Analysis of forest fires causes and their motivations in northern Algeria: the Delphi method

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Forest fires in Algeria are mostly human-caused and result from local social behavior, whether voluntary (arson) or involuntary (negligence). Understanding the reasons why fires start is, therefore, a crucial factor in preventing or reducing their incidence, developing significant prevention efforts and designing specific fire prevention campaigns. The Delphi method is a promising tool for improving knowledge about how fire starts and why, and above all helps reduce the number of fires started by unknown causes, the majority type in Algeria. The Delphi method uses a set of procedures for eliciting and refining the opinions of a panel of experts on a particular subject of interest. This method was used in three case studies, in coastal or inner wilayas (provinces) selected from a highly fire-prone area in north-central Algeria. Results showed the traditional use of fire in agriculture and forestry, in situations related to land use changes and in interpersonal conflicts are the major causes of voluntary fires. For involuntary events (negligence), experts unanimously identified the importance of the restart of fire, caused by fire crews who do not ensure the mopping up of controlled fires (91.49%) and the negligent use of agricultural fires, particularly stubble burning (80.14%). For voluntary fires (arson), results highlight the importance of fires set for land use changes (77.30%), pyromania (67.38%) and honey gathering (62.41%). Illegal dumping and burning of garbage was also mentioned by responders in all study-areas.

Keywords: Agricultural Fires, Algeria, Delphi Method, Fire Motivations, Fire Causes, Panel of Fire Experts, Wilaya

Introduction

Fire is the main cause of forest destruction in the countries of the Mediterranean Basin. About 50,000 fires sweep through 700,000 to 1 million hectares of Mediterranean forests, wooded lands and other land types each year, causing large economical and ecological damage, as well as loss of human life (Vélez 1999, Dimitrakopoulos & Mitsopoulos 2006). The Mediterranean basin is marked by a prevalence of human-induced fires, i.e., about 95% (FAO 2007).

The southern rim of the Mediterranean Basin is characterized by fewer forest fires than the northern one, but its forests are under the growing threat of climatic changes and vigorously increasing human pressure, particularly near the coastal areas where populations concentrate, thus increasing the demand for fuel, meat, food and new lands for urban growth. This translates into higher pressure on degraded wooded lands, coupled with unsustainable overexploitation for fuel wood and overgrazing (FAO 2012) and increased wildfire risk. Fire adds its effects as a factor of degradation and desertification in those countries, already historically characterized by a progressive loss of forest coverage.

Tab. 1 reports the forest fire situation in Algeria compared to southern Europe countries. The wildfire situation in Algeria results similar to or even worse than Greece’s, which has a much more significant forested surface (6,500,000 ha of Greece’s surface is wooded, of which 25.4% is occupied by regular forests).

Fires causes in Algeria (1985-2010)

Algeria has a long history of forest fires. National fire statistics cover about 160 years, dating back to 1853. Statistics show a severe depletion of forest resources: for example, from 1876-1962 (87 years), fires have affected 3,506,942 hectares (Meddour-Sahar et al. 2008b). Furthermore, over the period 1853-2001 (148 years), 5,049,777 hectares were affected; a value close to the forested area of the country in the XIX century, about 5 million hectares in 1830, before French colonization (Meghragueche 2006). Marc (1916) observes that catastrophic wildfire seasons (more than 140,000 hectares per year) have a decadal frequency; he hypothesizes a relationship between after-fire vegetation re-growth and burning by shepherds to reopen it to herds. Between 1853-2001 the average decadal area burned was 38,500 ha. Only two exceptions occurred: the 1912-1921 decade when average was 64,746 ha, and the even higher 1956-1961 decade when average was 66,042 ha. This latter period includes the Algerian war of independence (1956-1962). Data confirm the exacerbation of the fire phenomenon in periods of political turbulence and troubles (Marc 1916).

During the Algerian war, many wildfires were actually voluntarily started as scorched earth policy, the military strategy of destroying anything useful to the enemy. Napalm bombing was also occasionally used by the French Air Army to force out revolutionary groups who sought shelter in the forests in an attempt to deprive them of food and cover (Cooper 2003). Bombing was directed at Algerian guerilla units and used to destroy large numbers of villages, causing tremendous demoralizing effects. Such fires destroyed more than 70% of forest in Bou Taleb (Hodna mountains) by the end of the 1950s (Madoui 2000, 2002), and 220,000 ha in the Aures forests (Sari 1976). Meddour-Sahar et al. (2008a) estimates that about 645,414 ha of forest burned during the independence war period. The use of fire as a weapon has continued in recent years (starting in 1992) in counter-terrorism operations. For example, the Algerian government was implicated in the 2008 forest fires in eastern Algeria (CBS News 2008, Bekdouche 2010). By virtue of its long fire statistic history, Boudy
(1952) identifies Algeria as the country where the first research on fire causes was developed. According to the National Forest Inventory of 2003 (FAO 2010), the current situation of forest and other wooded land (OWL) in Algeria is dramatic. Forest and OWL cover a total of 4 177 000 hectares (1 492 000 and 2 685 000 respectively). This represents only 1.76% of the country’s total surface area (238 174 000 ha); whereas range area is 33 970 000 ha and desert, unproductive areas account for more than 80% (about 190 million ha are occupied by the Sahara region - Nedjraoui 2003). Only the northern, mountainous part of the country has a rather significant forestry coverage (about 16.4%). Climatic conditions are a significant contributory factor to the forest fire situation in Algeria. Prolonged summers (June to October) with nearly no rain and average daytime temperatures well above 30°C with daily peaks as high as 50°C like in Salah (2005), reduce the moisture content of forest litter to less than 5%. Under these conditions, even a small addition of heat (lightning, a spark, a match, a cigarette butt) can be enough to start a violent conflagration. However, fires are rarely ignited by natural causes. For example, in Algeria, not a single fire has ever been reported as caused by lightning, the only possible natural fire cause. Human activities, either directly or indirectly, are exclusively the causes of wildfires. Our knowledge of fire is rather satisfactory regarding how, when and where fire occurs, but we have scarce knowledge of its origin. We still do not know enough about who starts wildfires and why: on the subject we have mainly lists of credible (and sometimes obvious) motives for starting fires (Leone et al. 2003, Lovreglio et al. 2010). A feature of the phenomenon in Algeria is the relative predominance of causes classified as unknown. The statistical data for the 26-year period 1985 to 2010, for which we have almost complete information, show that unknown caused fires represent 79.79% of all fires (“Unknown” fires are the fires for which no known cause could be determined and/or supposed - see Tab. 2).

The recorded causes in the fire data do not reflect reality. In Algeria, it is commonly accepted that at least half of the fires attributed to unknown causes are either arson or secu-
about 150 000 to 450 000 ha and are described by the geographic indicators in Tab. 3.

All study areas are mountainous territories with a typical Mediterranean climate pattern, where hot and dry summers are a predisposing fire factor. The physical conditions are favorable to forest and/or agro-sylvic-pastoral suitability in a balanced framework. Forest types range from the wide forested complexes of Aleppo pine high forest of Bouira to the small surfaces of decimated forests of Boumerdes, represented mainly by Mediterranean maquis and some Aleppo pine forests, to some wide cork oak high forests in Tizi Ouzou. In many cases, degradation of such areas reflects a population accustomed to using forest as a “free-for-all”, with little concern for forest preservation (Thrigood 1981). Most fires occur during the summer months (39.63 % in August, 28.31 % in July, 20.31 % in September, 7.61 % in October and 4.14 % in June). In the study areas, 8 124 fires burned 118 965 ha of forest land during the period 1985-2010. This represents 325 fires per 4 758 ha annually, with an average area burned of 15 ha per fire (Fig. 2).

Experts’ panel

The selection of Delphi participants directly influences the quality of the final results. Participants (or experts) in a Delphi study must have the background and experience concerning the target issue, be capable of helpful inputs, and be ready to revise their judgments (Hsu & Sandford 2007). In addition, they must correctly and seriously give their contribution. The following four requirements for “expertise” are key features of participants involved in Delphi studies (Adler & Ziglio 1996):

- knowledge and experience with the issues under investigation;
- capacity and willingness to participate;
- time to participate;
- communication skills.

The experts involved in our forest fires Delphi survey are the non commissioned forest fire officers of the State Forestry Service working for the country General Directorate of Forests (DGF), an agency of the Ministry of Agriculture and Rural Development. These professionals are trained and competent within the specialized area of knowledge under investigation. They are actually involved in compiling yearly forest fire statistics, which have been produced since the mid 1980s (Law 84 of 23/06/1984). Based on those statistics, funds for forest fire fighting are allocated to the most affected wilayas, and specific budgets are made available for defense infrastructures construction and maintenance (fire-breaks, water points, look-out towers etc.). The number of experts for each study area is given in Tab. 4.
The three panels of experts included a total of 141 respondents. The number of experts is well balanced among areas and, in addition, their number is well above the minimum of at least 10 (Delbecq et al. 1975). The use of the questionnaire allows for anonymous responses, giving group members the freedom to express their opinions without feeling pressured by the wider group or dominant members. Actually, one of the main problems with people of the strongly hierarchical, military-like organization State Forestry Service, is avoiding negative group communications. In round one, participants were asked to preliminarily rate each of the 29 causes on a 1 to 5 scale, with 1 being “strongly disagree” and 5 being “strongly agree” (Likert 1932). In round 2, based on their perception and experience, experts were asked to identify the eight most relevant fire causes in their area of activity. These were selected from those in round 1 reaching a value of 5 on the Likert scale at least 60% of the time. We then asked them to rank the eight selected causes in decreasing order of importance from 1 (most important) to 8 (least important).

**Results and discussion**

**Frequency**

As a first interesting result, the frequency of illegal garbage dumping and burning, and the problem of fire restarts are very important in our study areas. Experts mention them as the most important causes 88% and 85% of the time, respectively (Tab. 4). Garbage burning is related to the high population density of the study areas and is, in general, a cause of general concern for Algeria (Meddour-Sahar & Derridj 2010). Among causes in the voluntary category, the most frequently identified is related to interest in land use changes (77.3%), followed by causes referring to pasture renewal (67.38%), wild honey gathering (62.41%) and pyromaniacs (67.38%) - see Tab. 4, Tab. 5, and Fig. 3). Another interesting finding is that the majority of expert responses converge towards a rather limited number of causes (Fig. 3). More than 60% of experts identified causes in decreasing order of importance from 1 (most important) to 8 (least important).

**Tab. 4 - Study areas and fire causes in order of decreasing frequency. (N): number of experts.**

| Bouira (N = 41) Main motives | Frequency (%) | Boumerdes (N = 47) Main motives | Frequency (%) | Tizi Ouzou (N = 53) Main motives | Frequency (%) |
|-----------------------------|---------------|---------------------------------|---------------|---------------------------------|---------------|
| Restart of fire             | 97.55         | Agricultural works (burning of cut bush, stubble burning) | 95.74         | Illegal garbage dumping and burning | 90.56         |
| Cigarette remains           | 95.11         | Restart of fire                 | 93.62         | Restart of fire                 | 84.9          |
| Illegal garbage dumping and burning | 92.67 | Forest works (burning of cut bush) | 82.98         | Agricultural works (burning of cut bush, stubble burning) | 75.58         |
| Interest in land use changes | 92.67         | Illegal garbage dumping and burning | 80.84         | Cigarette remains              | 75.46         |
| Agricultural works (burning of cut bush, stubble burning) | 92.67 | Interest in land use changes | 80.84         | Forest works (burning of cut bush) | 73.58         |
| Pasture renewal             | 87.88         | Pasture renewal                 | 78.71         | Pyromania                       | 67.38         |
| Wild honey gathering        | 87.79         | Cigarette remains               | 72.34         | Interest in land use changes    | 62.37         |
| Conflicts related to wildland ownership | 82.92 | Cigarette remains | 72.34         | Cigarette remains              | 62.25         |

**Fig. 2 - Number of fires and burned area in north-central Algeria (1985-2010).**
Forest fires causes and motivations in northern Algeria

Tab. 5 - Rank-ordering (1 to 8) of most frequent fire causes in study areas.

| Rank-Order | Bouira                        | Boumerdes                      | Tizi Ouzou                      |
|------------|-------------------------------|--------------------------------|--------------------------------|
| 1          | Agricultural works (burning   | Agricultural works (burning   | Agricultural works (burning    |
|            | of cut bush, stubble burning) | of cut bush, stubble burning) | of cut bush, stubble burning)  |
| 2          | Cigarette remains             | Restart of fire                | Illegal garbage dumping and    |
|            |                               |                                | burning                        |
| 3          | Illegal garbage dumping and   | Forest works (burning of cut   | Interests in land use changes   |
|            | burning                       | bush)                          | Cigarette remains              |
| 4          | Pastoralism                   | Illegal garbage dumping and    |                                |
|            |                               | burning                        |                                |
| 5          | Interests in land use         | Cigarette remains              | Restart of fire                |
|            | changes                       |                                |                                |
| 6          | Wild honey gathering          | Interests in land use changes   | Forest works (burning of cut   |
|            |                               |                                | bush)                          |
| 7          | Restart of fire               | Pastoralism                    | Pyromania                      |
| 8          | Conflicts related to wild land | Wild honey gathering           | Conflicts related to forest    |
|            | ownership                     |                                | policy                         |

actually refer to involuntary causes, namely negligent restart of fire, agricultural use of fire, fires caused by smoking activities or accidents, including matches (vehicles, walkers). The most frequent causes (frequency > 80%) are related to the restart of fire followed by illegal garbage dumping and burning, and agricultural works (burning of cut bush). As can be seen in Tab. 4 and Tab. 5, the voluntary and involuntary categories (40% and 50% respectively) of fire causes are responsible for 90% of all fire starts in the country. This result is well coherent with the general opinion of experts, who claim an excess of emphasis attributed to voluntary fires (Vélez 2000).

Rank ordering

Within the category of causes of voluntary fires, defined as “the inner drive, reason or incentive that induces or prompts a specific behavior” (Rider 1980, O’Connor & Redsicker 1996), there are interesting results when looking at ranked causes (Tab. 5). For example, the panel of experts attribute the majority of fire ignitions to cultural (traditional) causes (agricultural works: burning of cut bush, stubble burning, pastoralism), followed by revenge (fires set for political reasons, conflicts with Public Administrations), personal interests (e.g., in land use changes) or social and/or interpersonal tensions (conflicts related to wild land ownership or forest policy - Leone et al. 2002). Their answers are rather homogeneous and convergent (a few causes account for 54% of all fire starts), despite the obvious difference of study areas (Tab. 5).

The experts considered only 11 out of 29 possible causes initially presented to them. The remaining 18 causes appear rather scattered, with few cases for each; results confirm the absolute unimportance of natural fires in the Algeria wildfires problem. One possible explanation for the importance of the traditional agricultural use of fire as a source of wildfires is that farmers use it not only to eliminate crop stubble, but more importantly to push back the forest to make room for agricultural expansion. Thus, fires started in cultivated fields easily spread to nearby forests (Dimitrakopoulos 1995). In spite of the obvious risks, farmers often set fire to agricultural residues even when large out-of-control fires are burning in the same area (Vélez 1999). In the Tizi Ouzou wilaya, the second highest cause reported by experts is illegal garbage dumping and burning. The north-central part of the country is densely populated (on average 356 inhabitants per km²) and is characterized by the proliferation of illegal, uncontrolled dumps along roadsides. Consequently, the burning of waste at legal or illegal garbage dumping sites has increased at an alarming rate in recent years. In Tizi-Ouzou, the presence of more than 30 illegal garbage dumping sites, mainly along roads, has been reported (Meddour-Sahar & Derridj 2010). This cause is ranked third and fourth, respectively, for the Boumerdes and Bouira wilayas. Many garbage dumping sites are located in nearby forest areas. Organic wastes generate methane, which is extremely flammable and can contribute to fire ignition and to the spread of forest fires (Dimitrakopoulos 1995). In these cases, the use of fire to reduce the accumulation of garbage must be interpreted as a tough but inevitable “problem solving” solution by inhabitants, who have no other more sustainable alternative for waste disposal and are, therefore, obliged to eliminate their solid waste accumulation by fire or by directly throwing it in ravines or rivers, which can cause more serious health problems. In the Boumerdes wilaya, the second highest cause of fire ignitions is the restart of fires, caused by firefighters’ incomplete mop-up of controlled fires, leaving hot areas to reignite. A possible explanation for their apparently negligent behavior is the conditions of insecurity in the region, where terroristic groups are known to be rather active. Another possibility could be, as in Tizi Ouzou wilaya, the high number of fires that fire crews must respond to. They are over-extended, and therefore have no possibility or enough time for mopping-up any fire after it has been controlled. In Algeria, forest firefighting crews are seasonally paid and are made up of about twenty people from local communities and a foreman. All crews fall under the responsibility of a fire officer on duty in DGF. In general, these crews are not properly equipped. This can also be a contributing factor to the problem of lack of mop-up in controlled fires (Meddour-Sahar & Derridj 2012). Foresters are the first to intervene after a fire alarm; Firemen and Civil Protection officers can also intervene, the latter much better equipped. Negligent disposal of cigarettes (throwing of butts or matches from vehicles and/or by walkers) is a rather transversal cause of fire starts and is the second highest cause in the Bouira province. This negligent, careless behavior of individuals is very frequent and generates
fire outbreaks, especially along the tourist routes in Algeria. This cause could be in some way reduced by regular campaigns, aimed to increase awareness of the problem by rural and urban population. Forest fire as a major socio-ecological threat and, as a consequence, affects the local culture and traditions. Fire is not only a problem, but an intrinsic factor of forest management and a symptom of serious social conditions or any particular event that trigger pyromaniac activities affecting the incidence of pyromania-caused fire starts.

Conclusions and final remarks

We must preface this section by stating that the results of the study represent only the collective, informed opinion of the experts participating in the Delphi Panel, but that, at this time, there is no alternative mean to produce better information. Forest fire in itself is not a problem, but an intrinsic factor of ecosystem disturbances when it develops within its natural regime. However, it is also a cultural tool used in all traditional rural societies for multiple purposes, including land management. Its improper use is the most conditioning factor for Mediterranean forest management and a symptom of serious social and territorial problems of the forest system in many cases. Considering that human action is the main cause of fires in Algeria, knowing the causes of fires is a crucial factor in designing policies and programs for wild-fire prevention. Prevention requires a shift in the approach to fire fighting from fire suppression, based mainly on investments for emergency measures, to a long-term policy of removing the structural causes of fire starts (Birot 2009). The high percentage of fires reported under unknown causes in Algeria (79.97%), is a serious obstacle for the development of any policy/program aimed at reducing the number of fire events by targeting specific social groups, activities or behaviors. In this study we applied a Delphi method in three sites of northern-central Algeria to identify the most relevant fire causes. Study results confirm that the causes of forest fires in the northern-central region of the country are substantially invariable through time, because they are mainly related to local culture and traditions (Lovreglio et al. 2010). From the study findings, we can confidently conclude that the majority of fire occurrences in the northern-central region is principally due to unsuitable and negligent use of fire in agriculture, conflictive behaviors, and/or social tensions. Additionally, in all three study sites illegal garbage dumping and burning is considered a frequent and important cause of fires. In synthesis, the Delphi method results depict fire setting in the context of a very traditional, rural society characterized by a poor “problem solving” ability similar to other cases observed by the authors in Italy (Lovreglio et al. 2010). Typically, interpersonal problem solving ability is significantly related to the socio-cultural level of the subjects. From our results, fire represents a preferential solution that resolves problems such as grass renewal, land for cultivation or space for urban growth etc. immediately, but are deemed inadequate by modern cultural and social standards. Ranking the causes of fire starts in order of importance and relevance in Algeria permits us to establish priorities when designing policies or programs of actions to address them. For each of the causes, a series of prevention measures can be imagined, discussed and verified.

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Supplementary Material

Appendix 1 - List of forest fire causes identified for Algeria, divided into three main categories: accidental, negligent, and deliberate.

Link: Meddour_Sahar_098@suppl001.pdf