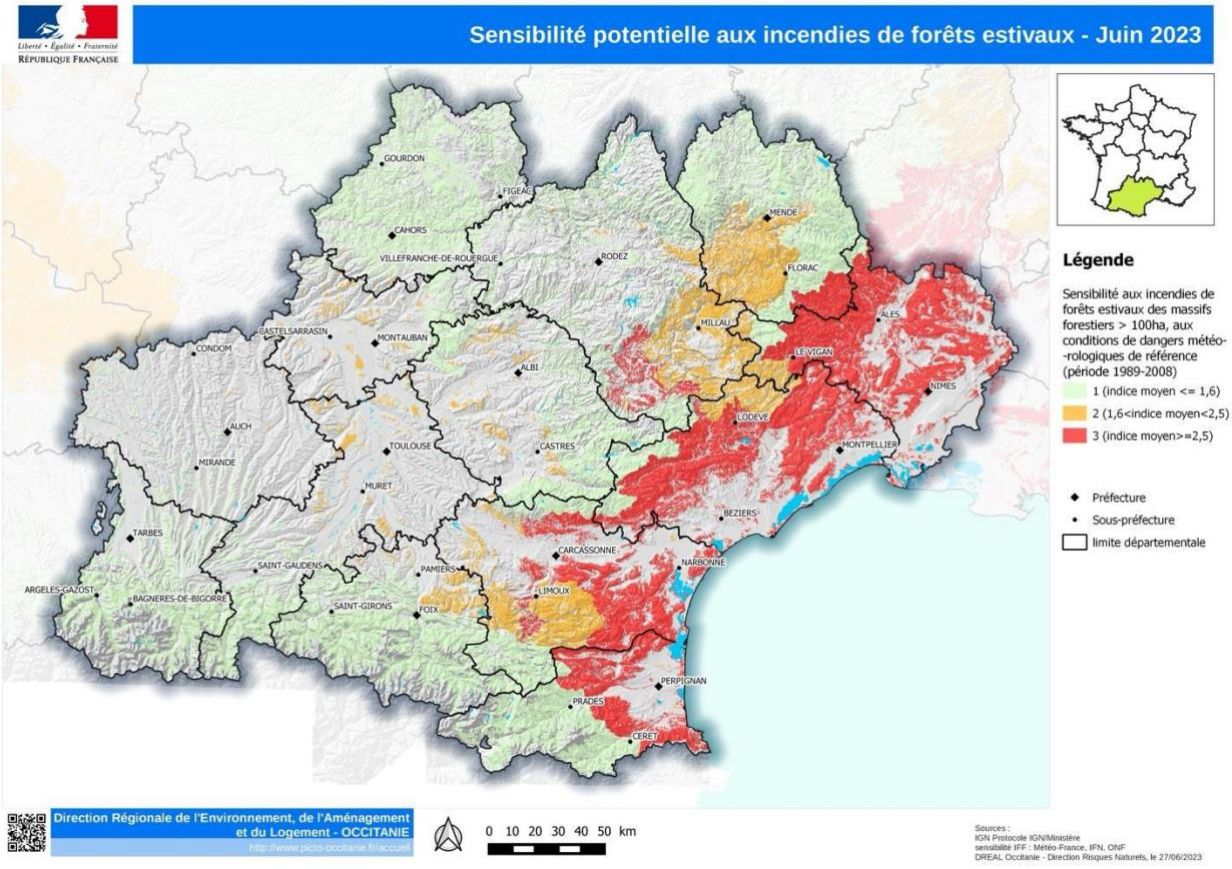

Figure 6: Potential summer wildfires vulnerability in Occitanie region in June 2023. Source: Occitanie's Regional Directorate of Environment, Land Planning and Housing (2023).

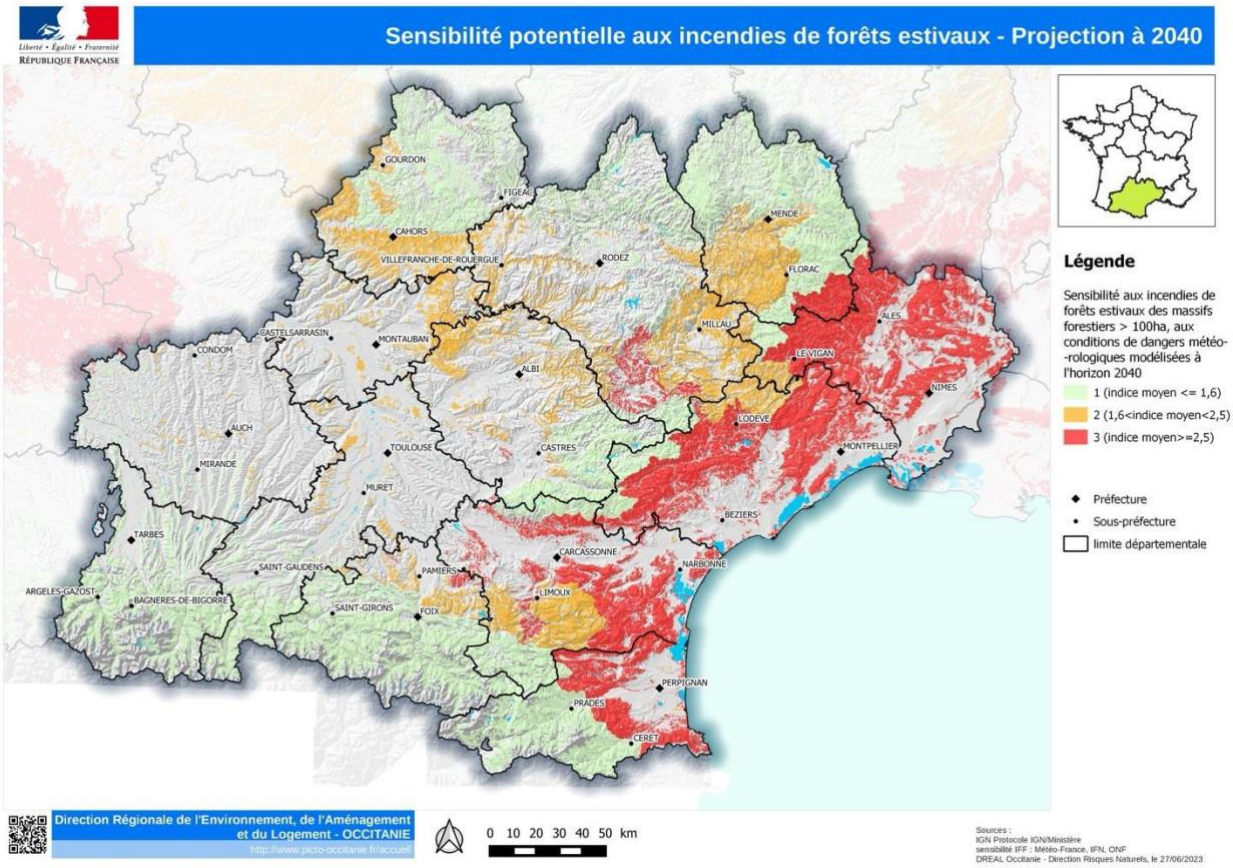

Figure 7: Potential summer wildfires vulnerability in Occitanie region, projection to 2040. Source: Occitanie's Regional Directorate of Environment, Land Planning and Housing (2023).

As the Occitanie region is diverse in ecosystem types, different capacities and strategies were and are being established. For instance, in the Mediterranean plains and foothills (mostly in the previous Languedoc Roussillon area, on the eastern Occitanie), fire activity is high, especially during summer, due to extreme weather conditions and high fire weather indices with aggressive fire suppression strategies being done rather than limiting fire by weather or fuel availability (Curt et al., 2014). Here, although current suppression efforts are effective, including rapid initial attacks, they may face challenges from climate change and fuel loads accumulation which could potentially lead to larger and more destructive fires if suppression measures are not successful in the early stages (Curt et al., 2014; Moreno et al., 2021). Whereas in the cool peri-Mediterranean mountains, there is less fire activity due to limited fire suppression resources, high landscape fragmentation, low human activity, and generally unfavorable fire weather. Here, the existing fire suppression capacity is considered sufficient for the current low level of fire activity, but it may need to be enhanced in anticipation of increased fire activity due to climate change (Curt et al., 2014).

4.1.4. Policy fire suppression history

Historically, most governments in Mediterranean-basin countries have adopted a "zero fire policy" that prioritizes fire suppression and professional firefighting services or centered in short-term fuel management (Moritz et al., 2014; Górriz-Mifsud et al., 2019). France, just like most European Union countries' wildfire policies initiatives concentrate on suppression and the reduction of the use of fire that can be effective in managing fire activity in the short term (Tedim et al., 2016; Curt & Frejaville, 2017). However, it is considered it did not solve the problem of wildfires, as large and destructive fires continue to occur annually, often escaping initial control and burning extensive areas (Lahaye et al., 2014). This strategy is considered as not being able to fully address the new generation of wildfires with extreme behavior and high intensity (Tedim et al., 2016; Evin et al., 2018). While this approach provided a sense of security to local populations, it has also led to a detachment from the socio-ecological reality of wildfires (Górriz-Mifsud et al., 2019).

The 2022 unusual fire season resulted in the law of the July 10th of 2023, which aims to reinforce wildfire prevention in the whole national territory. This is also why words related to "awareness raising", "trainings", "communication" and "risk consideration" in planning documents have appeared. The law now requires these new concerned territories to develop planning documents and a stakeholders' organization similar to what has been done in the so-called "historical territories", concerned by wildfires for a longer period of time. Also, funding has been released to implement this policy and recruitment has been taking place, with a new generation of fire-related jobs and personnel, which also demand trainings. Communication and awareness raising were brought as they are being done to diverse publics, such as elected officials' trainings to raise their awareness about their role in enforcing the households' legal vegetation clearing obligations (OLD), but also training them on crisis management and the communication involved with firefighters and the media. Besides, other communication campaigns have been done to the lay public seeking to educate them and reduce ignition sources.

4.2. Governance

Considering governance as the interplay among policies, stakeholders and decision-making, this section presents details of stakeholders' relations and their activities, as well as the current policy framework regarding wildfires in France.

4.2.1. Stakeholders' relations

The proportion of cited stakeholders found is somewhat similar to those of Huber-Stearns et al. (2021) working in a broader context, 67 actors were identified by 53 stakeholders, with 19 being cited multiple times, and participants identifying an average of 21 actors per case study. Here, working in a smaller context, 38 stakeholders were cited by the 19 interviewees, with an average of 5 stakeholders identified per stakeholder and with 14 stakeholders cited more than once.

Organizations and actors interacting to address common problems by integrating knowledge and capacities are called "governance networks" (Hamilton et al., 2019; Kirchner et al., 2024). They have emerged as effective tools for addressing large-scale, multi-jurisdictional forest management issues and help bridge stakeholder gaps, facilitate information flow, and tackle cross-boundary challenges that traditional organizations may struggle with (Fischer, 2018). Governance outcomes are shaped by interactions between actors and the landscape, though some enabling or blocking factors remain unclear (Hamilton et al., 2019). Understanding both formal and informal institutions is key to fostering collaboration among stakeholders (Esther et al., 2018).

Networked and complex governance system with several types of actors with diverse mandates, skills and relationships working together have its added value and are recognized in forest policy and in Southern European countries (Aguilar & Montiel, 2011). Globally, multi-stakeholder dialogues, knowledge co-production, and policy co-design are increasingly used to improve outcomes by reducing uncertainties and information gaps, to mobilize resources, foster innovation, and facilitate learning (Huber-Stearns et al., 2021; Skrimizea et al., 2021; Baratella et al., 2023). The never-ending inclusion of more stakeholders and sectors, and working in broader landscapes, is necessary in complex and multi-scale climate adaptation processes (Brenkert-Smith et al., 2017). In this way, identifying actors and their roles helps to overcome capacity constraints and enabling more effective collective action, involving a complex web of organizational and interpersonal relationships, with variations of who is invited to participate, how the participation is organized and the role of each actor (Aguilar & Montiel, 2011; Andriollo et al., 2021; Huber-Stearns et al., 2021; Kirchner et al., 2024).

Nature, viewed as a public good, is typically managed by public actors, with wildfire protection seen as a public responsibility, justifying government involvement (Loomis & González-Cabán, 2008; Arnouts et al., 2012; Kirchner et al., 2024). French forest policy remains state-driven, with

top-down decision-making, though non-governmental, private, and commercial actors can also play roles (Aguilar & Montiel, 2011; Arnouts et al., 2012). Government involvement and formal institutions are vital in supporting collaborative governance by creating spaces for diverse groups to interact and share experiences (Borg et al., 2015; Esther et al., 2018; Hamilton et al., 2019). Because of pre-established power imbalances, stakeholders may not have the same ability and influence to create and scale up narratives and construct the meaning of hazards for society (Brenkert-Smith et al., 2017; Kirchner et al., 2024). Within a network, there may also be the so-called “policy entrepreneurs”, more proactive than others and skilled at navigating the political landscape to link certain policies to specific issues, creating "windows of opportunity" (Arnouts et al., 2012). One stakeholder noted their proactive role in proposing solutions, despite not holding decision-making power. Actors on the margins of a network can benefit from bridging organizations, which facilitate information flow across management scales, reduce costs, and resolve conflicts by pooling resources from multiple sources (Folke et al., 2005; Borg et al., 2015; Huber-Stearns et al., 2021; Kirscher et al., 2024). One stakeholder highlighted their role in bridging national, regional, and municipal levels, ensuring information and demands flow between authorities and local communities, much like the community leader described by Brenkert-Smith et al. (2017) and by Kirschner et al. (2024), also advocating for the creation of bridging institutions.

Some challenges to translate policy into practice is related to the scale they are designed, implemented and enforced (Brenkert-Smith et al., 2017). National and regional scale can be more focused on designing and implementing programs and policies, as well as build opportunities for community engagement and initiate activities across sectors (Moritz et al., 2014; Brenkert-Smith et al., 2017; González & Ghermandi, 2024; Kirchner et al., 2024). Meanwhile, regional and local dimensions are considered the core of network governance and can be encouraged to better fit the environments they are in, playing a critical role in terms of language, public understandings and programs needed (Brenkert-Smith et al., 2017; Hamilton et al., 2019; Huber-Stearns et al., 2021). The local level also usually has the most cooperative actors, since they tend to prefer local partners and interactions to bring the highest results (Hamilton et al., 2019). This emphasizes the importance and promise of local collaborations (Huber-Stearns et al., 2021), noted by two stakeholders.

Scientists argue that wildfire risk reduction should be addressed at larger scales while also adopting regional and local approaches to better align with specific contexts (Hamilton et al., 2019; Huber-Stearns et al., 2021). Governments, with their capacity to manage large-scale geographic and

multidimensional problems, are thus well-suited for addressing wildfire risks (Vigna et al., 2021) but must remain flexible to regional and local needs. This is why connecting scales can enhance wildfire risk reduction efforts (Brenkert-Smith et al., 2017). One major challenge in wildfire management is developing region-specific policies, given the unique characteristics of each area and the distrust in top-down management approaches (Kete, 2023). In the current study, laws are done nationally, with regional and mostly departmental implementation and local enforcement, similar as found by González & Ghermandi (2024) comparing countries, where regions, provinces or autonomous communities (here national and regional level) are those responsible for proposing actions and those responsible for enforcement are the municipalities. Stakeholders highlighted discrepancies among departments in regulations, advocating for a more harmonized and homogeneous regulatory framework within regions with similar socio-ecological contexts.

Since not all stakeholders have the same allocation of financial resources, experience, and institutional capacities, sometimes they require this resources' sharing (Aguilar & Montiel, 2011; Andriollo et al., 2021; Huber-Stearns et al., 2021). Sometimes municipalities at high risk may not be the ones able to put more financial and/or human means on Integrated Fire Management (IFM) activities. To have a working wildfire prevention system, though, this pooling needs a greater sense of collaboration aiming to protect territories that are at a higher risk but may have lower resources, understanding that protecting this one territory is also a way of protecting other territory.

Interviews also revealed that, overall, each actor has a clear and defined role, which turns the system effective in wide actor participation and institutional fragmentation (Kirscher et al., 2024). Overlapping activities among stakeholders may appear, leading to redundancy in roles and unexpected disturbances) even with actors coordinating regarding landscape characteristics, infrastructure, fire behavior, and jointly plan activities to avoid duplication and support better decision-making (Hamilton et al., 2019; Huber-Stearns et al., 2021. Despite opportunities to interact, some actors lack coordination ties to others due to antagonistic relationships and differing values, such as preferences for wildfire suppression to protect timber or scenic values versus ecological management trying to mimic natural ecological disturbances through prescribed burning (Hamilton et al., 2019). This was brought by one interviewee that advocated for the management of Integrated Fire Management equipment (firefighting roads, water points, watch towers, fuel breaks) taking ecological principles into consideration (Piqué & Domenèch, 2018), postponing and/or changing location of equipment because of nesting and breeding period and location. This

goes in the way that risk mitigation coordination among actors may bring successful outcomes if actors seek to align their management strategies with other actors' strategies to implement actions in partnership (Hamilton et al., 2019).

4.2.2. Stakeholders' activities

Different countries propose diverse policy approaches targeting various stages of fire events. Recent studies show that around half of the management actions occur in the pre-fire stage, focusing on fuel management and risk reduction (Brenkert-Smith et al., 2017), here with similar results, where prevention is the main focus of most stakeholders, with another quarter divided between during-fire actions, primarily fire control, and post-fire recovery efforts (Huidobro et al., 2024). Besides these, some of the most often discussed strategies are also public awareness and communication campaigns, defensive infrastructure design and training, fuel management, and the use of detection and suppression systems (Aguilar & Montiel, 2011; Curt et al., 2014).

Usually, similar actors of same scale and type have similar roles, and some actor types have a broader and more diverse role scope than others (Huber-Stearns et al., 2021), the first was the case for public forest management activities, and the latter for administrative and regulatory actors. Funding mostly came from State agencies and local government is mostly in enforcement, communication, outreach and advocacy (Huber-Stearns et al., 2021; Kirschner et al., 2024). Considering the time scale, short-term actions are related to mitigation ad preparedness actions, trying to reduce impacts (Brenkert-Smith et al., 2017), long-term actions regarding adaptation to reduce vulnerabilities and increase resilience seems to be lacking.

Even though institutions are committed to increasing prevention activities, the emergency response is still the default choice (Kirschner et al., 2024). Most fire management agencies prioritize quick suppression of fires when they are small, utilizing resources such as fire crews, air tankers, and fire trucks. Other key actors are involved in planning evacuations, emergency investments, sheltering, crisis communication, and coordinating with collaborators during fire events (Huidobro et al., 2024). Here, suppression and post-fire investigation happened in the departmental level, while in Kirschner et al. (2024) in Italy it was done in the state level. Volunteering occurred at the regional level for Kirschner et al. (2024) and here it is organized in the municipal or inter-municipal level. Also, prevention activities in Italy happen in a regional level, and in France it seems to happen on all levels, depending on the type of prevention activity.

Some stakeholders' activities are not solely on one part of the Integrated Fire Management (IFM) framework, this was also found in Pacheco et al. (2020) where most research focused on prevention but few research focused on more than one phase of the IFM. This makes sense as IFM activities are all linked and can overlap (UNEP, 2022). Even though most organizations work mostly on prevention, some organizations are involved both on prevention and post-fire actions.

Despite interviewees not having time limits to express themselves, sometimes they might have forgotten one or other activity that the organization does simply for not being actively involved on it or sometimes because of a lack of a complete view of all the organization's activities. It was attempted to interview as many people as possible to try to build a complete view of the sector, but this cannot be guaranteed. It is noteworthy that IFM activities categorization was done solely focusing on what that specific stakeholder said about its own organization. Although stakeholders listed other organizations' activities, this was not considered.

4.2.3. Policy framework

French's wildfire-related strategy primarily relies on laws, regulations and departmental prefectural decrees mandatory to follow. These measures give French authorities tools aiming to anticipate and respond to an increased wildfire risk driven by urbanization, tourism, and infrastructure development, which can lead to more frequent ignitions (Curt & Frejaville, 2017). Wildfire policies are often shaped by responses to catastrophic events, opening windows for new legislation, as governments reflect on past actions and identify areas for improvement to reduce future losses (Brenkert-Smith et al., 2017; Huidobro et al., 2024). This occurred with the 2023 Law of July 10th, enacted after the severe 2022 fire season.

Understanding how policies are implemented, enforced, and their effectiveness is essential for evaluating their impact on shaping landscapes and reducing wildfire risk. Stakeholders highlighted several challenges to policy effectiveness: lack of human resources and funding, underdeveloped fuel breaks, and inadequate technical mapping resources. The July 2023 law created new jobs to address these issues, as people are needed to review planning documents and regulations, as well as to implement and enforce this new policy (Pandey et al., 2023) and employment opportunities in firefighting, surveillance, and community guards could promote economic development in wildfire-prone areas (Kete, 2023). According to stakeholders, recruitment remains difficult due to a lack of applicants and funding. Additionally, many roles are not fully dedicated to wildfire-related

activities, resulting in time constraints and heavy workloads for those involved in prevention activities. As some activities need a lot of attention, with trainings and/or field visits, this can make people cautious to take this subject into account as they are aware they will need to devote a considerable amount of time for it. As for funding, stakeholders emphasized the need for increased funding for prevention efforts without reducing response budgets as in 2017 one-third of resources were allocated to prevention and two-thirds to suppression (Curt & Frejaville, 2017). Similar issues, such as insufficient staffing and funding for wildfire prevention, have been observed in Greece (Kalabokidis et al., 2008), mostly to develop wildfire prevention activities, such as fuel break construction and land clearing.

Some of last century France's fire suppression policy actions remain in place today (e.g. improved fire danger predictions, communication on fire risk, and restrictions on forest access during high-risk periods). This focus on suppression has successfully controlled the size and frequency of fires, particularly small-to-medium ones, leading to a reduction in burned area (BA) (Lahaye et al., 2014; Marco et al., 2016; Curt & Frejaville, 2017; Evin et al., 2018; Ganteaume et al., 2019; Bountzouklis et al., 2022). This strategy is still seen as effective nowadays, as brought by several stakeholders with the code "burned area reduction". Kirchner et al. (2024) also found, in Italy, that stakeholders considered policy well defined to address wildfire risk, however also encountering implementation and non-compliance challenges. Policy success metrics could shift from focusing only on BA reductions to also using avoided socio-ecological damages (Kirscher et al., 2024) and metrics such as human lives lost, economic damages, soil erosion, carbon emissions, and biodiversity loss (Moreira et al., 2020), with "avoided damage values" brought by two stakeholders. While some fire effects can be estimated through expenditures made by households to mitigate wildfire impacts on private property, assessing impacts on public forests and non-market public goods presents a different challenge (Loomis & González-Cabán, 2008).

France's core strategy emphasizes early intervention, with rapid initial attacks on all ignitions, regardless of fuel type or weather conditions, aiming to contain fires before they grow too large and difficult to manage (Curt & Frejaville, 2017; Evin et al., 2018; Pandey et al., 2023). Firefighters, foresters, and volunteers aim to extinguish fires within ten minutes of being reported, keeping them under one hectare in size (Curt & Frejaville, 2017). This massive initial suppression can potentially lead to larger and more destructive fires if suppression measures are not successful in the early stages (Curt et al., 2014). As wildfires are becoming more aggressive, with sometimes

multiple fire outbreaks, suppression efforts are proving more costly and less effective, as seen in France in 2003, 2016, and 2017 (San Miguel Ayanz et al., 2013; Evin et al., 2018; Alló & Loureiro, 2020; Pandey et al., 2023). One stakeholder agreed on the policy's effectiveness but cautioned that, on days with unfavorable conditions, even well-organized efforts may fail to prevent wildfires.

While France's fire suppression policy has effectively reduced burned area (BA) (Lahaye et al., 2014; Curt & Frejaville, 2017), it also creates a "fire paradox" in ecosystems like the Mediterranean, where fire is a natural ecological process (Lahaye et al., 2014; Pereira et al., 2017; Depietri & Orenstein, 2019; Pausas & Keeley, 2019; Moreira et al., 2020; Pereira et al., 2021). Suppression leads to vegetation growth and fuel accumulation which heightens the risk of more severe wildfires if not managed (Curt & Frejaville, 2017; Moreira et al., 2020; Wunder et al., 2021; Pandey et al., 2023). Increased fuel, combined with human activity and climate change, amplifies ignition potential and wildfire vulnerability (Curt & Frejaville, 2017). Early success in suppression obscured the unintended consequence: while the number of fire ignitions remains high, most burn areas are now under one hectare (Tedim et al., 2016), data also brought by one stakeholder.

Although France has implemented regional and local fire prevention regulations, stakeholders identify key challenges, particularly their weak enforcement, which leads to non-compliance and higher wildfire risk. Public awareness and education on wildfire risk and prevention are more than necessary and urgent. Communities, when being passive actors, are often unprepared to deal with increasingly extreme wildfire events, resulting in significant damages and casualties when these events occur (Górriz-Mifsud et al., 2019). On a positive note, France’s policy, through the household legal vegetation clearings obligations (OLD) encourage community active involvement in property maintenance, creation of fire breaks, and fuel management zones (Pandey et al., 2023).

The academic community increasingly advocates for shifting from a fire suppression focus to prioritizing prevention, mostly through fuel management (Santos et al., 2021), while also emphasizing mitigation and preparation to minimize wildfire impacts (Moreira et al., 2020). Preventive measures alone might be insufficient and must be combined with land-use regulations, climate adaptation policies, and increased public awareness of fire safety (Alló & Loureiro, 2020). Efforts were done with the Law of July 10th 2023 to include preventive and suppressive measures in several scales, such as in land and forest plans process, focusing on local contexts, supported by Aguilar & Montiel (2011) and Vigna et al. (2024). Therefore, forest fire prevention programs

emphasizing on initiatives focused on public participation, education, and accountability for fire safety measures are essential (Alló & Loureiro, 2020).

4.3. Ecosystem Services (ES) identification and valuation

The assessment of ecosystem services (ES), which involves their identification, characterization, and valuation, has become a key interdisciplinary activity connecting scientific research with policymaking (Orenstein & Groner, 2014). Social approaches to ES assessment are defined by the application of social science and humanities research methods (e.g., surveys, interviews, ethnographies) and the valuation of ES in non-monetary terms (e.g., perceptions and values) (Orenstein & Groner, 2014). Few studies have explored the identification or perception of ES by stakeholders, particularly focusing on how different stakeholders perceive and prioritize ES (Lamarque et al., 2011). Understanding social perceptions of values is crucial for designing agri-environmental policies that promote multifunctionality, considering stakeholders' diverse views (Bernués et al., 2014). An example of using ES valuation to shape management actions was done where residents valued both their access to recreation and the natural character of their community, with hazard reduction efforts being tailored to respect these values, such as thinning rather than removing shrubs (Kolden & Henson, 2019).

Different stakeholders often hold varying values and perceptions regarding ES, leading to trade-offs between ES (Martín-López et al., 2012). Relational values, related to how people perceive their relationship with ecosystems are closely linked to the specific role and position of each stakeholder (De Vreese et al., 2019). This illustrates the challenge faced by people representing institutions, who must differentiate between the institution’s vision and the personal one, often without clear guidance on which perspective to prioritize (Depietri & Orenstein, 2020; Lamarque et al., 2011; Ruiz-Frau et al., 2018). This issue was addressed here always focusing on stating for the interviewee to bring the institutional view. In this way, the responses should not be considered solely as the institution’s view itself, but rather as a suggestion of a direction of activities and decisions to be made (Kirscher et al., 2024).

Considering that Mediterranean scrublands and forests, adapted to historical fire regimes and grazing patterns, are crucial for providing food resources (such as wild fruits and mushrooms), materials (including cork and timber), and regulating freshwater quantity, soil erosion, and carbon sequestration (Balzan et al., 2019), they are highly recognized for their social and recreational

value. Here, recreation was the most cited ES, similar as in Lamarque et al. (2011), services identified were often the most visible ones (e.g., recreation, aesthetics, natural risk reduction), although less visible services (e.g., pollination, soil fertility) emerged during ranking, but in a lesser proportion. In a study in different countries, same ES groups were cited in a similar order, with the most valued ESs being wood production and biodiversity conservation, followed by recreation, water quality, and carbon sequestration (Juerges et al., 2021).

Recreation was the most cited ES when asked about the ES dynamics before and after a wildfire. Other ES cited were biodiversity conservation and water quality, considering wildfires diminish the quality of forest recreation for certain visitors and can negatively impact wildlife habitats and water quality (Loomis & González-Cabán, 2008; Palaiologou et al., 2021). Since wildfires can alter the landscape for decades, they can lower the potential for recreation, tourism, and economic revenue (jobs, tourists, etc.) as users frequently switch destinations, and wildfires are known to cause a decrease in the landscape aesthetics over time (Pereira et al., 2021; Roche et al., 2024). Wood production was also cited to be negatively impacted by wildfires, with a decline in the wood value affected by a wildfire (Pereira et al., 2021).

While fires are often viewed negatively, they provide essential ES such as nutrient recycling, habitat creation, and regulation of tree density (Moritz et al., 2014; Depietri & Orenstein, 2019). Here it is again important to differ fires from extreme wildfire events and megafires. Globally occurring, fire has both beneficial and detrimental effects on ecosystems, having molded biomes into what they are now, helped humans survive and thrive over time, and has even been a significant cultural component in some situations (Pereira et al., 2021). While systems may be ecologically resilient over long periods or large scales, post-fire conditions might not be socially acceptable in the short term or at local scales as human perceptions of acceptability can evolve over time, influencing the degree of acceptance for new conditions (Higuera et al., 2019). Policies, incentives, and social movements can help stakeholders and managers appreciate the value of new post-fire conditions or find innovative ways to achieve long-term goals during the recovery process (Higuera et al., 2019), like brought by two stakeholders that refrained organizations to replant right after a wildfire in an effort to restore that ecosystem, as the mortality rate was about 80% after the first years. They highlighted the public motivation to act right after a wildfire, but that replanting may not be the most adapted solution and can be a loss of money. One stakeholder proposed, instead, to motivate citizens to frequently observe the post-fire conditions in terms of appearance of

animals, plants' resprouting, to understand that the ecosystem was regeneration on its own. In this sense, three participants talked about the ecological role of fire, saying that a wildfire is more a human catastrophe then an ecological one, as nature will adapt to this new open environment, although in a longer time scale.

This ES identification and valuation showed that recreational values and biodiversity conservation are highly valued by stakeholders and should be considered in future decisions, such as prioritizing fuel management works in highly frequented parks to maintain its recreational value or in protected areas to maintain its biodiversity levels, or even use fire to do so in ecosystems where biodiversity is promoted by it.

4.4. Recommendations

To manage extreme wildfire events effectively, a combination of proactive landscape management, public participation in wildfire risk reduction, and continuous vigilance by firefighting forces is essential (Evin et al., 2018). Public policy needs to undergo a paradigm shift in order to prioritize fire prevention above fire suppression and to take into consideration the social, ecological, and economic factors that contribute to the start and spread of wildfires (Lecina-Diaz et al., 2023).

A well-rounded fire policy should aim at preventing ignitions caused by human activities, reduce the extent of BA through effective suppression (which was obtained in France after the 1994's fire suppression policy), and actively modify fire behavior through strategic fuel management (Curt & Frejaville, 2017). Even with a good suppression capability and a legislative body in place, it is difficult to reduce wildfire occurrence and damages over the long run without community involvement. Because of this, communities continue to be in charge of achieving goals, suggesting a change from top-down to a more collaborative decision-making process and the development of more fire-aware and resilient communities (Tedim et al., 2016). In this sense, broader and comprehensive public education campaigns should be launched to raise awareness about wildfire risks and the importance of prevention measures (Pandey et al., 2023).

In regions like Oregon in the United States, collaborative efforts among community-based organizations, environmentalists, and land management agencies have shifted the approach to wildfire risk management working together to implement thinning practices, restore forests, and use fire as a management tool. The results demonstrated a positive feedback loop where local self-organization effectively reduces wildfire risk and enhances the economic viability of forest

management practices (Fischer, 2018). The creation of volunteer groups and enhanced cooperation between public agencies, local landowners, and volunteer organizations were proposed as strategies to strengthen local wildfire management capacity but may be hindered by a lack of administrative support and coordination (Kalabokidis et al., 2008; Kirchner et al., 2024). In this case, France has volunteer groups within municipalities, which would be interesting to analyze as Fernández-Blanco et al. (2022) did with the forest defense groups in Catalonia.

Also, a precondition for any change is to create awareness among decision makers, policymakers and land managers on fire's ecological role and promoting laws that balance fire management with development and conservation (Shlisky et al., 2007; Schmerbeck et al., 2015). The official forestry world is reluctant to acknowledge that prudent and knowledgeable use of fire can be an interesting and valuable tool of risk management and reduction, which is one reason why the shift to more balanced policies that include the use of fire remains unreached (Tedim et al., 2016). Moreover, prescribed burnings (PBs) usually have a low understanding and acceptance by people, which could be further studied as understanding stakeholder perceptions is key to anticipating barriers to adaptation and mitigation efforts and ensuring public collaboration (Vigna et al., 2024).

France has made significant progress in wildfire management, and some activities must be continued and increased, such as prevention ones. Work should be continued on creating and updating regulatory documents, nevertheless improving its enforcement, mainly the households' legal vegetation clearings obligation (OLD) ones, putting a stronger focus on increasing public awareness (which may also result on a better OLD implementation). Also, public and private participation could be fostered, in a hybrid governance model to manage larger areas over longer time scales with further research needed to refine these approaches, for instance in the fuel breaks and grazing development, with a long-term fuel and risk management view (Curt & Frejaville, 2017; Fischer, 2018).

Finally, while interview and survey methods mark initial steps in integrating social dimensions into ES assessment, further steps such as follow-up surveys, community discussions, and scenario development are essential to fully incorporating social tools into ES evaluation frameworks (Orenstein & Groner, 2014).

5. Conclusions

Governance on itself cannot be directly compared among countries, as each one develops and adopts frameworks adapted to its social, ecological and economical contexts. Thus, this study results does not aim to generalize the situation to other French regions, or even other European countries, but it can give insights for the study area and beyond. The main current subjects in the wildfire context in France are related to updating wildfire-related planning documents in historical territories or creating a first generation of them in new territories adapting the historical ones to their territories. Also, creating and/or maintaining and improving Integrated Fire Management (IFM) equipment (firefighting roads, water points, watch towers, fuel breaks) and its mapping, besides dealing mostly with the implementation of OLD through awareness raising campaigns.

France's national policy is highly focused on intensive initial fire suppression and fuel management (in rural and peri-urban areas). Nevertheless, this strategy may be showed as inefficiency in the light of the new generation of forest wildfires, or megafires, still not common in Southern France. Aiming for the worst scenario, the preventive measures demanded today by stakeholders, such as creating fuel breaks, promoting grazing and forest management, as well as those in their way of being enforced, such as the peri-urban vegetation clearings, may only show results in several years, but may work as a steppingstone for the future wildfire context. As the latest law is quite recent (2023) and brought several changes to planning documents and law enforcement, France's strategy still needs more time to be completely evaluated, where today's preventive measures and future ones will show if they will be enough to deal with extreme wildfire events. Plus, it can be also a challenge to prove that a strategy is efficient if its results are proved on avoided damage, calling for other types of indicators.

In terms of limitations of this study, one of them regards time constraints and the number of stakeholders involved in Integrated Fire Management (IFM). Since snowball sampling was used, stakeholders always listed others and sometimes new relevant stakeholders to contact. However, it was not possible to interview some actors because of lack of time from both sides (interviewer and interviewee). This makes that some subjects and practices may also be underrepresented because of lack of participation of certain organizations that could detail it more. Nevertheless, the number of interviews made was considered sufficient, reaching a considered saturation point, where

supplementary interviews would not add many more relevant information, since several stakeholders were already repeating themes.

Another limitation is related to the fact that the policy framework changed in 2023, with a lot of stakeholders not being able to measure the efficiency of the policies as they are still in the beginning of structuring all the changes proposed and required by the law. This, in turn, made that some job positions were open, and some interviewees were also new on the subject, not having enough time to be able to analyze the whole context and framework and give in-depth answers. Fortunately, this was a small part of the sample, and most people worked in the subject for at least 5 years, with some working for even more than 20 years, which therefore consolidates the information derived from the data.

Other limitation was the non-inclusion of communities' volunteers and non-governmental organizations (NGOs) related to environmental subjects. Both of them were contacted but some didn't reply or had time constraints while others, when quickly asked by phone, said they do not deal with this subject, thus staying out of the sample. Nevertheless, it would still be interesting to add their opinion on the subject.

Sometimes stakeholders said that they work on prevention, but did not specify what they meant by that, unfortunately not being able to categorize their activities. Because sometimes answers were not concise and people can get lost in subjects, maybe in future interviews the question asked can be "could you briefly summarize your mission/activity in one phrase?", to reduce complexity when coding answers. This is something that should be taken more care of in the future, which was not done here to not cut interviewee's rationale in the middle of their thought and to respect their discourse time. Another alternative would be to do a quantitative survey with activities listed and stakeholders check the box of activities they do.

One interesting thing that could have been done if more focus was given to the ecosystem services (ES) valuation is to ask participants to rate fire and wildfire-related ES benefits and prejudice in the short-term (1-year post-fire), medium term (10 years post-fire) and long-term (50-100 years post-fire), maybe appearing more answers related to fire benefits on the long-term.

As this research was exploratory, it was a first step understanding the wildfire-related policy and governance framework, as well as ecosystem services (ES) views of the forests, although it would

be interesting to know if ES valuation and dynamics changes among public, private and civil organizations, which could be further explored in a statistical sample with a survey.

Contrary to what found in other studies that stakeholders only see ecosystem disservices related to fires or they do not see the forest as a resource for risk reduction, it was not the case here as fire ecology was cited by three stakeholders and that risk reduction was considered one ecosystem service, not directly related to preventing wildfires, but to prevent natural risks after wildfire events, such as landslides.

Although some practices may be done in other parts of the French territory, such as grazing and prescribed burning, according to interviewees, these are practices to be developed in the region and/or in the department. Maybe if this study was done in other region and department with other organizations interviewed, the results would probably be different, and some subject could be more or less developed than here.

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Appendix

1. Semi-structured questions

(Introduction giving the current context + important to state to ask the person to answer with an institution regard, not personal + asking for consent for recording)

1st part: Institutional role

1. What is your job/occupation? For how long you have been working in this position?
2. In the last 5 years (or for the period the person is working in the region), did you experienced/worked with wildfires/extinguished wildfires? Could you give me an idea about the proportion of the wildfires, for instance, in terms of size or number of wildfires?
3. In the last 5 years (or for the period the person is working in the region), do you see an increase in the wildfire risk in the region?
4. What are the main causes of wildfires in the region?
5. In the last 5 years (or for the period the person is working in the region) until now, what are the activities your institution carried out related to preventing, managing, or extinguishing wildfires?
6. From these activities, is there something you would like to do more? Why you don't?

2nd part: Communication, collaboration with other institutions

7. Which actors are relevant for you in the context of working with wildfires in Occitanie?
8. How would you describe the contact and communication with them?
9. Any suggestion on how your institution could be more connected and engaged with others?
10. Is there any institution you believe that should be more active? In which ways?

3rd part: Policy effectiveness

11. What are the main actions you see the government doing for preventing wildfires?
12. In your perspective, how effective are these actions on the ground?
13. (If answer is not effective) Why do you think it is not effective?

14. What would you suggest for governments to do differently to be more effective?

15. (If answer is effective) Why do you think it is effective?

4th part: Ecosystem services

16. What are the most valuable things that nature, in Occitanie, gives to local citizens?

17. From these, what you consider to be the 3 most important things for the local citizens?

18. After a wildfire event, would you say the values of these things change? How?

19. Which of these could be the most negatively impacted by wildfires?

20. Which of these could be the most positively impacted by wildfires?

5th part: Final comments

21. Are there other institutions or people you consider important to add into this research?

22. Do you have any additional comment?

(Conclusion and thanking the person for their time)