CINEFORUM
ISSN : 0009-7039
Vol. 65. No. 2, 2025

Forest fires in the Souk Ahras area (North Eastern Algeria) Assessment and Analysis

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Submission date: June 2024 **Acceptance date:** September 2024 **Publication date:** April 2025

Abstract
Forest fires are one of the main natural hazards of the world's forests. The Mediterranean forest, in general, and that of the Souk Ahras region, in particular, has undergone significant deforestation in recent decades as a result of fires which may upset the ecological balance, the conservation of forest ecosystems and associated species.
The originality of this work lies in the study of the evolution of forest fires in the Souk-Ahras region over an eleven-year period (2008 - 2018).
In fact, during this period, 889 fires burned 5025. 8 ha of plant formations and undoubtedly caused immense losses of wood, goods and sometimes human lives.
Although the anger of this disaster can be frightening, the forest fire will always remain a problem that every individual face and must find a solution to.
Keywords: Souk Ahras, Fires, Forests, Assessment, Analysis.

Introduction
Forest fires are one of the main natural hazards of forests in the world. In some countries and regions, such as the Mediterranean, they are even the most significant natural hazard in forests, forests that can be affected in the long term or even irreversibly. Despite considerable efforts in prevention and extinction actions, large forest fires remain recurring events that often interact with infrastructure and housing, thus affecting large sections of the population (Plana et al., 2016).
Of all the factors of forest aggression in the Mediterranean and more particularly in Algeria, forest fires are the most devastating factor of degradation by its losses due to its intensity and brutality which affect large forest and pre-forest areas in short periods. Its consequences are observed on the environmental or ecological, social and economic level (Moro, 2006).
Forest and natural area fires constitute the most dangerous disaster to human life in several Mediterranean countries, including Algeria. The consequences on the natural environment are much more serious, since they result in immediate forest losses. In Algeria, the area covered annually by fire is 26,015 ha (Asnouni, 2016).
The Souk Ahras region, rich in forest heritage, is a thriving study environment for conducting serious research on forest fires and their impact on the environment.
The analysis of the statistics of the balance of forest fires in the Souk Ahras region shows that the latter does not escape the phenomenon of forest fires. Its vision consists of an

organization of data based on the number of fire outbreaks, the burned area, the burned area per fire, the fire risk and the annual loss of wooded capital.
The objective of this publication is twofold:
(i). Inventory (report) of forest fires in this region during the period 2008 – 2018.
(ii). Analysis of the phenomenon.

Materials and methods

Presentation of the study area

The Souk-Ahras region is located in the north-east of Algeria. It is located at the gates of Algeria in a natural passage between Tunisia and the rest of the country.
It is limited (Fig. 1):

- To the North-East by the wilaya of el Taref.
- To the northwest by the wilaya of Guelma.
- To the south by the wilaya of Tébessa.
- To the South-West by the wilaya of Oum-El-Bouaghi.
- To the East through Tunisia.

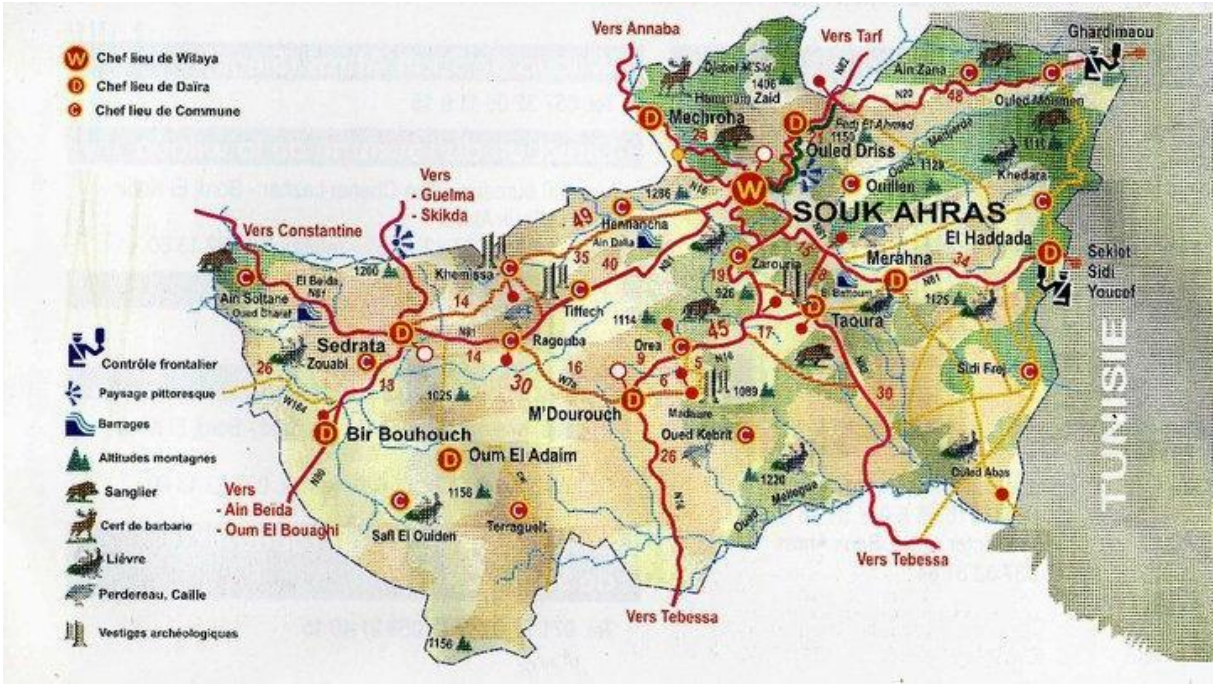

Figure 1: Location of the study area (CFS A, 2018)

The Souk-Ahras region is distinguished by two essential characteristics: the mountainous North, part of the Tell Atlas, and the South, part of the high plains.
The region is characterized by a scarcity of water; this is explained by climatic conditions with clearly insufficient precipitation on the one hand and the lack of means and infrastructures for rational recovery and storage on the other hand (Zouaidia, 2006). We note the presence of three wadis: Oued Mellegue, Oued Medjerda and Oued Echaref.

The climate is characterized by hot and dry summers from 25 to 35°C in July and August, and a cold, wet winter from 1 to 15°C in January. Precipitation varies between 350 and 650 mm/year.
The forest area is estimated at 97,280 hectares, representing 23% of the total area of the region.
The main species are pine d'Aleppo (33569 ha), l'eucalyptus (29779 ha), cork oak (12535 ha), zeen oak (4837 ha) and others (16560 ha).

Data collection

The data from the forest fire survey during the period 2008 - 2018 collected from the forest conservation of the Wilaya of Souk Ahras, relate to the description and analysis of each fire.
The analysis of forest fires was based on the development of a summary sheet, reporting the following information:

- Nature of the burnt plant formations
- Date and time of fire
- Burned area
- Number of fires
- Area burned by fire source
- Annual fire risk, number of fires
- Annual loss of forest capital, burned area

Results and discussion

Report on forest fires in the Souk-Ahras region (Period 2008-2018)

- ***Distribution of forest fires according to plant formations***

During the period 2008-2018, we recorded a total burned area of 5025.8 ha for 889 fires. The forest is the plant formation that was most affected by the fires with 2856.15 ha or a rate of 56.82% of the total burned area during this period.
This is explained by the density and sensitivity of the plant cover of the Mediterranean-type forests of northern Algeria, characterized by great fragility and particular sensitivity to fires due to flammable and highly pyrophilic material (resinous, very dense undergrowth, etc.) (Khelifi, 2002).
Furthermore, the scrubland is moderately affected. We recorded 1839.75 ha, or a percentage of 36.6% of the total burned, then in last position come the scrubland with 329.9 ha, or 6.56% of the total burned area (Tab.1 and Fig. 2).

Table 1: Plant formations burned in the Souk-Ahras region (Period 2008 -2018)

Plant formations	**Forests**	**Maquis**	**Brushwood**	**Total**
Burned areas (ha)	2856.15	1839.75	329.9	5025.8
Burned areas (%)	56.82%	36.6%	6.56%	100.00%

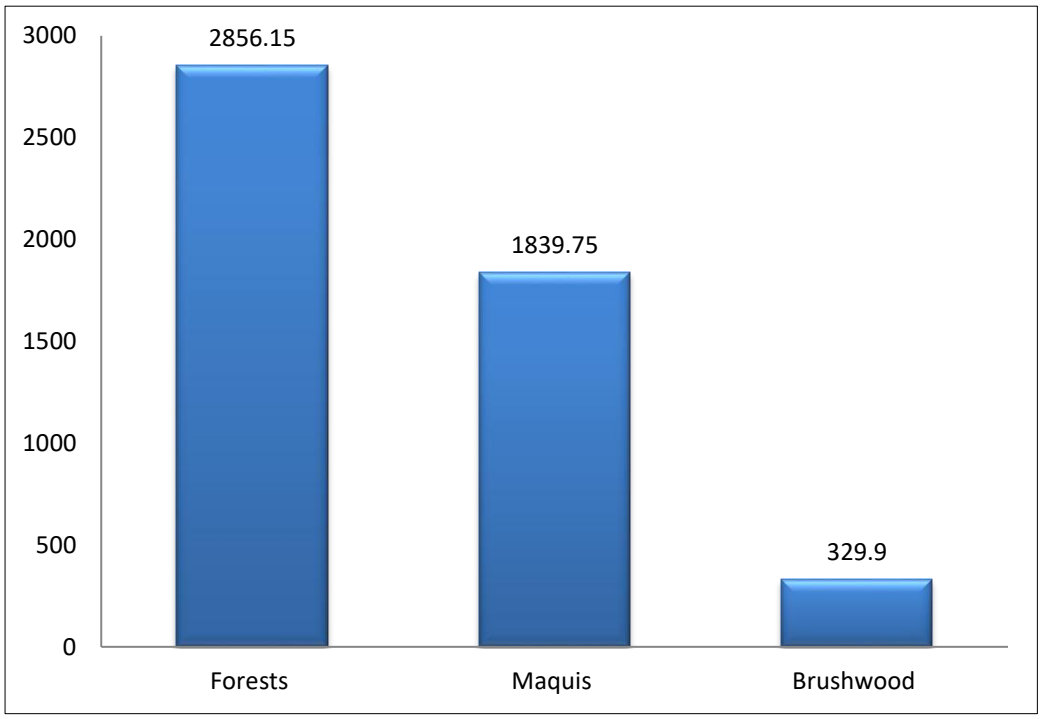

Figure 2: Burned vegetation formations in the Souk-Ahras region (Period 2008 - 2018)

- ***Distribution of forest fires by species***

Of the 5025.80 ha of forest plant formations affected by fire during the period 2008-2018, it should be noted that the Aleppo pine remains the species most affected by fire with an area of 2356.35 ha or a percentage of 46.88% of the total burned, then comes the scrubland with 1839.75 ha or a rate of 36.60%, the cork oak in third position with an area of 422.1 ha or a rate of 8.39%.

The scrubland represents 6.56% or an area of 329.9 ha (Tab. 2 and Fig. 3). If not for the rest of the species, they are little affected because the dominant species in the forests of the study region are the Aleppo pine and the cork oak.

Table 2: Plant species burned in the Souk-Ahras region (Period 2008-2018)

Essences	P'in of Aleppo	Cork oak	Zeen Oak	Cedar	Eucalyptus	Alfa	Maquis	Brushwood	Other Species	**Total**
Burned areas (Ha)	2356.35	422.1	26.25	0	30	0	1839.75	329.9	21.45	**5025.80**
Burned areas (%)	46.88%	8.39%	0.52%	0%	0.59%	0%	36.60%	6.56%	0.42%	**100.00%**

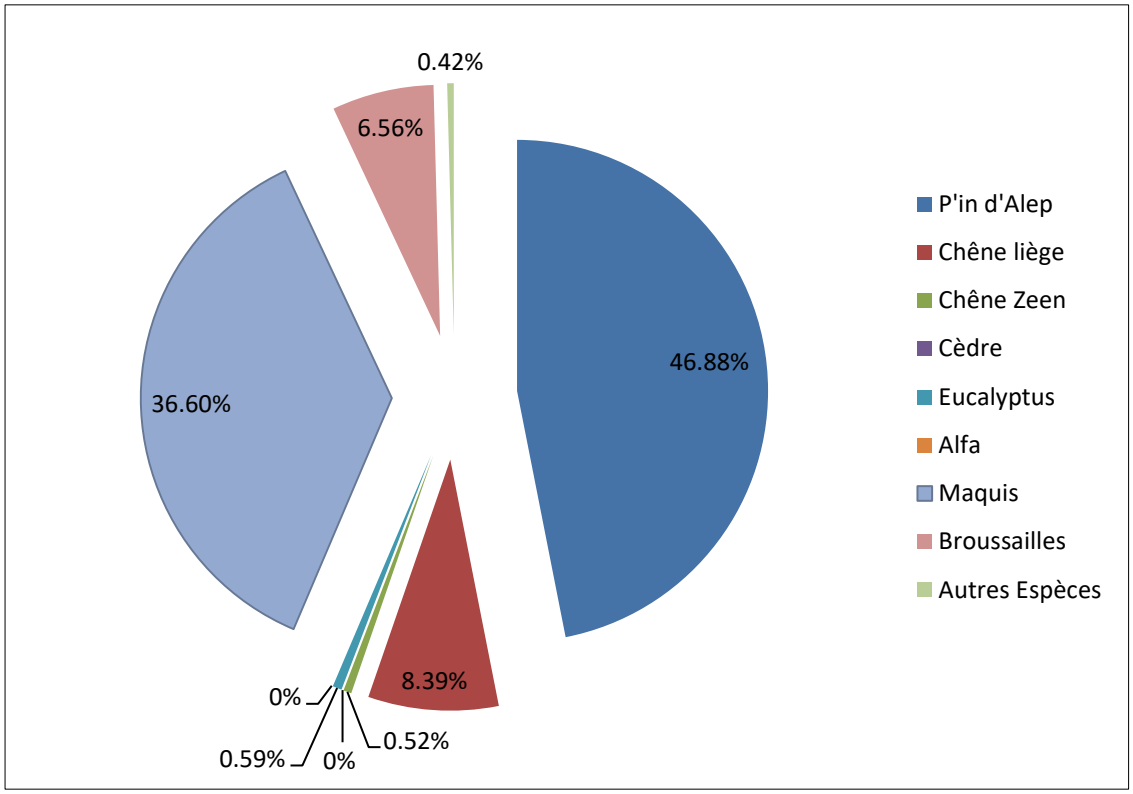

Figure 3: Plant species burned in the Souk-Ahras region (Period 2008-2018)

- ***Annual distribution of forest fires***

The assessment for the period 2008 - 2018 shows a total area covered by fire of 5025.80 ha for 889 outbreaks.

By examining the fire situation individually by year, we see that the greatest number of fire outbreaks were recorded during the three years 2010, 2012 and 2014 with 134, 148 and 121 fire outbreaks respectively (Tab. 3). The latter led to a fatal loss of the surface area of the vegetation cover. Indeed, for the three years, 2658.30 ha or 52.89% of the total burned were recorded. But the year 2012 remains the most dramatic, where the surface area covered by fires was 1346.75 ha or a rate of 26.79% of the total burned area (Fig. 4).

Furthermore, it should be noted that the number of outbreaks decreased significantly in 2018 compared to previous years with a downward trend in the area covered by fire. This positive result could be attributed to the protective actions undertaken and the presence of more significant intervention resources.

Table 3: Annual frequency of forest fires in the Souk-Ahras region (Period 2008-2018)

Year	**Number of households**	**Burned areas (ha)**	**Burned areas (%)**
2008	106	627.1	12.47%
2009	43	79.3	1.57%
2010	134	443.85	8.83%
2011	62	250.5	4.98%
2012	**148**	**1346.75**	**26.79%**

2013	31	171	3.4%
2014	121	867.7	17.26%
2015	54	169.4	3.37%
2016	90	604.2	12.02%
2017	98	344.5	6.85%
2018	2	121.5	2.41%
TOTAL	**889**	**5025.80**	**100.00%**

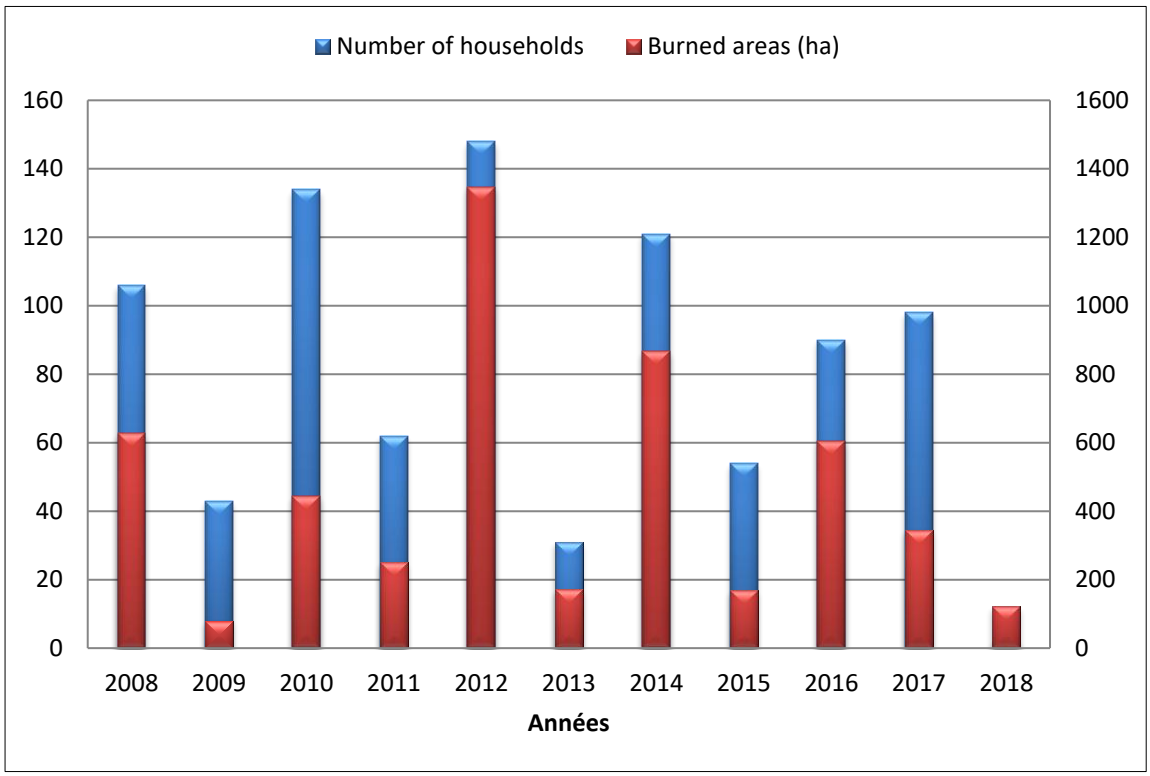

Figure 4: Annual frequency of forest fires in the Souk-Ahras region (Period 2008-2018)

- ***Monthly distribution of forest fires***

Depending on weather conditions, the frequency and magnitude of fires vary from month to month and from year to year.

However, during the period 2008-2018, it was found that the month of August was the most critical. 504 fires broke out during this period (2008-2018) and covered 69.30% of the total burnt area, i.e. 3483.3 ha.

Then comes the month of July, when 222 fires were recorded with an area of 921.5 ha, representing 18.33% of the total area burned. Similarly, during the month of September, when there were 130 fires and 11.13% of the area burned (Tab.4).

The months of October and June come far behind with 18 and 15 of the total outbreaks respectively. For the other months of the year, no outbreaks are recorded (Fig. 5).

This can be explained mainly by the conjunction of seasonal meteorological factors which are favourable to fires (strong and hot winds, excessive drought, etc.) during the hottest

period of the year and also by certain human behaviours in relation to the parallel increase in tourist pressure during this holiday period.

Table 4: Monthly frequency of forest fires in the Souk-Ahras region (Period 2008 – 2018)

Month	**Number of households**	**Burned areas (ha)**	**Burned areas (%)**
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	0	0	0
June	15	32.75	0.65%
July	222	921.5	18.33%
August	504	3483.3	69.30%
September	130	559.75	11.13%
October	18	28.5	0.56%
November	0	0	0
December	0	0	0
TOTAL	**889**	**5025.80**	**100.00%**

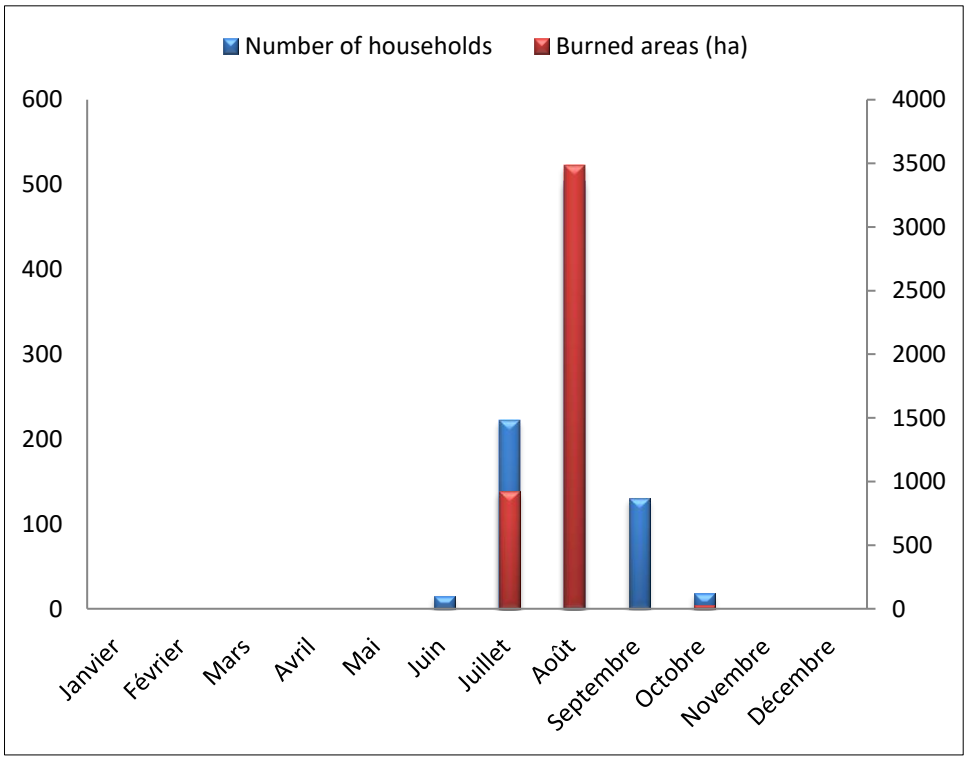

Figure 5: Monthly frequency of forest fires in the Souk-Ahras region (Period 2008-2018)

- ***Distribution of forest fires by time slot***

When counting forest fires according to the reporting time, we see a very high number of fires that occurred between six o'clock (06:00) and eight o'clock (20:00). This number is 815, which represents 91.67% of the total number of fires reported during the period 2008-2018. During the night, a minimum of only 74 fires are counted, i.e. a rate of 8.32%.

Table 5: Hourly frequency of forest fire outbreaks in the Souk-Ahras region (Period 2008-2018)

Time slots	**0h to 06h**	**06h to 10h**	**10 a.m. to 12 p.m.**	**12 p.m. to 4 p.m.**	**4 p.m. to 6 p.m.**	**6 p.m. to 8 p.m.**	**8 p.m. to midnight**	**Total**
Number of households	20	120	178	430	45	42	54	889
Percentage (%)	2.24%	13.49%	20.02%	48.36%	5.06%	4.72%	17.33%	**100.00%**

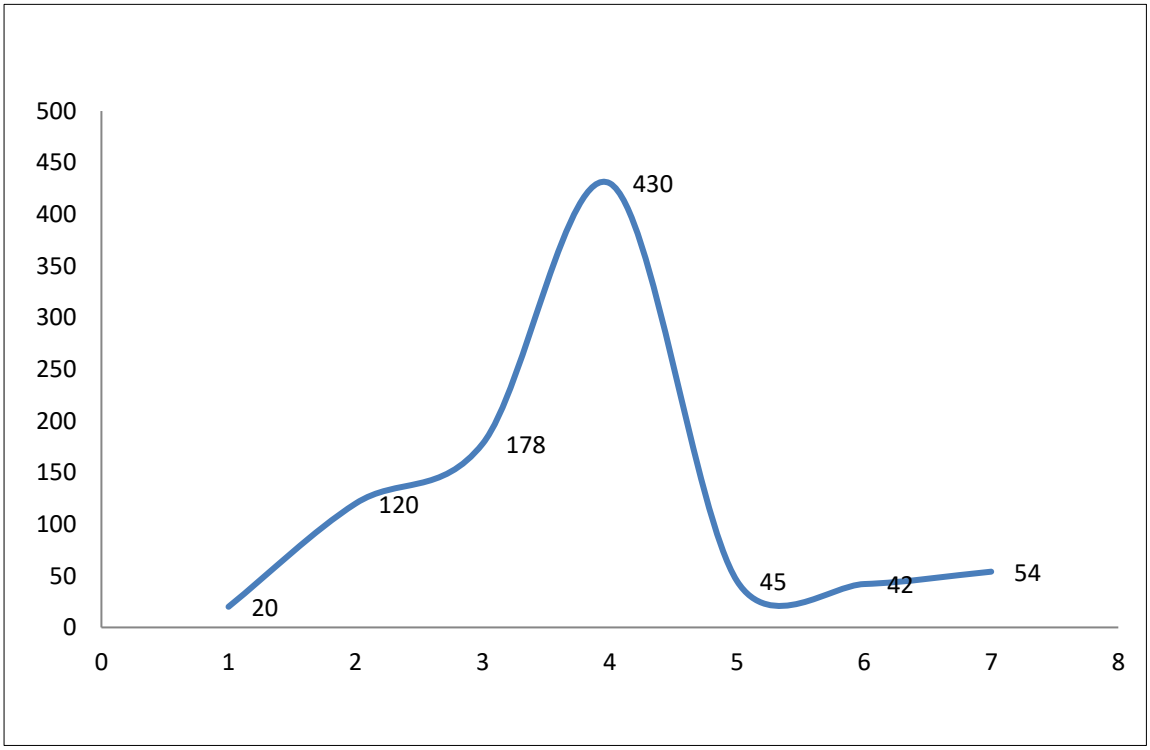

Figure 6: Hourly frequency of forest fire outbreaks in the Souk-Ahras region (Period 2008-2018)

- ***Distribution of fires by surface area class***

Table 6 shows a ranking of fire outbreaks in order of burned areas during the study period 2008-2018; the number of fires that did not reach 10 hectares amounts to 700 outbreaks, or 78.74%. For the other classes, a low number of 89 outbreaks between 10 ha and 50 ha, or 10.01% of the total, is recorded (Fig. 7). Then the number gradually decreases with the increase in area. This provides some information on the effectiveness of the intervention.

Furthermore, it must be recognized for a perfect meaning of the observed phenomenon, that these burnt areas were most often the result of numerous fires of small and medium importance, rather than one or more fires of large importance.
However, weather conditions, the nature of the species, the structure of the vegetation and the relief determine the vulnerability of our forests. Furthermore, I am convinced that the extent of a fire also depends essentially on the speed of its extinction and this will explain why a large proportion of declared fires do not exceed 10 hectares.

Table 6: Ranking of forest fire outbreaks by order of importance of burned areas in the Souk-Ahras region (Period 2008-2018)

Area slices (ha)	0 to 10	10 to 50	50 to 100	100 to 600	+ 600	**Total**
Number of households	700	89	36	34	30	**889**
Percentage (%)	78.74%	10.01%	4.04%	3.82%	3.37%	**100.00%**

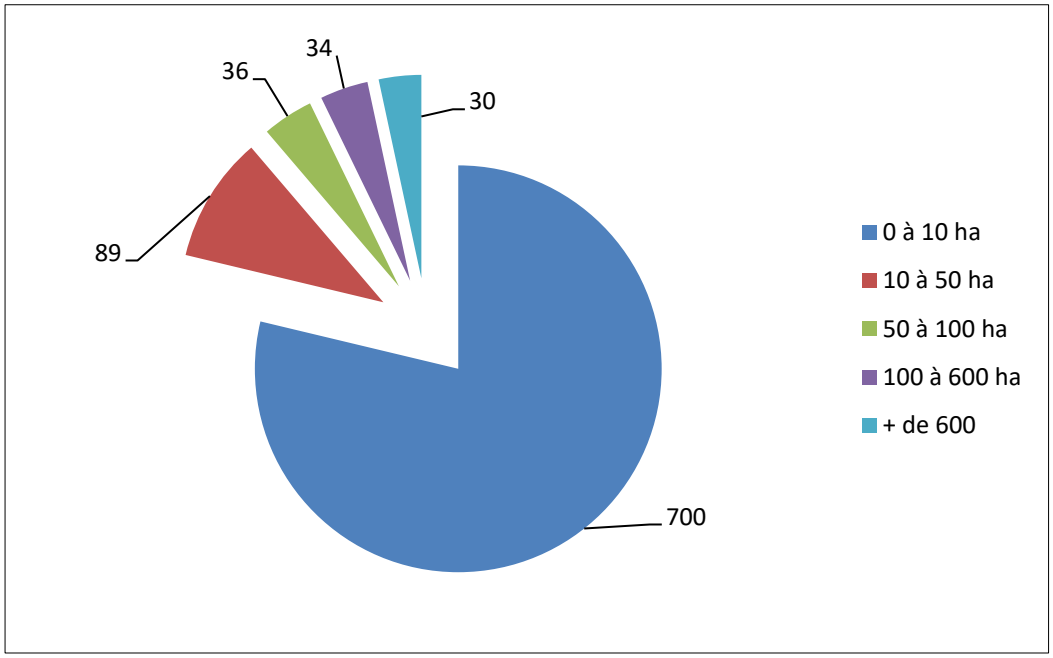

Figure 7: Ranking of forest fire outbreaks by order of importance of burned areas in the Souk-Ahras region (Period 2008-2018)

- ***Distribution of forest fires by day of the week***

If we examine Table (7) and Figure (15) showing the frequency of forest fires during weekdays, we see an almost total uniformity in the number of fires from Saturday to Friday. At least, the highest numbers of fires correspond to the weekend days. For the rest of the days, we see a slight increase on Wednesdays.

Table 7: Frequency of forest fires during weekdays in the Souk-Ahras region (Period 2008-2018)

Week days	**Saturday**	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Total**
Number of households	158	101	97	123	136	131	143	**889**
Percentage (%)	17.8%	11.4%	10.9%	13.8%	15.4%	14.7%	16.2%	**100.00%**

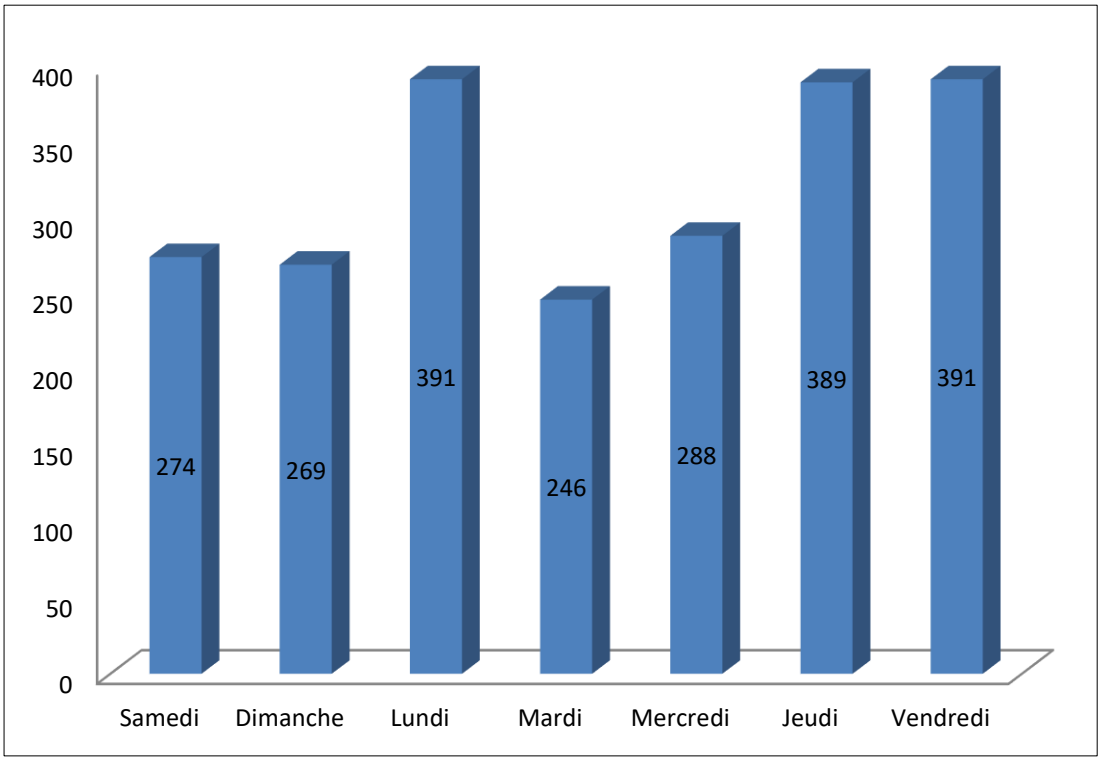

Figure 8: Frequency of forest fires during weekdays in the Souk-Ahras region (Period 2008-2018)

Relationship between fires and climatic factors

- **Relationship between forest fires and precipitation**

A close relationship between precipitation and the number of fires. Thus, it is observed that'an increase in precipitation'always accompanies'a decrease in the number of outbreaks of'forest fires and vice versa (Tab. 8 and Fig. 9).

Table 8: Relationship between precipitation and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

Year	Number of households	Precipitation from June to October (mm)	Precipitation from June to October (%)
2008	106	78.6	8.50%
2009	43	167.8	18.15%
2010	134	66.7	7.21%
2011	62	100.5	10.87%
2012	148	34.7	3.75%
2013	31	89.9	9.72%
2014	121	61.7	6.67%
2015	54	101.6	10.99%
2016	90	67.8	7.33%
2017	98	75	8.11%
2018	2	80	8.65%
Total	**889**	**924, 3**	**100%**

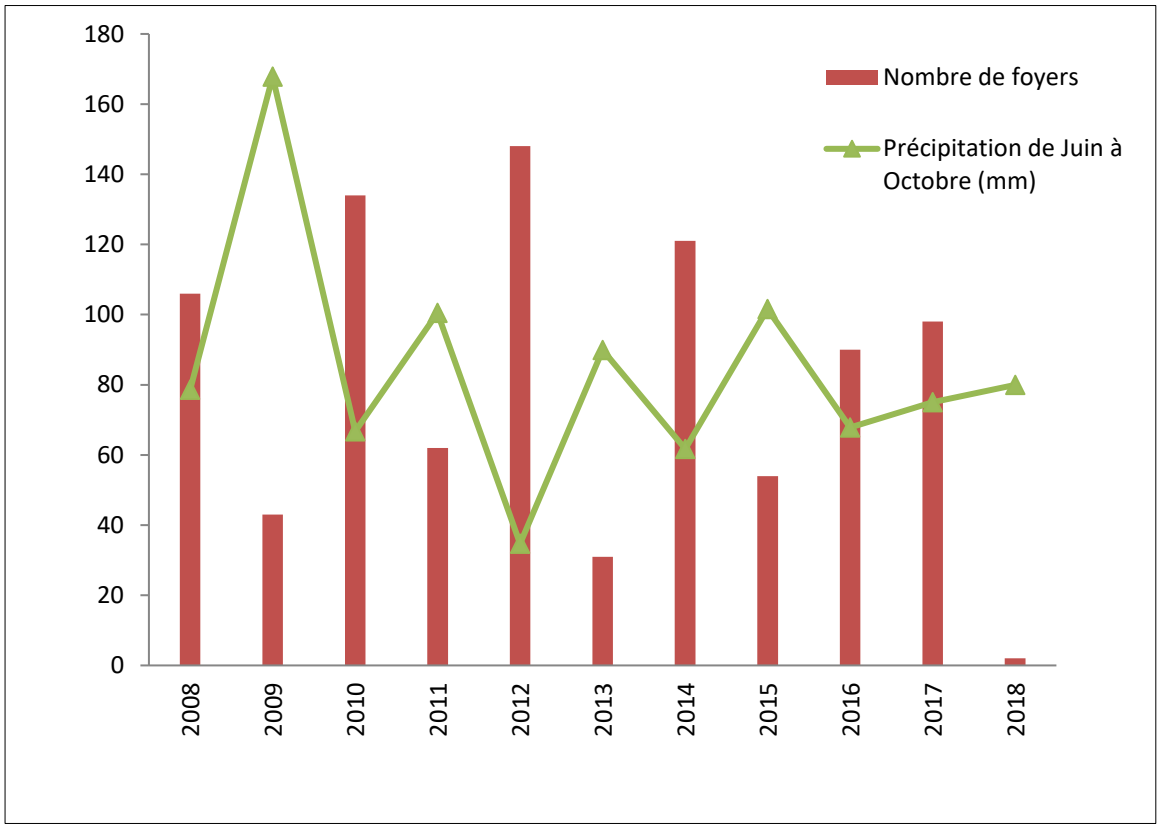

Figure 9: Relationship between precipitation and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

L'2012 was the most critical year from the point of view of forest fires, where a minimum of rainfall was recorded compared to other years (3.75%) of total rainfall.

On the other hand, the'year 2009, exposed to significant precipitation (107.8 mm or 18.5%) is characterized by a minimum number of outbreaks of'forest fires (only 43 outbreaks).
This explains the impact and role of precipitation on the phenomenon of forest fires. The more abundant the precipitation, the higher the rate of'The humidity of the fuel increases and therefore the frequency of fires decreases. On the contrary, if there is less precipitation, the fuels are less humid, which therefore promotes the'outbreak of fires.

- **Relationship between forest fires and maximum temperatures**

An increase in temperatures is favorable to forest fires, and a decrease in temperatures also leads to a decrease in the number of fires starting (Tab. 9 and Fig.10).
Temperature plays a very important role in the sense that it indicates the condition of the passage of heat from one substance to another, it is a factor that affects the availability of energy. Furthermore, it promotes the evaporation and drying of fuels and therefore makes them more vulnerable to the risk of fire (Halimi, 1980).

Table9: Relationship between maximum temperatures and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

Year	Number of households	Maximum temperature from June to October (°C)
2008	106	39.3
2009	43	31.7
2010	134	38.8
2011	62	34
2012	148	39.6
2013	31	29.7
2014	121	32
2015	54	35
2016	90	37.7
2017	98	38
2018	2	31.6

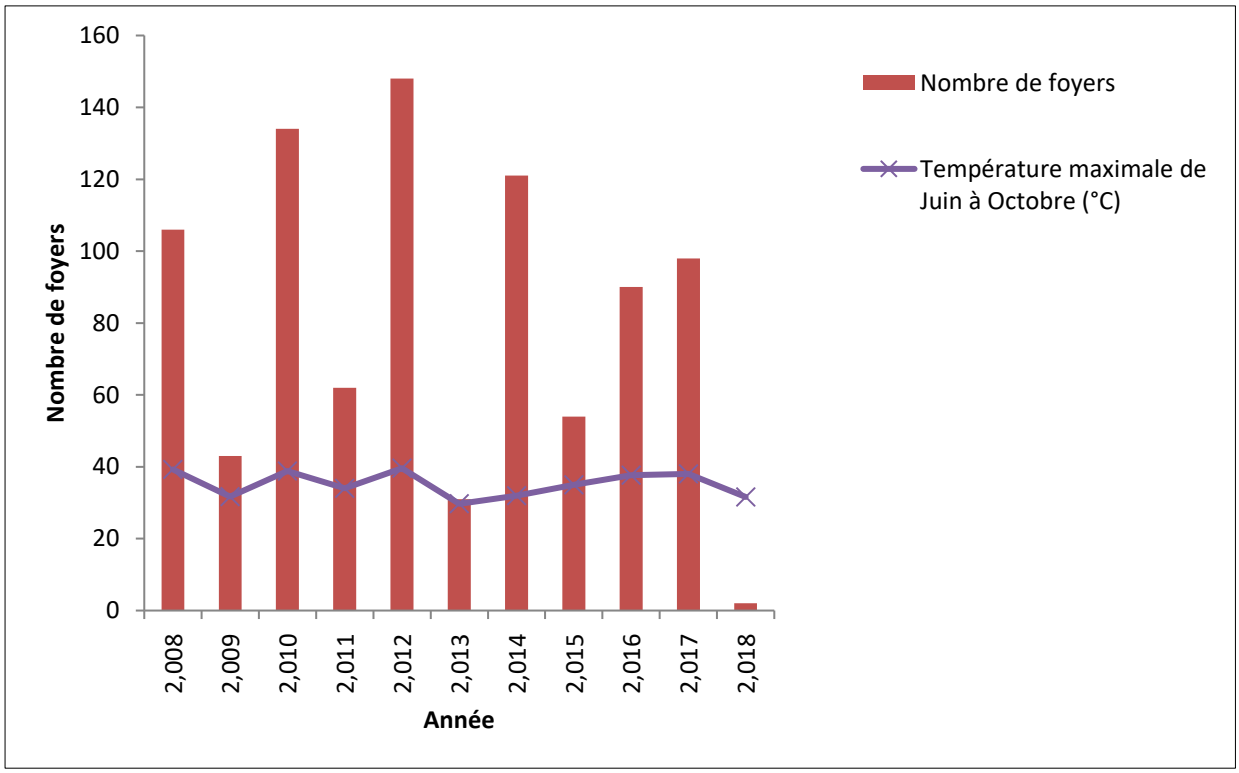

Figure 10: Relationship between maximum temperatures and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

- **Relationship of forest fires with relative air humidity**

The influence of humidity can be'explain at the level of fuels including'humidity is dependent on the'humidity of the'air is the water content of the fuel(Layec, 1989).

So, a decrease in the'humidity of the'air leads to an increase in the number of forest fires (Tab. 10 and Fig. 11).

Table 10: Relationship between average relative humidity (%) and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

Year	Number of households	Average relative humidity from June to October (%)
2008	106	54
2009	43	61
2010	134	35
2011	62	68
2012	148	59
2013	31	68
2014	121	57
2015	54	48
2016	90	50
2017	98	55
2018	2	71

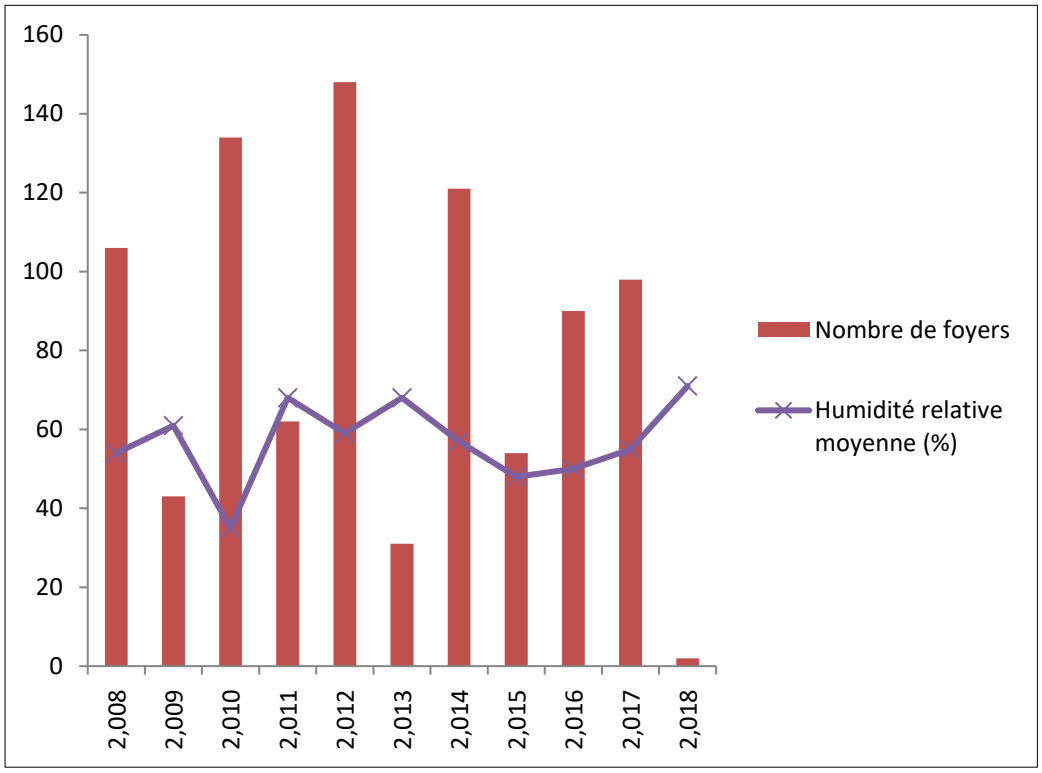

Figure 11: Relationship between average relative humidity (%) and the number of forest fire outbreaks in the Souk Ahras region (Period 2008 - 2018)

- **Relationship between forest fires and wind speed**

In addition to the role of transporter over long distances of sparks or burning materials, the wind which dries the fuel and which is an inexhaustible reservoir of oxygen for the fire helps in a more than significant way to the propagation of the fire; it directs it according to its direction and it heats the fuels facing the fire (De montgolfier, 1989).

Wind is considered to be a factor that aggravates the severity of fires by acting on the combustibility process. Thus, the more the wind blows, the drier the fuels are and therefore the combustion is faster. It is necessary to consider not only the wind speed but also its direction. (Dupuy, 2000).

Table 11: Relationship between average wind speed (m/s) and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

Year	**Number of households**	**Average wind speed from June to October (m/s)**
2008	106	3.5
2009	43	3.0
2010	134	3.2
2011	62	3.1
2012	148	2.8
2013	31	2.7
2014	121	3.6

2015	54	2.0
2016	90	2.3
2017	98	2.8
2018	2	2.1

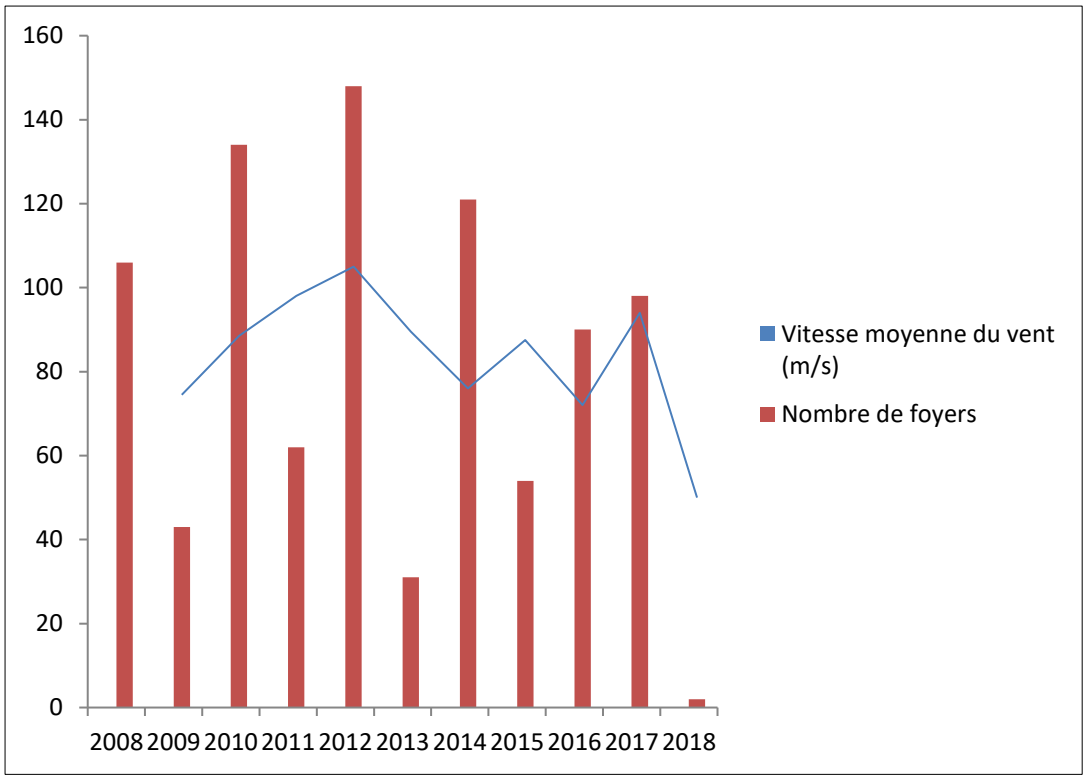

Figure 12: Relationship between average wind speed (m/s) and the number of forest fire outbreaks in the Souk-Ahras region (Period 2008 - 2018)

Forest fire control policy in the Wilaya of Souk Ahras

The conservation of the Souk Ahras forests has set up an operational system on the following points of view:

- **On the awareness level**

Prevention aims, among other things, to suitably modify human behaviors, by informing and raising awareness among the population (Asnouni, 2016). One of the major objectives of information is to explain why the forest must be protected and how to protect it (example of radio broadcasts, conferences, days, open days on the forest administration, television broadcasts and participations, press, etc.).

- **On the regulatory level**

Preparation and approval of wilaya orders relating to the prevention and fight against forest fires and their implementation from the beginning of the campaign in 01/06 until October 31 of the year (Order on the campaign for preventive fight against forest fires, Order on the opening of the campaign for preventive and active fight against forest fires, Order on the installation of municipal intervention groups, etc.).

- **On the prevention level**

Prevention is used in a broad sense, it refers to the measures taken before the fire in order to reduce the risk and the previous measures to reduce the risk of fire (monitoring and alert, lookout post, mobile forest brigades, forest tracks, firebreak trenches, water points, etc.).

Conclusion

Forest fires are and will remain one of the major destructive problems for Mediterranean forests in general.

Today, less than 5% of fires are considered to be of natural origin, mainly due to lightning; for the rest, man is directly or indirectly involved in the destruction of the forest.

From the data provided by the conservation of the forests of Souk Ahras in the form of daily, monthly, annual and hourly reports, we created a database in order to analyze the phenomenon of forest fires in this locality for a period of 11 years from 2008 to 2018,889declared fires have destroyed an area of 5025.8 ha. This result allows us to establish an average of 456.89 ha per year for these years. The highest number of fires in 2012148homes with a rate of 26.7% of the total number recorded. On the other hand, in 2018 the burned area is considered acceptable compared to the annual average recorded in the wilaya, this is due to several factors, including the factor. The month of August is the month which totals the greatest number of homes, i.e. an average of504fires, and the largest area 3204.3 ha. Concerning the times, the largest share of fires was counted during the day and more specifically between 6 a.m. and 8 p.m.

The analysis of the parameters gives an idea of the means of control, the speed of the intervention and the possibility offered by the terrain for the penetrability of the control equipment.

To reduce the effect of fires, knowledge of fuels is an indicated solution in the management of forest ecosystems. Two fundamental elements seem to intervene in this case. On the one hand, the climatology factor, and on the other, human activity.

Given these results, the danger of forest fires remains significant, which requires development plans based on the fire risk prevention plan which itself is based on forest fire sensitivity maps.

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