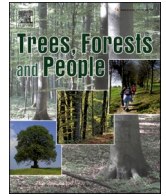




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Bridging wine and forestry sectors to reduce wildfires: Wine actors' perceptions, their role in risk reduction and externality labelling

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ABSTRACT

To mitigate wildfire risk, fire-smart landscapes present a promising strategy, integrating fuel discontinuities through a mosaic of agricultural and forested areas. However, the role of farmers in enhancing wildfire resilience within this mosaic remains underexplored. This exploratory study in four European Mediterranean countries aims at unveiling the factors modulating wine growers' wildfire risk perception, their related agency and demand for recognition.

Our survey sample consisted of mainly rustic land managers (78 %), which often had also roles of wine producers (48 %), PDO (7.5 %) or winery (18 %) representatives, or wine experts (23 %). Portuguese respondents lead in ownership rates, with Spanish ones exhibiting larger average holdings. Our findings show the interlinkage between wine sector and wildfire risk management: wine growers influence the interface between woodlands and farmlands. Sixty-five percent of land managers were also forest owners, but only 25 % had a forest management plan. Catalan respondents rank higher in association membership, Spanish and Italian respondents tend to have more plans, and Italians are more likely to have sold wood. Approximately 24 % of respondents reported past wildfires within their property, and 32 % in their vicinity. Land managers reported a high wildfire concern (7.5/10), with Spanish respondents scoring higher (8.4) than Portuguese (6.5), French (6.1) and Italians (5.1). The closer experience of wildfires and owning also forests correlated with higher concern levels. Only one-quarter of land managers are aware of a fire prevention plan for their property, and among those pre-suppression measures dominate.

Forty-five percent of respondents declared interest in financial support for implementing wildfire risk reduction measures, followed by technical support (39 %). French respondents were less keen to support. Over one-third of the sample indicated interest in a fire-smart label in the marketable products to recognise the externality effect of fire risk reduction. Most respondents did not believe that would improve their sales, and 23 % reported excess of brands. These results call for: i) targeted information and financial mechanisms to vineyard managers to align with fire risk reduction measures and engage in forest management, and ii) co-design of any fire-smart produce label to ensure effectiveness and acceptance.

1. Introduction

As wildfires represent a recurrent phenomenon in the Mediterranean region, its vegetation is adapted to some degree to such contingency. These past years raising temperatures and decreasing precipitations have increased the impact and extension of wildfires, which occur on a more and more dense and continuous landscape, thus allowing for more available fuel (Sil et al., 2019). Such rising severity entails challenges for the adaptation capacity of the vegetation (pushing towards new ecosystems) and consequently different ecosystem services provision, as

well as losses for humans (e.g. assets, homes, infrastructure).

The scenario of extreme forest fires is becoming more frequent, also in countries with strong suppression systems (Regos 2022; Grünig et al. 2023). Typically, countries have focused their pre-fire risk management policies mainly on reducing ignitions (through restrictions and penalties), early warning systems, and on pre-suppression infrastructure - fire breaks, water points and accessible roads. Such strategy might be insufficient as the fuel configuration across the landscape remains unmanaged. Moreover, the costs of fire breaks maintenance are elevated and should increase in the future, suggesting a need of new

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collaborations with local activities and stakeholders (Moreira et al. 2020). Agriculture (extensive livestock, arboriculture and vineyard) is an activity that, if self-sustaining economically, maintains fuel discontinuities that could be potentially included when planning a holistic landscape strategy (Moreira et al. 2023; Silva et al. 2023; Lecina-Diaz et al. 2023) -the so-called “productive firebreaks” (Pulido 2021; Bertomeu et al. 2022).

However, fire risk has increased in rural areas because of farmland abandonment in the Mediterranean Europe. This process responds to several interlinked phenomena, chiefly: (i) the declining presence of humans in rural areas (since the industrialization) that reduces the available rural work force, whose role evolved due to (ii) agrarian mechanisation, which becomes essential to maintain competitiveness within a (iii) globalised agricultural economy. Agriculture has, thus, concentrated in highly productive and accessible lands, gradually casting mountain agriculture aside. Forest has expanded over those areas without necessarily being exploited or managed (Frei et al., 2024). In many Mediterranean hills covered by woods, miles of dry-stone walls bear witness to an agricultural past. A side effect of such abandonment is the lack of maintenance of related agriculture structures (terraces, paths, irrigation channels and reservoirs), which could be of interest for the fire suppression strategy. Furthermore, this European farmland abandonment crisis will persist in the coming years (Perpiña Castillo et al. 2018), aggravating fire hazard in southern countries (Viedma et al. 2015). Such continuous abandonment highlights the fragility of agriculture sector in Mediterranean rural areas and interrogates its capacity to engage in collaboration mechanisms between fire risk management and agricultural production. Yet, the socioeconomic aspects underlying the agriculture-wildfires interaction remain understudied.

Thus, our guiding research question is: how do agriculture producers perceive wildfires and their agency in wildfire risk management? Therefore, the main objective of this work is to disclose the variables that modulate farmers’ wildfire risk perception in Mediterranean Europe. Through this study, we aim primarily at understanding (specific objectives) farmers’ productive factors, their relationship with forest management, fire-related concerns, and engagement in fire-reduction measures. A secondary objective relates to their potential interest in mechanisms recognising their externality in terms of fire security.

Among farm activities, we focus on wine growing and industry, as it emerges as a propitious sector to align with wildfire-related landscape interventions, for several reasons. First relates to its generalised economic profitability (in contrast with other crops): according to the EU Farm Accountancy Data Network Farm (FADN 2024) for 2022, the net added value of vine farms is the second following horticulture farms. Secondly, due to its globally well-structured institutions thanks to historical Designations of Origins (DO) and cooperatives. Thirdly, because its linkage to the surrounding landscape and its ability to transmit to the consumer key production characteristics: since beginning of 21st century, the wine industry is integrating the consciousness of landscape and “terroir” in its communication and sales strategies. Besides, in some regions, wine Designation of Origins participate in local planning policies -for example in France: the National Institute in charge of Designations of Origin development (INAO for its acronym) must be consulted for any modification in urban planning concerning farmlands within DO, as it is consulted for natural areas management (French Law of 9th of July of 1999). Finally, vines have been historically grown in fire-prone Mediterranean countries, and many famous vineyards have been developed in dry terraces, demonstrating its capacity of adaptation to tough soil and dryness sites. Therefore, vineyards adjacent to forests present interesting assets to be considered in planning fire risk management. Nevertheless, we lack knowledge on the wine growers’ and cellars’ interest and capacity to collaborate with forestry and risk management.

2. Conceptual framework

This work is framed within the Fire-Smart Territory (FST) concept, as defined by Leone et al. (2020:207): “FST is a territory with a shared governance model, in which empowered communities with high levels of knowledge and skills are able to decide and manage wildfire risk to keep it very low, through economic and social activities that not only can contain (in the end eliminate) wildfire hazard but promote the benefits of fire use”. Fire-Smart Territories initially emerged as an optimized risk-reduction management within the forest, emphasizing the integration of prescribed burning. However, the landscape spatiotemporal characteristics that affect fire behavior and impacts -the so-called Fire Regulation Capacity (Sil et al. 2019)- are also modulated by different land uses, entailing that agricultural plots play a relevant role in modifying fuel distribution. Hence, Fire-Smart Territories imply a wider territorial planning across the agriculture, stockbreeding, and forest sectors (Pulido et al. 2023). The recognition of the role of agricultural fields in the wildfire risk reduction is rather recent (Sil et al. 2019; Campos et al. 2022; Fu et al. 2023; Regos et al. 2023). Stimulating agriculture has been referred as an “indirect” strategy for wildfire risk reduction or a “bio-economy/rural development” approach (Wunder et al., 2021).

To operationalize the non-forest component of the Fire-Smart Territory concept, understanding the perceptions (awareness, fields of interest) and capacity for action (land rights, relationship with forests, assets at stake) of the respective land managers remains crucial -which constitutes a research niche. Abandonment of agricultural plots (especially those in mountainous areas, typically closer or surrounded by forests) has been driven by structural difficulties in mechanization, relatively lower productivity, lack of labor and land fragmentation -ultimately deriving in spontaneous forest expansion. Higher-order economic development drivers of forest transition are extremely difficult to reverse (Wunder et al. 2021) -thus the micro-level factors determining the maintenance (or even recovery) of farmlands in strategic areas for wildfire prevention is crucial for appropriately targeting any incentive mechanism.

As Fig. 1 shows, farmers’ decision-making relies on financial and non-financial factors (Hayden et al. 2021). Hence, profit generation, patrimonial maintenance, and/or social recognition from innovative or high-quality produce constitute decision-triggers, even if weighed differently by each farmer. Land managers choose whether to keep on farming in strategic parcels, invest in them or even expand their productive land based on positive financial balance meeting economic expectations, combined with particular interest in more ecological practices and/or maintaining cultural heritage (e.g. dry-stone walls, traditional varieties). In addition, farmers may implement productive operations that modulate the wildfire spread within their fields and adjacent forests, thus mitigating the risk for their produce. The resulting mosaic configuration will determine if moving towards a Fire-Smart Territory (in case of appropriate balance, location and management of farmlands) or a poorly fire-regulated territory (with continuous forest).

However, to adopt fire-smart decisions within their productive system, farmers may need to receive signs of their (social and internal) demand. We take then the perspective of disclosing who captures the benefits of the ecosystem services provided by the fire-smart mosaic. Market benefits derived from provisioning services are privately captured by the farmers, thus constituting a crucial economic incentive. This is complemented by other privately (within-property) enjoyed benefits of cultural (e.g. heritage, own recreation), and regulating (soil humidity, pest reduction) services. Landscape beauty can eventually also be captured by land managers through increased value added to their wines (Tempesta et al. 2010) or being themselves managing a rural tourism business -e.g. enotourism (aka wine tourism). However, mosaic landscape maintenance also produces relevant ecosystem services for externals -typically not captured by the land manager, such as scenic beauty (for nearby homeowners or external recreationists), community identity, or fire risk regulation.

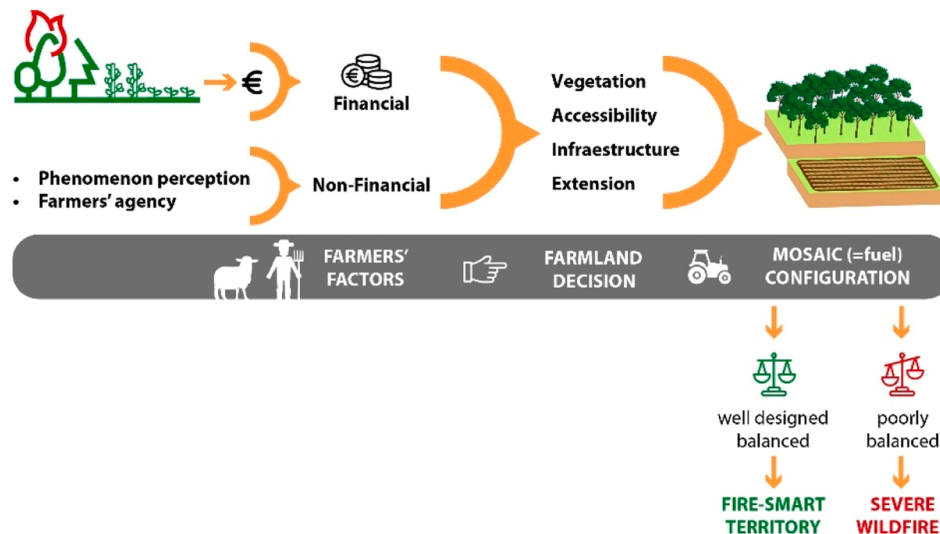


Fig. 1. Conceptual framework: from farmers' decision-making factors to landscape configuration and its consequent wildfire risk.

One potential economic mechanism for rewarding the externality effect of fire risk reduction is labelling marketable products whose production includes good practices in fuel reduction (Ascoli et al. 2023; Wunder et al. 2023). Indeed, Leone et al. (2020:209) proposed even a Fire-Smart Territory certification “to support and compensate individuals, communities and organizations for their efforts to reduce and maintain the fire risk at low levels”.

This paper investigates on the self-perceived role of farmers -particularly vineyard managers- as providers of the security service of wildfire risk mitigation, and their incentive factors. This information can guide policy and social interventions towards empowering farmers, increase their wildfire risk culture, and facilitate their economic activity. thus putting into practice the Fire-Smart Territory approach in Mediterranean Europe.

3. Materials and methods

3.1. Study region

Three European Mediterranean countries were targeted: Spain, France and Italy. Their selection follows: i) the vineyards significance (EUROSTAT 2022): altogether amount for 75 % of the European area under vines (910,859, 792,565 and 688,985 hectares respectively) and 38 % of production, and ii) wildfire frequency (San-Miguel-Ayanz et al. 2023). Complementing these three States, efforts were done to gather some observations from Portugal, owing to its relevance in wildfire occurrence and its rank as 5th in vine area (173,254 ha) -yet reaching fewer responses. Those four countries show variable degrees of private forest ownership (UNECE and FAO 2019), implying also a likelihood of landholders owning both forest and vines. This does not happen in Greece, which also faces significant wildfires, but its forests are 92 % publicly owned and its vineyards' extension is far smaller from the previous (103,058 ha). In all countries, farmers have no legal responsibilities in landscape management and their influence in landscape planning is limited -with the exception of France. In none of them, wildfire risk management include viticulture-related activities -beyond restricting burning of pruning residues during high fire risk days. Relevant exceptions constitute the Galician Model Villages (Wunder et al. 2023) or the Extremaduran Mosaic project (Pulido et al. 2023), both in Spain. In these States, agricultural and forestry supporting structures (extensionists, associations, administration) work in silos, and wildfire risk is so far not bridging them. Yet, incipient interest is being generated bottom-up through seminal workshops and articles in

specialised magazines. Indeed, some labels are emerging in e.g. Spain around extensive grazing (Soy-Massoni et al. 2022), which could be expanded to other agrarian produce.

3.2. Data collection design

This study follows an exploratory, semi-quantitative approach to depict the current situation, find preliminary evidence of common trends and potential heterogeneity across countries and land managers' characteristics.

To this end, an online survey was launched in spring-early autumn 2023 in five languages (French, Spanish, Catalan, Italian and Portuguese). The survey was distributed through professional networks and specialised technical magazines, and respondents engaged on a voluntary basis. The target respondents were mainly land managers (vineyard owners or managers), but a shorter version was also available for other value chain agents, namely wine makers, sommeliers, wineries, or Protected Designation of Origin (PDO) representatives. The view of value chain actors becomes fundamental as they can potentially transmit along the wine production and promotion the externality value through a prospective label.

The survey (Supplementary material #1) was semi-structured, containing mostly closed questions -to allow comparability across respondents- and a few open-ended spaces to capture also nuances and comments from the participants. Exploratory interviews (Darnay et al. 2022) feed the concepts underlying the questionnaire. The survey contained 6 blocks (see Table 1, 48 questions), covering the relationship with their landscape, in particular with their nearby forests and the wildfire risk and interest in a specific label and/or network reckoning the role of vineyards within the wildfire risk management. Respondents' concern on wildfire was captured through a 0–10 scale where they had to score their worry level on wildfire risk.

The target sample size was the maximum possible, reason for mapping country and regional stakeholders, and sending up to two reminders to networks and contacts' intermediaries avoiding viticulture busy periods (e.g. grape harvest). The survey was closed when further efforts lead to no additional responses. 323 responses were collected from the five questionnaires, out of which 161 were mostly (95 %) fulfilled: 101 from Spain (out of which 78 in Catalan), 40 from France, 14 from Italy and 6 from Portugal -see Fig. 2 and dataset (Górriz-Mifsud et al. 2024). Interestingly, a significant part of survey abandonment happened when arriving to the question on the property size. The wine region with more responses corresponds to PDO Penedès (Catalonia) (N

Table 1
Survey blocks and variables across Mediterranean countries.

Blocks	Variables
Demographics	Age, gender, location
Role within wine sector	Profiles
Productive factors	Rustic holding size Ratio of vineyards within the holding Wine tourism Stockbreeding in vineyards
Relationship with nearby forests	Land rights (ownership, rental, both) Forest size Ratio within the property Tree species Membership in land/fire management associations Forest planning
Relationship with wildfire risk	Sources of support Proximity of wildfire experience Wildfire risk mitigation measures Insurances Perceived hazard: wildfire concern [0,10] Perceived exposure: wildfire exposed elements Perceived vulnerability: wildfire severity
Demand for recognition and support	Interest in recognition of the fire regulation externality Interest in an externality label Current labels

understood that data saturation¹ was achieved given that responses represented the diversity and nuances of most of the subject variables (i. e. roles, sizes, wildfire experience, forest ownership, enotourism).

In addition, a dedicated workshop was conducted in October 2023, with key representatives of the wine value chain, particularly wineries and vineyard managers. This workshop served to collect qualitative information about potential explanations to the survey findings.

3.3. Data analysis

To address our research questions, this study followed an exploratory approach, thus focusing on the descriptive (univariate) analysis of the data to ascertain the overall trends of wine sector respondents across Mediterranean countries. To meet our general objective, bivariate analysis was performed to check potential correlations between wildfire concern and: i) enotourism, ii) ratio of forest area within their property, iii) nearby wildfire experience, iv) insurance adoption, and v) demand for support in wildfire risk management. The analyses were first run at an aggregated level (i.e. all countries) to ascertain broad trends across the studied countries. Descriptive statistics at country level and Kruskal-Wallis test were applied to detect significant variations in e.g. wildfire concern or land management -except for Portugal, where the insufficient number of responses limited feasibility of Kruskal-Wallis test. We highlight the country -specific differences to underscore the nuance of

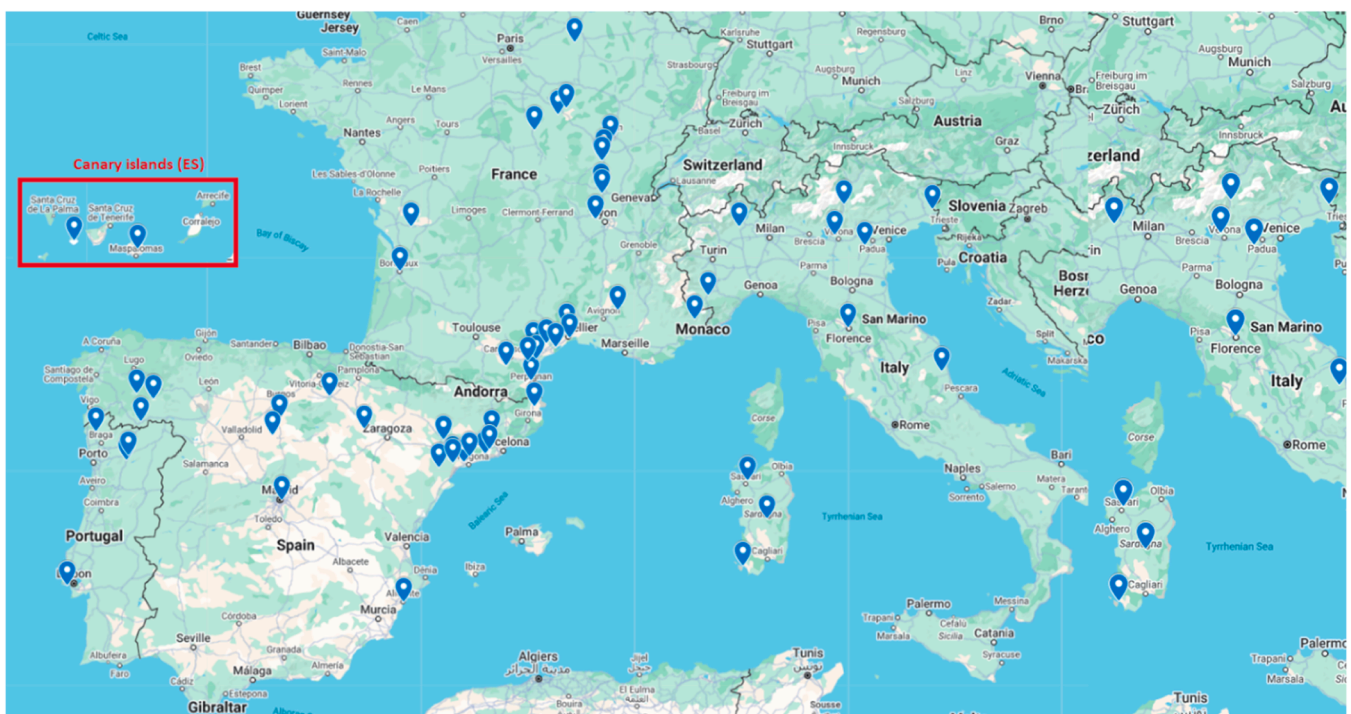


Fig. 2. Location of survey respondents. Source: own elaboration based on GoogleMaps.

= 40), followed by PDO Cava (N = 26), French regions Bourgogne and Languedoc (N = 8 each), and Valdeorras (Galicia) (N = 6). The differing rate of voluntary response per country and region probably reflects the uneven interest in this incipiently discussed topic -chiefly, consulted experts have confirmed the notable disconnection between farming and forestry in Portugal (pers. comm.). Being exploratory research, the sample size is a function of the purpose of the study and its complexity, rather than of statistical parameter (Francis et al. 2010). We then

the regions' findings.

4. Results

4.1. Demographic profiles and role within the wine sector

The sample consisted of mainly men (63 %), between 46 and 65 years old (53 %), followed by the group between 26 and 45 years old (35

¹ Sensu Glaser & Strauss (1967) referring to the point in data collection when no new additional data are found that develop aspects of a conceptual category.

%). France showed larger ratio of women (42 %), with Italy in the opposite trend (25 %) -see Suppl. Material #2 for further country-level details. No statistically significant evidence has been found between gender and other variables -i.a. holding size, fire experience, wildfire concern, preventive measures, or preferences for externality recognition.

As per their role, 48 % self-identified as wine producers, 33 % as wine growers, 18 % as representatives of wineries, 8 % as representatives of Designations of Origin, and 23 % as wine experts -each respondent able to have more than one role.

4.2. Farmers' productive factors

Three-quarters (N = 125) of our respondents reported managing some piece of rustic/non-urban land (the specific legal term differs across countries), either through ownership (69 %), ownership and rental (27 %), or uniquely rental (7 %) -with larger ratios of land ownership in Portugal (75 % own the land, N = 3), followed by Spain (69 %, N = 55), Italy (67 %, N = 8) and France (62 %, N = 18). Supplementary Material #3 shows the detailed country-level data.

The average land holding size reported has been of 88.4 hectares (median: 24 ha). The largest holdings corresponded to Spain (average: 98.9 ha, median: 25 ha, N = 80) -skewed due to the large Catalanian respondents, whose average is 121.1 ha, N = 62). France follows (average: 59.3 ha, median: 23 ha, N = 29), with Italy showing smaller holdings (average: 17.3 ha, median: 10 ha, N = 12). Portuguese replies contained extreme situations: one respondent of 1000 ha and another of 1 ha, N = 4; thus, being the average an inadequate indicator.

A large portion of the respondents declared counting with wine tourism as a side-activity: this is larger for France (53 % respondents, N = 16) than in Spain (45 %, N = 36). The findings for Portugal (50 %, N = 2) and Italy (75 %, N = 9) are to be considered carefully owing to the limited number of responses.

4.3. Relation between vineyard managers and surrounding forests

Vineyard holdings were reported to consist of mainly vineyards (61 % of their extension on average), 64 % respondents count also with other crops (covering 21 % of their property area) and 65 % encompass also forests (for whom those occupy 28 % of their area). The rest of the property was composed by constructions, winery, infrastructure for visitors, or fallow land -when applicable. Regional differences could be observed within Spain, where Catalonia displayed larger rates of forest land within the property (33 % holding area, N = 45) vs rest of Spanish respondents -where on average only 16 % (N = 15) of the area of the holding corresponds to forests. France and non-Catalonian Spain showed larger specialisation of vineyard holdings, with >70 % property area dedicated to vineyards.

The most frequently reported surrounding dominant forest tree species are, by far, "pines" (26 %, respondents could not detail further), followed by those able to distinguish *Pinus halepensis* (17 %), next by *Quercus ilex* (13 %) and *Castanea sativa* (6 %) -consistent with the Mediterranean area composition. Twenty-two percent recognised not knowing the tree species.

Among those land managers who also own a piece of forest (64 %, N = 80), only 24.7 % report counting with a forest management plan -less frequent for French respondents in comparison with the rest. Few land managers report having benefited from the forest wood: 68 % have not sold wood in the last 20 years, and among those who have traded, only 3.8 % (N = 3) declare having obtained positive gains -13.8 % declared that "sales covered the costs", thus neutral gains, and 15 % declared a net loss owing to harvest expenditures exceeding the sales. These trends are consistent across countries.

Forest Owners' Associations typically facilitate wood mobilisation-or at least related membership can be considered as a proxy of social capital towards forest management. Amongst simultaneous vineyard

and forest managers (N = 80), only 11 % are engaged in foresters associations. This proportion is, however, biased due to the sensible higher percentage of Catalan respondents who are members of a Forest Owner Association (16 %, N = 7), whereas French, Italian and Portuguese respondents show negligible ratios. In addition, 26 % Catalan respondents are members of a Forest Defence Group -which are associations of fire volunteers (Rodríguez Fernández-Blanco et al. 2022), this question was posed only to that subsample as per its regional specificity.

4.4. Fire-concerned vineyard managers

Part of our survey respondents declared concern about wildfires. Within a scale from 0 (not worried at all) to 10 (maximum concern), the average land manager reported 7.5 -in contrast to the 8.06 of non-farmers (winery or PDO representatives). Most Spanish land managers report a high concern (8.44, N = 80), followed by far by Portuguese (6.5, N = 4), whereas French respondents (6.07, N = 12), and Italians (5.08/10, N = 12) perceived lower risk in their areas. These differences being significant (KW H: 21.4296, p-value: 0.00002, N = 121 as insufficient responses from Portuguese land managers do not permit to include them in this analysis). Suppl. Material #4 illustrates State-level details.

We found a significant positive -yet weak- correlation between the part (%) of the holding dedicated to forests and the degree of wildfire concern (Pearson r: 0.2494, p-value: 0.005034) -Suppl. Material #7. No significant correlation was found between those producers involved in wine tourism and wildfire concern (Pearson r: -0.0575, p-value: 0.472635). Yet, this result differed when zooming into the countries (Supplementary material #5) with land managers from Spain showing an average larger concern if engaged in wine tourism (8.694, N = 36) than those without wine tourism (8.227, N = 44) -without significant differences observed (Pearson r: 0.0877, p-value: 0.439191). Land managers from other countries did not show such trend -even the contrary.

Twenty-six percent of wine growers reported having experienced a wildfire "on their own holding", and 32 % "in their municipality, valley or massif" (in contrast with 61 % of non-farmer respondents). Therefore, over half of our sample had some exposure to the wildfire risk. We cannot assess whether there was self-selection bias among respondents -which is plausible. No statistically significant differences were found across land manager respondents from Spain, France and Italy (Kruskal-Wallis H statistic is 5.9494, n-1: 2, N = 121, p-value: 0.05106) -Portuguese replies were too few for running this test.

A significant difference in wildfire concern for land managers was found depending on their prior wildfire experience (Kruskal-Wallis H statistic: 21.5341, n-1: 2, N = 125, p-value: 0.00002). By crossing the previous two questions we found an expectable higher concern (average: 9.3) of farmers reporting a fire within their holding, than those reporting a fire in the vicinity (average: 8.15) and those without any close exposure to wildfires (average: 6.05) - a trend that is shared across the analysed countries (see Supp. Material 6 and Fig. 3).

Indeed, 66 % respondents perceived that their property could be affected by a fire, because is located close to a forest or bush area. As this question pretended to capture the landscape configuration, the ratio varies across countries, with Portuguese, Italian and Spanish respondents showing between 70 % and 75 %, several points over the French (52 %) replies -38 % reported having their fields further away from forests. As exposed elements to potentially be burnt, 85 % report the farmlands, followed by far productive infrastructure (33 %), and inhabited houses (27 %). The exposed assets depend on the complexity and particularity of each property, so only some respondents report potential damages to animals (11 %), cultural heritage (22 %), and humans (15 %). Respondents acknowledge a high (30 %) or very high (12 %) risk that these assets will burn in the event of a wildfire reaching their property.

Yet only 20.2 % report counted with an insurance for the agricultural losses in the event of a wildfire (just 1.6 % stated the equivalent for the

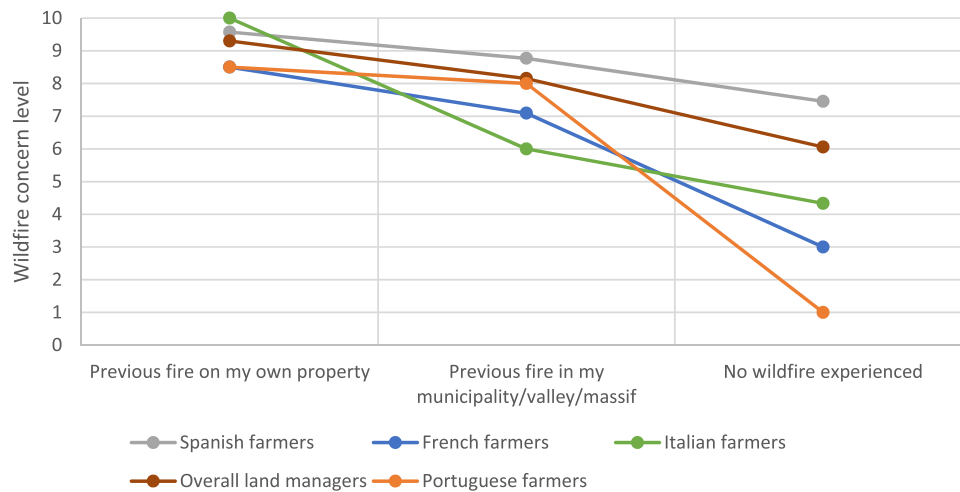


Fig. 3. Wildfire risk concern and previous fire experience of land managers.

forestry part), and 20 % for damages in houses. 30 % declared that their insurance covers other type of calamities, and 38 % acknowledged not counting with any insurance. No correlation was found ($p\text{-value} > 0.05$) with the perception of wildfire risk -thus the insurance adoption depending on other factors.

The workshop revealed three main reasons for wildfire concern among wine sector representatives:

1. potential losses in their yields (burnt grapevines) or in the organoleptic characteristics of the grape due to the smoke taint,
2. potential reduction of their scenic beauty linked to their wine tourism and marketing,
3. general awareness and attachment to their territory.

Among land managers with a forest management plan, 70 % (N = 24) indicated that such plan includes wildfire prevention measures. Despite the limited size of this subsample, some trends can be found. First, all those reporting awareness of fire prevention measures hold a preoccupation level over 5 -meaning that those who are less worried (<5) do not even know about preventive measures affecting their plots. Seventy-five

percent of them report having the measures implemented, with two indicating they did not have time because these were too recently planned, another was in the process, and finally other argued that their cost is excessive. Respondents from Spain (80 %, N = 12) and France (71 %, N = 5) are those executing at least part of the planned fire risk mitigation measures.

From a wildfire risk reduction perspective (Table 2), it can be observed that most frequently reported measures fall in self-protection of assets and the so-called “pre-suppression” strategy -which primarily facilitates the response. These were the establishment a security buffer without biomass around buildings and infrastructure, and road maintenance for the firefighters’ access (59.3 % both). Other pre-suppression actions were water pools for firefighters (33.3 %), and only in a few cases the establishment of firebreaks (11.1 %). As “prevention” (strictly speaking this is avoiding the ignitions), it is relevant that one-third-of the subsample were careful with the potential sparks stemming from their running activity -i.e. machinery. As “preparedness” measures which modify fuel distribution, 44 % reduced biomass within the forest as thinning or shrub cleaning, or applied prescribed burning (30 %); with near one-third-reducing the rests of pruning activities (33 %) and

Table 2

Frequency of the wildfire measures included within the rustic property where the vineyard is located according to their role within the wildfire risk management phase (multiple answers possible). % within land managers with wildfire prevention plan.

Wildfire risk phase	What measures does your property’s prevention plan include?	Overall		Spain		France		Italy		Portugal	
		N = 27	%	N = 15	%	N = 7	%	N = 1	%	N = 4	%
Pre-suppression	Security perimeter without vegetation around buildings and facilities	16	59.3 %	9	60.0 %	6	85.7 %	0	0.0 %	1	3.7 %
	Maintenance of roads for firefighters access	15	55.6 %	9	60.0 %	5	71.4 %	0	0.0 %	1	25 %
	Water points/reservoir for firefighters	9	33.3 %	6	40.0 %	3	42.9 %	0	0.0 %	0	0.0 %
	Firewall	3	11.1 %	2	13.3 %	1	14.3 %	0	0.0 %	0	0.0 %
Prevention	Watch out for machinery that can cause sparks on days of high fire risk	9	33.3 %	7	46.7 %	1	14.3 %	0	0.0 %	1	25 %
Preparedness	Reduction of branches, bushes or tree density	12	44.4 %	10	66.7 %	1	14.3 %	0	0.0 %	1	25 %
	Shredded pruning waste	9	33.3 %	8	53.3 %	1	14.3 %	0	0.0 %	0	0.0 %
	Prescribed burnings	8	29.6 %	5	33.3 %	3	42.9 %	0	0.0 %	0	0.0 %
	Activation of abandoned agricultural plots or in forest areas in strategic areas to stop or slow down the spread of fire	6	22.2 %	6	40.0 %	0	0.0 %	0	0.0 %	0	0.0 %
	Extensive livestock farming to reduce bushes (controlled grazing)	2	7.4 %	2	13.3 %	0	0.0 %	0	0.0 %	0	0.0 %
I don’t know	5	18.5 %	0	0.0 %	0	0.0 %	1	100 %	4	100 %	

some also acting in farmlands by establishing new crops in abandoned plots or strategic areas (22.2 %). Use of extensive livestock was only punctual (7.4 %). Table 2 shows that respondents from Spain contemplate more fuel reduction while in France security perimeter and fire-fighters' roads dominate. Prescribed burning is only reported by a few French and Spanish managers, and controlled grazing and recovery of abandoned land is captured in Spanish replies. Most respondents from Italy and Portugal are unaware of any planned wildfire measures within their property.

In some countries/regions, wildfire prevention measures are not mandatory, but there is higher-level wildfire prevention plan. Requested about the awareness of such higher planning that would encompass their property, only 20 % indicated the existence of such plan, 52 % stated that there is no plan covering their land, while 28 % recognised not knowing about it. 60 % of Spanish respondents and 58 % of Italian ones think there is no such supra-property prevention plan, in contrast with 31 % of French managers -see Suppl. Material #4. Instead, 24 % of French managers, 19 % of Spanish wine growers, and 8 % of the Italian ones are aware of such plans.

When asking about their acquaintance with financial management to facilitate forest management, only 11.3 % (N = 9) confirmed having benefited from them, 15 % knew of these aids exist but had never used them, 19 % were unsure about their existence, and 55 % were not aware of such aids. Spanish respondents show larger awareness of such aids (35 %), and indeed larger ratio of usage (15.4 %). Unawareness of such aids is more acute for Italian (90 %), French and Portuguese forest owners (67 % both).

4.5. Interest in wildfire risk reduction support and in a fire-smart produce label

Requested for their interest in receiving a specific support for implementing wildfire risk reduction measures, on average 46 % respondents declare interest in financial support, followed by technical support (41 %) -see Fig. 4. Spanish respondents shape the sample trends in this regard, as they are more numerous and tend to demand more support (especially financial). French respondents are more inclined towards no requesting support and are particularly less interested in networking for knowledge and concern sharing. On the opposite, Italian respondents pointed their largest interest towards the networking. A positive but weak correlation is found between concern on wildfire occurrence and aggregated demand for support (of any type): Pearson r : 0.4065, p -value < 0.00001.

Next, the survey explored the current experience with labels, to move afterwards to the new proposal. Thus, it inquired the typology of labels that producers were already employing. Respondents indicated mainly the Protected Origin Designation (73 %), followed by organic agriculture (48.6 %). PDO is predominant among French respondents (85 %), followed by Spanish (72 %) and Italians (50 %). Organic farming

prevails among Spanish wine growers (63 %), with France and Italians respondents showing significantly lower rates –22 % and 12.5 % respectively. Other less frequent labels have been biodynamic agriculture (16.2 %), sustainable tourism (9.9 %), sustainable forest management (7.2 %, which concentrates in Spain), ISO (6.3 %) or EMAS (Eco-Management and Audit Scheme) (1.8 %). Eleven percent declared not counting with any label. Italian respondents exhibit the largest ratio of biodynamic labelling (25 %), followed by France (18.5 %) and only incipiently in Spain (16 %). Suppl. Material #8 displays the country-level details.

Producers engage in these labels mainly to reinforce their product (70 %), and to boost their visibility (49 %). Other reasons seem to be more secondary or case-specific: to have access to subsidies (28 %), to get recognition from the administration (20 %), to raise sales (19 %), to increment their product price (23 %), or to increase visitors (11 %). Such overall trend is followed by Spanish and French respondents (Suppl. Material #8), whereas Italians give the largest prominence to the greater visibility (71 %, N = 5) and Portuguese expect a larger price (67 %, N = 2).

According to our sample, the recognition of the wildfire risk reduction role of agricultural fields would be preferably realised through public aids (58 %), through social recognition (53 %) while 23 % would like to capture it through the sale of the agricultural produce -see Fig. 5. The demand for public aid is more acute for respondents from Spain (68 %) and less intense for French ones (37 %). The largest support of French respondents (48 %) falls in the willingness for a social recognition of this risk reduction role. Near 11 % of the sample do not see relevant any recognition as they do not perceive anything new in this role. Besides, 13 % do not have a clear opinion on this matter.

We requested about the potential interest in a label that would make explicit the role of the fire-mitigating management of farmlands where their produce comes from (Fig. 6). Near one-third-(30 %) of all respondents did not have a clear position, whereas 35 % were in favour of the new brand to recognize their effort in this area. Spanish respondents were especially prone to a label that recognises their effort in this matter (40 %), followed by the recognition of their socio-environmental corporate responsibility (35 %). Overall, the respondents did not expect to improve their sales through such label (only 6 %). The most relevant negative predisposition towards the label stemmed from the current excess of labels (23 %). French respondents seemed to be the most sceptic regarding the proposed brand (34 % by aggregating both negative answers), owing to their low rates of interest and high hesitance (45 %). 23 % respondents had a negative attitude due to the extra effort this would imply for them.

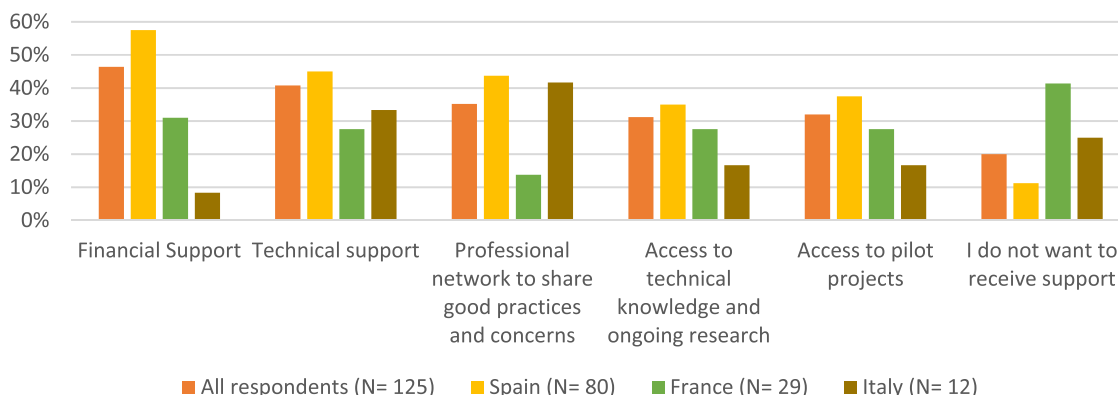


Fig. 4. Wine growers' interest in receiving support for fire prevention - per respondent country.

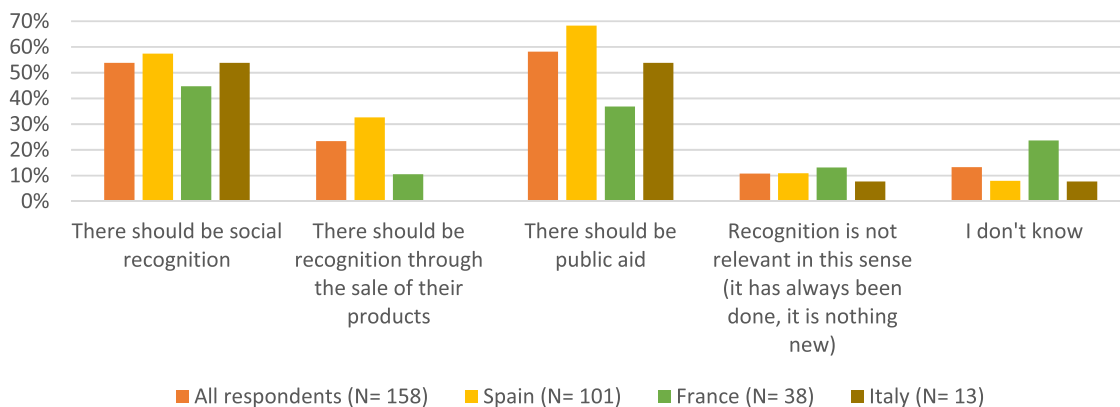


Fig. 5. Wine growers' and non-farmers' responses (disaggregated at State level) to the question "Following the recent forest fires, there is narrative of recognizing and/or encouraging the tasks of prevention of wildfire damage caused by some agricultural producers through the implementation of good practices (forest management, recovery of crops in areas strategies, grass and cereal mowing management, innovations in soil management.....). What do you think?". More than one option was possible.

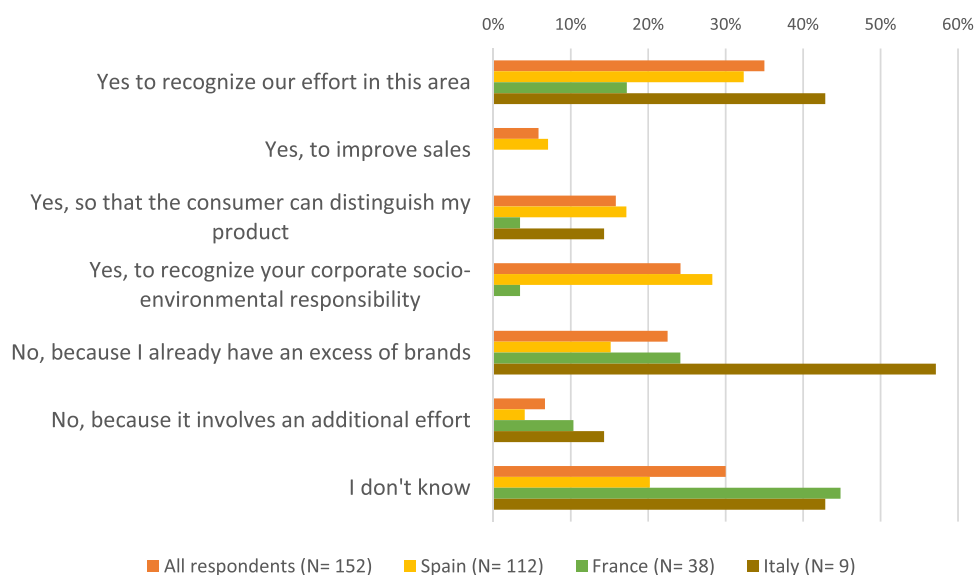


Fig. 6. - Responses to the question "Would you be interested in incorporating a brand to distinguish agricultural products that implement good practices in fire prevention into your company/products?".

5. Discussion

5.1. Wine sector role and position regarding fire risk

Our study has gathered evidence from two groups of respondents: those managing directly land (N = 125) -and thus potential contributors to wildfire risk mitigation, and non-farmers (n = 36) that can promote fire-smart produce through their value chain role. Thus; this section provides valuable insights into the self-perceived role of vineyard managers in wildfire risk mitigation.

Despite being land managers, interestingly, we find a trend to self-identify with the most advanced role within the wine value chain. This is, even allowing for multiple selection of roles, 61 % land managers do not disclose their role as wine growers because they also work as either wine producers, winery or PDO representative, or wine expert. Wildfires affect and can be affected differently according to those roles. Wine producers avoid grapes affected by smoke taint (Brodison 2013), and particularly those engaged in wine tourism have intrinsic incentives to invest in surrounding scenery maintenance. Winery representatives, instead, focus on marketing objectives, being aware of the messages each consumer type may require and label feasibility. PDOs, in turn,

follow the incentive of the common good for their club members (Torre 2006). Therefore, PDO representatives gather a holistic overview of their territorial context allowing them to focus on the challenges and opportunities for vineyards in the fringes. Land managers simultaneously counting with multiple perspectives can plan their farmland interventions considering different market demands -sensu Goncharuk (2017): from marketing (e.g. labelling) to landscape aesthetics (e.g. enotourism). Vineyard managers, hence, represent multifaceted actors with a comprehensive view of the land that, which enables a more integrated approach to land management, including wildfire risk mitigation. However, the current institutional agriculture-forestry divide is reflected in vineyard managers' disconcert on which could be their role in fire mitigation, impeding effective strategies. Notwithstanding the efforts done to reach wine cooperative members, we acknowledge they are not well represented in our sample -thus probably requiring a different approach channel in future research.

Our sample counts with self-selection biases due to the voluntary character of the survey. Few answers arrived from wine regions with negligible contact to forests – the so-called “vineyard seas”, usually located in plain areas, e.g. Cariñena, Rioja, Castilla la Mancha. Such bias does not limit our findings given that our target is just land managers in

the periphery of the vineyard extension or located in rural areas with farmland abandonment process -who are those with a potential effect on the fuel discontinuity. Therefore, the identified trends constitute interesting insights for policymaking, insofar as they provide hints on incentive design features for the fire-relevant land managers. Our sample is also skewed towards medium and large winegrowers, given that our average respondent's vineyard area exceeds by 4 times the French (10.55 ha) and the Italian (2.28 ha) mean size, and by 32 times the Spanish mean (1.88 ha) (EUROSTAT 2022). Despite this, our results still hold true given that precisely the landowners with larger properties are those potentially combining agricultural with forest ownership, and therefore key for a comprehensive landscape management.

Our sample includes responses in new fire areas in Europe -as shown by the French responses in Burgundy. These illustrate the emerging interest on the wildfire topic -as these events, despite still very minor in magnitude (10 and 18 hectares in 2022 and 2023 respectively) are relating with increasingly often heatwaves.

Wine tourism differs by country, leading Italian and French respondents. Wine and gastronomy tourism were introduced in France and Italy first in 1930's, with its boom in the 21st century deriving from a strong public support - see Lignon-Darmaillac (2009) for France. Thus, this complementary revenue is more consolidated in those countries than for the Iberian producers. Our survey results display that wine tourism's impact on wildfire awareness varies by region, with only respondents from Spain more sensitive to fire risk. We suspect this relates to the lower number of observations from the other countries, and their concentration in non-traditionally fire-prone areas (e.g. in French Bourgogne), or rather to the strong dependence on those revenues in tourism-heavy countries -e.g. Spain. More observations from Portugal, Italy and France would be required to confirm this trend, as the wine tourism has an a priori business interest in maintaining a green, appealing cultural and natural scenery to show to their visitants -hence more favourable towards few, low-intensity fires. Moreover, wine tourism often implies dedicated investments (i.a. reception, tasting, or shop building, personnel) that could be endangered by wildfire risk. Hence, vineyards with enotourism in fire-prone areas are likely more inclined to adopt fire-smart practices that contribute to the maintenance of scenic landscapes, thus blending fire mitigation strategies with tourism development.

Our Spanish respondents lead the awareness of supra-holding risk management plans, as well as the implementation of its foreseen practices. Spain does indeed show relatively more wildfire events than France and Italy, which represents a plausible reason for a stronger institutional framework. For instance, wildfire defence plans (DFCI by its acronym) are mandatory uniquely across southern France (article 1-133.2 of the Forest Code) whereas in Spain all municipalities must have similar plans (Royal Decree 15/2022) -covering thus all wine producing regions. Nevertheless, all the studied States share the increasing wildfire impacts aggravated by the agricultural land abandonment (Perpiña Castillo et al. 2018), offering opportunities for cross-country cooperation in this realm.

5.2. Wine growers' land ownership and use

Our respondents predominantly own the parcels they work. Secure land rights implies a long-term attachment with the land use, which allows for adaptive capacity and is thus favourable for risk perception and related mitigation practices (Jabbar et al. 2020).

Respondent land managers report predominant vineyard area, with a subset owning also some forest extension -particularly larger landowners. Our sample included few small vineyard managers. This profile remains more difficult to identify and to motivate to fill in voluntary surveys, especially if they have alternative (e.g. financial) concerns to thrive in their business. In addition, they are less likely to hold forests, and their individual contribution to the fire risk reduction is limited -see Fu et al. (X. 2023) as reference for minimum buffer areas for effective

fire behaviour modulation. Yet, in some wine regions (e.g. northern Portugal, Galicia or Bierzo) micro-plots of vineyards dominate, and thus a strategy to mobilize and to spatially coordinate them for effective wildfire reduction is crucial, despite the more demanding efforts to catalyse larger number of (sometimes vulnerable) people. Mechanisms that strengthen local social capital and articulate collective action are thus recommended. France shows interesting examples of foresters' syndicates specific for wildfires (e.g. ARDFCI in Aquitaine). The process for establishing Authorised Syndicate Associations (ASA) or Official Syndicate Associations (ASCO) is complex, but its mandatory membership ensures spatial aggregation. Yet, they do not bridge the agro-forest divide. Instead, the Catalan Forest Defence Groups allow membership for any inhabitant, being mandatory a minimum ratio of forest owners (Górriz-Mifsud et al. 2019). The Portuguese AGIP (Integrated Landscape Management Areas) fall in an intermediate status (Cunha et al. 2024). Such models could serve as inspiration for social innovations involving also farmers and any volunteer in massif-level fire risk mitigation, and consequently increase community resilience (Rodríguez Fernández-Blanco, 2022).

5.3. Vineyard management and forest integration

Our findings show the potential interlinkage between the wine sector and the wildfire risk management domain insofar as the first manage (directly -wine makers- or indirectly -through the wine production/market and wine tourism) an interface between woodlands and farmlands.

Yet, our survey reflects an apparent disconnection between the wine and forestry sectors. While vineyard managers often own forests or border forested areas, their awareness of forest management practices relevant to wildfire risk reduction is limited. The predominant vineyard land use specialisation of the respondents may lead to sustainability improvements in focused uniquely on within-property ecosystem services, overseeing the cross-boundary effects (Tahon and Batt 2021) -including the management of green cover during the dry season or forest islets. This sectoral fragmentation calls for policy interventions that break down these silos and promote integrated management strategies across agriculture and forestry sectors.

Some country-level trends are to be considered when designing policy interventions adapted to each setting. Spanish respondents reported larger rustic parcels and forest share -chiefly in Catalonia. Instead, Italian and Portuguese wine growers exhibit more fragmented holdings. The larger the holding, the more likely is to include some (or larger) fragment(s) of forest. The specific fragmentation of farmland and the fact that the holding contains or not also forestland depends on the historical patterns of each region -e.g. inheritance laws, maintenance of feudal property schemes, agrarian specialisation, natural afforestation after phylloxera (Cervera et al. 2017). Balancing vineyard specialisation with sustainable forest management represents an opportunity for ecosystem resilience, while also a challenge, particularly for smaller land managers. Therefore, policies to encourage farmers' awareness of wildfire risk require adaptation in its messages and complexity to the forest-vineyard acquaintance.

Differences have been detected across regions regarding the wine sector respondents on the perceived wildfire risk, with respondents from Spain scoring higher concern. Fire-derived losses are perceived to concentrate on grape production. Rochard (2024) has identified the wildfires' impacts on vineyards, which are coincident with the reasons for concern expressed by our workshop participants: smoke taint and reduced scenic beauty, while he also adds the chemical effects of salt water and the fire retardants discharged from hydroplanes. The amount of assets exposed to wildfires (vineyards but also infrastructure and others) could be a reason for counting with insurance, but our findings indicate that this is not the case. The identified low insurance ratios are aligned with low penetration of insurance services in the agricultural sector, and more acutely in the forestry domain. Similar results are

found in Australia, where high concern levels do not necessarily lead to more insurance adoption (Eriksen and Gill 2010). This situation leaves the farmers very vulnerable in the wildfire contingency, yet careful attention is required to the requested premiums, the indemnity offers, and the risk aversion of farmers.

The survey revealed that practices currently adopted that reduce the fire risk concentrate in pre-suppression. These have limited effect in reducing fuel accumulation and consequently affect the fire behaviour and its severity. Fire-smart landscapes would rather focus on preparedness (i.e. biomass reduction) measures, where vineyards can play a strong role in disrupting the horizontal fuel continuity by maintaining a mosaic. Such disruption may take place by either maintaining current farmlands or changing land use from forest to farmlands -particularly in strategic areas for fire responders' attack (Finney 2001; Bertomeu et al. 2022) or to protect the Wildland-Urban Interface (X. Fu et al. 2023). To determine whether vineyards locate in strategic areas, mapping those is a necessary region-specific task, as per the dominating winds, topography, location of population and critical infrastructure, and other potential social values (Krsnik et al., 2024). Other fire-smart farmland management actions could be the reduction of soil vegetation interlines when it dries, thinning, or technical grazing, which modify the fine fuel availability in summer and thus affect the fire behaviour. Thus it may occur that the concerned land managers apply routine practices that contribute to risk mitigation as part of their farming culture -as found in Australian livestock producers (Smith et al. 2015).

Further, our study identifies a gap in the integration of wildfire risk mitigation into vineyard management practices. While some vineyard managers with forests already implement practices such as thinning and biomass reduction, the majority are not engaged in strategic forest management due to low profitability from forest plots. In Mediterranean regions, forests often yield minimal financial returns, which diminishes incentives for landowners to adopt sustainable forest practices -particularly when the dominant tree species (*Pinus halepensis*) shows a low market price, but silvicultural works imply high operational costs (Górriz-Mifsud et al., 2016). Thus, policies targeting financial incentives and education programs for vineyard managers could help bridge this gap and encourage more proactive forest management.

These financial factors affect the conception of the forest piece either as "a cost" -i.e. when no generating net benefit- or a self-sustaining component of the property -i.e. profitable "enough". Based on Domínguez & Shannon (2011) dimensions for private forest management decisions, our findings would categorise the mixed (predominantly vineyard) land managers as showing limited profitability (with lower than expected revenues, "a complain") and more likely to engage in risk mitigation measures when showing higher wildfire concern ("a fear"). To guide their potential forestry proactivity, they would need "an archetype to follow" (Domínguez and Shannon 2011) to engage in preventive silviculture -as shown by respondents' interest in technical information on this matter. This is crucial as per their limited integration within the forest sector -e.g. low rates of membership in forest associations.

5.4. Financial mechanisms and the fire-smart produce label to recognize fire-mitigating efforts

Missed opportunities for active forestry are shown by only one fourth of forest management planning, especially in our respondents' medium-to-large properties. Broader adoption of forestry planning among farmers and collective action initiatives are encouraged to reduce wildfire risk and generate supplementary income. Wine growers holding forests could be nudged towards making use of existing silviculture supporting mechanisms. In the European Union (EU), existing financial aids usually derive from the measures co-funded by European Agricultural Fund for Rural Development (EAFRD) articulated through the corresponding national or regional Rural Development Plans. Many countries adopt specific measures for promoting sustainable forest

management (6502.1 for the 2020–2027 programming period, and 8.5 for the 2014–2020), and wildfire risk reduction (6881.2 for the 2020–2027 period, and 8.3 for the 2014–2020). In Mediterranean EU regions, these measures are typically offered to land managers. Yet, the extended unawareness on the existence of such financial support indicates that the vineyard managers are frequently distant from the forestry domain. This may relate to their (lack of) interest but can be also closely associated to the lack of extension services for technical advice. In addition, subsidies stimulating green farming practices could include lines or criteria that align with wildfire risk mitigation practices, at least in fire-prone areas.

Making strategic areas for fuel discontinuity as profitable farmlands would be an ideal. However, land use change for installing new vineyards in the European Union is constrained by the maximum allowed allocation per Member State (after the EU Regulation No 1308/2013). But if there was no such limitation (which occurs for other crops), sunk costs for breaking up the ground in currently high-fuel loaded parcels, and the probable lower soil productivity of such lands imply an opportunity cost -with economic balance being even negative in some cases. Productivity in such strategic zones is even more aggravated by the fact that farmland largely adjacent to forests is more impacted by roe deer and wildboar losses -implying defensive costs. These arguments would ground a financial support to incentivize vineyards in less attractive, yet fire-strategic areas which would acknowledge the positive externality of this regulatory ecosystem service provided to society.

Such financial incentive can rely on public or market mechanisms. Focusing on innovative, private-driven options, our survey explored the acceptance of a "fire-smart" certification. Labelling is a mechanism to distinguish a produce from potential substitutes, hence guiding the consumer choice, and justifying a price bonus. If such bonus compensates the additional costs of farming in less profitable areas, wine growers would be encouraged to maintain -or to even plough new fields. In this model, productive fuelbreaks would be maintained (at least partly) through market mechanisms via the produce revenues (Wunder et al. 2023). The introduction of a fire-smart produce label could serve as a promising mechanism to incentivize vineyard managers to adopt wildfire mitigation practices. The wine sector is susceptible to participate in a wide portfolio of labels, which adds to the bottle tag information (e.g. brand, type of grape, geographical origin). Our respondents actively participate in labelling. While around 13 % in Italy, 14 % in France, and 15 % in Spain of the total vineyard area is under organic production (OIV 2021), our respondents report higher ratios. This reveals that our sample was somehow biased towards highly environmentally concerned producers. Comparability of the other analysed labels remains difficult because they are specific to the vineyard characteristics, e.g. whether the holding also includes forests, or has sufficient entity to also include wine tourism activities. Our study finds rather that respondents from Spain, Italy, and France showed varying degrees of interest in the proposed fire-smart label, with Spanish producers exhibiting the most enthusiasm. This suggests that there is potential for a market-based solution to encourage fire-smart practices, particularly if the label can be aligned or integrated with existing certifications. The hesitance regarding this label probably stems from the already wide portfolio of wine labels. Our interpretation is that wine producers anticipate that either the consumer is not able to handle an additional set of information in the bottle, or the distinction regarding wildfire is not going to be valued more than other pre-existing labels. Indeed, food consumers tend to value PDO stronger than organic certification, having carbon footprint as the least ranked (de-Magistris et al. 2017). For beef and lamb meat consumers, Lecgeui et al. (2023) found that origin proximity was valued more than the typology of pasture, and that indicating pasturing for wildfire mitigation did only imply minor additional value than pasturing in forests. Therefore, being the wine sector with abundant certifications, any new label must prove its value to consumers and producers, particularly in terms of environmental benefits and market differentiation. The wildfire risk mitigation label

would need to find its niche within the consolidated ones (e.g. PDO, organic) or other emerging pro-environment labels (e.g. High Nature Value farming, the French Label Bas Carbon). The risk of consumers weighting pre-existing labels higher than the wildfire prevention role may stem from the fact that the taste is not necessarily related to the risk reduction benefit beyond the vineyard – thus this public good value is altruistic. Producers may then foresee that price- and taste-sensitive consumers are less likely to consider such variable in their purchase choices. However, the ultimate taste experience of the consumer is modulated also by the information received regarding that wine. Hence, the success of the fire-smart label would likely depend on consumer education and awareness, as well as the support of specialized retailers who can train customers to decode the label meaning (Kaczorowska et al. 2019). These findings indicate the need for further exploring the wine consumers' profile to disclose the target market for this label, as it was done for lamb meat from wildfire prevention buffer grazing (Soy-Massoni et al. 2022). Indeed, labels are then seen by our wine sector respondents more as a distinction feature rather than a market tool to increase their quantity or price, at least in the short run. Beyond direct market bonus, or complementing them, such distinction may be thus seen as opening opportunities to become prioritised in public funds fostering pro-environmental production systems. Such combination may become a realistic approach to combine new private and traditional public revenue channels to finance resilient landscapes.

6. Conclusions

Through a survey, the relation of wine sector actors -particularly vineyard managers- with wildfire risk has revealed policy-relevant features for operationalising fire-smart territorial strategies. Vineyard managers are key to wildfire risk mitigation, particularly in Mediterranean regions where agriculture meets forests. Integrated vineyard and forest management offers significant opportunities to reduce wildfire risks and enhance landscape resilience. However, sectoral fragmentation, limited financial incentives, and lack of awareness hinder effective integration.

Wine growers showing larger concern of wildfires locate closer to forests, count with forests in their holding, and have experienced prior wildfire occurrence in their property or its vicinity. Spanish respondents report larger rustic land area, more propense to contain forests, show stronger wildfire concern levels and implement more mitigation measures. Instead, French and Italian wine growers are more engaged in enotourism and show the lowest fire concern. French lead in vineyard specialisation. Spanish and French wine growers show the highest rates of forest management planning and are more aware of fire prevention planning. The differing fire concern levels across countries suggests the need for country-specific wildfire risk management strategies, tailored to the specific fire risk culture, challenges and administrative (e.g. property size) settings. Cross-regional collaboration could enhance wildfire preparedness by sharing best practices.

Sixty-five percent of respondent wine growers also hold forests, which on average occupy between 25 and 40 % of their property. This ratio varies from near 40 % in France to 83 % in Italy. Our survey respondents indicate that their forest parcels tend to be managed with lower intensity – due to limited knowledge, and/or profitability. Their scarce forest management planning implies that targeted awareness raising, and technical support is required, particularly in strategic zones for wildfire spread. In holdings nearby forests, the agricultural produce as well as related infrastructure is exposed -yet, our respondents report negligible insurance coverage and limited knowledge on how to mitigate the wildfire risk.

This sectoral fragmentation calls for policy interventions that break down the agriculture and forest silos and promote effective fire risk strategies that incorporate productive landscapes. While only a small portion of more fire-concerned wine growers are aware of wildfire prevention plans and their measures, those are mostly implementing

them. Still, these reported measures are skewed towards pre-suppression infrastructure, whereas fire-smart territories may require vegetation management. Fuel-reducing actions are generally costly, and likely not recovered through the mainstream wine produce price. Financial mechanisms such as subsidies and technical assistance are necessary to support vineyard managers adjacent to forests in adopting wildfire mitigation practices. The format of such incentive could be a fire-smart territory label, that could entail monetary benefits from public administration and wine consumers, but also social recognition. Italian respondents are less keen to an additional label, and jointly with the French they do not foresee improvement of sales. Instead, Spanish wine actors show more enthusiasm for such differentiation. The mixed reception of such fire-smart label underscores the crucial involvement of wine stakeholders in its design and promotion, as well as to define its niche within the current wine certification portfolio. This will ensure label acceptance -perceived as rewarding and not burdensome- and effectiveness while adapting to the heterogeneous wine sector realities along Mediterranean countries. Policies to educate consumers and ally with retailers would enable the label viability. A coordinated, landscape-scale approach to risk management will reduce wildfire risks and build more resilient Mediterranean landscapes.

CRediT authorship contribution statement

Elena Górriz-Mifsud: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Funding acquisition, Conceptualization. **Soazig Darnay:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Funding acquisition, Conceptualization. **Marc Rovellada Ballesteros:** Investigation, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Elena Górriz-Mifsud, Soazig Darnay and Marc Rovellada report financial support provided by European Commission. Soazig Darnay reports financial support was provided by European Commission. Marc Rovellada reports financial support was provided by European Commission. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.tfp.2025.100835](https://doi.org/10.1016/j.tfp.2025.100835).

Data availability

We have shared the data through the ZENODO repository, see here DOI: 10.5281/zenodo.14202743

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