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Forest fire motives in Sardinia through the perception of experts

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Abstract

Wildfires statistics for Sardinia (Italy) exhibit a very high number of unknown causes: all merged, they account for about 78%. In order to reduce their number, which really hinders any preventive approach, we tested Delphi method, the structured communication technique which relies on a panel of experts.. Results, obtained in collaboration with the Regional Forestry Service (CFVA), put in evidence the concordance among the highest frequency of motifs in regional statistics, as from CFVA databases and those resulting from Delphi survey. Our study reveals a modest prevalence of intentional causes (53 % of total number), also on a provincial basis, v. unintentional ones (46%). All of them can be classified as negligent use of fire in agriculture, namely stubble (or other agricultural wastes) burning, inappropriate or uncontrolled mop-up , negligent use of motors, open flames, electric or mechanical devices, non compliance with regional reglements concerning fire prevention and control. Voluntary fires are also related with agriculture and a traditional rural society, in which fire is a well rooted tool.

Keywords: *Delphi method, fire causes, fire smart, forest fire protection plans, individual fire report, integrated fire management, negligent behaviour, panel of experts, traditional ecological knowledge.*

1. Introduction

In this paper, we deal with the implementation of a Delphi survey in the eight provinces of the island of Sardinia (Italy), aimed to produce statistics on wildfires causes mainly avoiding unknown causes which represent about 78% (1998-2011) of the total.
Sardinia is a real hotspot for wild fires, which are a recurrent presence.The second largest island in the Mediterranean Basin after Sicily, with a surface of about 2,408,989 hectares, Sardinia is prevalently hilly; 13.6% of the island is mountainous, 18.5% is flat and 67.9% is rugged and hilly.
Forests cover a total of 1,213,250 hectares of which forest cover respectively 583.472 hectares, i.e 24,22%,; other woodland cover 629.778 hectares i.e. 26,14%; thus Sardinia has a forestry index of 50,36 % (Salis *et al.*, 2013).

1.1. Climate and territory of Sardinia

The climate is inner Mediterranean (Chessa & Delitala, 2012; Vacca *et al.*, 2002), or dry summer subtropical (*Subtropical Csa* type after Köppen, 1936) with an exceedingly long summer and a short humid winter interspersed with three short rainy seasons.
Maximum temperatures of 35-40 °C are repeatedly recorded and peak temperatures climb occasionally well above 45°C as in 2003 and 2009. An absolute maximum of 48,0 °C was recorded in 1965 in Macomer (Chessa & Delitala, 2012).
Wind speed can largely exceed 13,5 m/s (Chessa & Delitala, 2012) with a maximum registered speeds of 64 knots for NW winds in Cagliari and 59 for W winds in Alghero (respectively 118 and 109 km h^{-1}; Osservatorio Industriale della Sardegna, 2000).

1.2. **Fires: number and surfaces**

About 600,000 ha of woodland were burned in Sardinia in the last 120 years (D'Angelo & Enne, 2000). In the period 1970-2010 fire occurrence is documented (Regione Autonoma della Sardegna, 2011) by the following data (mean ± S.D. and CV, coefficient of variation) :

Number of fires   *3,341 ± 1,113 (0.34)*

Burned surface (ha)   *38,336 ± 27,619*   *(0.70)*

Burned forested surface (ha) 7,701 ± 6,847 (0.87)

Sardinia exhibits the highest incidence of wildfires among Italian Regions.

1.3. **Fire suppression effort**

To counter such a recurrent calamity, since the '80s the autonomous Region of Sardinia has improved its fire suppression apparatus. Despite relevant investments in human and technological resources, results are apparently acceptable. If burned surfaces diminished, due also to improved suppression procedures which insure initial attack within 14' as an average, thus containing 97% of fires under 10 hectares, the number of events (a yearly average of 2,800-3,000) remains accordingly unchanged along time (Boni, 2004).

1.4. **Fire causes**

There are a variety of motivations for wildfires in Sardinia and their recognition is the key to finding a solution for a more efficacious control (Jollands *et al.*, 2011).

It is actually accepted (Birot, 2009; Montiel & Herrero, 2010) that facing the increasing wildfire threats demands a shift from suppression-oriented policies to preventive and integrative policies aimed at removing the structural causes of wildfires. But this pro-active approach requires a good knowledge of the causes contributing to wildfires.

Forest fire statistics, yearly compiled by CGVA (The Sardinian Forestry Rangers Corps) on the basis of individual fire reports, confirm that agropastoralism still plays a major role among the causes of fires, with a positive correlation between sheep number and burned surfaces.

In Tab. 1 motifs, as assessed by CFVA for 1998-2011 and stored in its databases, are reported with their statistical code, where C stays for involuntary, D for voluntary or deliberate. Only motifs with a frequency > 2.00% are considered.

Tab.1 - Motives in order of importance for provinces (1998-2011) through the official statistics by CFVA

Statistical code	Description	Frequency	Frequency in %	Province where frequency is maximum
C09	Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes)	47	12.40	Oristano
C05	Fires caused by inappropriate or uncontrolled mop-up	28	8.70	Oristano
C11	Fires caused by the careless use of machinery	33	7.80	Sassari-Olbiatempio
C08	Non compliance with the the Regional Ordinance relating to the Prevention and Control of Fires	25	7.60	Oristano
C01	Fires caused by cigarette stubs or matches	27	6.80	Sassari-Olbiatempio
D12	Fires caused by behavioural disturbance (pyromania)	28	6.70	Ca-Carbonia Iglesias

C15	Fires caused by poor power line maintenance	27	6.30	Sassari-Olbiatempio
D02	Fires caused by agricultural and forestry activities for the clearing of uncultivated land	21	6.10	Oristano
D03	Fires caused by conflicts or revenge among private owners (for pasture)	32	6.00	Ca-Carbonia Iglesias
D17	Fires caused with the intent of creating an alert situation in firefighting structure	26	5.90	Nuoro-Ogliastra
D13	Fires caused by revenge or retaliation referable to poaching	15	4.20	Oristano
D04	Fires caused by conflicts or revenge among private owners or shepherds and public agencies (for pasture)	15	2.70	Nuoro-Ogliastra
D18	Fires caused by arson (not otherwise defined)	11	2.60	Nuoro-Ogliastra

Such statistic are based on less than 23% of the 8,428 fires occurred in the period 1998-2011.In many cases motifs are classified as unknown voluntary or unknown involuntary, without a specific motive. All merged, unknown causes account for 77.65% and therefore do not give the sufficient information deemed necessary for a more preventive approach.

In order to reduce the number of unknown events, in collaboration with CFVA we tested the Delphi method.

2. Materials and methods

2.1. The Delphi method

The Delphi method (Dalkey & Helmer 1963, Linstone & Turoff 2002) is an iterative process based on the principle that *"a group of experts usually performs better than any one expert because the group possesses at least as much knowledge as its most knowledgeable member"* (Henderson, 2008).

2.2. *The panel of experts and the questionnaire*

For our Delphi survey, carried out in 2012, experts were the non commissioned officers working for CFVA. As from their statement, their knowledge of wildfires is very good for 54% of them, excellent for 14%. They were convened in four successive sessions from one or several neighboring provinces. Number of experts per session varied from 14 for the merged provinces of Nuoro-Ogliastra to 30 units in the provinces of Cagliari-Carbonia/Iglesias, for a total number of 98. Number of experts was balanced among areas and, in addition, well above the minimum (at least 10, Delbecq *et al.*, 1975). Structured questioning was achieved through the use of *ad hoc* questionnaires, reporting the motives of forest fires for Sardinia as used by GFVA in official statistics (Saba, 2004). Experts were asked to recognize the four most relevant fire motives in their area of duty and were then invited to rank such motives in order of decreasing importance, giving a score ranging from 1 (maximum) to 4 (minimum). In previous works we used a range of 1 to 8 (Lovreglio *et al.*, 2006, 2008, 2010, 2012 ; Meddour-Sahar et a.l 2013). Reducing rank score range to 1 to 4 obliges respondents to make a more severe selection in their responses. Controlled feedback was achieved by discussing responses, and then asking the panel members whether they wanted to change their judgements.

3. Results

Rank-ordering is the mode of rank-scores. Causes, from our survey, result involuntary for 46%, voluntary for 53 %, natural for 1 %; values are coherent with the general opinion that voluntary fires are often overestimated or overemphasized (Vélez, 2000).

A comparison between the voluntary/involuntary motifs as detected by CFVA in the period 1998-2011 and the motifs identified by the panel of experts was carried out.

In some provinces voluntary fires are clearly prevailing in CFVA official statistics, with the exception of Cagliari-Carbonia Iglesias, where Delphi assesses a majority of voluntary fires.

Motifs issued from Delphi survey and arranged following the mode of rank-scores are presented in Fig.1. Identification codes in the bar chart reflect the official list of causes as proposed by CFVA (Saba, 2004).
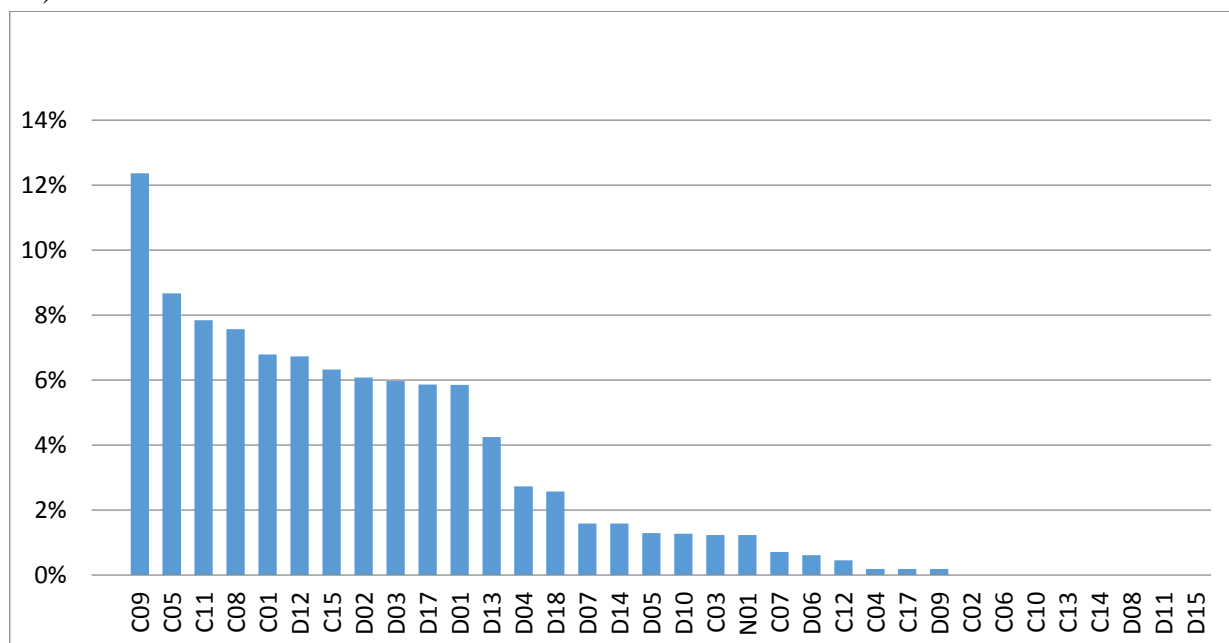

Figure 1 Frequency (%) of the motifs on a regional scale as a result of Delphi method

In Tab. 2 we present the motifs as assessed in the regional wildfires databases and results of our Delphi survey, in terms respectively of frequency and rank order.

Tab.2 - Motives at regional level: comparison between data from regional databases and data from Delphi survey

Motives frequency Data from regional databases		Motives frequency Data from Delphi survey		Motives rank order (1 to 4) Data from Delphi survey	
C09	Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes)	C09	Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes)	1	C09 Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes)
C05	Fires caused by inappropriate or uncontrolled mop-up of fires	C05	Fires caused by inappropriate or uncontrolled mop-up of fires	2	C05 Fires caused by inappropriate or uncontrolled mop-up of fires
C11	Fires caused by the careless use of machinery	C11	Fires caused by the careless use of machinery	3	C11 Fires caused by the careless use of machinery

C08	Non compliance with Regional Ordinance relating to the Prevention and Control of Fires	C08	Non compliance with Regional Ordinance relating to the Prevention and Control of Fires	4	C08 Non compliance with Regional Ordinance relating to the Prevention and Control of Fires

Results put in evidence the full concordance among the highest frequency in regional statistics, as from CFVA databases and the motifs as perceived by the experts in Delphi survey:

In the following Tab. 3 we present the top motives, i.e. those ranked 1 to 4, through the Delphi method, on a provincial scale.

Tab. 3 - Rank order of motifs by Province

Rank	Oristano	Sassari-Olbiatempio	Ca-Carbonia Iglesias	Nuoro-Ogliastra
1	C.05 Fires caused by inappropriate or uncontrolled mop-up	C.11 Fires caused by the use of machinery (motor, flame, electric or mechanical devices)	C.09 Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes)	C.09 Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes
2	C.09 Fires caused by agricultural and forest activities (burning of stubble and agricultural wastes	C.15 Fires caused by poor power line maintenance	D.03 Fires caused by conflicts or revenge among private owners (for pasture)	D.02 Fires caused by agricultural and forestry activities (clearing of uncultivated land)
3	C.08 Non compliance with the Regional Ordinance relating to the Prevention and Controll of Fires and Abusive stubble burning	C.03 Fires caused by cigarette stubs or matches	D.12 Fires caused by behavioural disturbance (pyromania)	C.11 Fires caused by the use of machinery (motor, flame, electric or mechanical devices)
4	D.02 Fires caused by agricultural and forestry activities (clearing of uncultivated land)	C.08 Non compliance with the Regional Ordinance relating to the Prevention and Control of Fires and Abusive stubble burning	D.17 Fires caused with the intent of creating an alert situation in firefighting structure	D.17 Fires caused with the intent of creating an alert situation in firefighting structure

4. **Discussion of results**

The results represent only the collective informed opinion and judgement of the experts participating in the panel about fire motives but, at our opinion, there is no alternative way to produce better results,

with the exception of information issued from sentences beyond recall for identified culprits (Leone *et al.*, 2009).

Our research was based on the opinions of professionals with an interest, knowledge and field experience in wildfires, assuming that replies are frank and well meditated.Their responses should however be taken to be truth-as-observed by experts not exact science (Jollands *et al.*, 2011).

By the Delphi method, unclassified causes of wildfires in Sardinia are eliminated, thus allowing to express more clear information on the possible roots of the phenomenon.

Our results reveal the relevant importance of unintentional causes, which are prevailing also on a provincial basis. All of them can be mainly classified as negligent use of fire in agriculture (burning of residues, stubble burning, negligent use of agricultural machinery, non compliance with regional regulations concerning use of fire..).

A closer analysis of motifs reveals only two cases of voluntary reasons: creating an alert situation in fire fighting structure, though ranked at 4th position, and pasture conflicts; the latter recalls the importance of traditional pastoral activities in the island. If we exclude from analysis pyromania, all others motifs are directly or indirectly connected with agricultural activities and a rural society. In many cases the threshold between voluntary and involuntary is rather fuzzy, such as the case of stubble burning behind official date fixed by regional regulations. Voluntary fires, on the contrary, are more limited but they also partly refer to the use of fire in agriculture.

In the province of Oristano inappropriate mop-up is referred to extinction operations not carefully carried out. Limited to Sassari and Olbia-Tempio province, we notice fire caused by lack of maintenance of power lines. Both situations give a clear info about possible solutions, respectively improving suppression procedures and ensuring power lines efficiency through maintenance.

Results reflect a society accustomed to using forest and rural spaces, with scarce respect and care and without concern for its preservation (Thirgood, 1981; Dimitrakopoulos and Mitsopoulos, 2006).

Causes and their motives, as issued from our research (involuntary for 46%, voluntary for 53 %, and natural for 1 %, as percentages of respondents' judgments), are well consistent with the general trend reported in current literature (Catry *et al.* 2010).

In Sardinia, traditional abilities and know-how of fire use represent a deeply rooted tool for agricultural activities (Silva *et al.*, 2010b), a true *TEK, traditional ecological knowledge* (Ribet, 2002) well used by a still fire-relying community (Lazaro & Montiel, 2010).

5. **Conclusions and final remarks**

Delphi method for the identification of the major causes and reasons of forest fires exploits the good level of panellists' expertise and their knowledge of the territory and of local socio-economic scenarios behind the phenomenon of wildfire, in a rather quick and easy way (Lovreglio *et al.*, 2006, 2008, 2010, 2012; Meddour-Sahar *et al.* 2013).

As in the case of Sardinia, where official info about wildfires is rather poor, Delphi method is intended for use in stuations where statistic method are not possible due to the lack of appropriate data.

Understanding the most frequent causes and reasons in different social contexts can definitely help the prevention measures and the efforts in modifying the behavior of individuals in complex social contexts.In our study area recognizing the presence of a fire-relying community, as from Delphi results, could suggest an approach locally based on a different and fire-smart application of the traditional use of fire, rather than the conventional and regulatory, restrictive measures of prevention. This could represent a fair example of integrated fire management, sensu Fire Paradox.

6. **Acknowledgements**

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