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Practitioner Perceptions of Wildland Fire Management across South Europe and Latin America

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Abstract: Wildfire presents a challenge to natural resource managers the world over, and the intentional setting of fires can be used to alleviate some of the challenges associated with wildfire management. Prescribed burning can be used prior to wildfires to reduce fuel loads and promote ecological integrity in fire-adapted systems, while suppression burning can help firefighters control the direction, extent, and intensity of wildfire behavior under extreme conditions. In both cases, the success of intentional fire use depends on training, knowledge, experience, and institutional and social support. The influence of these factors can significantly impact whether fire use is perceived as positive or negative, increasing or decreasing, and whether managers are supportive of its incorporation into their management planning and decision-making. Perceived impediments to fire use are likely to differ based on location, level of training and experience, and even the social context of fire management specific to different job positions in natural resource management. In order to explore how managers and stakeholders across the world perceive fire use, we surveyed over 700 respondents from 12 countries and three continents. This study represents the largest survey of perceptions on managed fire use ever conducted. Perceptions differed across age categories, job positions, and regions. Countries or regions with larger amounts of wildfire area burned tended to be more supportive of fire use for suppression, while countries with less wildfire had less positive perceptions of fire use for either prescribed or suppression burning. Bureaucracy and social perceptions were identified as impediments to using prescribed fire prior to wildfire occurrence, but neither were identified as impediments to fire use during suppression procedures. Across the countries, fire use in suppression was viewed more positively than prescribed fire use prior to wildfire occurrence.

Keywords: prescribed fire; wildland fire; suppression burning; counter fires; fuels management; fire severity; fire use perception

1. Introduction

Wildland fires play an integral role in numerous ecosystems globally [1]. However, fire regimes have changed throughout history, mainly due to changes in human activities and climate [2]. Humans modify landscapes by changing fuel loads and continuity [3], and climate warming now provides more frequent extreme weather conditions [4,5]. Large fires are a threat in many areas, including South Europe, Australia, and North and South America, and cause significant annual losses in terms of human lives, environmental damage, and economic disruptions [6].

The use of prescribed fire is one option for landowners and managers to reduce the negative consequences of wildland fires [4,7]. Prescribed burning can be used to decrease fire risk or fuel load, to

modify fuel structure and distribution of fuels across the landscape [8,9], to perpetuate native ecosystem community assemblages [10], and to manage habitats for grazing [11,12]. Across much of Europe, pre-industrial fire regimes were associated with farming land use and low-severity burning [13]. The decline in rural farming and rural population densities, along with large-scale afforestation and lack of forest management has led to pronounced increases in fuel loads, and therefore fire risk [1,13]. Prescribed burning is a potential management tool which can be used in such areas to reduce these impacts. In many cases, fire-adapted biological communities are promoted by the use of prescribed burning, imbuing the practice with overall ecological benefits [1,11,14].

An alternative type of fire use is broadly defined as "suppression burning", which includes various techniques for applying fire (e.g., often referred to as burnout, back firing, line firing, counter firing, and strip burning) to help control wildfire behavior. Although the control of wildfire spread and/or intensity is the primary objective, the application of suppression fire (although typically burning under more extreme weather conditions) can have some similar results to prescribed burning; namely, the reduction of fuel loads and fuel continuity, in addition to any ecological impacts. Both types of fire use can decrease an area's overall fire risk—they differ mainly with regards to how close in time to wildfire occurrence the fire is ignited, the conditions under which it burns, and typically the degree of planning and pre-firing evaluation of potential impacts. Firefighting agencies have considered the use of fire as a complementary tool to other firefighting techniques, largely in response to increasingly hazardous and life-threatening wildfire suppression conditions [12]. Although infrequently mentioned in studies of fire use, the value of prescribed firing techniques for training wildfire suppression professionals should not be overlooked. For example, a study in Spain showed that firefighting agencies rely on such training to increase the effectiveness and safety of their fire suppression forces [15].

The use of fire (in prescribed burning, fire suppression, and for training purposes) is limited in some countries and regions of Southern Europe and South/Central America. Several authors evidenced potential limitations of the application of fire use in these regions. In Italy, limitations are detailed in several studies [16,17]. Ascoli and Bovio [17] state that unfavorable land characteristics, conflicting management goals, a hostile socio-cultural environment, and an inadequate regulatory framework have supposedly limited the application of prescribed burning in Italy. Nevertheless, from 1982 to 2012, the legislation at the Italian regional level has been updated to consider the use of fire, and new procedures to authorize prescribed fires allowed for experiments and application, even within National Parks. There are only a few studies about the history of fire use across entire regions; a good example is [18] for the European Alps. In other regions, there are more extensive studies on forest structure and fire history. For example, in an old *Pinus nigra* forest in Spain, it has been documented the importance of recurring fire as well as intentional fire use [19]. Shindler et al. [20] reviewed tools for forest managers to address how citizens perceive conflict with regards to forest issues, including fire use. These fire use conflicts can be due to unfavorable land characteristics, conflicting management goals, low social acceptability, hostile socio-cultural environment, or inadequate legislation [17]. Nevertheless, prescribed fire maneuvers are needed for quality, professional fire training for wildland and structural firefighters alike [4].

To chronicle present day fire use trends, and to determine the most influential factors in relation to the use of fire for prevention (prescribed burning) and fire for suppression, we conducted a digital survey of 726 people across Spain, Italy, Portugal, Mexico, and Central and South American countries. Targeted respondents were self-identified as having experience in fire application, and included paid firefighters, volunteer firefighters, forest rangers, forest managers, fire chiefs, and academic faculty and academic or agency researchers. While intrinsically subjective, the broad experience of these fire practitioners incorporates different perceptions that can be compared across regions to detect similarities and differences. We examined the first-hand knowledge of a wide range of wildland fire practitioners to help characterize the relationship between wildland fire and intentional fire use across different countries. Our unique geographic scope allowed for the examination of regional differences in the use of fire, including how perceptions of fire use corresponded to location, experience, age,

and job position. This is the first international survey to access such a large pool of respondents, and provides novel data regarding the present state of fire use perceptions across continents. Such data can be used by policy makers and managers alike to determine the effectiveness, challenges, and future needs for their fire use programs.

2. Methods

2.1. Study Scope

We obtained data (726 responses to the questionnaire) from several countries: Spain, Italy, Portugal, Argentina, Colombia, Brazil, Chile, Mexico, and a few respondents from other South American countries. Questionnaires were identical but were available in four different languages: Spanish, English, Italian, and Portuguese. The Portuguese version incorporated two translations, since Brazilian Portuguese differs from that spoken in Portugal. These translations helped clarify terms which may not translate directly among dialects, and promoted the clear identification of generalities in job positions and tasks.

We analyzed data considering several regions to evaluate differences in the use of fire among them. All regions have numerous wildland fires each year which have negative social and economic consequences. Italy (IT), Portugal (P), and Brazil (BR) were considered as distinct geographic units for this study. Other countries in South America (excluding Brazil) made up a single geographic unit (SA) due to lower sample sizes from individual countries and similarities in responses within that group. In Spain, where we received over 500 responses, we conducted additional analyses addressing geopolitical regions with different fire management agencies and diverse levels of wildland fire occurrence. Responses from Spain were organized into eight different regions, considering the following attributes [4]: (1) type of suppression leadership (i.e., leadership under an unified emergency agency or under a forestry agency); (2) geography and ecoregions; (3) weather and climate conditions; and (4) fire activity, in terms of number of fires and burned area per year. These eight regions are North (SP-N, including Galicia, Asturias, Cantabria, and Basque Country as well as León and Zamora provinces), North-Northeast (SP-NNE, including Navarra, La Rioja, Aragón), Northeast (SP-NE, i.e., Catalonia), East (SP-E, including Valencia and Murcia), North-Central Spain (SP-NC, including Castile-Leon (but not León and Zamora provinces) and Madrid), South-Central Spain (SP-SWC, including Castile-La Mancha and Extremadura), South (SP-S, i.e., Andalusia), and Spanish Islands (SP-I, including Balearic and Canary islands).

2.2. Data Collation

Data was obtained through voluntary participation (from 6 February to 7 May 2014) in digital surveys distributed by email lists developed through the MasterFUEGO academic program centered at the University of Lleida in Spain, and via social media (Facebook™ and LinkedIn™) and wildland fire websites. Additionally, emails were sent to different institutions, including official forestry and fire-fighting agencies, as well as professional associations. It is estimated that 3200 people were invited to answer the survey, although replication across the different dissemination mechanisms could not be quantified, as some list servers were proprietary, with members who could only be viewed by the host. If our estimates are correct, the response rate was approximately 22%. It is true that this (most likely) varied widely from region to region.

The surveys had several fields, beginning with a section on demography where people identified their age, gender, job position, level of or years of experience in their job, country, region, and agency where they work (i.e., public administration, private companies, or "other"). Then, we asked respondents to identify the most influential reasons or factors (including age, job position, gender) that may limit fire use in general terms, both in fire prevention and suppression actions. This was implemented by a set of questions—one for each factor—and they had to respond with one out of five levels, ranging from "not influential" to "strongly influential". Questions also addressed if respondents

thought that fire use would increase in the future, the level of education and training in their agencies in fire use, etc. Mostly, we provided potential answers, and asked the respondents to rate these reasons. Occasionally, they were asked to fill in an open-answer (blank) question. There were a total of 25 questions, and 95 percent of respondents completed the entire survey.

We obtained 726 survey responses from 12 countries (Table 1). The majority of responses were from Spain (500), and all analyzed Spanish regions had a minimum of 50 respondents. Brazil, Italy, Portugal, and "Latin America except Brazil" also have this minimum number of responses, except Portugal, which had 49 respondents. All job positions analyzed have enough data to perform statistical analysis (more than 60 respondents). The most frequently reported job position was "forest manager" (35.5% of the total data). Both forest ranger and paid firefighter comprised approximately 15% of the total. Table 2 displays the number of respondents by job position and region. Figure 1 shows the number of responses by age and job category. Most respondents were between 31 and 40 years old (38.5%), followed by people aged 41 to 50 (30.5%). Respondents were mostly men (86% of total respondents). Name and e-mail addresses were not mandatory fields; however, many filled in one or two of these fields. Therefore, the survey was open to anonymous persons.

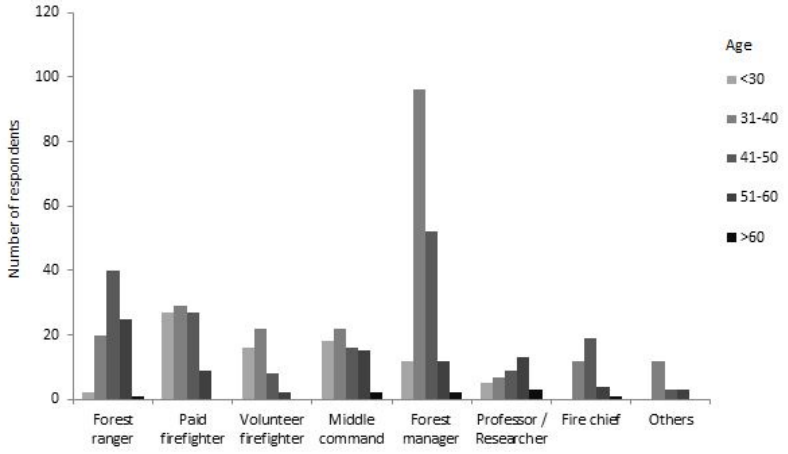

Figure 1. Number of responses by age and job category. Forest Ranger; Paid Firefighter; Volunteer Firefighter (includes Civil protection personnel and paid firefighters from units only occasionally involved in wildland fire suppression); Mid command (i.e., Mid Fire Chief (below Battalion Chief) or Mid Forest Manager or Mid Civil Protection Manager); Forest Manager; Faculty and Researcher; Fire Chief (i.e., Battalion Chief and up); and Others.

Table 1. Number of responses by region and age.

	Total Number of Respondents	Age Range				
		<30	31–40	41–50	51–60	>60
Brazil	50	9	15	15	10	1
Portugal	49	11	23	13	1	1
Italy	65	1	19	23	17	5
Latin America except Brazil	55	10	23	11	10	1
Spain-E	67	4	28	24	11	0
Spain-Islands	54	3	27	19	5	0
Spain-N	52	9	18	19	5	1
Spain-NE	107	22	32	34	19	0
Spain-NNE	50	13	19	14	4	0
Spain-CN	57	15	19	15	8	0
Spain-S	58	3	23	18	13	1
Spain-CS	61	9	34	15	3	0
Total	726	107	280	222	106	11

SP-N: North Spain; SP-NNE: North-Northeastern Spain; SP-NE: Northeastern Spain; SP-E: Eastern Spain; SP-NC: North-Central Spain; SP-SWC: South-Central Spain; SP-S: South Spain.

Table 2. Number of respondents by job position and country or region.

Region	Total Number of Respondents	Forest Ranger	Paid Firefighter	Volunteer Firefighter	Middle Command	Forest Manager	Professor and Researcher	Fire Chief	Others
Brazil	50	0	11	4	6	15	9	1	4
Portugal	49	2	5	7	4	23	4	4	0
Italy	65	9	3	12	14	10	5	8	4
LA	55	2	2	7	8	28	7	1	0
SP-E	67	15	12	3	6	25	1	1	4
SP-I	54	11	4	2	3	32	1	1	0
SP-N	52	15	15	0	6	13	1	2	0
SP-NE	107	7	24	16	15	15	7	20	3
SP-NNE	50	13	8	1	3	17	4	4	0
SP-CN	57	5	12	2	9	21	5	3	0
SP-S	58	13	8	1	5	22	2	3	5
SP-CS	61	14	7	1	4	29	0	2	4
Total	726	106	111	56	83	250	46	50	24

Descriptors: Forest Ranger; Paid Firefighter; Volunteer Firefighter includes civil protection personnel and paid firefighters from units only occasionally involved in wildland fire suppression; mid-level command could be a mid-level fire chief (below battalion chief) or a mid-level forest manager or civil protection manager; Forest Manager; Faculty and Researcher; and Fire Chief is, for example, a battalion chief or higher level position Countries or regions: Brazil, LA (LatinAmérica except Brazil), Portugal, SP-N (Northern Spain), SP-NC (North-Central Spain), SP-SC (South-Central Spain), SP-S (Southern Spain), SP-NNE (North-NorthEastern Spain), SP-E (Eastern Spain), SP-I (Spanish Islands), and Italy.

2.3. Data Analysis

We carefully checked our database before performing the statistical analysis to ensure that internal inconsistencies were solved. These errors included responses such as having too many years of experience when too young, and having limited years of experience when being old. In these cases, we requested (to the person involved) a review of the specific, possible, errors, and incorporated these corrections or removed their responses where corrections could not be made. This was possible because although "name" and "e-mail address" were not mandatory fields, many opted to fill one or two of these fields. For any respondents with unsolvable inconsistencies who could not be reached, their entries were removed from the analysis.

We analyzed data though descriptive as well as statistical comparison methods to search for differences among countries (geographic units), job positions, age, years of experience, or other variables which may influence the use of fire. Contingency tables and Pearson's Chi squared test were used to carry out these comparisons with statistical significance at the $p < 0.05$ level.

3. Results

Most respondents believed that fire use will increase in the future (79.9% of total), while only 14.3% answered that it will not. Nearly 7% of people did not answer this question. A majority of respondents were confident that local fire services are qualified to use fire in fire prevention and also in fire suppression tasks (62.8% of total in both cases were confident). The most important advantages of prescribed burning perceived by respondents were "the economic advantage of using fire versus other tools", and its "usefulness to train firefighters and fire crews in highly reliable training scenarios" (Table 3, fire use in fire prevention).

Table 3. Respondents' perception of factors either limiting or favoring the use of fire for prevention purposes. Data displays perception of respondents (percentages of total, $N = 726$) on influence in the use of fire in prevention.

	1	2	3	4	5
	No Influence	**Little Influence**	**Neutral**	**Influential**	**Strongly Influential**
Is the Use of Prescribed Fire Favored Because . . . ? *					
It is a natural tool/Fire is environmentally beneficial	20.25	19.26	23.94	22.24	14.31
It is an economically viable tool	7.21	10.89	17.54	33.38	30.98
It is a feasible tool	12.86	21.29	33.29	20.57	12.00
It is a useful tool for training firefighters	8.69	10.54	21.79	21.94	37.04
Is the Use of Prescribed Fire in Limited Because . . . ?					
Lack of social acceptance	11.75	10.21	18.74	28.81	30.49
Complex bureaucracy to use fire	8.27	11.08	21.46	30.29	28.89
Complex bureaucracy in policy decisions	11.72	13.70	20.20	25.28	29.10
Not enough training of supervisors/ Not enough training of firefighters	16.27	24.05	26.31	21.50	11.88

*, The actual questions were: Which is the reason limiting the use of prescribed fire for prevention? "Natural tool" means that prescribed fire is used because managers consider it appropriate for ecosystem health and maintenance; "economic tool" means that managers consider the use economically viable in comparison to other options; "feasible tool" means that managers consider fire the fire viable in general terms; "useful for training firefighters" highlights the importance of the use of fire in real situations in training; "social acceptance" as a negative factor that influences the use of fire; "administrative obstacles" is when it is difficult to get permissions or authorizations; "political decisions" means that politicians do not allow the use of fire in prevention; "technical limitations" means a lack of knowledge and training in technicians, firefighters, or managers.

Sixty-four percent of total respondents answered that fire use is "economically viable" (i.e., they answered that economic viability is either an influential or strongly influential factor). Sixty percent of respondents felt that using prescribed burning to train firefighters and teams could increase the frequency of fire use (Table 3). The most important challenges to prescribed fire use for wildfire prevention were the social acceptability of using fire and the obstacles presented by bureaucratic paperwork. Technical limitations to fire use were perceived as having less of an impact on the difficultly of its use (only 33.3% of people considered it as either an influential or very influential factor).

In relation to questions asked regarding factors limiting the use of fire in suppression, getting permission from the supervisor to implement a suppression burn (where fire is ignited to pre-burn fuels in advance of an approaching wildfire) or other fire techniques was identified by respondents as an important difficulty. Additionally, lack of appropriate ability to analyze and forecast fire behavior was cited as an impediment to firefighters' use of prescribed burning during fire suppression (Table 4). Social acceptability and lack of enough quality training were not seen as influential factors determining the use of fire in wildfire suppression.

Table 4. Responses identifying which factors are perceived as limiting the use of fire in suppression. Data displays perception of respondents (percentages of total, N = 726) who chose the degree of influence of each factor.

Is the Use of Suppression Fire Limited Because . . . ? *	**1**	**2**	**3**	**4**	**5**
	No Influence	**Little Influence**	**Neutral**	**Influential**	**Strongly Influential**
Lack of social acceptance	23.31	17.42	17.98	20.79	20.51
Lack of good enough training of workers	11.46	18.95	24.75	25.88	18.95
Difficultyin getting supervisor's permission to use fire	16.67	16.92	18.41	25.62	22.39
Difficulties in finding the spatiotemporal opportunity to be efficient in using suppression fire	9.92	20.82	31.59	24.08	13.60
Lack of ability to analyze and forecast fire behavior	14.15	17.93	20.87	25.63	21.43

* "Lack of social acceptance" is when population does not accept fire; "lack of information" means that population do not know the use of fire; "fire behavior analysis" means the ability of our managers, technicians, or firefighters to use fire in suppression.

3.1. Factors Influencing the Perception of Fire

In this section, the analyzed factors were gender, age, years of experience, job position, and region of the respondents. Some demographic factors, such as gender, did not influence any responses, perhaps because the overwhelming majority of respondents were male (86.4%). However, the other four factors had pronounced effects for many of the survey questions (Tables 2–4).

3.1.1. Age and Years of Experience

Age corresponded to differences in the perception of fire use for two important questions (Table 1). First, younger respondents (<30 years old) reported that the future use of fire will increase (84.4% of total). Although a majority of more-senior people (>50 years old) considered that fire will be used in the future more frequently, this percentage is lower than in the younger age group (67.47% of total; $p < 0.01$). Second, people over the age of 50 consider that the credibility (lack of social acceptance) of management using prescribed fire is not limiting prescribed fire use (only 25% of this group considers this factor influential or strongly influential). In contrast, the other age categories considered this factor as influential or strongly influential (60% of respondents aged under 50 years).

3.1.2. Country or Region

Responses to multiple questions differed according to region (Table 1) where respondents work. Portuguese respondents seemed to be very supportive of the use of fire, and they considered prescribed fire use in wildland fire prevention a positive tool. All Portuguese respondents considered that prescribed fire use will increase in the future, and more than 90% recognized the positive benefits of fire use in relation to economic, ecological, firefighting training, and knowledge. The north region of Spain seemed to be the region with the lowest affinity for prescribed fire use. Although most people in north Spain believed that fire use would increase in the future, respondents reported that fire did not have positive effects ecologically (75%) or economically (50%), and was not socially acceptable (50%).

With regards to suppression-related aspects, most respondents perceived burning to train suppression forces as very important. However, it was not so clear in southern Spain, Latin America except Brazil, or northwest-central Spain. Regarding perceptions of whether fire use in suppression is frequent enough in a given region at present, several regions reported that it is not used often enough: SP-NNE (76%), Italy (70%), SP-CS (66%), and Brazil (43%). However, in other regions, the amount of fire being used today in suppression activities was perceived as being "close to frequent enough" (SP-N, SP-NE, and Portugal).

Concerning perceptions of whether "There is a sound analysis of the effects and lessons learned when fire is used", Spain-NE stands apart from the rest of the regions, with 80% of respondents reporting "Yes". In contrast, in the rest of the regions, only 51% felt positive about lessons learned analyses, and 30% answered "No".

The training of supervisors was not considered an important limiting factor in fire use in NE Spain, but was identified as very important in Brazil (0% and 55% identified this factor, respectively). The only two regions where lack of training in lower-rank firefighters was not identified as a major impediment to fire use were Spain-E and Spain-S. Every other region considered this lack of training for lower-rank firefighters to be an important challenge influencing fire use.

Countries or regions with higher levels of wildfire acreage burned tended to be more supportive of fire use in suppression (and prescribed fire for vegetation management to a lesser degree), while countries or regions with less annual percentage of wildland area burned had less positive perceptions of either type of fire use. Table 5 summarizes two different categories; i.e., High and Low wildland fire levels. Regions are named as High if the "mean annual percentage of wildfire acreage burned" is greater than 0.3% and fire use by forest service and emergency agencies is facilitated by the legal framework. It is named as Low if it does not fulfill one of those two requirements. The grouping is based on the mean annual percentage of wildfire acreage burned. For this reason, Italy was classified in the Low group (high fire rate but no legal framework for fire use). For most regions, this involved 21 years of fire statistics (1991–2011). High involved 377 respondents (including Portugal, Spain-E, Spain-N, Spain-NE, Spain-S) and Low involved 349 (total 727 respondents) (Brazil, Latin America except Brazil, Spain-NNE, Spain-SC, Spain-NC, Spain-Islands, and Italy). Regarding the question "Is the emergency dispatch adequate to use fire in suppression actions?", there is a significantly higher percentage (77.0%) in "High" respondents that said "Yes", while only 47.6% said so in "Low" regions (Chi-squared test = 67.78, $p < 0.001$). Fewer than 6.5% did not reply to this question (7.7% in "Low" vs. 4.2% in "High"). There are fewer undecided in the "High" group, while there is a clear preference for stating that the emergency dispatch is fit to use fire in suppression actions.

Table 5. Regions in two different categories, "High" and "Low" wildland fires levels.

Region	Wildland Fire Levels	Fire Use by Forest Service and Emergency Agencies	Mean Annual Percentage of Wildfire Acreage (Burned)
Spain-E	high	legal/facilitated by legislation	0.88
Spain-N	high	legal/facilitated by legislation	1.33
Spain-NE	high	legal/facilitated by legislation	0.4
Portugal	high	legal/facilitated by legislation	2.1
Spain-S	high	legal/facilitated by legislation	0.33
Spain-NNE	low	legal/facilitated by legislation	0.15
Spain-NC	low	legal/facilitated by legislation	0.16
Spain-SC	low	legal/facilitated by legislation	0.28
Spain-Islands	low	non facilitated by legislation	0.47
Italia	low	non facilitated by legislation	1.29
México	low	no data	0.25
Chile	low	no data	0.15
Uruguay	low	no data	0.135
Argentina	low	no data	no data
Brazil	low	no data	no data

Regions are designated as "High" if the mean annual percentage of wildfire acreage burned is greater than 0.3% and fire use by forest service and emergency agencies is facilitated by the legal framework. It is designated "Low" if it does not fulfill one of these two requirements.

3.1.3. Job Position

Job position exerted a significant influence on respondents' answers to multiple questions. We asked respondents to identify as one of eight different job positions (Table 2). The most pronounced difference among groups was between academic faculty-researchers and forest rangers. Faculty-researchers think that fire use frequency will increase for the management of the forests and grasslands (96% of total). However, for forest rangers, only 70% forecasted an increase in the use of fire in the future. In relation to using prescribed fire prior to wildfire occurrence, all groups considered fire to be a positive factor and also considered it an "ecological benefit". However, forest rangers considered this factor significantly less relevant, with only 15% supporting its role. Faculty and researchers, paid firefighters, middle command, and fire chiefs identified this factor as more relevant (i.e., 57% of faculty and researchers, and 55% of fire chiefs).

A slight majority of respondents (51.75%) reported that they believe that agencies follow up fire use actions to monitor the effects of fire on vegetation. However, this number was lower in forest rangers (30.15%). They might consider that agencies do not accomplish this work properly. Faculty-researchers, paid firefighters, middle command, and fire chiefs consider obstacles in bureaucratic paperwork as a major influential factor determining fire use in fire prevention. All of the job categories reported that this is influential or very influential, with 57.2% as the mean value. Higher values correspond to faculty-researchers and fire chiefs (80%) and lower values for forest rangers (43%).

Volunteer firefighters believed that it was difficult to use suppression fire due to the obstacles to getting permission from the fire boss, or lack of enough quality training of firefighters and fire crews. Faculty-researchers and fire chiefs had the highest values (56%). Few differences were found among job positions in relation to the perception of fire use in fire suppression. Faculty-researchers had a higher perception (37.5%) than other groups regarding the frequency of considering the use of fire in suppression. Forest rangers were the category with the lowest support (21%) for the use of fire in fire suppression considering all questions globally.

4. Discussion

Prescribed fire use is considerably limited in some countries and regions of Southern Europe, Mexico, and Central and South America [12,17]. In the context of climate change and the problems caused by large fire events under extreme weather conditions, many authors consider fire as a useful tool to reduce the impacts of future wildland fires [11,21–24]. Many papers study fire effects on vegetation and fuels when used for fire prevention and fire suppression. They search for the best

fuel treatments, fire ecology thresholds, and conditions promoting ecological resilience and reduced wildfire severity [8,9,25,26]. However, there are few studies that analyze the perception of prescribed fire amongst the groups actively engaged in wildland fire management; those that exist have focused on perceptions in the US [7,27].

Notable results have been found in this work in relation to the perception of fire use. Most respondents consider that the use of fire will increase in the future as both prescribed burning and suppression fire. Therefore, prescribed burning could be a useful tool employed to a greater extent in the future. Economic benefits and the usefulness of prescribed burning for training firefighters seem the most influential factors for increasing fire use in the future. Mechanical treatments are usually more expensive than prescribed burning and may not be as effective, since fuels are often not removed, but only redistributed [9,28]. They are an opportunity to increase fire use, reduce fuel loads in the forest, and train firefighters. According to our results, regardless of region, job position, and age, the perception of prescribed fire as useful for training firefighters was evidenced by 53.3% to 78.5% of respondents, with the exception of forest rangers (48%), and higher values for faculty and researchers and fire chiefs. This might suggest that such training should be continued and increased where appropriate.

Technical limitations do not seem to be a major problem for using prescribed fire as a fire prevention tool, although most regions reported that a lack of training for entry-level firefighters was a significant barrier. More important, however, were the lack of social acceptability and bureaucratic obstacles which were identified as increasing the difficulty of using prescribed fire for fire prevention. Not surprisingly, these limitations were not highly cited as preventing the use of prescribed suppression fire for wildland fire suppression purposes. During a wildfire incident, the public is already experiencing the negative consequences of wildfire, and may be more likely to overlook what additional nuisance may be caused by suppression burning if it leads to wildfire control. It may be that these perceptions are based on inherent dissimilarities in how management decisions are made regarding fire use. In many instances, different sets of rules and protocols govern the two different types of prescribed fire use. In the US, for example, prescribed fire use for fire prevention on federal lands is subject to strict protocols under the National Environmental Policy Act, which requires months to years of planning and formal addressing of public concerns. In stark contrast, prescribed fire use for wildfire suppression can be implemented as needed, on a case-by-case basis, and immediately, as it serves the stated purpose of protecting the public and their property. Although ample evidence exists to support the use of prescribed fire for reducing potential wildfire risk and damage, the bureaucratic support for its implementation as a preventative measure is limited in the countries and regions analyzed here. Notably, in NE Spain, where leaders in fire management have pushed for decreasing legal barriers to the use of prescribed fire for prevention, respondents were more supportive of its use than in any other region.

Public agencies and administration should improve their protocols and training to facilitate fire use in both forest restoration and fire suppression. It is necessary to work on social acceptability [20] of fire use when conducting fuel and vegetation activities in order to ensure that potential practitioners and citizens cooperate in achieving safe and effective wildfire prevention.

All job positions believe that fire use is increasing, and they agree in most responses related to the benefits and difficulties of fire use in prevention and suppression. However, we found significant differences across job positions for many of the other questions. All groups, especially faculty-researchers, are more confident than forest rangers about the benefits of prescribed burning. This difference could be due to the lack of proximity forest rangers may have to fire science and the results of fire effects monitoring. Faculty-researchers are studying and evaluating the effects of prescribed burning, while forest managers and fire chiefs might be in a closer contact with researchers and fire science. Although forest rangers might also have access to fire science, they may not be as involved as researchers or forest managers and paid firefighters. A potential solution to this problem would be to expand prescribed fire education and training courses, which demonstrate the effects

of prescribed burning both ecologically and for fire suppression, to reach forest rangers specifically. For example, forest rangers in Spain are not generally required to attend such training or gain such knowledge through educational programs. More research should be done on the requirements of Forest rangers in other countries. For those analyses not using the geographical provenance as discriminant, the larger weight of the Spanish sample size might compromise if the results do apply to the whole study area. This could be true, for example, in Forest Rangers responding differently to all other groups. This could not apply in Brazil, Portugal, and LA (Latin America except Brazil), because there are too few respondents from those groups in those geographic areas. No more compromises were found for other job positions, age, or gender.

Additionally, our results show that social acceptability and quality training are not seen as influential factors in the application of suppression burning. In contrast, social acceptability was identified as influential or strongly influential where prescribed fire is used for wildfire prevention. We still believe that much participative management has to be done to ensure that there is widespread social acceptability on the use of fire by firefighters for both suppression and for ecological objectives. Additionally, despite the fact that a majority of respondents believe that training is already good, we believe that there is still a need for increased quality training towards the safe and efficient use of fire in suppression actions [12].

5. Conclusions

Countries or regions with higher levels of wildfire acreage burned tended to be more supportive of fire use in suppression, while countries with less wildfire had less positive perceptions of fire use for either prevention or suppression. Bureaucracy and social perceptions were identified as impediments to using prescribed fire for fuel reduction (i.e., prevention), but neither were identified as impediments to fire use during suppression procedures. Across the countries, fire use in suppression was viewed more positively than fire use in prevention. Most people believed that the use of fire will increase in the future for both prevention and suppression purposes. Social acceptability and lack of enough quality training are not seen by respondents as influential factors in the use of fire in suppression, but training in fire use for prevention was seen as lacking for lower-level positions. This discrepancy is an important consideration for leaders planning the preparation of the future fire workforce. Quality training is not widespread, and therefore fire use might not be performed properly. Prescribed fires usefulness to train firefighters and fire crews in highly reliable training scenarios is largely seen by respondents as a very positive and effective pursuit.

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