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**ADVANCES IN
FOREST FIRE
RESEARCH**

DOMINGOS XAVIER VIEGAS

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Forest fires hotspots in EU Southern Member States and North Africa: a review of causes and motives

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Abstract

Despite enhanced fire suppression efforts the number of fires has increased in Europe and in North Africa, above all in Portugal, and the extinction oriented model of fire control is no more suitable to change the trend. Hence, the need of shifting from a reactive model grounded on a fast and strong reaction, to more pro-active procedures supported by prevention, aimed not only to fuel reduction but also to gradually intervene on the causes of fires. In this perspective, a fair knowledge of man-caused fire outbreak motives is a crucial point. This paper intended to compare and interpret those motives in Portugal, Italy and Algeria obtained through the perception of experts (forest experts and other practitioners). In this research new data was collected in the North Region of Portugal and data already available for Algeria and Italy was commented.

The results of the research highlighted great similarities of the main fire causes and motives identified by the experts from the case-studies in the three countries. Fire outbreak motives are not related with deliberate fire setting but, mainly, with the use of fire in rural activities. Fire is a manageable tool that is still needed in many agro-forestry systems. One of the findings of this study pointed out the need to design and develop specific prevention programs able to reduce fire incidence and promote practices more respectful of the tradition and needs of rural communities, often criminalized for their habitudes of using fire as a multipurpose tool. Deliberate fire can represent isolated and sporadic actions however, some of them result from organized and even criminal interests. Finally, this paper argues that improved fire prevention to address the roots of fire problems cannot be achieved without a deep knowledge of the complexity and diversity of the fire outbreak motives.

Keywords: *CBFiM, concertation, Delphi technique, EU, fire outbreaks motives, forest fire cause, integrated fire management, North Africa, occupational fire, prevention*

1. Introduction

Each year burned area continues to be substantial in Europe and in other Mediterranean countries (Table 1). Enhanced fire suppression efforts and investments in human and technical resources (e.g. important aerial fleets; updated methods and technology to fight fires; emergency response organization, coordination and support) limited the damages but did not solve the fire problem which is far from being controlled. The incapacity of reducing the number of ignitions, the apparition of events that grow to previously unheard sizes, and more frequent and complex fires in the wildland urban interface, are alerting signals of the need to improve and change forest fires policies. A mainly extinction oriented model of fire control seems not well adapted to cope with new forest fire scenarios (Molina *et al.* 2010; Montiel and Herrero 2010; Sebastián López *et al.* 2011).

Table1 - Forest fires in Southern European and North Africa countries

| Country | Average yearly burnt area (ha)* | Average yearly number of fires (no.)* | Maximum annual burnt area (ha) | Average forest fire density no. fires/ km ² | AAR** |
|----------------------|---------------------------------|---------------------------------------|--------------------------------|--|-------|
| Spain (1980-2012) | 171,593 | 15,263 | 484,476 ¹ | 3.0 | 0.84 |
| Portugal (1980-2012) | 108,334 | 18, 613 | 425,726 ² | 20.3 | 3.31 |
| Italy (1980-2012) | 113,496 | 9,736 | 227,729 ³ | 3.2 | 1.14 |
| Greece (1980-2012) | 47,141 | 1,554 | 225,734 ³ | 1.2 | 0.57 |
| Algeria (1986- 2010) | 35,025 | 1,637 | 271,598 ⁴ | 0.07 | 0.85 |
| France (1980-2012) | 26,383 | 4,880 | 75,566 ⁵ | 0.9 | 0.53 |
| Morocco (1960-2009) | 2,987 | 260 | 11,174 ⁶ | 0.06 | <0.01 |
| Tunisia (2005-2010) | 1,554 | 750 | 3,551 ⁷ | 0.5 | <0.01 |

¹In 1985; ²In 2003; ³In 2007; ⁴In 1994; ⁵In 1989; ⁶In 2012; ⁷In 2010

Source: *European Commission, 2013; **Annual Average Risk (AAR) i.e. the percentage of the wooded area burnt each year (FAO, 1999)

Even though forest fires have not usually been considered as a natural hazard by the scientific community (McCaffrey 2004), since the last decades of 20th century they have been recognized as natural hazards (e.g. floods, earthquakes) by the state agencies and institutions, such as NASA or European Union (EU) (Leone and Lovreglio 2003) and, consequently, as a problem to be covered by Civil Protection (or Civil Defence in some countries). Forest fires are a civil protection/defence problem in the moment of suppression, but they are the result of complex interrelationships between society-environment-economy, thus requiring a rather different approach shifting from the reactive model, typical of Civil Protection, to more pro-active procedures supported by a prevention strategy (EFIMED 2012; Xanthopoulos 2012; Marino *et al.* 2014; Raftoyannis *et al.* 2014).

A symptomatic solution dealing with problems, as they arise, but failing to address the underlying causes, can increase the chance that the same problem will crop up in the future. In the case of forest fires, this means to allocate resources to short-term fixing of symptoms, increasing emphasis on fire suppression, instead of dealing with the causes of problems (Collins *et al.* 2013), so neglecting fire prevention. The “*firefighting trap*” metaphor as used in business domain (Collins 2012; Collins *et al.* 2013) well depicts such a short sighted cycle of problem-solving.

Policy makers and fire managers should pursue a balanced approach to suppression and prevention activities (Collins *et al.* 2013) aimed not only at fuel management but also to intervene on the causes of forest fires which are predominantly the result of anthropic activities (FAO 2012). Thus, actions must effort to change individual, social and institutional behaviours, but they meet a weak point in the general lack of in-depth knowledge of causes and forest fire outbreaks motives which according to FAO (1999) is a “*precondition for the implementation of prevention adapted solutions*” (p. 41). It is actually biased by the relevant incidence of unknown causes [e.g. 95% in Morocco (European Commission 2013), 80% in Algeria (Meddour-Sahar *et al.* 2013), 60% in Tunisia (Ben Jamaa and Belhaj 2011), 16% in Italy (CFS 2012), 49% in Portugal (ICNF 2012)]. This is due to the current system of producing forest fires statistics through an a-critical processing of individual forest fires reports, compiled soon after control activity is over. The task is difficult without appropriate surveys, which are impossible in the presence of a great number of events, most of them of less than 5 ha, and without the identification of each ignition point.

This study intended to interpret the motives (i.e. “the intentional state which prompts or moves one to act”; Wrathall 2005: p. 118) of forest fires outbreaks in Portugal through the perception of forest experts, and compared the results with previous studies realized in Italy and Algeria, by a method which consistently reduces the incidence of unknown motives. This paper argues that improved fire

prevention to address the roots of fire problems requires a deep knowledge on the complexity and diversity of man-induced fire causes and motives and should be sensitive to their spatial variation.

2. Methods

In the absence of sufficient data and/or complete knowledge in regard to forest fires motives the Delphi technique, grounded on a structured process to collect opinions from a group of experts, can be used. This collective judgment, although made up of subjective opinions, is considered to be more reliable than individual statements and is thus more objective in its outcomes.

In Portugal, a research of forest fires causes using Delphi method was conducted in the North Region (NUT 2), with about 3.6 millions of inhabitants (INE 2012) and a surface of 21,278 km². It is among the most fire prone regions of the country where, between 1980 and 2011, a total number of 351,550 fires was recorded which burned 1,219,609 ha. The North Region encompasses 86 municipalities, but the urban municipalities of Porto and S. João da Madeira were excluded from the analysis. To the 84 selected municipalities a questionnaire was sent by email to be answered by the Forest Fire Technical Division of each municipality which is responsible for the Municipal Plan for the Defence of the Forest Against Fire, as established by the Decree-law 17/2009. The questionnaire contained the Portuguese official list of the three level structure of fire causes reporting 68 motives (<http://www.icnf.pt/portal/florestas/dpci/Resource/doc/estatist/dgrf-codificacao-causas.pdf>; Camia *et al.* 2013), divided into seven main categories (i.e. *negligent usage of fire, accidental, structural causes, incendiary, natural, unknown, and rekindle*) with their identification codes. Experts should identify the fire outbreaks motives in their territories, classifying them by a Likert scale from 1 to 5 (ranging from *not important* to *extremely important*); successively, they were asked to rank the six most important motives in decreasing order of importance from 1 (the *most important*) to 6 (the *least important*). Sixty nine valid answers were received (i.e. a return rate of 82% of the contacted sample). The information from the questionnaire was analysed and a fire motive rank-ordering was established as the mode of rank-scores. The early results of this procedure are presented and discussed in this paper. The following step will be the organization of meetings in different municipalities of the North Region to circulate, validate and discuss the results from the questionnaire.

The procedure used in Portugal was slightly different from the one used in Algeria and Italy concerning the two rounds interspersed with a feedback and the number of ranked motives, only six in Portugal instead of the eight in Algeria and Italy. These differences did not have implications in the comparative study. Detailed information on the methodology used in Algeria and Italy can be found in Meddour-Sahar *et al.* (2013) and Lovreglio *et al.* (2006), respectively.

In Algeria, the Delphi method was used to identify forest fires causes and motives in the three most affected *wilayas* (equivalent of NUTS 3, Departments) i.e. Bouira, Boumerdes, and Tizi Ouzou (Meddour-Sahar *et al.* 2013; Meddour-Sahar 2014).

In Italy, the same method was used in the 29 most affected provinces in the Centre and South of the country, in two National Parks (NP) in the South of the Country (NP of Gargano, NP of Cilento and Vallo di Diano) and in some minor administrative units such as Mountain Communities (MC) (Lovreglio *et al.* 2006; De las Heras *et al.* 2007; Lovreglio *et al.* 2008; Leone and Lovreglio 2009; Lovreglio *et al.* 2010a,b; Marciano *et al.* 2010; Regione Puglia 2012).

Although it was interesting to consider Spain in this study, the data obtained also using Delphi method (APAS and IDEM 2003, 2004; Dolz Reus and Franco Irastorza 2005; Franco Irastorza and Dolz Reus 2007) were not comparable for methodological differences.

3. Results

The frequency analysis of forest fires outbreak motives reported as extremely important by the panel's members in North Region of Portugal showed a large variety of motives, where just five of 68 possible reasons were not identified as extremely important by the experts. The most mentioned were rekindle

(considered by 54% of the municipalities) and management of forestry or agricultural vegetation (e.g. renewing pastures, 48% of the municipalities' responses; clearing of forest areas, 45%; clearing of agricultural areas, 41%). Other motives were related with conflicts in the use of resources (e.g. hunting conflicts, 30%), influence on economic/market activities (e.g. pressure on wood market, 20%), social and interpersonal tensions (e.g. conflicts between neighbours, 26%; revenges and retaliatory actions, 24%), and antisocial behaviours (e.g. pyromania, 38%; vandalism, 32%).

The rank obtained from the modal values of the extremely important motives classified from 1 to 6 by the panel's members highlighted the same reasons although presenting them in slightly different order (Table 2). Thus, the most important fire ignition motive in the North Region of Portugal was renewing pastures which was identified as the first one in 16 municipalities and the second one in another nine municipalities. Still related with management of forestry or agricultural vegetation cleaning the agricultural lands and cleaning forest lands appeared in rank 2 and 3, respectively. Pyromania appeared in rank 4, being the main motivation in eight municipalities. In rank 5, appeared vandalism as well as rekindle. Conflicts between neighbours were classified in rank 6.

The results of the rank ordering in North Region of Portugal were not very different from the ones found in Algeria and Italy. Furthermore, in these countries fire, as a manageable tool needed in many agro-forestry systems, appeared as the main reason for fires outbreaks. In Algeria (Table 3), the use of fire in agricultural works was the main motive in the three wilayas together with vegetation management activities (i.e. creation or renewal of pastures, forest works, and wild honey hunting). Illegal garbage dumping and burning, mentioned in the three wilayas although in different rank position, is an "inevitable 'problem solving' solution by inhabitants, who have no other more sustainable alternative for waste disposal" (Meddour-Sahar *et al.* 2013: p. 251). Other negligent reason was cigarettes remains. Deliberate fires (i.e. intentionally caused by human, according to the harmonized classification scheme of fire causes in EU, Camia *et al.* 2013) were mainly related with interests in land use changes. Rekindle appeared important in Algeria too, where it is caused by fire crews who do not always ensure the mopping up of controlled fires but as well as by the so called "security fires" (Meddour-Sahar *et al.* 2013).

In Italy (Table 4), with the exception of the Province of Bari, the negligent motives are also more important than deliberate use of fire. Multiple motives in the same rank order reflect the

Table2 -Experts panel perception on forest fire ignitions motivations, in Portugal (answers N=69; orange colour for deliberate causes, green for negligent causes, and grey for rekindle)

| Frequency | Rank | Motives | Modal values for its position category | | | | | |
|-----------|------|--------------------------------|--|-----------------|-----------------|-----------------|-----------------|-----------------|
| | | | 1 st | 2 nd | 3 rd | 4 th | 5 th | 6 th |
| 33 | 1 | Renewing pastures | 16 | 9 | 1 | 0 | 1 | 1 |
| 28 | 2 | Cleaning of agricultural areas | 1 | 10 | 3 | 3 | 4 | 0 |
| 31 | 3 | Cleaning of forest areas | 3 | 3 | 9 | 5 | 2 | 3 |
| 26 | 4 | Pyromania | 8 | 3 | 3 | 7 | 1 | 2 |
| 22 | 5 | Vandalism | 8 | 2 | 1 | 2 | 3 | 0 |
| 37 | 2 | Rekindle | 8 | 6 | 6 | 2 | 3 | 2 |
| 18 | 6 | Conflicts between neighbours | 1 | 4 | 4 | 0 | 2 | 4 |

Table 3. Perception of experts' panels on forest fire ignitions motivations in Algeria (orange colour for deliberate causes, green for negligent causes, and rekindle in grey)

| Wilaya | 1 | 2 | 3 | 4 | 5 | 6 | Source |
|------------|--------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------|------------------------------------|----------------------------------|
| Bouira | Agricultural works (stubble burning) | Cigarette remains | Illegal garbage dumping and burning | Creation or renewal of pastures | Interests in land use changes | Wild honey hunting | Meddour-Sahar <i>et al.</i> 2013 |
| Boumerdes | Agricultural works (stubble burning) | Rekindle | Forest works (burning of cut bush) | Illegal garbage dumping and burning | Cigarette remains | Interests in land use changes | Meddour-Sahar 2014 |
| Tizi-Ouzou | Agricultural works (stubble burning) | Illegal garbage dumping and burning | Interests in land use changes | Cigarette remains | Rekindle | Forest works (burning of cut bush) | |

Table 4 - Perception of experts' panels on forest fire ignitions motivations in Italy (N.A.-Not available; orange colour for deliberate causes, green for negligent causes, and rekindle in grey)

| NUTS | 1 | 2 | 3 | 4 | 5 | 6 | Source |
|---------------------------|--------------------------------------|--------------------------------------|---|--|---|---|-------------------------------|
| NUTS2 Basilicata Region | Agricultural works (stubble burning) | Creation or renewal of pastures | Agricultural works (stubble burning) | Creation or renewal of pastures | Ownership controversies | Retaliation against public administration | Lovreglio <i>et al.</i> 2006 |
| NUTS3 Province of Taranto | Burning of fallow land | Agricultural works (stubble burning) | Agricultural works (stubble burning) | Creation or renewal of pastures | Creation or renewal of pastures | Illegal garbage dumping and burning | Lovreglio <i>et al.</i> 2008 |
| MC of Vallo di Diano | Agricultural uses | Agricultural works (stubble burning) | Hunting products in areas scorched by fire passage (e.g. mushrooms, wild asparagus) | Cigarettes remains | Hunting products in areas scorched by fire passage (e.g. mushrooms, wild asparagus) | Fire-crackers and bottle-rockets | Lovreglio <i>et al.</i> 2010a |
| | Burning of rests | | Agricultural works (stubble burning) | Agricultural uses | Burning of rests | | |
| | | | Ownership controversies | | Ownership controversies | | |
| NP of Gargano | Agricultural works (stubble burning) | Creation or renewal of pastures | Protest of seasonal fire-fighters | Agricultural works (stubble burning) | Creation or renewal of pastures | Protest of seasonal fire-fighters | Lovreglio <i>et al.</i> 2010a |
| | | | Retaliation against public administration | | | | |
| | | Protest of seasonal fire-fighters | Fire caused with the intent of being included in fire-fighting crews | Fire caused with the intent of being included in fire-fighting crews | | | |

| | | | | | | | | |
|----------------------------------|---|---|---|--|-----------------------------------|---|-------------------------------|-------------------------|
| NUTS3 Province of Bari | Fire caused with the intent of being included in fire-fighting crews | Agricultural works (stubble burning) | Agricultural works (stubble burning) | Creation or renewal of pastures | Building speculation | Hot vehicle exhaust pipes | Lovreglio <i>et al.</i> 2010a | |
| | | Protest of seasonal fire-fighters | Cleaning of road/railroad | Fire caused with the intent of being included in fire-fighting crews | Protest of seasonal fire-fighters | Building speculation | | |
| | Agricultural works (stubble burning) | Ownership controversies | Protest of seasonal fire-fighters | | Ownership controversies | | | |
| NP of Cilento and Vallo di Diano | Creation or renewal of pastures | Hunting products in areas scorched by fire passage (e.g. mushrooms, wild asparagus) | Hunting products in areas scorched by fire passage (e.g. mushrooms, wild asparagus) | Ownership Controversies | Plantation cleaning after harvest | Hunting products in areas scorched by fire passage (e.g. mushrooms, wild asparagus) | Lovreglio <i>et al.</i> 2010b | |
| | | | | Agricultural land cleaning after harvesting | Burning of rests | | | Ownership Controversies |
| | | | | Burning of rests | | | | |
| NP of Gargano | Creation or renewal of pastures | Agricultural works (stubble burning) | Vegetation burning to earn agricultural land | Burning of fallow land | Burning of rests | Agricultural works (stubble burning) | Leone and Lovreglio 2009 | |
| | | | | | | Fire lit to depreciate tourist areas | | |
| | | | | | | Fire lit for game or divertimento | | |
| 29 NUTS3 Central South | Creation or renewal of pastures | Agricultural works (stubble burning) | Agricultural land cleaning after harvesting | Agricultural land cleaning after harvesting | Hunting conflicts and poaching | Mental troubles and pyromania | Marciano <i>et al.</i> 2010 | |
| NUTS 2 Region of Apulia | Burning of fallow land | Agricultural works (stubble burning) | Burning of fallow land | Burning of rests | Creation or renewal of pastures | Mental troubles and pyromania | Regione Puglia 2012 | |
| | | | | Agricultural works (stubble burning) | | | | |
| | | | | Cleaning of road/railroad | | | | |
| NUTS2 Region of Sardinia | Agricultural and forest activities (burning of stubble and agricultural wastes) | Rekindle | Careless use of machinery | Non-compliance with Regional regulations | N.A | N.A | Lovreglio <i>et al.</i> 2014 | |

difference of experts' perspective. The main negligent reasons (classified in rank 1) in all the study-areas were agricultural burnings (e.g. *stubble burning*, *creation or renewal of pastures*, *burning of fallow*, *burning of rests*, *agricultural land cleaning after harvesting*). Also considered in the rank of the six most important fire outbreak motives appear: *fire-crackers and bottle-rockets*, *careless use of*

machinery, cleaning of road/railroad, hot vehicle exhaust pipes, cigarettes remains, and illegal garbage dumping and burning. Garbage dumping and burning is a negligent action in the current EU causes classification (Camia et al. 2013), where it is considered a form of waste management. Anyhow, mainly in the South of Italy, it is related to illegal dumping and successive burning by organized criminality, for which illegal waste and garbage traffic and disposal represent an important eco-business; for this it must be classified as voluntary, related to illegal profits.

Deliberate fires motives in the Italian case-studies appeared very diverse and with different profiles. The most important motives are profit activities to obtain goods, job or even money (e.g. *hunting products in areas scorched by fire passage as mushrooms and wild asparagus; building speculation; vegetation burning to earn agricultural land; fire lit to depreciate tourist area; fire caused with the intent of being included in fire-fighting crews*). Social and interpersonal tensions (e.g. *hunting conflicts and poaching, ownership controversies*) can also explain some fire setting. Some forest fires events could be attributed to negligent behaviours (e.g. *fire-crackers and bottle-rockets; careless use of machinery; hot vehicle exhaust pipes*). The experts also identified fire outbreaks as a mean of protest and contestation against public or installed powers (e.g. *retaliation against public administration and protest of seasonal fire-fighters*) as well as *noncompliance with regional regulations*. Antisocial behaviours (e.g. *pyromania, vandalism*) did not appear as relevant as happened in Portugal. *Rekindle* was not considered significant in Italy, and was just mentioned in Sardinia Region.

Forest fires outbreaks motives hotspots in all the case-studies were related with the fire use in agriculture burnings and vegetation management. The representativeness and the profile of deliberate fire motives are distinctive between the case-studies.

4. Discussion

Forest fire outbreaks motives are not a fixed and immutable concept being used through the centuries. *“Fire’s definition has changed with its cultural circumstances. It takes its character from its context”* (Pyne 2006: p.1). Main motives behind fire outbreaks found in the study-areas can be categorized in three main groups: traditional fire use (TFU) which refers to communities using fire for land and resources management purposes, based on traditional know-how (Lázaro 2010); deliberate fires; and rekindle, each of them putting different challenges in developing measures to reduce their incidence. TFU explains most of the fires in Portugal, Italy and Algeria as it is a deeply-rooted tool for land and resources management purposes, namely *agricultural or forest residues burning* and for *creating or renovating pastures*. TFU has been facing a very restrictive legal framework (Lovreglio and Leone 2010) resulting from the incapacity to understand that *“fire for humanity is more than a problem or a process. It is a relationship”* (Pyne 2006: p.6). The illegal use of fire is often carried out as a *hit-and-run* practice (e.g. by shepherds setting fires during the night and escaping to avoid prosecution) many times taking place even in days of high fire danger which can provoke the occurrence of large and severe fires. TFU still represents an efficacious way of “problems-solving” by aged rural societies, whose members persist with practices now considered with disdain by the dominant urban society; the latter sometimes adopts a top-down approach deciding plans and programs in the rural context without concertation nor listening the rural communities. For decades state agencies ignored this reality and the criminalization of TFU in land management activities and the lack or absence of alternatives just aggravated the problem. Problems solving through the use of fire fits with the relevant concept of *“man responsible, but not guilty”* as theorized by Dumas et al.(2013) and well indicates a possible direction for prevention measures based on the scientific knowledge, respect and wise re-utilization of T.E.K. (Traditional Ecologic Knowledge: Ribet 2002) in rural areas. The criminalization of TFU and the public strategies to deal with high impact fire events, mainly through subsidies to overlap property damages, can inhibit the TFU and transform it in deliberate fire. Considering the high representativeness of the negligent use of fire in agricultural and forestry works in the investigated fires with known causes (46% in 2012 in Portugal, according to ICNF 2012), an improved action on

TFU could have a significant contribution for a sustained reduction of fire occurrence. The concept of integrated fire management offers the framework to enhance TFU (FAO 2006; Silva *et al.* 2010) which implies making communities part of the solution requiring a community-based fire management (CBFiM) approach i.e. “*an approach to fire management in which local communities are actively engaged in the development, and in some instances the implementation, of fire management strategies designed to prevent, control or utilize fires in ways that will improve their livelihood, health and security*” (FAO 2011: p.4).

Deliberate fires in all study areas represented only a part of the arson motive classification as proposed by NCAVC (National Centre for the Analysis of Violent Crime) of FBI Academy (Icove and Estep 1987; Douglas *et al.* 1992), namely: *vandalism, excitement, revenge, crime concealment, profit, and extremist*. These classes were also proposed by the new classification scheme of fire causes in EU (Camia *et al.* 2013). In the study-areas the classes retrieved were mainly *vandalism, revenge, and profit* (including some cases of deliberate fires by organized crime, e.g. *fire lit to depreciate tourist area* as was mentioned in Italy).

“Logics” behind deliberate fires can be a consequence of processes acting: (i) at different spatial scales (e.g. some fires are related with local conflicts that originate revenges; others can be associated with the constraints of a top-down approach by state agencies, interest of non-local groups or even criminal organizations); (ii) with different frequency (i.e. some fires are isolated events; others can have a high frequency reflecting the repetition of the same fire outbreak motive). The representativeness and the profile of deliberate fire outbreak motives resulted distinctive between the case-studies. Most of the motives identified in the case-studies appeared as a consequence of local dynamics reinforcing the importance of adopting CBFiM approach with adapted strategies of intervention. A small part of deliberate fires can be interpreted as a reaction from the peasantry to the exclusion from their environment imposed by the urban society (Zarraga Moreno 1988) and the top down approach used by the state supporting policies that affect the forms of local life (e.g. forestation of commons, too restrictive nature conservation policies, precluding hunting). Others can be related with taking profit of sectorial policies (e.g. hunting law, nature conservation law) or spatial planning (e.g. urban sprawl planning). Others can result from the management of resources imposed without assessing the impacts on the economic dynamic, environment quality and social relationships in each territory. In some cases they can represent a reaction against benefits established by law which can create conditions favourable to the exploitation of local resources by people from outside the communities, for instance changes of land use. Antisocial behaviours in Algeria and Italy (e.g. *pyromania, vandalism*) did not appear as important as happened in Portugal where *pyromania* can be related with the misuse of the term. There are different solutions to deal with deliberate fires. Law enforcement is important not only to penalize behaviours but mainly to control business opportunities related with fires. However it is not the only solution mainly because “a one fits all” strategy more than solving a problem can develop it.

The importance of *rekindle* is different among the case-studies considered in this paper. The frequency of fire restart is higher in Portugal and the situation has aggravated over the years (Pacheco *et al.* 2012). “*The high number of rekindles results from the pressure on the suppression system which works at constantly very high levels of capacity utilization, and is constantly requested to immediately combat all the new fires*” (Pacheco *et al.* op. cit.: p.10). *Rekindle* is important in Algeria too and can be explained by the pressure on the suppression apparatus, adding to the specific lack of security in some forested areas due to problems of terrorism, which make dangerous working in forests (Meddour-Sahar *et al.* 2013). In Italy, *rekindle* is not present in the official list of motives, with the exception of the autonomous Region of Sardinia where it appeared in the second rank. Reducing the incidence of *rekindle* could be achieved directly by enhancing suppression effectiveness (e.g. better training in mop-up operations), active surveillance, increased crew capacity and by adjusting dispatch rules (Pacheco *et al.* 2014). Indirectly, it could result from the reduction of the number of fire outbreaks which implies a decrease of the pressure on suppression apparatus. Pacheco *et al.* (2013) presented

quantitative evidences of the advantages of investing in prevention to reduce *rekindle* as well as “*to invert the vicious circle of more fire, more teams*” (p.53).

5. Conclusion

It is a common place to say that addressing current forest fire problems requires more balanced suppression and prevention policies. The “*firefighting trap*” pointed out for the need to increase fire prevention clearly identifying the pitfalls of a single suppression approach. However, it is not possible to enhance prevention without a deep knowledge on the complexity of fire causes and outbreaks motives. This study showed the importance of adopting a cause-based approach focusing on the underlying reasons that induce specific negligent or deliberate behaviours.

Fire occurrence cannot be understood if disconnected from the social environment in which is produced (Zarraga Moreno 1988). The theoretical knowledge of the cultural and social construction of fire outbreak motives based on empirical studies is one of the requirements of paramount importance to enhance prevention. Without this scientific knowledge and its integration with local knowledge and the interests of the communities, the development of prevention programs can be misleading and contribute to discrediting the indisputable role of prevention. However, the immediate consequence should not be the design of a general model indistinctly applied in all contexts even with similar characteristics. From an operational point of view the theoretical framework should support prevention plans using a place-based approach, taking into account that more superficial is the knowledge of forest fire outbreak motives more inefficient and dangerous can be the transfer of findings from one context to another even with the same profile. An improved knowledge on fire ignitions motives can enhance forest fire prevention as implies a collaborative effort and communication between state agencies and local communities, thus necessarily adopting a CBFiM approach. However, it does not mean “a “*one size fits all*” approach, but rather it must be tailored to meet specific needs and circumstances to be an effective and sustainable approach to fire management” (FAO 2011: p.1-2).

Fire prevention oriented to the reduction of fire outbreaks is a complex issue comprising three processes: (i) knowledge of man-caused ignition motives; (ii) the development of specific targeted awareness campaigns promoting communities’ engagement to change attitudes and behaviours; (iii) and concertation between communities and public organizations. The latter is a very complex and ambitious goal. It needs to accommodate several interests and solve conflicts between several actors (e.g. forest services, shepherds, farmers) through proper communication, finding concerted and socially acceptable solutions, defining new relations between public policies, administration, and communities.

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