

# Wildfires in Algeria: problems and challenges

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In the scenario of the Mediterranean area, where about 54 000 fires and 0.4 million hectares of forest are burned and annually registered (2006-2010), the rank for Algeria is non-negligible with 4.11 million hectares of forest. The annual number of fires and the size of area burned depict a critical situation, which became rather dramatic in 2012. Climate change projections and the estimated changes to wildfire risk for the future decades (2030-2060) indicate that the entire Maghreb region, including Algeria, will be among the most affected areas of the Mediterranean. Longer fire seasons will be experienced and extended by an additional month with each passing year. Despite Algeria's recent investments in technical means for controlling forest fires, the current suppression-oriented model seems unable to cope with such a phenomenon. Furthermore, the model is unfit in view of the approaching scenario, when fire-exclusion policies need to be complemented with fuel-reduction techniques and fire prevention management. This study aims to establish an understanding of the context and public policy issues related to wildfire management in Algeria. Data were collected by distributing questionnaires to foresters with the objective of identifying obstacles and constraints hindering the efficacy of pro-active measures. Analysis of the data gathered indicates that Algerian foresters are well aware of the importance of prevention, contrasting with current governmental policies that are predominantly oriented towards improving the technical extinction apparatus. A SWOT analysis suggests possible strategic options for improving the efficiency of wildfire control by building on strengths, eliminating weaknesses, exploiting opportunities, and mitigating threats. The results of this study may be adapted to other countries with similar problems as those of Algeria.

**Keywords:** Algeria, Forest Fires, MENA, Prevention Policy, SWOT Analysis

## Introduction

In the period 2003-2010, more than 5 million ha of forest were burned in the Mediterranean region, and more than 600 000 wildfires were registered (FAO 2013). From 2006 to 2010, approximately 269 000 fires burned a total of 1 907 512 ha of Mediterranean forests, other wooded lands (OWLs), such as shrubland and grasslands (on average 54 000 fires and 0.4 million ha per year, respectively), and agricultural lands (FAO 2013); of the total area burnt (38%), about 731 000 ha were forests. Approximately 78% of these fires burned in four southern countries of the EU (Greece, Italy, Portugal, Spain), and 50% only in Portugal and Spain.

In the future climate change prediction scenarios, wildfire risk is forecast to increase nearly everywhere in the Mediterranean region (Giannakopoulos et al. 2009), with the southern Mediterranean area being at higher risk all year round. Projections for 2030 to 2060 suggest that the Maghreb (and the Balkans, North Adriatic, Central Spain, and Turkey) will suffer at least an additional month of high wildfire risk (Giannakopoulos et al. 2009).

Whereas the five southern member states of the EU (or Western Mediterranean countries - FAO 2013), the so-called *fire club* (Vélez 2000), are well considered within the fire literature, the same cannot be said for the sou-

thern Mediterranean Maghreb countries. For instance, it was only in 2010 that the European Forest Fire Information System (EFFIS) started to include Northern African countries in the mapping of burnt areas and the assessment of fire danger (European Commission 2013). The wildfire problems experienced in some Middle East and North African (MENA) countries, such as Algeria, are therefore almost unknown despite the fact that they significantly contribute to general wildfire statistics within the Mediterranean Basin area (Meddour-Sahar et al. 2013a). In the period from 2006 to 2010, for example, the total number of fires recorded in Algeria was 12 230 compared with 6 996 in Greece. The total burnt area in Algeria during the same period was 147 685 ha, representing about 8% of the total burnt area in Mediterranean countries (including forests, OWLs, and agricultural lands); this percentage was greater than for Bulgaria (3%), Turkey (3%) and France (3% - FAO 2013).

Fire management challenges are not currently an object of great interest in North Africa, where recent literature on wildfires is rather scarce and mainly oriented towards fire ecology studies (Madoui et al. 2006, Ouelmouhoub & Benhouhou 2007, Bekdouche et al. 2011, Slimani et al. 2014) or remote sensing analysis (Khader et al. 2009, Guettouche et al. 2011, Haddouche et al. 2011). In the Western Mediterranean region, a number of researchers have approached the challenges of fire management by exploiting the knowledge of experts: with local farmers and fire experts in Spain (Zarraga Moreno 1988, Marino et al. 2014, Raftoyannis et al. 2014); in the analysis of training provided to Portuguese forestry workers and their opinions on fires (Colaço 2005, Colaço et al. 2005, 2006); regarding the prevention of unwanted fires (Boström et al. 2013); regarding agro-forestry farmers/landowners' attitudes towards fire prevention, including their perceptions of the causes of fires (Xavier & De Belém Martins 2010); and in the evaluation of the reduction of forest fire risk in Catalonia (Mogas & Riera 2001). A number of other projects have adopted similar approaches, such as FireSmart (Sebastián-López et al. 2011) and FireParadox (Silva et al. 2010a). Moreover, the Community-Based Fire Management (CBFiM) approach to fire management (FAO 2011) adopts similar tools, such as the Participatory Rapid Appraisal, to identify the strengths and weaknesses of projects. We consider expert analyses to be a potential and practical tool for developing a deeper understanding of fire management issues in Algeria, which provides a highly useful and relevant case study for exploring some of the challenges related to wildfires (*i.e.*, fires are a permanent threat

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within the country and little research has been conducted by fire science researchers). In addition, the results of this study will be of significant interest to other countries with similar socio-economic conditions.

In recent years, Algeria has invested in fire suppression activities. However, until now no national assessment has been conducted on the wildfire control apparatus within the country. Our interest stems from the need to examine the current organization and to develop strategic recommendations for overcoming possible obstacles and limitations. Hence, the purpose of this study is to survey and evaluate the national wildfire control service in Algeria, establishing an understanding of the context and public policy issues related to wildfire management, with the objective of identifying obstacles and constraints hindering the efficacy of pro-active measures. Research was conducted using the criteria of the FireSmart project (EU 7<sup>th</sup> Framework Programme 2007-2013 concerning forest fire preventive measures) with the collaboration of the Algerian Forest Administration (General Directorate of Forests, DGF), which permitted and provided direct, personal contact with foresters. Thus, the opportunity was given to evaluate the results with those already obtained in Southern Europe (Silva et al. 2010b, Marino et al. 2014).

## Methods

### *Study area: history, wildfire policies and current control apparatus*

In the wildfire scenario of the Mediterranean area, the rank for Algeria is non-negligible with 4.11 million ha of forest (58% of which is degraded bush; forestry ratio 1.76%). The paucity of forests and the growing threat of desertification render fires particularly devastating. Despite huge investments in the national fire control apparatus, the yearly number of wildfires is increasing. From 1876 to 2012, the cumulative surface burned in Algeria was 5 272 717 ha, which is close to the forested area of about 5 million ha in 1830 before the French colonization (Megrerouche 2006). During certain seasons, the number of burned surfaces surpassed 200 000 ha, as in 1956, 1983 and 1994 (204 220, 221 367 and 271 598 ha, respectively). More recently (1985 to 2010), 1636 fires were annually recorded and on average 35 024 ha of forest were burned (Meddour-Sahar 2014). The current forest fire fighting policy is based on suppression and prevention; the latter mainly relying on the colonial model (De Ribbe 1869) of fire prevention grounded on infrastructures that are not distributed across the territory according to risk level but rather according to administrative and local political criteria (Meddour-Sahar 2014). The main actors of fire policy in Algeria are the Civil Protection

organizations (Ministry of the Interior and Local Governments) and the Forest Service (Ministry of Agriculture and Rural Development). A plethora of other stakeholders are also involved. This results in the existence of multiple decision-making centers, which are ineffective and inefficient. Wildfire protection programs are implemented by the Forestry Service (2229 individuals organized within 456 Forest Mobile Patrols for initial attacks and 922 units staffing 375 fire lookout towers). In addition, there are 6000 Civil Protection units and 42 088 seasonal forest workers. The program also relies on 40 4WD Medium Tankers, 800 firefighting trucks, 1617 water points, 32 556 ha of firebreaks, and 37 933 km of forest roads and fire trails (Meddour-Sahar et al. 2013b).

### *Structured questioning*

Research was conducted through a quantitative survey administered to technicians working in the DGF who are involved in forest fire control field operations. Structured questioning was achieved through the use of an *ad hoc* questionnaire borrowed from the FireSmart questionnaire (Sebastián-López et al. 2011). The questionnaire included 62 questions structured into five groups of closed-ended questions, with a predetermined set of potential responses (professional activity; forest fire management; forest fire prevention; infrastructures; conflicts influencing fire prevention), and an open-ended question. Responses to the questions were classified using scores from 1 to 10, or the Likert scale (Likert 1932). Other scales were also used, mirroring the same technique used within the FireSmart questionnaire. When the scale of 1 to 10 was used, results were expressed in terms of mean  $\pm$  standard deviation (SD).

### *Panel of experts*

The DGF provided the names of all foresters operating within the 40 *wilayas* (provinces) of northern Algeria that experience wildfire problems. These foresters are involved in forest fire control and therefore considered to be very knowledgeable. From this list we randomly selected 10 people per *wilaya*, for a total of 400 individuals, to serve as our panel of experts. The questionnaire was mailed to each member of the panel.

### *SWOT Analysis*

The questionnaire results were synthesized using a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. The Strengths and Weaknesses are internal, controllable factors, which can be acted upon; they exist now and refer to the current situation. The Opportunities and Threats are external, independent and uncontrollable factors (Ghiculescu et al. 2011); they refer to

events that might happen in the future or are waiting to happen (Suh & Emtage 2005). SWOT analysis is a common tool used for analyzing a project, program, activity, etc. (Suh & Emtage 2005, Lu 2010, Ghazinoory et al. 2011), and for obtaining support for strategic planning and decision-making (Marino et al. 2014). SWOT analysis is often used within the forest sector (Blinn et al. 2007, Rauch 2007, FAO/JRC/CFS 2008, Gerasimov & Karjalainen 2008, Plana 2010, Marino et al. 2014). However, to our knowledge, the present study is the first to apply this technique to forestry issues in Algeria and at MENA country level.

## Results and discussion

### *Participants' background information*

From the 400 foresters contacted by e-mail at the national level, we received 228 replies, representing a response rate of 57%. The responses were irregularly distributed per *wilaya*. A sample profile in terms of age, gender, level of education, type of employment, and working region was recognized as a factor influencing perception/opinion of respondents (Williamson et al. 2005, Colombo 2006, Raftoyannis et al. 2014). Our sample (N=228) is mainly composed of males (n = 221, 97%). The presence of females (n = 7) is concentrated in the 31- to 41-year age-group. The dominant age-groups were 41 to 51 years (122 individuals, 54% of the total, followed by the 51+ age-group (54 individuals, 24% of the total). The sample was therefore composed of mostly aged people (176 individuals, 3 females), representing 77% of the total; the average age of the interviewees was 46 years. "Experience" was divided into four age-groups (<11, 11-21, 21-31 and 31+ years) yielding the following values: 11 to 21 years (26%) and 21 to 31 years (52%). In conclusion, 78% of the respondents have an experience at more than 11 years of age. All grades, with 7 classes, were contacted, 3 of which were represented by officer classes (*Conservateur*, *Inspecteur Divisionnaire*, *Inspecteur subdivisionnaire*) accounting for 48% of the respondents. All respondents with the officer's grade have a university level education (Degree in Forestry Engineering).

Chi-squared test statistics of dependency between age, experience and all items in the questionnaire were carried out by Sphinx survey and statistics software package (<http://www.sphinxsurvey.com/>). Dependency between age, experience, and the responses to the questionnaire that were calculated as significant are reported in Tab. 1.

As expected, the driving factors were age and experience. Although we obtained the most important results, not too much emphasis was ascribed to personal influence, considering that all contacted individuals work

within the DGF (a homogeneous technical and administrative unit with a strong hierarchy and well-defined set of customs, norms, and standards and in which all components share common rules, values and objectives). In short, we considered the DGF as a unit in which interpersonal differences were not so crucial.

#### Forest fire management

Results are presented in terms of average rating or percentage of respondents agreeing or disagreeing with the statements. Appendix 1.1 presents the results of the questions relating to management and response. The responses were scored on a scale from 1 to 10 points, with 10 being the highest score; the scores were expressed as mean  $\pm$  SD and were rather scattered. High scores (8 points and over) were only attributed to the importance of the forest and to the ecological and environmental impact of fires. Medium scores (6 to 8 points) were attributed to a number of issues, with the importance of prevention receiving the highest score ( $7.56 \pm 2.38$ ). Other issues receiving a medium score were training of personnel, the investigation of causes of fire, campaigns and public awareness, the importance of politics, and the effects of fuel management. The question of whether wildfires are important from a socio-economic point of view received a rather moderate score ( $6.57 \pm 3.14$ ). Relatively low scores (less than 6 points) were attributed to technical factors hindering fire prevention, scarce perception of fire by the public, conflicts of interest among different social agents, coordination among different agents intervening in fire control, and economic factors. The lowest score ( $4.40 \pm 2.93$ ) was recorded for the question if legal factors were limiting the success of forest fire prevention activities.

#### Forest fire prevention

Appendix 1.2 presents the experts' responses in relation to fire prevention activities. The responses were classified using a five-point Likert scale. The results were commented by the sums of percentages of 1 and 2 (*Strongly disagree* and *Disagree*) and 4 and 5 (*Agree* and *Strongly agree*), without considering the neutral opinion of undecided respondents, which reached a maximum of 25.76% and a minimum of 1.75% of responses. "Prevention" (93.89% as the sum of *Agree* and *Strongly agree*) was perceived as a more efficacious strategy than extinction of forest fires. We emphasize this high value because "an empirical generalization or communication is deemed objectively true or confirmed if there is a broad consensus on this subject by a group of experts" (Mitroff & Turoff 1975). This finding aligns Algerian foresters to those of other countries, where prevention is considered the priority approach

**Tab. 1** - Chi-squared test statistics of dependency between age, experience, and responses to the questionnaire. (df): degrees of freedom.

Dependency	$\chi^2$	df	1-p (%)
Age/Experience	194.82	9	99.99
Age/Grade	54.87	18	99.99
Age/ <i>Wilaya</i>	124.76	78	99.94
Age/Budget (financial contribution to prevention)	23.43	12	97.57
Age/Training	26.33	12	99.04
Age/Detection	53.45	27	99.82
Age/Cleaning, thinning and pruning of forests	45.50	27	98.56
Experience/Grade	59.96	18	99.99
Experience/ <i>Wilaya</i>	103.48	78	97.16
Experience/Detection	44.15	27	98.01

ach (Molina et al. 2010, Montiel & Herrero 2010, Sebastián-López et al. 2011, EFIMED 2012, Marino et al. 2014).

We defined an index of agreement ( $I_{ag}$ ) according to the following formula (eqn. 1):

$$I_{ag} = \frac{\% (Agree + Strongly agree)}{\% (Strongly disagree + Disagree + Undecided)}$$

i.e., from the percentages in columns (4+5) / (1+2+3) in the Appendix 1.2. The higher the ratio, the stronger the level of agreement. A strong level of agreement ( $I_{ag}$ ) was found for the following statements (the ratio is shown in brackets): "forest fire prevention is more effective than extinction" ( $I_{ag} = 16.53$ ), which received the highest agreement level; "public awareness directed at the rural population reduces the forest fire problem" ( $I_{ag} = 12.42$ ); and "it is necessary to provide legislation and specific recommendations for fire prevention within the wildland-urban interface" (WUI -  $I_{ag} = 10.40$ ).

We found a more modest  $I_{ag}$  for the following statements: "suitable planning of land uses benefits forest fire prevention" ( $I_{ag} = 4.85$ ) and "an increase in financial expenditure on prevention multiplies its effectiveness" ( $I_{ag} = 4.70$ ). Finally, the lowest  $I_{ag}$  was recorded for the following statements: "public forests are properly managed for forest fire prevention" ( $I_{ag} = 0.62$ ) and "private forests are properly managed for forest fire prevention" ( $I_{ag} = 0.21$ ). These results confirm the need to focus further on wildfire prevention (Marino et al. 2014).

#### Infrastructures

Responses (Appendix 1.3) are characterized by relatively high SDs, indicating a wider dispersion of respondents' points of view. Traditional infrastructures (forest roads and fire trail networks, fuel breaks, lookout towers and water supply points) as well as monitoring and detection were highly rated, scoring more than 8/10 ( $8.60 \pm 2.08$  and  $8.16 \pm 2.67$ , respectively). Forestry operations as well as opening and maintenance of fuel breaks ( $8.03 \pm 2.41$ ) and cleaning, thinning and pruning ( $8.60 \pm 2.08$ ) were well appreciated by the foresters. Meteorological

forecasting systems ( $7.12 \pm 2.8$ ) and fire risk and hazard prediction ( $6.81 \pm 2.68$ ) were also rated highly. On the contrary, fuel management and techniques (Lovreglio et al. 2014, Torres-Manso et al. 2014) such as controlled grazing ( $6.06 \pm 3.04$ ) and prescribed burning ( $4.86 \pm 3.11$ ), which are new for Algeria and not known by personnel, were rather poorly rated. A similarly low rating was given to restrictions on public activities ( $6.00 \pm 2.74$ ).

#### Conflicts

Using a scale from 1 to 4, respondents were asked to rate to what degree conflicts hinder the management and prevention of forest fires, with 1 and 2 expressing a low degree and 3 and 4 a high degree. Conflicts could be classified (Appendix 1.4): between groups of actors (e.g., urban and rural populations), but also within the same socio-professional group (e.g., among residents), and between people and the State, the latter represented by the foresters. In this case, conflicts are probably related to areas such as forests and parks where the interests of local residents and the State diverge. The main conflicts occur between livestock and forest owners, followed by conflicts between residents in the WUI and the public administration. The results confirm the findings by other authors (Taylor 1997, Sebastián-López et al. 2011) and are evidently related to the presence of conflicting forms of land use.

#### Open-ended questions

Responses provided to the open-ended questions can be grouped within the following categories: awareness; finance; fire-fighting organization; legislative measures; policy; population; prevention; silvicultural measures; and training and recruitment. Because responses are rather difficult to synthesize, we translated their text from French or Arab into English and created a word cloud where the importance of each term is directly related with their font size. The results of this representation are shown in Fig. 1.

"Prevention" was identified as the most frequent and important word. This result in-



Fig. 1 - The cloud of most frequently cited words (50 words).

indicates that foresters in Algeria are well aware of the relative importance of prevention contrasting with current governmental policies, which are mainly oriented towards improving the technical extinction apparatus.

*SWOT matrix of forest fire management in Algeria*

SWOT analysis permits the formulation of suggestions to improve prevention and control strategies. For its implementation, results from the survey and other research (Meddour-Sahar 2014) were utilized. Such analysis identified the most important internal and external factors and, consequently, derived strategies. A list is presented in Tab. 2, which includes only the more prominent items of SWOT components, each of which is identified by the capital letter of the component and a progressive number (e.g., S1, S2, etc.).

The qualitative assessment identified 5 factors of strengths (S), 17 of weaknesses (W), 13 of opportunities (O) and 10 of threats (T). Weaknesses were the most significant determinant, with an overall importance of about 38%.

*SWOT strategy formulation*

A SWOT matrix conceptually indicates distinct alternative strategies, based on the interactions of different variables. Four sets of strategies can be formulated by pairing each of the internal factors with each of the external ones, namely: (i) SO (maxi-maxi strategies): internal strength(s) realize the available external opportunities (ideal case); (ii) ST (maxi-mini strategies): internal strength(s) minimize the potential impact of external threats; (iii) WO (mini-maxi strategies): reduce internal weakness(es) or develop missing strength(s) to realize external opportunities; and (iv) WT strategies (mini-

mini strategies): reduce internal weakness (es) and avoid or minimize external threats (defensive strategy, worst case scenario - Weihrich 1982, Rauch 2007, Ghazinoory et al. 2011, Mohamad et al. 2012, Ohadi et al. 2013).

*Evaluation of possible strategic options*

The final step of our SWOT analysis was to suggest possible options for improving the efficiency of the wildfire control apparatus in Algeria. Combinations of SWOT factors yielded comprehensible results (e.g., W1, O3 means that Weakness 1 and Opportunity 3 have been considered).

*WO and WT strategies*

- Given the increased frequency of large fires it is mandatory to adopt modern fighting techniques, such as suppression fires and aerial means, and to improve the infrastructure network to ameliorate access to forests (W1, O3). It is also important to avoid the loss of traditional knowledge in the use of fire (TFU, traditional fire use) as a management tool (W1, T3) by incorporating people from the countryside (experts in TFU) into firefighting crews.
- An impressive network of infrastructures (firebreaks, water supply points, forest roads and fire trails) has been realized in Algeria, but it lacks the necessary and timely periodical maintenance, which alone can assure continued efficiency.
- It is mandatory to maintain infrastructures (W5, O3) also by exploiting the traditional knowledge of fire use (W5, T3) and using controlled grazing (W5, O12; W5, T6). These measures need to be accompanied by a better use of fire as a smart prevention tool (W3, O6) under the form of prescribed burning, which should be gradually introduced (W5, T3) and accompanied by ap-

- appropriate training of personnel.
- Resolving the irregularity of funding is a priority for improving prevention in order to eliminate poor maintenance of prevention infrastructures (W5, W8, O3).
- An increase in the number of fires within WUIs is not accompanied by an adequate awareness of risk by inhabitants. Possible mitigation measures are information campaigns targeted at WUI inhabitants (W2, O2, O10, O11) and the inclusion of fire smart WUI management in urban plans for fire prevention (W3, O2).
- The careless or illegal burning of straw and other residues, but mainly the dumping and subsequent burning of garbage in or near forests is among the most frequent causes of wildfire ignition (Meddour-Sahar et al. 2013c). A different and wiser use of burning under legal regulations should therefore be disciplined by the new Forestry Code (W4, T3 and W4, O8).
- Preventive silvicultural measures, such as thinning, pruning, and local shrub clearings, are efficacious but costly; incentives and obligations (W6, O3) should therefore be introduced within the Forestry Code (W6, O8) and public forest management plans (W6, O4).
- Preventive silvicultural measures as above must also be promoted to foster the resistance and resilience of forest areas, if affected by fire (W8, O1).
- Privately owned forests must be clearly identified by the Cadastre (W6, O9), and owners should benefit from an appropriate regime of incentives. This could create job opportunities for local residents (W6, O1) and help to reduce the popular belief that the forest is nobody's land (W6, T2). When people have formal and legally recognized ownership of resources and can see long-term benefits from their land management, they will tend to be more concerned with the protection and sustainable management of those resources (FAO 2011).
- The national policy for wildfire control gives excessive emphasis to fire extinction at the detriment of fire prevention (W7, O3), since suppression-oriented actions seem to prevail (W7, T1). Future scenarios of higher risk, intensity and frequency of wildfires (W7, T7) confirm the restriction of suppressive actions and the opportunity presented by not limiting policy choices to suppression efforts but by investing more in fire management and prevention.
- The inadequate distribution of personnel among and within the different *wilaya* does not align with the risk criteria, and the number of personnel is substantially low if related to forest extension. We suggest an increase (W8, W9, W10, O5) in budget levels and DGF staff (W9, O3), with personnel distribution focused in priority areas identified by fire risk maps

**Tab. 2** - Relevant factors identified in each SWOT category.

Strengths	Weaknesses
S1. Algeria has specific policies and laws for wildfire fighting	W1. Increasing frequency of large fires
S2. Importance of forest sector in local job creation	W2. Insufficient awareness of residents living in WUI areas
S3. Important fire fighting apparatus mainly based on infrastructures (e.g., firebreaks, water points, lookout towers, forest roads and fire trails)	W3. Increase in fire number within WUI areas
S4. Reforestation program of 1 245 900 ha with an investment effort of U.S.\$ 133 million	W4. Increased number of fires caused by the careless burning of stubble, weeds and garbage
S5. Projects of Rural Development (PPDR) for job creation	W5. Insufficient maintenance of infrastructures
	W6. Inadequate regulations governing preventive measures
	W7. Protection against wildfires limited to fighting activities
	W8. Lack of funding for fire prevention through silvicultural measures
	W9. The distribution of personnel not meeting the risk criteria
	W10. Lack of personnel in relation to the country's forest extension
	W11. Multiplicity of actors in fighting apparatus
	W12. Lack of adequate penalties against culprits in general forest legislation
	W13. Spontaneous and limited scope of awareness programs
	W14. Lack of weather stations
	W15. Non-involvement of citizens when faced with a fire
	W16. Lack of adequate training of personnel
	W17. Inadequate knowledge of high risk areas
Opportunities	Threats
O1. Creation of more jobs and income for local residents	T1. Suppression-oriented actions more important than prevention
O2. Dedicated legislation for the WUI areas	T2. Forest belonging to no one in the mind of the average citizen
O3. Increasing the extinction efficiency ensuring a fast attack; improvement of auxiliary tools (maps, GPS, etc.)	T3. Loss of traditions in the knowledgeable use of fire
O4. Management plans for all state forests	T4. Increasing arson where the land is of great value
O5. Increase the number and improve allocation of human resources; permanent training of technical staff	T5. Land use changes cause an increasing number of fires
O6. Use expert tactics and preventive fire in forest management	T6. Overgrazing in forests
O7. Severe fire police	T7. Climate change and thus expected risk that the phenomenon could worsen
O8. Approval of the new Forestry Code	T8. Rural exodus and suburbanization
O9. Finalization of the forest registry to update the ownership of forests	T9. Low level of interaction between researchers and managers
O10. Information and awareness campaigns	T10. Forest management not given high priority on the political agenda
O11. Increase citizens' awareness about consequences and social costs of fires	
O12. Introduce controlled grazing	
O13. Scientific and technical know-how on wildfire control	

(W14, O5). This could also lead to more job and income opportunities for local residents (W9, O1).

- A plethora of stakeholders are currently involved within the wildfire fighting apparatus. This results in an inefficient multiplication of decision centers, at the detriment of extinction efficiency (W11, O3), and calls for a reduction of stakeholders and a well-defined chain of command and control.
- Lack of adequate penalties against culprits in current forest legislation and extremely low fines have no deterrent effect, but rather represent a challenge for repeat offenders to ostentatiously break the law. A review and update of the monetary revaluation of fines and a reformulation of the penal system for voluntary fire setting should be introduced within the new Forestry Code together with more severe actions on the part of fire police (W12, O7,

O8).

- Authorities must be given the tools to reduce arson where forested land is of great value due to urban sprawl, a situation that is being caused by rural exodus and suburbanization (W12, T4, T8).
- Authorities must be given the tools to contain the increasing number of deliberate fires caused by illegal land use changes (W3, T5), which are not currently prosecuted.
- Awareness campaigns appear rather generalist, abstract and not oriented to change the negligent behavior of specific social groups. It seems mandatory to invest in awareness campaigns that are clearly targeted (W13, O10), professionally projected and inspired by so-called social communication.
- Campaigns must increase citizens' awareness of the impacts of fires and the consequences and social costs of fires (W13,

O11), as well as the high cost of post-fire relief and recovery.

- Campaigns should influence public understanding and change citizens' largely indifferent attitude to wildfires (W15, O11). For example, campaigns should encourage more collaboration from the public. A more active participation in firefighting operations from the public is sometimes inadvisable, since it could imply important operational problems mainly related to safety. Promoting associations of properly trained volunteers is an option that is showing good results in several countries.
- Weather stations are currently irregularly distributed, and their main objective is to collect data for agricultural purposes. It seems necessary to install a network of automatic weather stations within forested areas to facilitate the calculation of fire danger and risk indexes, which could improve preparedness for wildfire events and

extinction efficiency (W14, O3; W17, O3, O6).

- Lack of adequate training of personnel means there is difficulty in obtaining more efficient prevention and suppressive actions. Researchers and managers occupy two distinct and largely unconnected worlds, which are separated by mutual distrust (W16, T9). It is advisable to integrate and combine scientific and technological know-how with new training (W16, O5, O13), thus enabling personnel to employ expert tactics and modern preventive fire use (suppression fires, prescribed burning) in forest management (W16, O6).
- Risk areas are irregularly distributed across the territory, and the control apparatus is not currently aligned with this distribution. It is necessary to focus actions on specific high-risk areas (W17, O3), which are identified using risk-maps.

#### *ST and SO strategies*

- Algeria has specific firefighting policies and laws. It seems necessary to update these policies and laws under the form of a modern and stringent discipline in regards to arson and negligent fire, including the creation of dedicated legislation for WUIs (S1, O2, O8) and an update of the Forest Cadastre and the new Forestry Code (S1, O9).
- The importance of the forest sector for local job and income creation is not well perceived as a priority within the current political agenda. This gap must be filled (S2, T10) as a subsidiary tool of PPDR (Projects of Rural Development).
- The important fire fighting apparatus and the impressive network of infrastructures must be integrated by a better interaction between researchers and managers (S3, T9) and in the scope of permanent training of personnel (S3, O5). Traditional knowledge in the use of fire must be exploited to develop and implement expert tactics and preventive fires, thereby improving extinction efficiency (S3, T3, O6).
- The ambitious reforestation program of 1 245 900 ha is a relevant strength because it demands an efficacious firefighting program, but it is not coherent for the state, due to the lack of management plans for state forests. All new afforestation areas must be endowed, from their project phase, with management plans that pay specific attention to fire prevention (S4, O4, O6). In such areas, forest management must receive high priority on the political agenda (S4, T10), which is inclusive of the need to increase employment and local income (S4, O1).
- PPDR are a powerful tool for local job creation (S5, O1), which in turn can be an efficacious means for facilitating a deeper involvement of local residents (S5, O11).

## Conclusions

A qualitative SWOT analysis based on the literature review, personal knowledge and the opinions of a number (N=228) of wildfire experts using questionnaire surveys allowed to explore the national fire control apparatus in Algeria and identify its strengths and weakness. One of the more significant findings emerged from this study is that increasing suppression efforts alone will not solve the forest fire problem, especially in the future scenarios of higher fire risk, frequency and intensity and of increasing numbers of large fires in WUIs (Herrero 2009, Lampin-Maillet et al. 2010). Underpinning this study is the knowledge that fire exclusion-oriented policies need to be complemented with forest fire prevention management (Fernandes 2010, 2013), mainly in the form of fuel-reduction techniques and large-scale fuel management. This study highlights the need to further focus on wildfire preventive actions and to make prevention a permanent activity. Our results are therefore coherent with the recommendations of the “Athens Declaration on Forest Fires” (MIO/ECSDE 1987) in the fields of research, communication and information, and education and training.

There are challenges and difficulties ahead, not least because wildfires are a very visible and immediate threat. This means that it is often more socially and politically expedient to commit resources to suppression activities than to address the issues involved in long-term fire prevention measures and management (FAO 2011). In addition, preventive actions (mainly fuel-reduction techniques, including large-scale fuel management and fire prevention management of forests) are often less visible than suppression materials, such as firefighting tanker airplanes, 4WD vehicles and firefighting trucks, and therefore receive less political attention and are assigned fewer resources (FAO/JRC/CFS 2008).

As a result of this study, Algerian foresters are aware of the opportunity to shift from a mere control policy to a more prevention-oriented one; they strongly call for a more pro-active approach on the part of the General Directorate of Forests. This viewpoint is in line with the opinions of foresters working in other countries. Forest fire prevention is actually considered to be one of the pillars of integrated, sustainable forest management (Montiel & Galiana 2005, Silva et al. 2010a, 2010b, Moreira et al. 2011). Investments in suppression-oriented actions at the expense of prevention are considered a weakness in the SWOT analysis of wildfire legislation and policy for the Mediterranean region (FAO/JRC/CFS 2008). Foresters’ participation in the survey permitted the identification of many obstacles to the implementation of a more efficacious control activity, sug-

gesting reality-based strategic recommendations to overcome such obstacles. The results from our research are coherent with those obtained by the FireSmart project in EU countries (FIRESMART 2011) and with those observed in Europe in the frame of the European Integrated Project FIRE PARADOX (2006-2010), which provided recommendations for long-term policy measures able to encourage a shift in the current wildfire situation (Aguilar et al. 2009, Herrero et al. 2009). The lack of management in public and private forests, the view that fire prevention is judged to be more effective than extinction, the importance of training technical staff, the non-appropriate transfer of knowledge to forest fire prevention, and the importance of infrastructures are among the most important common issues, but are of course accompanied by specific differences.

Herein, we highlight the importance of the survey conducted among Algerian foresters. This is the first research paper for Algeria, and perhaps any MENA country, to have approached this sensitive subject. These foresters have an institutional monopoly on forest fire fighting and therefore refrain from publicly discussing their performance and opinions. Their collaborative participation in this survey is a cornerstone in the firefighting history of the country.

Most of the recommendations suggested, particularly those involving people from local communities, are fully applicable to other countries. The Community-Based Fire Management model (FAO 2011), whose strategy is grounded on the substantial involvement of local communities in preventing, controlling or using fires (for controlling weeds, reducing the impact of pests and diseases, generating income from non-timber forest products, creating forage and hunting, etc.), is an interesting and potentially useful approach for helping managers and decision makers in Algeria and other countries of North Africa and at MENA level to address wildfire issues. Significant improvements could be achieved by promoting more active participation by the public in firefighting operations; for instance, in establishing associations of properly trained volunteers, an option that is producing good results in several countries.

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## Supplementary Material

**Appendix 1** - Wildfires in Algeria: problems and challenges. (1) Management of wildfires (Mean and Std. Dev.); (2) Prevention of forest fires; (3) Rating of techniques and activities aimed at the prevention of wildfires (average  $\pm$  Std. Dev.); (4) Possible conflicts.

**Link:** [Meddour\\_1279@suppl001.pdf](#)