



The Dilemma of Wildfire Definition: What It Reveals and What It Implies

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OPEN ACCESS

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Specialty section:

This article was submitted to
Fire and Forests,
a section of the journal
Frontiers in Forests and Global
Change

Received: 17 April 2020

Accepted: 04 November 2020

Published: 09 December 2020

Citation:

Tedim F and Leone V (2020) The
Dilemma of Wildfire Definition: What It
Reveals and What It Implies.
Front. For. Glob. Change 3:553116.
doi: 10.3389/ffgc.2020.553116

This paper presents the results of an explorative survey, based on a questionnaire sent by email, about how wildfire experts, operating in different countries, perceive wildfire and express their mindset by defining “wildfire” from a list of 14 terms and how they justify their preference for the term selected as the most important. Using a five-point Likert Scale, results from 221 valid replies indicate a general convergence toward a reduced number of terms. Six of them exhibit a mean >3.20 (*Disturbance*, *Natural hazard*, *Climate-sensitive hazard*, *Socio-ecological hazard*, *Socio-ecological disturbance*, and *Social-ecological hazard*). The three most preferred terms (i.e., *Disturbance*, *Natural hazard*, and *Climate-sensitive hazard*) reflect wildfire as a natural process or phenomenon (about 59% of the replies). The three terms characterized by both the social and ecological adjectives (i.e., *Socio-ecological hazard*, *Socio-ecological disturbance*, *Social-ecological hazard*) occupy relatively less favorable positions in the ranking. For each term, a synthesis of the explanations given by the respondents is provided, together with a critical comment. Our findings show very different perceptions of wildfires inclusively within the same disciplinary field. In addition, for the same term selected, different definitions are often presented. This reflects sectorial, disciplinary, and personal perspectives of the wildfire phenomenon and the lack of a common understanding of wildfire “nature” (i.e., its own identity). The different perceptions on wildfire concept influence the knowledge that can be used by decision makers to improve wildfire management policies. This work puts into perspective one of the most widespread problems in science: the lack of appropriate and similar terminology across different scientific fields dealing with the same problem. A common conceptualization of the nature of wildfires and the creation of a common language across different scientific fields related to wildfires is of paramount importance to address the complexity of the existing problems, and enhance an interactive communication not only among scientific community but also with stakeholders and citizens.

Keywords: catastrophe, disturbance, disaster, Likert Scale, natural hazard, wildfire causes

INTRODUCTION

The worldwide distribution of wildfires (Krawchuk et al., 2009; Archibald et al., 2013; Moritz et al., 2014; Doerr and Santín, 2016; International Union of Forest Research Organizations, 2018) reflects the coincidence of three basic requirements: (i) fuel able to burn and sustain combustion allowing fire spread, (ii) environmental conditions that promote combustion, and (iii) a source of ignition, which starts the combustion process (Krawchuk et al., 2009).

Wildfire is the term used in this paper to describe any unplanned and uncontrolled fire started on shrubs or forest. This term predominates in North America and has been increasingly used everywhere. Nevertheless, the terms bushfire and forest fire are used in Australia and Europe, respectively. Other terms are also used to describe the same phenomenon depending on the type of vegetation burned (landscape fire, vegetation fire, wildland fire, and grass fire) or the context they occur in (e.g., wildland urban interface fire, rural fire, and peat fire), but the fire phenomenon as a combustion of vegetation in an open environment follows the same physical and chemical laws everywhere.

Wildfire is perceived and classified as a *natural hazard* by global data sets [e.g., EM-DAT (CRED), NatCatSERVICE (Munich RE)], international institutions [such as the National Aeronautics and Space Administration (NASA), the United Nations Office for Disaster Risk Reduction (UNDRR)], political entities (e.g., European Union), and governments (e.g., Middelmann, 2007; Queensland Fire Emergency Services, 2017), as well as scientists (e.g., Viegas, 1998; McCaffrey, 2004; Xanthopoulos, 2008; Wisner et al., 2012; Tarolli and Cavalli, 2013; Moritz et al., 2014; McCaffrey et al., 2015).

Wildfires have also been categorized as: *mixed hazard* (Lourenço, 2007), *semi-natural hazard* (Cavan and McMorro, 2009; Gazzard et al., 2016), *environmental hazard* (Smith and Petley, 2009; Smith, 2013), *climate sensitive hazard* (Emrich and Cutter, 2011; Bedel et al., 2013), *aggression* (Shea, 1940; Parlement Européen, 1996), *biophysical* and *biologic hazard* (Smith and Petley, 2009; Gill and Malamud, 2015), *disturbance* (White and Pickett, 1985), *ecological disturbance* (Krawchuk et al., 2009; Schmerbeck and Kraus, 2015), *natural disturbance* (Binelli et al., 2001; Roberts, 2004; Bond and Keeley, 2005; Peterson and Leach, 2008; Elliott et al., 2011; Ponomarev et al., 2015), *perturbation*, *social*, and *ecological* or *socio-ecological disturbance* (Coughlan, 2013; McCaffrey et al., 2015), and *socio-ecological pathology* (Fischer et al., 2016).

The plethora of terms reflects the relevance of wildfires in different research, political, and operational domains, but also reveals the lack of a common understanding of wildfire “nature,” i.e., its “own identity”; hence, different representations and misunderstandings of the same phenomenon make it difficult to establish a sustainable wildfire management policy (Pausas and Keeley, 2019).

The precision and aptness of definitions can influence: (i) the efficiency of the measures adopted to address and solve the problem, (ii) the societal relationships with wildfire, (iii) the perceived nature of the problem, (iv) the policy making process, (v) the range of policy solutions to be considered, and (vi) the governance level that will bear responsibility (Morss, 2005; Fifer and Orr, 2013; Pescaroli and Alexander, 2015).

The purpose of this paper is (i) to demonstrate that there are different perceptions of wildfire phenomenon inside the wildfire community (scientists and fire experts) and (ii) to discuss how these perceptions can affect knowledge production leading to wildfire management policies (ideally able to respond to the current wildfire challenges in a context of increasing occurrence of extreme wildfire events). This paper highlights that the lack of a comprehensive understanding of the wildfire

phenomenon (as a complex interplay of natural components and socio-economic and political drivers and conditions) leads to wildfires being treated as a threat to society, setting aside that fire also has a beneficial role in maintaining the ecological integrity of several ecosystems. This distorted and one-sided way of viewing wildfire as a threat impedes obtaining better outcomes in wildfire management.

MATERIALS AND METHODS

Survey Methodology

A literature survey using as keywords wildfire, wildland fire, forest fire, and bushfire was performed on Web-of-Science and Scopus. From such survey, 14 of the most common terms to interpret wildfire were selected. A questionnaire was prepared, to make an explorative survey by contacting a number of experts, operating in the academic and operational domain of wildfire at an international level. The purpose of this questionnaire was to evaluate the importance given by the respondents to each of the 14 selected terms and understand the explanations provided to justify the ranking of the most preferred term.

The questionnaire (see **Supplementary Material**) was composed of two closed-ended and two open-ended questions. In the first question, the 14 selected terms had to be rated using a five-point Likert Scale varying from 1 (*strongly disagree*) to 5 (*strongly agree*); respondents had the possibility to add other terms. In the second question, respondents were asked to put in decreasing order of importance the three terms they rated as *strongly agree* (score 5); in case the expert had not classified any term with score 5, terms rated as *agree* (score 4) should be considered.

In the third question, respondents were asked to freely explain their preference for the term classified as the most important.

In the fourth and final question, the respondents were asked to give information on their field of expertise. It was possible to provide more than one field of expertise. In the data analysis, an “*exclusive expertise*” means that the person’s background is related to only one disciplinary field. The term “*and others*,” added to a disciplinary field, means that the respondents declare expertise in different scientific fields.

The questionnaire was sent by email, between September and December 2015, to 690 experts that were selected from literature and the authors’ networks among researchers in universities and national and international research centers (e.g., IRSTEA—National Research Institute of Science and Technology for Environment and Agriculture, France, CIFOR—Centre for International Forestry Research), in International institutions [e.g., Food and Agriculture Organization of the United Nations (FAO), European Forest Institute (EFI), International Union of Forest Research Organizations (IUFRO), and Joint Research Center –(JRC)], and in organizations [e.g., Global Fire Monitoring Center (GFMC), International Tropical Timber Organization (ITTO), and The Nature Conservancy–(TNC)].

An effort was made to cover all the regions proposed by the UNISDR Global Wildland Fire Network (<https://gfmcc.org/globalnetworks/globalnet.html>) and the five global pyromes as identified by Archibald et al. (2013).

We received 223 replies, which represent a response rate of 32.4% that is rather satisfactory. As a matter of fact, e-mail response rates may only be ~25–30% without follow-up emails and reinforcements (Fincham, 2008). A relevant number of emails remained without reply ($N = 467$). We decided not to boost survey response rate, so we did not send reminders by e-mails to non-respondents, considering their lack of reply as induced by scarce interest. Out of 223 replies, 221 were considered valid, whereas two questionnaires were discarded because they were incomplete.

Many authors (Creswell, 2008; Boone and Bonne, 2012; Murray, 2013) proposed that data obtained using the Likert Scale could be classified as either interval or ordinal, giving to the researcher the choice of using descriptive statistics and parametric or non-parametric tests. Response items were therefore processed using the descriptive statistics recommended for interval scale items. In addition, we evaluated the “index of agreement” (I_{ag}) proposed by Meddour-Sahar (2015). The I_{ag} synthesizes the results of a Likert Scale taking into account the weighted ratio of positive responses vs. negative and neutral responses. The I_{ag} makes it easier to compare Likert Scale results. The higher the I_{ag} , the stronger is the level of agreement. Moreover, questions 1, 2, and 4 were also analyzed using descriptive statistics. A content analysis was applied to question 3 replies where respondents were asked to explain their preference for the term classified as the most important. In order to dispel doubts that data collected in 2015 could be outdated after 5 years, and considering that the global fire activity and the occurrence of disasters in several countries (e.g., 2017 in Portugal, 2018 in the US and Greece, and 2019–2020 in Australia) could have potentially triggered changes in the way experts perceive wildfires, we re-contacted the 221 respondents by email (the same email address as the one used in 2015) asking to provide the answer to the following questions: 1. Do you still consider your answers to be valid? 2. What would you like to change in your initial answer? Hitherto, 185 replies (84%) were received. One of the respondents declined the invitation declaring conflict of interests, 30 people did not reply to the invitation, and the email of 5 experts was no longer active. These data were qualitatively analyzed to identify the changes of perception by respondents, between 2015 and 2020.

Characterization of Respondents

The 221 respondents are distributed at a world scale (Figure 1), including the Mediterranean basin [$N = 91$, mainly from Italy ($N = 22$), Spain ($N = 22$), Greece ($N = 15$), Portugal ($N = 15$), France ($N = 9$), and Turkey ($N = 6$), the US ($N = 31$), and Australia ($N = 17$)]. Surprisingly, with the exception of Brazil ($N = 10$), and Argentina ($N = 9$), a rather scarce number of responses were obtained from areas where wildfires are a major problem, such as Indonesia, Malaysia, and many countries of Mesoamerica.

Out of the 221 participants, only six categories of expertise, encompassing a total of 173 people, had over 10 responses ($\geq 4.5\%$, Figure 2).

The most representative expertise was *Forestry* with 69 respondents (31.2%). A fair number of respondents declared

background in *Biology and Nature Sciences* ($N = 32$; 14.5%), *Geography* ($N = 24$; 10.9%), *Architecture, Engineering, Bioengineering* ($N = 13$; 5.9%), *Forestry and others* ($N = 13$; 5.9%), *Biology and others* ($N = 12$; 5.4%), and *Ecological, Environmental Sciences, Environmental Geology, and Natural Resources Management* ($N = 10$; 4.5%). All other groups of expertise have a representativeness $< 4.5\%$.

For a long time, foresters were the dominant group in treating wildfire problems. Currently, more disciplines are interested in the topic for different reasons (e.g., availability of funding), reflecting that wildfires are a wicked problem that forestry science or fire ecology by themselves cannot address, as physical, biological, social, and cultural dimensions of fire must also be considered. The variety of expertise responding to the questionnaire marks the interest of many disciplines in wildfires, even those (e.g., social sciences) that are considered distant from such issues but are crucial, considering that wildfires are a social-ecological phenomenon, i.e., can be both natural and human caused, and that fire spread is influenced by natural (e.g., climate, weather, topography, and vegetation) and human conditions (e.g., influence in fuel characteristics, fuel management at different scales, land use changes) and factors (e.g., urban sprawl, fire control, and demographic dynamics) as well.

RESULTS

Ranking of the Preference

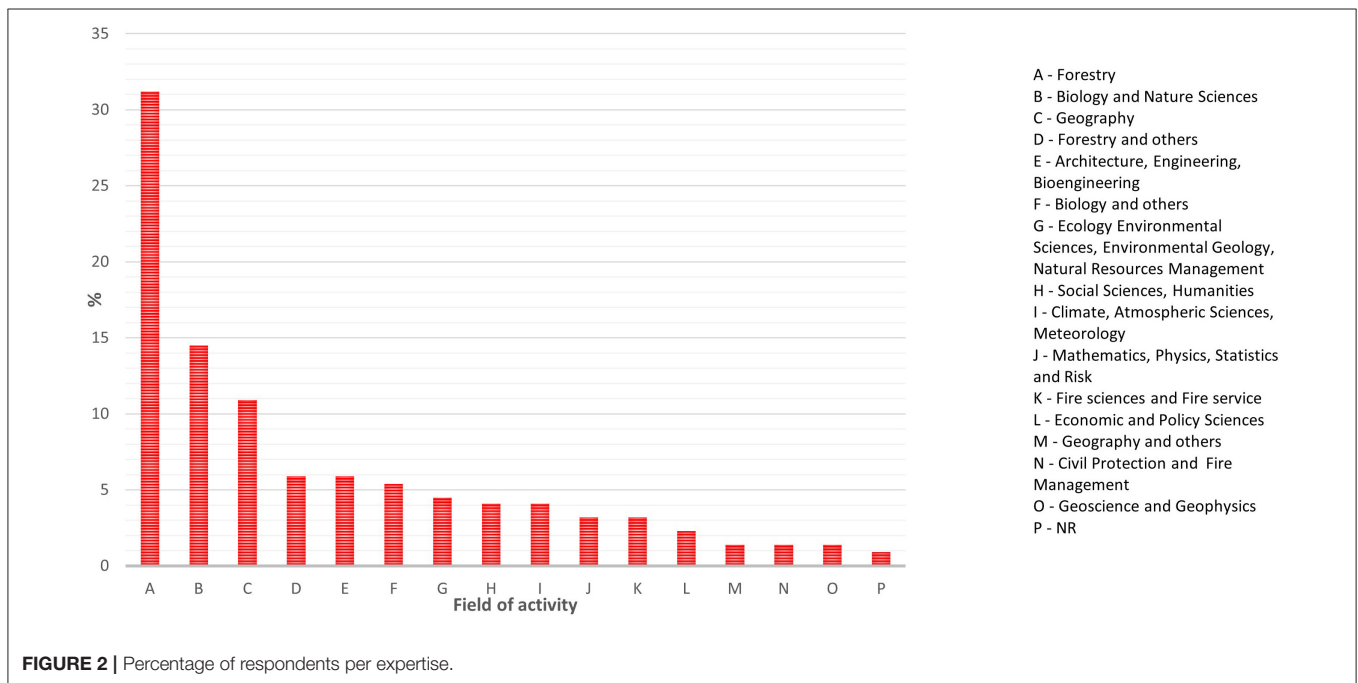
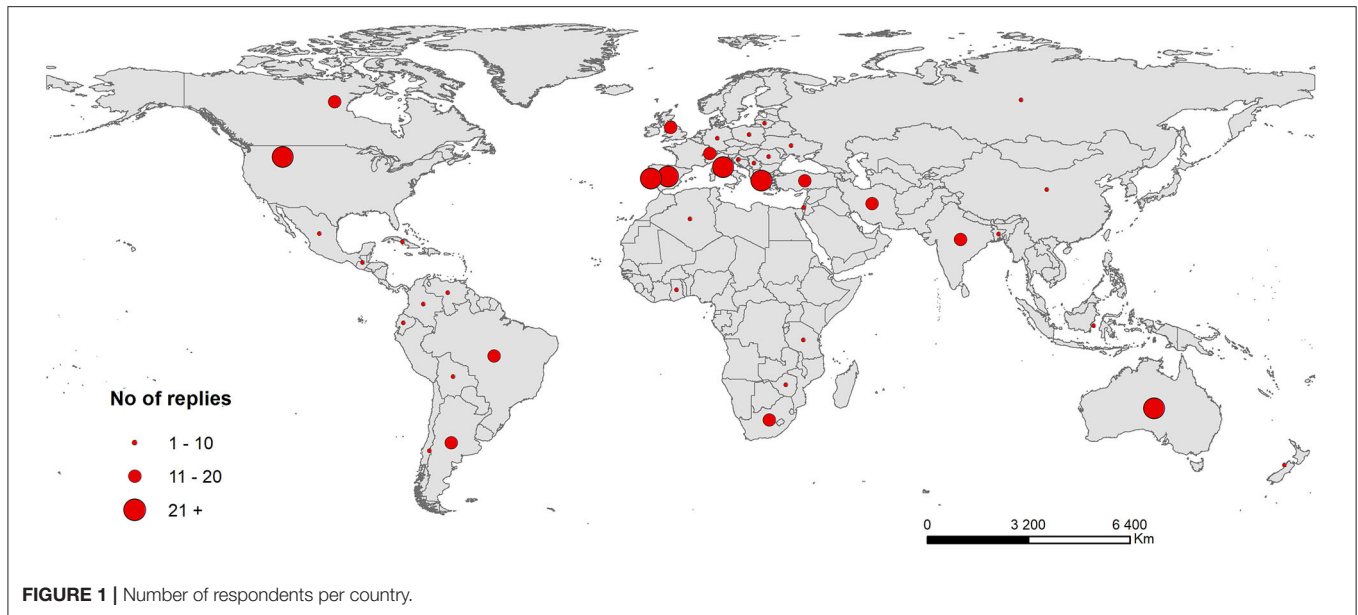
Descriptive Statistic of Likert Scale Scores

All the 14 terms considered in the questionnaire were used by the respondents (Table 1), but the results clearly indicate the general preference for a reduced number of them. Six of them (*Disturbance, Natural hazard, Climate sensitive hazard, Socio-ecological hazard, Socio-ecological disturbance, and Social-ecological hazard*) exhibit a mean > 3.20 , a mode ≥ 4.00 , a median of 4.00 and 3.00 (just for social-ecological hazard), reduced values of St. Dev., and $CV \leq 0.36$ suggesting a clear convergence in a small number of items.

The three most preferred terms (i.e., *Disturbance, Natural hazard, and Climate-sensitive hazard*) perceive wildfire as a natural process or phenomenon (about 59% of the replies). They have a mean exceeding the threshold of 3.50, a mode from 5.00 to 4.00, a median of 4.00, values of St. Dev. ranging from ± 1.12 to ± 1.19 , and CV ranging from 0.29 to 0.30. The three terms characterized by both the social and ecological adjectives (i.e., *Socio-ecological hazard, Socio-ecological disturbance, and Social-ecological hazard*) occupy a relatively less favorable position in the ranking, with the mean ranging from 3.45 to 3.29, mode of 4.00 and median from 4.00 to 3.00, values of St. Dev. ranging from ± 1.13 to ± 1.26 , and CV ranging from 0.34 to 0.36.

Relations Between Terms and Respondents' Expertise

For *Natural hazard, Climate-sensitive hazard, and Disturbance*, I_{ag} ranges from 3.72 to 2.73, whereas for *Socio-ecological hazard, Socio-ecological disturbance, and Social-ecological hazard* I_{ag}



ranges from 2.73 to 0.88, further confirming the preferences of the respondents for such terms (Table 2). *Social-ecological hazard* ($I_{ag} = 0.88$) results are less preferred than *Socio-ecological hazard* ($I_{ag} = 1.53$). The terms with lowest values of I_{ag} are *Aggression* ($I_{ag} = 0.19$), *Social aggression* ($I_{ag} = 0.17$), and *Quasi natural biohazard* ($I_{ag} = 0.12$).

Table 3 reports how the terms are preferred by the different expertise groups using descriptive statistics. In this table, 19 terms are included because some respondents added six new terms (*Natural disturbance*, *Ecosystem disturbance*, *Social-ecological disturbance*, *Natural perturbation*, *Natural event*, and *Vegetation*

fire) not initially considered in the questionnaire. *Quasi natural biohazard*, although present in the questionnaire, is missing in Table 3 because no respondent considered it as a preferred term.

Forestry, which is by far the largest group of expertise ($N = 69$), prefers 15 out of the 19 (79%) terms, with a marked preference for *Disturbance* ($N = 21$), *Climate-sensitive hazard* ($N = 12$), and *Natural hazard* ($N = 9$). More than any other expert group, foresters are involved with fires under different operational and research perspectives, ranging from suppression to prevention and planning, to using fire as a tool of landscape management (e.g., prescribed burning).

TABLE 1 | Basic statistics for the 14 terms used to characterize wildfires ($N = 221$).

Terms	Mean	Median	Mode	St. dev.	CV
Disturbance	3.96	4	5	±1.19	0.30
Natural hazard	3.92	4	4	±1.13	0.29
Climate-sensitive hazard	3.84	4	4	±1.12	0.29
Socio-ecological hazard	3.45	4	4	±1.26	0.36
Socio-ecological disturbance	3.37	4	4	±1.13	0.34
Social-ecological hazard	3.29	3	4	±1.18	0.36
Mixed hazard	3.19	3	3	±1.21	0.38
Natural disaster	3.18	3	4	±1.26	0.40
Semi-natural hazard	2.89	3	4	±1.19	0.41
Ecological catastrophe	2.71	3	2	±1.30	0.48
Bio-hazard	2.33	2	2	±1.21	0.52
Quasi natural bio-hazard	2.29	2	2	±1.02	0.44
Social aggression	2.18	2	1	±1.18	0.54
Aggression	2.12	2	1	±1.20	0.57

TABLE 2 | Total scores of Likert Scale and the index of agreement (I_{ag}) per term.

Terms	Strongly agree	Agree	Nor agree nor disagree	Disagree	Strongly disagree	No response	I_{ag} (%)*
Natural hazard	73	98	23	17	6	4	3.72
Climate-sensitive hazard	64	104	19	24	8	2	3.29
Disturbance	95	66	31	16	12	1	2.73
Socio-ecological hazard	43	87	43	29	13	6	1.53
Socio-ecological disturbance	32	82	59	30	18	0	1.06
Social-ecological hazard	35	67	65	37	14	3	0.88
Natural disaster	31	69	61	32	24	4	0.86
Mixed hazard	30	67	67	35	17	5	0.82
Semi natural hazard	17	60	58	58	24	4	0.55
Ecological catastrophe	23	45	48	55	50	0	0.44
Bio-hazard	9	37	42	68	61	4	0.27
Aggression	9	26	38	63	80	5	0.19
Social aggression	8	24	51	61	71	6	0.17
Quasi natural bio-hazard	4	20	69	79	44	5	0.12

* $I_{ag} = (Strongly\ agree + Agree) / (Nor\ agree\ nor\ disagree + Disagree + Strongly\ disagree)$.

Biology and natural sciences ($N = 32$) prefer only 6 of the 19 (33%) terms, namely, *Disturbance* ($N = 10$), *Climate-sensitive hazard* ($N = 7$), and *Natural hazard* ($N = 6$). In contrast with the previous group, it exhibits a narrower perspective preferably focused on terms related to natural processes and conditions.

Geography ($N = 24$) prefers 10 out of the 19 available terms (52.6%), with similar scores and a marked preference only for *Mixed hazard* ($N = 6$). Although with low scores, the terms included in the group defining wildfires as a *social* phenomenon are considered by the respondents with this background.

Forestry and others ($N = 13$) prefers 7 out of the 19 (36.8%) terms, with rather low scores, with exception made for *Disturbance* ($N = 4$) that, once again, is the preferred one.

Architecture, Engineering, and Bioengineering ($N = 13$) prefers 6 out of the 19 (31.6%), with *Natural hazard* ($N = 8$) as the most preferred term.

Biology and others ($N = 12$) prefer 6 out of the 19 terms (31.6%), with rather low scores, with exception made for *Natural hazard* ($N = 5$), thus confirming the previous observation.

All the remaining expertise groups also converge toward *Natural hazard*, *Disturbance*, *Climate-sensitive hazard*, and *Natural disaster*.

Frequency of the Terms Ranked in the First, Second, and Third Positions

Table 4 reports all the terms ranked in the first, second, and third positions, as requested by the second question in the questionnaire, aggregated in five categories. The first one gathers terms related to the ecological concept of disturbance; the second category, all the different terms recalling the concept of hazard; the third category, terms concerning aggression; the fourth category, terms concerning disasters and

TABLE 3 | Distribution of preferred terms per expertise.

Terms	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	NR	Total
Aggression							1										1
Bio-hazard	2						1										3
Climate-sensitive hazard	12	7	3		1	2	1		4			2		1			33
Disturbance	21	10	2	4		2	3	2		1	2	1			2		50
Ecological catastrophe	3		4	1	1		1										10
Ecosystem disturbance	1																1
Mixed hazard	2		6	1	1			1	1				1				13
Natural disaster	4		2	3	1	1		2			2			2			17
Natural disturbance		1	1														2
Natural event						1											1
Natural hazard	9	6	3	2	8	5		2	1	5	2	1	1		1	1	47
Natural perturbation	1																1
Semi-natural hazard	2	3					1										6
Social aggression	2			1													3
Social-ecological disturbance	1																1
Socio-ecological disturbance	4	4	1			1		1				1	1				13
Social-ecological hazard	1		1	1				1									4
Socio-ecological hazard	4		1		1		1		2	1						1	11
Vegetation fire									1								1
NR		1					1				1						3
Total	69	32	24	13	13	12	10	9	9	7	7	5	3	3	3	2	221

A, Forestry; B, Biology and Nature Sciences; C, Geography; D, Forestry and others; E, Architecture, Engineering, Bioengineering; F, Biology and others; G, Ecology, Environmental Sciences, Environmental Geology, Natural Resources Management; H, Social Sciences, Humanities; I, Climate, Atmospheric Sciences, Meteorology; J, Mathematics, Physics, Statistics and Risk; K, Fire Sciences and Fire Service; L, Economic and Policy Sciences; M, Geography and others; N, Civil Protection and Fire Management; O, Geoscience and Geophysics; NR, No response.

catastrophes; the fifth category, with terms non-contained in the questionnaire but proposed by the respondents; and, finally, no responses (NR).

The group of terms containing the word “hazard” has the highest preference in the three positions. However, the term *Disturbance* ($N = 50$), in the category of terms related to disturbance, is the one ranked most in the first position. *Disturbance* is followed by *Natural hazard* ($N = 47$) and *Climate-sensitive hazard* ($N = 33$) both belonging to the group of terms related to hazard. These individual terms are also the most representative in the second position with 47, 36, and 30 answers, respectively. In the third position, the most frequent terms are *Climate-sensitive hazard* ($N = 43$), followed by *Socio-ecological hazard* ($N = 26$), and *Natural hazard* ($N = 24$). Considering the sum of frequencies in the three positions, the respondents clearly express their preference mainly for terms recalling naturally generated events. The terms *Climate-sensitive hazard*, *Natural hazard*, and *Disturbance*, respectively, gather 106, 107, and 112 preferences, clearly dominating as already observed in basic statistical parameter description.

The accumulated frequency of “*Social ecological hazard*” and “*Socio-ecological hazard*” ($N = 88$) follows the three dominant ones.

How Respondents Explain Their Preference

All the respondents’ explanations to question 3 in the questionnaire (preference for the term put in first place) were

singularly analyzed, extracting what we named the *key concepts*. We processed 205 out of 221 questionnaires due to 16 missing explanations. A synthesis of the explanations provided by the experts is presented in **Supplementary Table 1**, in the annex. The explanations for each term are constructed putting together all the different definitions provided by the experts, regardless of their frequency, i.e., a concept expressed once has the same value of a concept expressed more times. For a better understanding of the results, we highlighted the arguments respondents used to explain their preference; it is evident that the same term can be differently perceived and employed in wildfire domain.

Disaster/Catastrophe

- *Ecological Catastrophe*

There is a relevant level of agreement within the experts that classify wildfires as an ecological catastrophe. Their focus is on the impacts caused by wildfires on ecosystems.

For the respondents that preferred *Ecological catastrophe*, the adjective “ecological” indicates that wildfire has an impact on ecosystems. It is not related to the origin of fire because just one response mentions the source of ignition, which can be natural or anthropogenic. The use of catastrophe is related to the effects of wildfires on ecosystems. Just one of the experts mentions consequences on society.

- *Natural Disaster*

The adjective natural is used by the respondents with three different meanings: (i) the source of ignition,

TABLE 4 | Frequency of the terms in the first, second, and third positions by category.

Category	Terms	1st position	2nd position	3rd position
Disturbance	Disturbance	50	47	15
	Natural disturbance	2	0	0
	Socio-ecological disturbance	13	18	14
	Social-ecological disturbance	1	0	2
	Ecosystem disturbance	1	0	0
	Total	67	65	31
Hazard	Natural hazard	47	36	24
	Climate sensitive hazard	33	30	43
	Mixed hazard	13	7	13
	Socio-ecological hazard	11	22	26
	Semi-natural hazard	6	14	6
	Social-ecological hazard	4	11	14
	Biohazard	3	2	3
	Quasi natural biohazard	0	0	0
Total	117	122	129	
Aggression	Social aggression	3	1	3
	Aggression	1	3	5
	Total	4	4	8
Disaster/ catastrophe	Natural disaster	17	16	14
	Ecological catastrophe	10	9	17
	Total	27	25	31
Others	Vegetation fires	1	0	0
	Natural perturbation	1	0	0
	Natural event	1	0	0
	Total	3	0	0
No response		3	5	22
TOTAL		221	221	221

(ii) fire as a component of ecosystems, and (iii) fire affecting ecosystems.

The term disaster is related to the effects and damage created by the fires that affect ecosystems and society.

Hazard

• Natural Hazard

The respondents associated the term “hazard” with social and ecological impacts of the fire (e.g., loss of life, injury or other health impacts, property damage, loss of livelihoods and services, and environmental damage). Although hazard has a negative connotation, not all fires result in significant or destructive impacts, but have that potential. So, wildfires may or may not have a negative impact on environment, on people living close to it, or on economy. Many wildfires should not be considered as a hazard and can have positive effects on ecosystems.

The adjective “natural” is explained by respondents under different perspectives: (i) a natural origin of wildfire outbreaks (e.g., lightning); (ii) wildfires are caused by natural factors (e.g., weather, climate, and vegetation); (iii) wildfires occur in the countryside or wildland in relation to many natural features (e.g., climate, weather, and vegetation type) regardless of the source of

ignition that can be natural or anthropogenic; and iv) fire as an element of the ecosystems.

Moreover, experts apply the term natural hazard to a multiplicity of situations: (i) a threat to society caused by nature, although its probability of occurrence is scarce because most wildfires are triggered by human activity; (ii) natural phenomenon, maybe caused by unnatural means, such as arson or human carelessness, or by natural means, such as lightning strikes; (iii) fire caused by natural reasons, such as high sun radiation, water deficit; (iv) any uncontrolled fire in combustible vegetation, that occurs in the countryside or a wilderness area, maybe compounded by the presence of humans; (v) an event in the natural environment with significant social-ecological impact; (vi) the wildfire dynamic associated to natural conditions prone to its occurrence; and (vii) events that may occur in nature, independent of man-made interventions (because of a natural presence of vegetation).

• Climate-Sensitive Hazard

Climate and weather conditions that affect the occurrence, frequency, intensity, and severity of wildfires are the main explanations to justify the preference for *Climate-sensitive hazard* and the lesser emphasis for social and vegetation aspects. The justifications presented by the respondents for their preference are: (i) wildfires can naturally occur, influenced by weather, fuels, and topography; (ii) climatic conditions affect the occurrence, frequency, intensity, severity, and the temporal patterns of wildfires, which are exacerbated by climate change; (iii) climatic conditions determine the quantity, type of vegetation, and fuel moisture conditions that are sensitive to climate change; (iv) wildfire effects are influenced by the regional climate: as mentioned by a respondent, a wildfire in boreal regions creates far greater (and longer lasting) damage in permafrost than what would be created in temperate zones of savannah grassland; (v) the release of combustion products such as black carbon contributes to the greenhouse effect; and (vii) wildfire activity is a marker of climate changes, temperature anomalies, and geospatial re-distribution of precipitation.

• Social-Ecological/Socio-Ecological Hazard

The explanation given by respondents to the term hazard is related to the impacts of wildfires not only on ecological systems but also on society. In fact, two main explanations are provided by experts that prefer social-ecological and socio-ecological hazard. First, they reflect the social and ecological dimension of wildfires, most of them having anthropogenic causes and strictly related to socio-economic aspects (e.g., land use, landcover, and fuel availability). Second, in many regions, wildfires are more connected with social than natural factors and feedback between ecosystems processes and human activities.

• Mixed Hazard

Wildfire as a *Mixed hazard* is differently justified by respondents. If for some of them the main justification is related to the natural or anthropogenic ignition causes, for others, the focus is on the natural and human elements at risk, or the need of vegetation for fire spread. Other

justifications are (i) human-induced fires are driven by climatic, weather, vegetation, and topographical conditions; (ii) the effects of fire on both human and ecological resources are a result of the interaction between natural and human factors and processes; (iii) most of the impacts are associated with human activity; and (iv) most of the cost (economic and human) is associated with human activity (e.g., land management, land use, housing development, need for water catchments, and storage).

- *Semi-Natural Hazard*

Three orders of explanations are used by the experts that prefer this term. First, wildfire is a semi-natural hazard because of its impacts on both natural and human systems. Second, ignitions can be natural or anthropogenic. Third, the human influence is not restricted to fire ignition. Human activities can create more hazardous landscapes (namely, by modifying ecosystems, land use, and land cover), increasing fuel load and continuity, promoting the invasion of flammable or invasive plant species. Thus, the occurrence of wildfires is controlled or affected by several socio-ecological factors and the interactions between them.

- *Biohazard*

The respondents that prefer *Biohazard* focus on the ignitions caused by lightning, and mainly on the fire effects on all forms of biological and natural resources. In addition, it is recognized that wildfires are induced either directly or indirectly by human actions.

Disturbance

- *Disturbance*

For the experts that prefer *Disturbance*, wildfire is a natural phenomenon that causes a removal of biomass and provokes an instantaneous or near-instantaneous change in the environmental conditions of an ecosystem; this change is highly variable in magnitude and in persistence, usually with temporary effects. For some experts, *Disturbance* is an ecological neutral term, not implying positive or negative effects. Fire, in general, creates a short period of environmental instability, and temporarily changes the composition or structure of the community, allowing some variations in species diversity, normally followed by a bounce back, after a given time-span, to the pre-fire conditions. Fire in natural vegetation can represent a factor of regeneration and resilience and a process affecting the homeostasis of ecosystems.

Wildfire is one of a group of natural and recurring disturbance processes that affect vegetation. Certainly, climate change and direct human impacts exacerbate these processes. However, they are, in themselves, nothing more than natural processes. Some respondents consider that wildfires are partly natural (fuel and weather/climate) and human (ignition and modified fuel continuum) phenomena that sometimes disrupt human interests

and values. The outcomes of wildfires may be judged undesirable depending on the values-at-risk. Wildfire disturbances turn into disasters or catastrophes only when valued resources are damaged or destroyed or when people that live in the area are affected.

Wildfires are not necessarily an environmental hazard, a disaster, or a catastrophe, depending if the ecosystem is adapted or not to fire. Wildfires result in ecological catastrophe when already threatened or endangered environments or species are irreversibly destroyed.

- *Ecosystem Disturbance*

Respondents that prefer *Ecosystem disturbance* consider that wildfires (both natural and human-induced events) temporally cause a disruption of the current state of ecosystems, with short or long-term effects on them. Overall, the ecosystems affected by a wildfire are very often able to bounce back to the pre-fire conditions, after a given time-span.

- *Natural Disturbance*

For respondents that prefer *Natural disturbance*, wildfires can have positive or negative impacts on natural and human systems. In a more restricted perspective, fire (influenced by climate, weather, and other environmental conditions) temporally affects the environment.

- *Social–Ecological Disturbance*

For respondents that prefer *Social–ecological disturbance*, wildfire is an element of the ecosystem evolution, connected to people living in the area. The physical processes and the social environment compound in a natural (or unnatural due to suppression activities) disturbance (or perturbation) to a coupled socio-ecological system. Anthropogenic activities, directly or indirectly, act as a socio-ecological disturbance, capable of rapidly changing the structure and functions in socio-ecological systems. Even when causes are mostly natural, consequences, prevention, and mitigation have a strong social component. The term “disturbance” has less negative connotation, and its origin can be natural or due to human activity.

Anthropogenic factors (e.g., ignition sources, land use, land fragmentation, firefighting forces, and strategies) are key drivers of the phenomenon in most parts of the world as much as weather/climate, fuel load, fuel types, and topography.

- *Socio-Ecological Disturbance*

This term is preferred by respondents based on three types of explanations: (i) wildfires can alter both the structure and function of natural ecosystems and also human societies, sometimes but not always negatively, (ii) wildfire occurrence, spread, and suppression (firefighting forces and strategies) are directly and indirectly influenced by different socio-economic factors and by environmental key drivers, such as weather/climate, fuel load, fuel types, and topography, and (iii) wildfire is a natural disturbance whose regime has been modified by anthropogenic activities. A significant portion of wildfires around the world occur within coupled social and ecological

systems, and even when causes are mostly natural, consequences, prevention, and mitigation have a strong social influence.

Aggression/Social Aggression

- *Aggression*

For the few respondents that prefer this term, wildfires are an offense to our ecosystem because, regardless of the causes, their effects have several degrees of magnitude and will always be an ecological catastrophe.

- *Social Aggression*

For the few respondents that prefer *Social aggression*, wildfires are an offense to nature that provokes negative impacts. The reasons for the aggression can be a social issue (e.g., competition with other territorial uses, disagreement with policies, conflicts for boundaries, land grabbing, or converting forests to farmlands or pastures).

Others

The respondents that prefer *Perturbance*, *Vegetation fire*, and *Natural event* consider that wildfires are events of natural or anthropogenic causes, not always turning into disaster, having a role in the maintenance of natural equilibrium of ecosystems.

Changes of Perception Between 2015 and 2020

The majority of respondents (68%) confirmed their previous opinions, whereas a minority (32%) suggested minor changes that were motivated by recent experience with wildfires (e.g., 2019–2020 fire season in Australia) or by the evolution in their mind-set. The changes of opinion were in different and even contradictory directions.

Recognizing the importance of climate change took several experts to increase the value attributed to *Climate-sensitive hazard*. One of the experts got the impression that fires exhibit increasing intensity and severity in the last decade, which may be the result of both extremely dry and windy climate, and biomass accumulation in the forest ecosystems due to the lessening of agricultural and forestry management.

The impact of the recent tragic events has taken several experts, even related to social sciences, to give greater prominence to terms like *Ecological catastrophe* and *Natural disaster*. Nevertheless, three experts gave less importance to the mentioned terms recognizing that not every wildfire event becomes catastrophe or disaster.

Several experts recognized that the social aspects must be more present in the understanding of wildfires, proposing more importance to terms like *Socio* or *Social–ecological hazard*, *Mixed hazard*, and *Semi-natural hazard*. On the contrary, two foresters decrease the importance of social influence on fire (reducing the values attributed to *Socio* or *Social–ecological hazard*) while enhancing the influence of climate on fire behavior.

One of the respondents reinforced the importance of natural hazard, although recognizing the influence of humans in triggering wildfires; the influence of climate, topography, and fuels was also highlighted.

Thus, we can summarize that the data gathered in 2015 maintain their interest and actuality 5 years later and that the changes in respondents' opinion in the last 5 years mainly consist in the increased awareness of the effects of climate on wildfire activity as well as wildfire as a socio-ecological phenomenon.

DISCUSSION

Misconceptions

In the body of the different explanations provided by the respondents, some misconceptions are present. The most frequent ones are statements about the origin of wildfires. For instance: “(...) *weather is a main source for wildfire ignition*”; “(...) *wildfires are caused by natural phenomena, such as drought*”; “(...) *caused by natural reasons such as high sun radiation, water deficit*”; “(...) *caused by different hazards such as severe droughts, strong winds* (...)”.

In the cases mentioned above, statements reflect some confusion and the unsatisfactory knowledge of the role of weather factors in fire ignition. The ignition source is the determining factor, i.e., the occurrence acting as priming factor of the combustion process by its high energy output. It can be a natural factor (lightning in the majority of the cases, a volcanic eruption in geographically limited conditions, very rarely a spark generated by landslides, and absolutely rare spontaneous ignition). These phenomena must ensure preheating, the first phase of combustion, which occurs at more than 100°C (Scott et al., 2012; Ganteaume et al., 2013; Prestemon et al., 2013; Franklin et al., 2018). Weather (i.e., temperature, wind, relative humidity, and precipitation), as well as topography (aspect, slope, shape of the area, elevation, and barriers), and fuel characteristics (i.e., fuel moisture, size, and shape; fuel fuel load, horizontal continuity, and vertical arrangement) are merely predisposing or contributing factors, which favor the process but do not start it [though high temperature is sometimes erroneously indicated as a causal agent; e.g., Forkel et al. (2012)].

Sometimes there is confusion between the concepts of climate and weather, as in the statement “*Fire spread depends on climate conditions: wind speed, wind direction, relative humidity, temperature and vegetation moisture*” where these conditions pertain to weather, not climate. Weather reflects short-term changes in the atmosphere, while climate is what the weather is like over a long period of time in a specific area.

Other cases of misconceptions are evident in the contrast presented about the definition (natural or anthropogenic) of fire ignition in the same statement, such as “(...) *although are natural events, their origin can be caused by (...) technological accidents*,” or “*Wildfires are a natural phenomenon maybe caused by unnatural means (such as human arson or carelessness), or by natural means, such as lightning*,” or “(...) *disaster the origin natural (...) although majority of wildfires has an anthropogenic origin related to the negligent use of fire*.” The contrast arises from the fact that wildfire is defined as a natural phenomenon because it can occur independently of human actions, but at the same time, it is mentioned that most of the fires have an anthropogenic origin.

There are some misconceptions related to the misunderstanding of the anthropogenic causes of wildfire ignitions. A statement such as “*The majority of forest fires caused by human activities can be termed as accidental fires*” does not comply with the different types of causes officially recognized, and certainly the adjective accidental is not properly used. In addition, a statement such as “*The most important human activity that can cause forest fires is the use of arson for clearing land*” is an example of misnomer for the term arson, arguably instead of the use of fire as a management tool (Camia et al., 2013).

Concerning wildfire impacts, we register statements such as “(...) *the whole ecosystem is destroyed*”; although expressively depicting a visual condition of temporary destruction, this statement does not acknowledge either the dual role, with positive and negative effects of fire in relation to ecosystem characteristics (Myers, 2006), or the mechanisms of resilience.

Finally, although they are not exactly misconceptions, we point out two aspects that reveal some difficulty in understanding the complexity of wildfires. One of the aspects is related to the use of different rational thinking to explain the terms. In the statement, “(...) *natural disaster implies some effect resulting from a natural process whereas a socio-ecological disaster implies some effect on society and its relationship to ecosystems regardless of cause*,” while to explain the meaning of natural disaster it is said that impacts are caused by a natural process, the explanation of socio-ecological disaster is based not on the factor triggering the event but on the impacts of fire on society and ecosystems. The other aspect is that many times, respondents limit themselves to explain just one of the words that compose the term. For instance, they explain why they use “natural” but not the term “hazard” and a frequent confusion is done in the use with a certain nonchalance of disturbance, hazard, disaster, and catastrophe as though they were synonyms.

The Dilemma of Wildfire Definition

The undoubted convergence of respondents on *Natural hazard*, *Disturbance*, and *Climate-sensitive hazard* suggests that less attention is paid to the possible interaction between fire occurrence and social conditions and factors. When fire is perceived as a natural phenomenon, caused by natural sources of ignition highly affected by climate (i.e., climate sensitive) and topography, scarce attention is given to the influence of social factors.

As a socio-ecological phenomenon, wildfire refers to the complex interactions of people and nature during all wildfire phases, connecting people and their communities to the places they live in and the impacts they have on those environments (Alexander, 1993; Westley et al., 2002; Kendra, 2007; Coughlan and Petty, 2012; Coughlan, 2013; Prior and Eriksen, 2013). This complies with the necessary understanding that in all the phases of the wildfire process, there is an interaction between ecological and human determinants, and sometimes, the latest are the most important factors (Vilimek and Spilkova, 2009). The majority of wildfires are induced by humans, who are sentient actors on the landscape (Pyne and Goldammer, 1997; Vitousek et al., 1997; Bond and Keeley, 2005; Lauk, 2009; Archibald

et al., 2012; Coughlan and Petty, 2012). Human actions can also create hazardscapes (e.g., increasing fuel load, through land use changes). At the same time, people can be victims of wildfires.

Natural and human-caused wildfires can be a hazard as, “(...) *may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation*” (UNDRR, 2017). The criterion to differentiate hazards is the triggering process that allows to distinguish natural hazards, predominantly associated with natural processes and phenomena, from hazards triggered by other types of factors (UNDRR, 2017). In this case, wildfires as mainly caused by human actions should not be classified as a natural hazard, as this points out that it is an *act of nature* we cannot avoid. Wildfires are unique among the various natural hazards (Moritz et al., 2014; Paton et al., 2015) because human action can actively reduce them either before or during an event (Middelmann, 2007; Pausas and Keeley, 2014), due to the complex interdependencies between people and the sources of wildfires (Paton et al., 2015) and because they are certainly among the most predictable ones (Biro, 2009). It is hard to find, among the natural hazards, another process that can be as predictable and manageable (but not always successfully) as wildfires. The uniqueness of wildfires is also evident in the fact that they can be controlled by fire itself, under the different forms of *suppression fire (counter fire, back fire, and burn out)*, and *prescribed fire* (Rego et al., 2007; Montiel and San-Miguel-Ayanz, 2009; Molina et al., 2010).

In order to become a disaster, a hazard has to affect vulnerable people (Cannon, 1994) and/or sensitive ecosystems. Disaster can be defined as “*A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts*” (UNDRR, 2017).

There is an ongoing debate about the term *natural disaster* (e.g., see Chmutina and von Meding, 2019) as “*A natural disaster, in a pure sense does not exist; rather there is the interaction of changes in physical systems with existent social conditions. The disaster itself occurs within society and not within nature*” (Weichselgartner, 2001: p.86). Although disasters are socially constructed, the use of *natural disaster* can be accepted to indicate that the event has a *natural trigger* that has its own characteristics representing different levels of threat to society. To classify a wildfire as a *natural disaster* is misleading because most of the outbreaks have an anthropogenic origin and because, as stated by several respondents, not all fires result in significant or destructive impacts, but have that potential. As an obvious corollary, in areas where there are no human interests, wildfires do not constitute a hazard nor do they turn into a disaster. Wildfires started by lightning in remote uninhabited areas, or other rare events originated by local natural causes, without human involvement, correctly remain a natural or physical event, independent of human activity.

Wildfire is a *Disturbance*, which is preferred by many experts; it does not imply positive or negative effects (Beever et al., 2020).

The terms *Aggression* and *Social aggression* seem, in a certain way, excessive, and they ignore the double role of fire as a threat and a benefit.

In synthesis, wildfire is a natural process that was already present before the appearance of human kind. Through the centuries, people started using fire with different purposes (Tedim et al., 2015), and at the same time, they have been creating more hazardous landscapes. Wildfire can be the trigger of a disaster that “*is influenced by what societies and citizens do, individually and collectively, to anticipate sources of risk, act to reduce and manage the risk prior to events occurring, and develop the knowledge, resources, skills and relationships to facilitate their ability to cope with, adapt to, and learn from wildfire events*” (Tedim et al., 2018: p.14).

In addition, the use of *natural* to label wildfires is misleading, as current wildfire activity across the world is directly and indirectly influenced by human actions. A proper definition of wildfire has important consequences in wildfire management policies and prevention approaches and where laws or regulations recall it as natural events.

CONCLUSION

This research identified the most common terms used to classify wildfires and critically analyzed the current definitions through the lens of a panel of experts contacted by email, operating in different countries at a global level. Although limited in the number of respondents, the research offers a perspective of the different preferences and, at the same time, of the personal interpretation of the terms, highlighting different thinking on wildfire complexity and even some misconceptions about basic wildfire knowledge. Each of the terms analyzed in this research was explained in different ways reflecting sectorial, disciplinary, and personal perspectives of the wildfire phenomenon. In addition, to define the same concept about wildfire, different terms were used.

This research faces one of the most widespread problems in science: the use of the appropriate terminology to communicate between scientists with different expertise and stakeholders so that all different scientific fields can work together toward a common understanding of wildfire problem. The unification of scientific terms, creating a common language across the several scientific fields related to wildfires, is of paramount importance as the current challenges of wildfire management require a transdisciplinary approach to address the complexity of the existing problems, produce new knowledge for development of practical effective solutions, and enhance an interactive communication not only among scientific community but also with stakeholders and citizens.

Wildfire is a natural phenomenon that can be beneficial (e.g., there are ecosystems that are fire dependent) or can be a hazard (i.e., can provoke damage to fire-sensitive ecosystems and to livelihoods and properties, can be responsible for injuries and fatalities). Frequently considered as a *natural hazard*, most wildfire outbreaks are related to human activities, so we consider it misleading to apply this term in connection with wildfire. Some fires are a *natural hazard*, but most of them are not. The same

happens with *climate-sensitive hazard* that is only focused on the influence of climate in wildfire occurrence.

We sustain that wildfire should be labeled as a *socio-ecological hazard* demonstrating the importance to consider the social dimension in the understanding of wildfire causes. This conceptualization is crucial to accommodate the ecological and social components in wildfire risk reduction.

Wildfires are not always a disaster or a catastrophe. Just a small number of wildfires become disasters or catastrophes when they affect vulnerable ecosystems and communities. An adequate wildfire risk reduction and a good physical and psychological preparedness can avoid the occurrence of damage and fatalities.

Wildfires are also a *disturbance* that can have beneficial and detrimental effects. The other terms identified in this article do not contribute to clarify the wildfire problem and enhance management policies.

Far from being an elegant but abstract semantic exercise, a proper definition of wildfires has important consequences in management and well-balanced policies. Improperly categorizing wildfires can be reductive and limitative of a better conceptualization of their nature and the establishment of more efficient policies to approach the problem and provide more efficient contributions to problem solving.

Scientific knowledge is in continuous evolution, and different approaches can be used; however, the “nature” of fire problem still lacks a common understanding, both ecologically and socially.

The increasing production of wildfire scientific knowledge has not been accompanied by a high impact on the ground for people, society, and the environment and has not improved the current wildfire management system (Tedim et al. in review).

Therefore, science should be differently conducted. Considering that wildfire knowledge is produced by an increasing number of disciplines acting in isolated silos, a possible approach could be the creation of a wildfire translational science, whose outcomes are policy relevant and easily applied to solve real world decision making and management problems, as they are related to the social and ecological context (Tedim et al. in review).

DATA AVAILABILITY STATEMENT

The original contributions generated for the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

FUNDING

This work was prepared in the frame of project AVODIS - Understanding and building on the social context of rural Portugal to prevent wildfire disasters (FCT

Ref: PCIF/AGT/0054/2017), financed by national funds by FCT-Foundation for Science and Technology, Portugal.

ACKNOWLEDGMENTS

The authors would like to express their deepest gratitude to the experts that participated in this research. The authors also thank the three reviewers and the Editor, for their careful reading of the

manuscript and their many insightful comments and suggestions that permitted to improve the quality of the paper.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/ffgc.2020.553116/full#supplementary-material>

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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