THE FIRE RISK OF THE PLANT GROUPINGS WITH *CISTUS* IN THE AREA OF TLEMCEN (WESTERN ALGERIA)

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Abstract

Our paper focuses on the assessment of the sensitivity to fire *Cistus* plant groupings in the region of Tlemcen (Western Algeria). The study area consists mainly of *Cistus*, *Pinus*, *Quercus* and *Tetraclinis* considered the main species in the community. The bioclimatic analysis shows that the study sites tend towards certain aridity over time resulting in higher maximum temperatures and a wide dry period during the year, representing a major factor departures fires. The phytoecological analysis shows that the study area tends towards a certain therophytisation. Shrub and tree strata are the most vulnerable and flammable, for this reason, a number of species has been the subject of this study is to determine the time of flammability and combustibility depending on the water content. Testing flammability and combustibility of 38 plant species were used to classify species in ascending order according to their sensitivity to light, and draw a map of susceptibility to fires matorrals of *Cistus* aiming at the prevention and the fight against the devastating forest fires through different methods of planning.

Keywords: *Cistus*, Flammability, Combustibility, Plant groupings, The fire risk, Strata, Tlemcen (Western Algeria)

Résumé

Notre article se focalise sur l'évaluation de la sensibilité au feu des groupements végétaux à *Cistus* de la région de Tlemcen (Algérie occidentale). La zone d'étude composée essentiellement de *Cistus*, *Pinus*, *Quercus* et *Tetraclinis* considérées comme essences principales du milieu. L'analyse bioclimatique montre que les stations d'étude tendent vers une

aridité certaine par rapport à l'époque traduit par des températures maximales élevées et une large période sèche au cours de l'année représentant un facteur prépondérant des départs des feux. L'analyse phytoécologique nous montre que la zone d'étude tend vers une thérophytisation certaine. Les strates arborée et arbustive sont les plus vulnérables et inflammables. Pour cette raison, un certain nombre d'espèces a fait l'objet de cette étude qui consiste à déterminer leur temps d'inflammabilité et de combustibilité en fonction de la teneur en eau. Les tests d'inflammabilité et de combustibilité de 38 espèces végétales ont permis de classer les espèces par ordre croissant selon leur sensibilité au feu, et de tracer une carte de sensibilité aux incendies des matorrals à *Cistus* ayant pour objectif la prévention et la lutte contre les feux de forêts dévastateurs à travers les différentes méthodes d'aménagement du territoire.

Mots clés: *Cistus*, Inflammabilité, Combustibilité, Groupements végétaux, Le risque d'incendie, Strates, Tlemcen (Algérie occidentale)

Introduction

The matorrals and Mediterranean forests are submitted annually to a drought in the summer. The lack of water due to limited or no rainfall, low air humidity and high temperatures with high evaporative demand increases the risk of wildfires (Rambal and Hoff, 1998). The fire has a significant presence and influence in the Mediterranean ecosystems, damage depends mainly on the intensity and frequency of fire. Reconstruction of vegetation is slow and repetitive fires can seriously endanger the renewal of the vegetation (Francis and Thomes, 1990, Ferran et al., 1992, Bautista et al., 1994, Moench and Fusaro, 2003).

Flammability is the property that a plant or plant part to ignite when subjected to heating. This quantity is linked to the notion of an outbreak of fire. As combustibility is the property that a plant or an entire plant to spread fire. This concept is involved in more than flammability scale indeed combustibility rather characterizes a whole plant formation with the different layers that comprise it. Parameters often used to describe the combustibility are twofold: the power of the flame front, the speed of propagation of the flame front (Alexandrian and Rigolot, 1992).

The appearance of the fire does not only depend on the weather, it also depends on the flammability of the vegetation. Flammability is considered dependent on the plant leaf hydration (Trabaud, 1974, Trabaud, 1976, Cappelli et al., 1983, Massari and Leopaldi, 1998). (Trabaud, 1976) describes a trend where the leaves with a lower percentage of water are easily ignited, while the leaves with a high leaf moisture rarely lit. Even if this was true for most species, an exception was found in the case of *Quercus*

pubescens, which quickly soared even at high moisture content. The dependence of the flammability of water requirement of plants and leaves is therefore also linked to other environmental factors, life history and eco-physiology of the plant. Some species are more flammable than others in the same water content (Massari and Leopaldi, 1998).

In addition to leaf moisture, volatile organic compounds such as monoterpenes are another possible factor driving flammability. These compounds are present and issued by most Mediterranean plants (Llusià and Peñuelas, 2000), but their actual effects on flammability are still controversial (Cappelli et al., 1983). (White, 1994) stated that the ignition was positively correlated with the monoterpenoid content. (Owens et al., 1998) confirm and strengthen the results of White.

The flammability of forest species classification is an essential component of the danger of fuel and fire risk assessment, which are important elements of judicial planning fire management (Le Houërou, 1973, Trabaud, 1976, Barney and Aldrich, 1980). In France, data on the flammability of species are used as part of the overall planning for the prevention of forest fires (Cemagref, 1990).

The flammability of plants (The ability of a species to ignite and maintain the fire) is a complex phenomenon whose direct measurement in laboratory conditions is difficult and uncertain, due to the absence of standard as well as the complexity of parameters involved methodology (Anderson, 1970, Mark, 1988). (Mark, 1988) reviewed the literature on laboratory methods for evaluating the flammability of plants and concluded that the flammability rating is rarely presented in absolute terms. Most methods are based on measuring the ignition delay of a plant sample (Time of ignition delay). In France, extensive research has been conducted to evaluate the relative flammability of Mediterranean species (Trabaud, 1976, Vallette, 1990). (Vallette, 1990) uses the term "flammable" as the ability of a fuel to ignite after being subjected to heat energy. This term coincides with the term "ignition" in American literature (Anderson, 1970).

A basic approach to assessing the flammability of plant species is the quantification (Measurement and analysis) of their physical and chemical properties. The physical and chemical properties of individual plants are considered major components of flammability (Mutch, 1970, Rundel, 198, Papio and Trabaud, 1990, Albini, 1992, Whelan, 1995). (Misbach, 1982) has classified several species according to their expected using only two properties (Heat content and the ignition temperature) flammability.

Our study is to assess the risk of fire plant communities based *Cistus* (*Cistus ladaniferus subsp. africanus, Cistus monspeliensis* and *Cistus salvifolius*) of two mountain ranges (Tlemcen Mountains and Traras Mountains), it will allow us to classify plants according to the following

flammability parameters: ignition delay, burning time and the height of the flame used by (Vallette, 1990) depending on the water content parameter. In this work, we make comparisons between the flammability parameters studied to get an idea about the status of taxa tested which allows us to better appreciate the sensitivity to light of our natural environment make. The stratification of the vegetation (Tree layer, shrub layer and herb layer) remains a fundamental component to analyze the problem.

Material and Methods

To determine the sensitivity of vegetation fire in the study area (Tlemcen Mountains, Traras Mountains), we adopted as the method of INRA of Avignon (France) (Vallette, 1990, Moro, 2004) to measure the flammability of 38 plant species (*Cistus ladaniferus subsp. africanus, Cistus monspeliensis, Cistus salvifolius, Ampelodesma mauritanicum, Arbutus unedo, Asparagus albus, Asparagus stipularis, Calycotome intermedia, Ballota hirsuta, Acacia cyanophylla, Chamaerops humilis, Ceratonia siliqua, Crataegus oxyacantha, Daphne gnidium, Cytisus triflorus, Erica arborea, Echium vulgare, Galium verum, Globularia alypum, Juniperus oxycedrus, Lavandula dentata, Lavandula stoechas, Olea europaea, Phagnalon saxatile, Pinus halepensis, Quercus suber, Quercus faginea subsp. tlemceniensis, Rhamnus alaternus, Lonicera implexa, Prasium majus, Rosa canina, Rubus ulmifolius, Salvia verbenaca, Tetraclinis articulata, Thymus ciliatus, Ulex parviflorus, Withania frutescens and Euphorbia helioscopiae*). For this purpose, different parameters were considered: the ignition delay, the duration of combustion and flame height expressing flammability, combustibility and intensity of combustion (The time in seconds was calculated by a multi-turn stopwatch to the ignition delay and combustion time, the flame height was measured using a scale in centimeters). The water content **[MF = (1 – MS) x 100]**[15] is a critical factor that comes into play as to whether or not influences on the parameters mentioned above (A sample of 2 g of fresh material for each species was placed in an oven 120 °C for 24 hours). The samples were collected during the spring season (Month of April and May 2013), a test of three samples (10g each) measured by an electric balance (1/1.000 gram) for each species was implemented using an infrared burner, wherein the temperature to start burning the samples was measured by a temperature probe of a multi-meter which corresponds to position 10 (850 °C). To have a flammability rating for each plant species, two things are needed: the average time of ignition and the ignition frequency, for our case, we took the first because all subjects

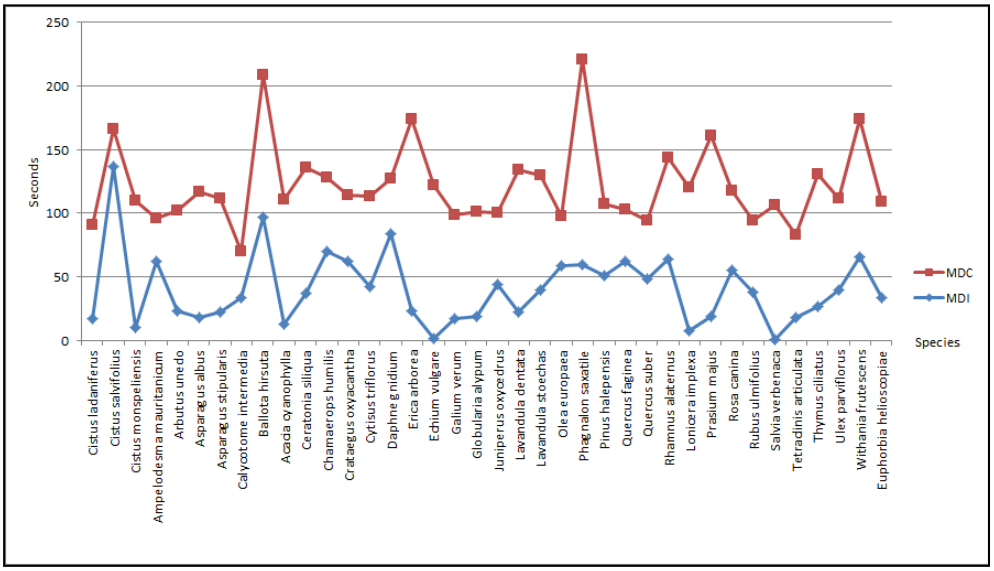
[15] **MF :** Fresh matter ; **MS :** Dry matter.

have tests positive using the classes from the following formula: (Class interval = maximum value - minimum value / number of classes). We note that we have also given a score for the other parameters (Flammability, combustion intensity and water content) using the same principle of classification mentioned above.

Results and Discussion

Flammability and combustibility

Figure 1: The average time of ignition (MDI) and the average duration of combustion (MDC) plant species (Study Area).



(Figure 1) shows that some plant species have a short ignition delay which varies between 1 and 60 seconds and a long burning time, which varies between 100 and 230 seconds (*Erica arborea, Arbutus unedo, Ceratonia siliqua, Lavandula stoechas, Ulex parviflorus, Thymus ciliatus, Lonicera implexa, Cytisus triflorus, Juniperus oxycedrus, Quercus faginea, Quecus suber and Pinus halepensis*), which remain extremely sensitive to fire representative groups of *Quercus suber* and *Quercus faginea* (Mountains of Tlemcen). For the same vegetation, there are plant species that have a long ignition delay and a long burning time, this is the case for *Cistus salvifolius* and *Rhamnus alaternus*. We also note that there are plant species that have a short ignition delay and a short burn time, so *Cistus ladaniferus, Calycotome intermedia* and *Crataegus oxyacantha*.

Plant species characterizing groups *Tetraclinis articulata* (Mountains of Traras), some taxa have a short ignition delay and a long burning time (*Cistus monpeliensis, Lavandula dentata, Globularia alypum, Galium verum,*

Erica arborea, *Asparagus albus and Asparagus stipularis*). We also observe that there are plant species with a short ignition delay and a short burn time, this is the case for *Tetraclinis articulata*, *Calycotome intermedia* and *Olea europaea*. For *Chamaerops humilis* species characterizing environments degradation pathway has a long ignition delay and a short burn time. These results allow us to affirm that these formations are vulnerable to forest fires.

(Figure 2 and Figure 3) clearly shows that for all of our study area, the vegetation is represented by 87% of highly flammable taxa and 42% of highly combustible taxa. The relationship between flammability and combustibility of plant species due to the outbreak and spread of wildfires process.

Figure 2: Flammability (Study Area).

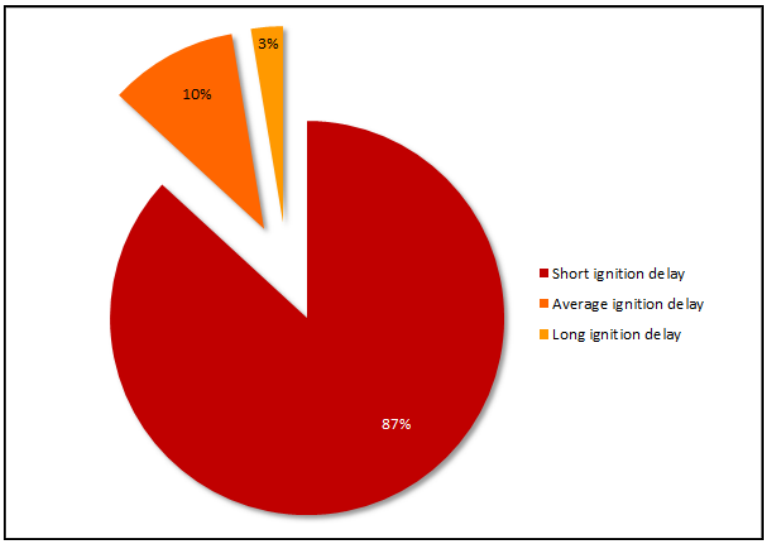
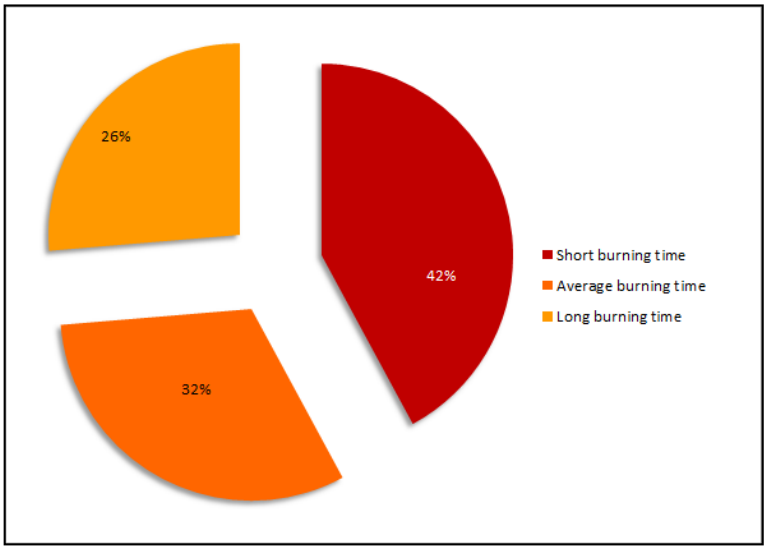


Figure 3: Combustibility (Study Area).



Combustion intensity and water content

Figure 4: Heights of the flame (MHF) of plant species (Study Area).

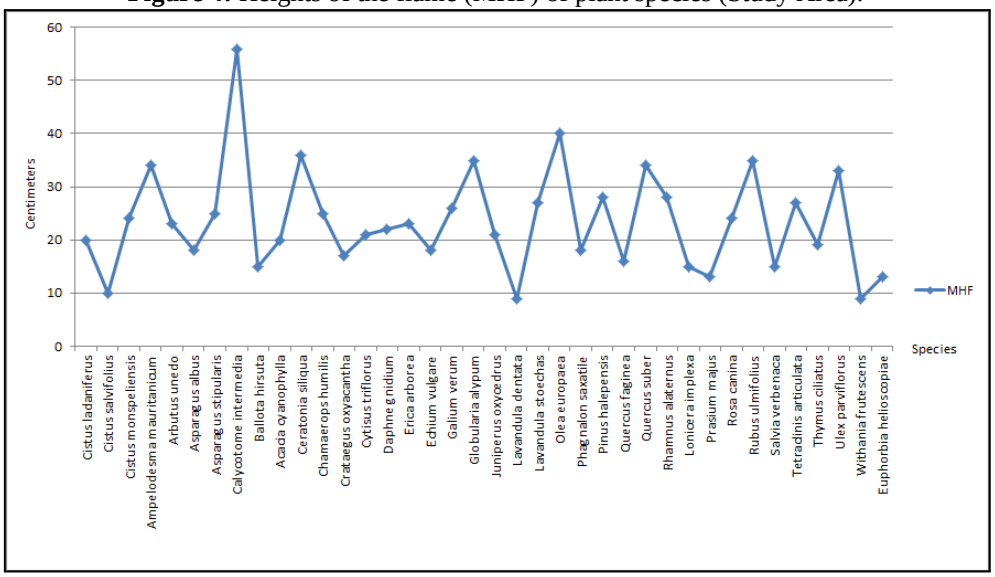
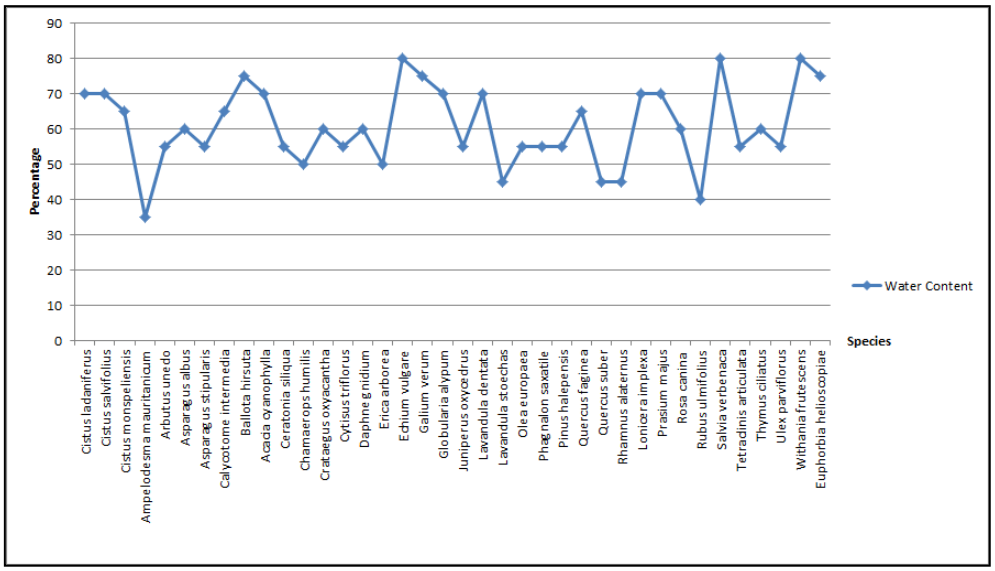


Figure 5: The water content (%) of plant species (Study Area).



(Figure 4) indicates the peak flame height between 20 and 60 cm, which is the case for the following plant species: *Calycotome intermedia*, *Ceratonia siliqua*, *Ampelodesma mauritanicum*, *Quercus suber*, *Cistus ladaniferus*, *Rubus ulmifolius* and *Ulex parviflorus* resulting in a high combustion intensity characterizing groups of *Quercus suber* and *Quercus faginea* (Mountains of Tlemcen). For groups *Tetraclinis articulata* (Mountains of Traras), we note that there is a peak for *Globularia alypum*

reflecting the intensive combustion and an average intensity of combustion *Tetraclinis articulata, Asparagus stipularis, Cistus monspeliensis, Olea europaea, Pinus halepensis* and *Galium verum*. The intensity of burning *Cistus salvifolius* remains low for both vegetation of the study area.

(Figure 5) shows the high levels of moisture content ranging between 60 and 80% of the plant species concerned are as follows: *Cistus ladaniferus, Cistus monspeliensis, Cistus salvifolius, Arbutus unedo Calycotome intermedia, Cytisus triflorus, Quercus faginea, Rosa canina, Lonicera implexa, Thymus ciliatus, Prasium majus, Lavandula dentata, Globularia alypum* and *Galium verum*, these rates coincide with the intensive combustion of most taxa and characterizing the vegetation of the two mountains in the study area.

For the entire study area, (Figure 6) shows that there is a percentage of 63% of plant species of the intensive combustion. Similarly, (Figure 7) indicates that there is a percentage of 42% of the taxa with high water content. We can explain these results by the combination of the amount of hydrated water releasing oxygen and essential oils, resins, gum that contains biological material.

Figure 6: Combustion intensity (Study Area).

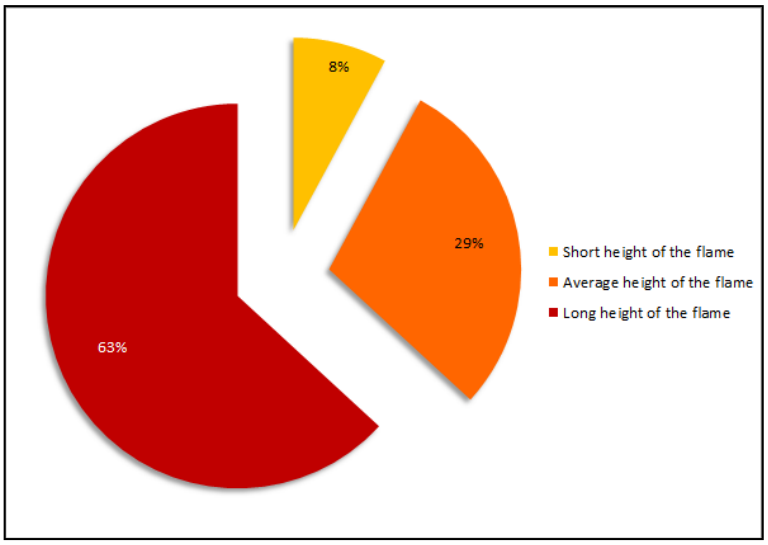
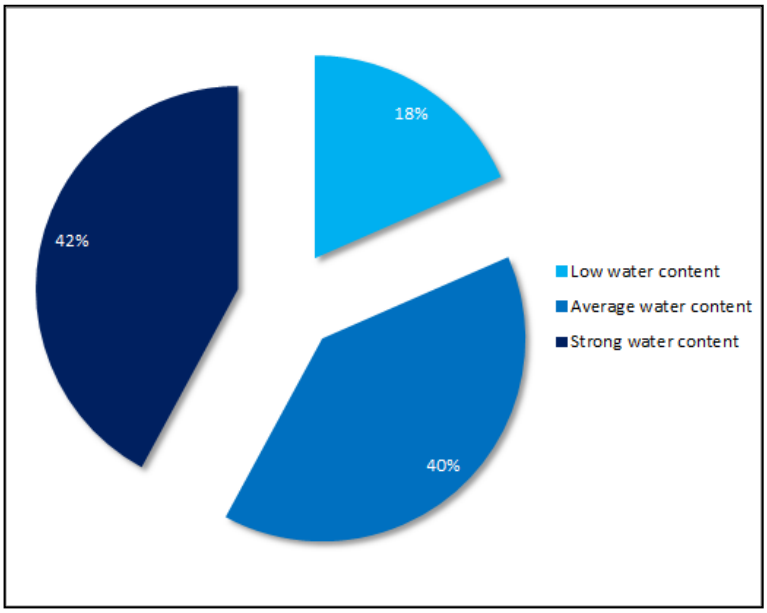


Figure 7: Water content (Study Area).



The classification of plant species according to flammability parameters and water content

The flammability of forest species classification is an essential component of the danger of fuel and fire risk assessment, which are important elements of judicial planning fire management (Le Houërou, 1973, Trabaud, 1976, Barney and Aldrich, 1980). Louis Trabaud and Jean-François Galtié in their work fire risk assessment, established a scoring species characterizing their susceptibility to the flammability and combustibility (Peyre, 1991).

For our study area, the classification of plants according to their scores for each parameter of interest is a fundamental step to better define the plant communities of our study area (Table. 1, 2, 3 and 4).

The resulting classes are:

Note of flammability (Seconds):

≥ 130 (1)
65 <…< 130 (2)
≤ 65 (3)

Note of combustibility (Seconds):

≥ 102 (1)
73 <…< 102 (2)
≤ 73 (3)

Note of combustion intensity (Centimeters):

≥ 20 (3)

10 <…< 20 (2)
≤ 10 (1)

Note of water content (Percentage):

≥ 65 (3)
50 <…< 65 (2)
≤ 50 (1)

Table 1: Classification of plant species according to note of flammability.

	Name of plant species	Family	Strata	Note of Flammability
High flammability	*Cistus ladaniferus*	Cistaceae	Shrub	3
	Cistus monspeliensis	Cistaceae	Herbaceous	3
	Ampelodesma mauritanicum	Poaceae	Shrub	3
	Arbutus unedo	Ericaceae	Tree	3
	Asparagus albus	Liliaceae	Shrub	3
	Asparagus stipularis	Liliaceae	Shrub	3
	Calycotome intermedia	Fabaceae	Shrub	3
	Acacia cyanophylla	Fabaceae	Tree	3
	Ceratonia siliqua	Cesalpiniaceae	Tree	3
	Crataegus oxyacantha	Rosaceae	Shrub	3
	Cytisus triflorus	Fabaceae	Shrub	3
	Erica arborea	Ericaceae	Shrub	3
	Echium vulgare	Boraginaceae	Herbaceous	3
	Galium verum	Rubiaceae	Herbaceous	3
	Globularia alypum	Globulariaceae	Herbaceous	3
	Juniperus oxycedrus	Cupressaceae	Tree	3
	Lavandula dentata	Lamiaceae	Herbaceous	3
	Lavandula stoechas	Lamiaceae	Herbaceous	3
	Olea europaea	Oleaceae	Tree	3
	Phagnalon saxatile	Asteraceae	Herbaceous	3
	Pinus halepensis	Pinaceae	Tree	3
	Quercus faginea	Fagaceae	Tree	3
	Quercus suber	Fagaceae	Tree	3
	Rhamnus alaternus	Rhamnaceae	Shrub	3
	Lonicera implexa	Caprifoliaceae	Tree	3
	Prasium majus	Lamiaceae	Shrub	3
	Rosa canina	Rosaceae	Tree	3
	Rubus ulmifolius	Rosaceae	Shrub	3
	Salvia verbenaca	Lamiaceae	Herbaceous	3
	Tetraclinis articulata	Cupressaceae	Tree	3
	Thymus ciliatus	Lamiaceae	Herbaceous	3
	Ulex parviflorus	Fabaceae	Shrub	3
	Euphorbia helioscopiae	Euphorbiaceae	Herbaceous	3
Moderate flammability	*Ballota hirsuta*	Lamiaceae	Herbaceous	2
	Chamaerops humilis	Palmaceae	Shrub	2
	Daphne gnidium	Thymeleaceae	Shrub	2
	Withania frutescens	Solanaceae	Tree	2
Low flammability	*Cistus salvifolius*	Cistaceae	Herbaceous	1

Table 2: Classification of plant species according to note of combustibility.

	Name of plant species	Family	Strata	Note of Combustibility
High combustibility	*Calycotome intermedia*	Fabaceae	Shrub	3
	Cytisus triflorus	Fabaceae	Shrub	3
	Juniperus oxycedrus	Cupressaceae	Tree	3
	Rubus ulmifolius	Rosaceae	Shrub	3
	Tetraclinis articulata	Cupressaceae	Tree	3
	Ulex parviflorus	Fabaceae	Shrub	3
	Ampelodesma mauritanicum	Poaceae	Shrub	3
	Crataegus oxyacantha	Rosaceae	Shrub	3
	Olea europaea	Oleaceae	Tree	3
	Pinus halepensis	Pinaceae	Tree	3
	Quercus faginea	Fagaceae	Tree	3
	Quercus suber	Fagaceae	Tree	3
	Rosa canina	Rosaceae	Tree	3
	Chamaerops humilis	Palmaceae	Shrub	3
	Daphne gnidium	Thymeleaceae	Shrub	3
	Cistus salvifolius	Cistaceae	Herbaceous	3
Moderate combustibility	*Cistus ladaniferus*	Cistaceae	Shrub	2
	Cistus monspeliensis	Cistaceae	Herbaceous	2
	Arbutus unedo	Ericaceae	Tree	2
	Asparagus albus	Liliaceae	Shrub	2
	Asparagus stipularis	Liliaceae	Shrub	2
	Acacia cyanophylla	Fabaceae	Tree	2
	Ceratonia siliqua	Cesalpiniaceae	Tree	2
	Galium verum	Rubiaceae	Herbaceous	2
	Globularia alypum	Globulariaceae	Herbaceous	2
	Lavandula stoechas	Lamiaceae	Herbaceous	2
	Euphorbia helioscopiae	Euphorbiaceae	Herbaceous	2
	Rhamnus alaternus	Rhamnaceae	Shrub	2
Low combustibility	*Erica arborea*	Ericaceae	Shrub	1
	Echium vulgare	Boraginaceae	Herbaceous	1
	Lavandula dentata	Lamiaceae	Herbaceous	1
	Lonicera implexa	Caprifoliaceae	Tree	1
	Prasium majus	Lamiaceae	Shrub	1
	Salvia verbenaca	Lamiaceae	Herbaceous	1
	Thymus ciliatus	Lamiaceae	Herbaceous	1
	Phagnalon saxatile	Asteraceae	Herbaceous	1
	Withania frutescens	Solanaceae	Tree	1
	Ballota hirsuta	Lamiaceae	Herbaceous	1

Table 3: Classification of plant species according to note of combustion intensity.

	Name of plant species	**Family**	**Strata**	**Note of Combustion Intensity**
Strong combustion intensity	*Cistus ladaniferus*	Cistaceae	Shrub	3
	Cistus monspeliensis	Cistaceae	Herbaceous	3
	Ampelodesma mauritanicum	Poaceae	Shrub	3
	Arbutus unedo	Ericaceae	Tree	3
	Asparagus stipularis	Liliaceae	Shrub	3
	Calycotome intermedia	Fabaceae	Shrub	3
	Acacia cyanophylla	Fabaceae	Tree	3
	Ceratonia siliqua	Cesalpiniaceae	Tree	3
	Cytisus triflorus	Fabaceae	Shrub	3
	Erica arborea	Ericaceae	Shrub	3
	Galium verum	Rubiaceae	Herbaceous	3
	Globularia alypum	Globulariaceae	Herbaceous	3
	Juniperus oxycedrus	Cupressaceae	Tree	3
	Lavandula stoechas	Lamiaceae	Herbaceous	3
	Olea europaea	Oleaceae	Tree	3
	Pinus halepensis	Pinaceae	Tree	3
	Quercus suber	Fagaceae	Tree	3
	Rhamnus alaternus	Rhamnaceae	Shrub	3
	Rosa canina	Rosaceae	Tree	3
	Rubus ulmifolius	Rosaceae	Shrub	3
	Tetraclinis articulata	Cupressaceae	Tree	3
	Ulex parviflorus	Fabaceae	Shrub	3
	Chamaerops humilis	Palmaceae	Shrub	3
	Daphne gnidium	Thymeleaceae	Shrub	3
Moderate combustion intensity	*Asparagus albus*	Liliaceae	Shrub	2
	Crataegus oxyacantha	Rosaceae	Shrub	2
	Echium vulgare	Boraginaceae	Herbaceous	2
	Phagnalon saxatile	Asteraceae	Herbaceous	2
	Quercus faginea	Fagaceae	Tree	2
	Lonicera implexa	Caprifoliaceae	Tree	2
	Prasium majus	Lamiaceae	Shrub	2
	Salvia verbenaca	Lamiaceae	Herbaceous	2
	Thymus ciliatus	Lamiaceae	Herbaceous	2
	Euphorbia helioscopiae	Euphorbiaceae	Herbaceous	2
	Ballota hirsuta	Lamiaceae	Herbaceous	2
Low combustion intensity	*Lavandula dentata*	Lamiaceae	Herbaceous	1
	Withania frutescens	Solanaceae	Tree	1
	Cistus salvifolius	Cistaceae	Herbaceous	1

Table 4: Classification of plant species according to note of water content.

	Name of plant species	Family	Strata	Note of Water Content
Strong water content	*Cistus ladaniferus*	Cistaceae	Shrub	3
	Cistus monspeliensis	Cistaceae	Herbaceous	3
	Calycotome intermedia	Fabaceae	Shrub	3
	Acacia cyanophylla	Fabaceae	Tree	3
	Echium vulgare	Boraginaceae	Herbaceous	3
	Galium verum	Rubiaceae	Herbaceous	3
	Globularia alypum	Globulariaceae	Herbaceous	3
	Lavandula dentata	Lamiaceae	Herbaceous	3
	Lonicera implexa	Caprifoliaceae	Tree	3
	Prasium majus	Lamiaceae	Shrub	3
	Salvia verbenaca	Lamiaceae	Herbaceous	3
	Euphorbia helioscopiae	Euphorbiaceae	Herbaceous	3
	Quercus faginea	Fagaceae	Tree	3
	Withania frutescens	Solanaceae	Tree	3
	Cistus salvifolius	Cistaceae	Herbaceous	3
	Ballota hirsuta	Lamiaceae	Herbaceous	3
Moderate water content	*Arbutus unedo*	Ericaceae	Tree	2
	Asparagus albus	Liliaceae	Shrub	2
	Asparagus stipularis	Liliaceae	Shrub	2
	Ceratonia siliqua	Cesalpiniaceae	Tree	2
	Cytisus triflorus	Fabaceae	Shrub	2
	Juniperus oxycedrus	Cupressaceae	Tree	2
	Tetraclinis articulata	Cupressaceae	Tree	2
	Thymus ciliatus	Lamiaceae	Herbaceous	2
	Ulex parviflorus	Fabaceae	Shrub	2
	Crataegus oxyacantha	Rosaceae	Shrub	2
	Olea europaea	Oleaceae	Tree	2
	Phagnalon saxatile	Asteraceae	Herbaceous	2
	Pinus halepensis	Pinaceae	Tree	2
	Rosa canina	Rosaceae	Tree	2
	Daphne gnidium	Thymeleaceae	Shrub	2
Low water content	*Erica arborea*	Ericaceae	Shrub	1
	Lavandula stoechas	Lamiaceae	Herbaceous	1
	Rubus ulmifolius	Rosaceae	Shrub	1
	Ampelodesma mauritanicum	Poaceae	Shrub	1
	Quercus suber	Fagaceae	Tree	1
	Rhamnus alaternus	Rhamnaceae	Shrub	1
	Chamaerops humilis	Palmaceae	Shrub	1

We note that non-flammable plants are: *Asphodelus microcarpus, Sedum acre, Urginea maritima* and *Smilax aspera*.

The classification of flammability parameters and water content according to the strata

Figure 8: Flammability according to the strata of plant species (Study Area).

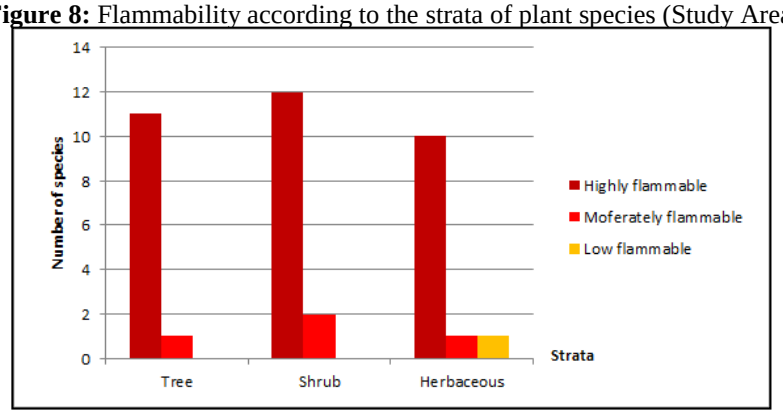


Figure 9: Combustibility according to the strata of plant species (Study Area).

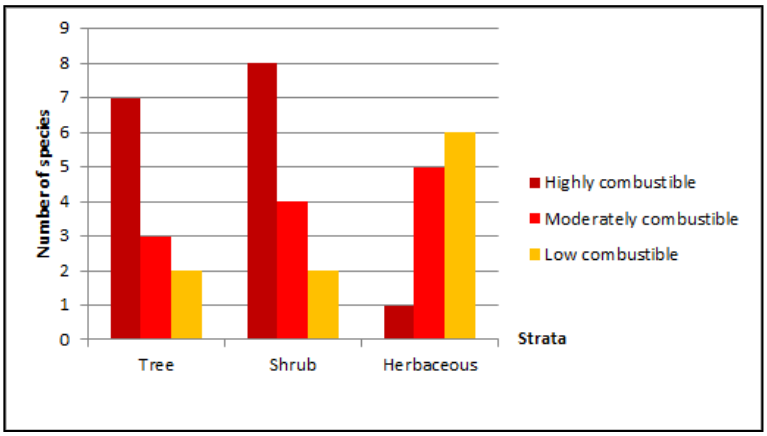


Figure 10: Combustion intensity according to the strata of plant species (Study Area).

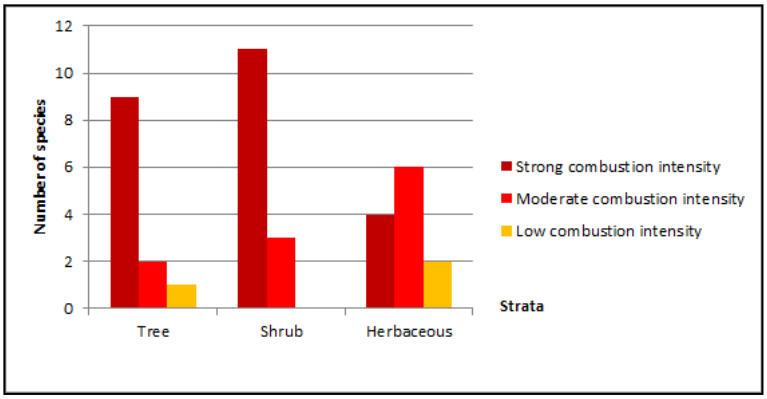
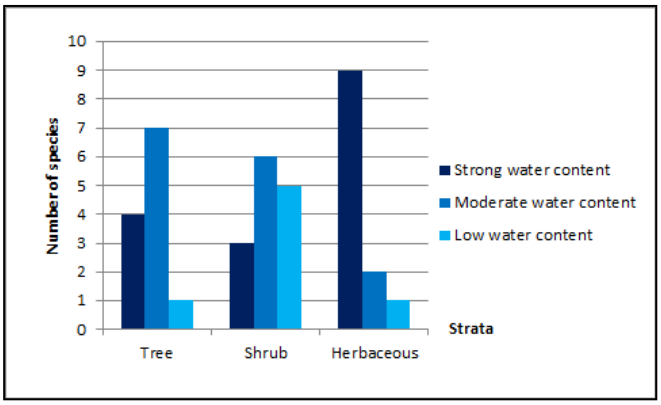


Figure 11: Water content according to the strata of plant species (Study Area).



(Figure 8) shows that the three strata (tree, shrub and herbaceous) are dominated by highly flammable plant species, moderately flammable taxa remain low in the three strata or layers while low flammability species are only herbaceous with a small amount.

(Figure 9) shows that only the tree and shrub layer is dominated by highly combustible plants and a small amount of fuel little by taxa against the herbaceous layer is dominated by few taxa fuel and a small amount of highly combustible plants. Moderately fuel plants are moderately represented for the three strata.

(Figure 10) shows the tree and shrub layer is dominated by taxa intensive combustion while the herbaceous layer is moderately represented by these plants. The latter is dominated by taxa to medium combustion with low representation for plants with low combustion intensity. Taxa medium and low intensity of combustion are poorly represented in the tree and shrub layer.

(Figure 11) indicates that the taxa with high water content are at the herbaceous layer while they are moderately represented in the tree and shrub layer. By cons, plant species in average water content are at the tree and shrub layer while in the herbaceous layer is poorly represented. The taxa with low water content are strongly represented in shrub layer by against the tree and herbaceous layer are represented by small amounts.

We can conclude that the tree and shrub strata remain the most vulnerable to forest fires in our study area.

The development of a risk map forest fires of Tlemcen region is a necessary step to make it easier for forest managers to determine an appropriate strategy against forest fires.

To achieve this goal, we used the method of scoring vegetation of our study according to the note flammable range and the combustibility of their plants and their classification based on the interval class to achieve the three

representative classes of the study area (high risk, medium risk and low risk) (Table. 1, 2, 3 and 4).

(Figure 12) clearly shows that the mountains of Tlemcen (Forest of Hafir and Pre-forest of Zarifet) and Mountains of Traras (Pre-forests and matorrals of Ghazaouet and Nedroma) represented by the degraded *Quercus suber* plant groupings, *Quercus faginea* and *Tetraclinis articulata* colonized by three species of *Cistus* (*Cistus ladaniferus*, *Cistus monspeliensis* and *Cistus salvifolius*) natural ecosystems remain at high risk and have a high sensitivity was fire. By cons, in the middle of these two mountains and the steppes that lie below the mountains of Tlemcen channels, we notice the presence of highly degraded ecosystems in arid and semi-arid marked by a medium and low risk.

From this, we can say that the prevention of forest fires and the long-term forecast for a map projection to the future with the help of GIS (Geographic Information System) and remote sensing as well as awareness are necessary steps to be taken to avoid any devastating disasters that can happen again in the near future.

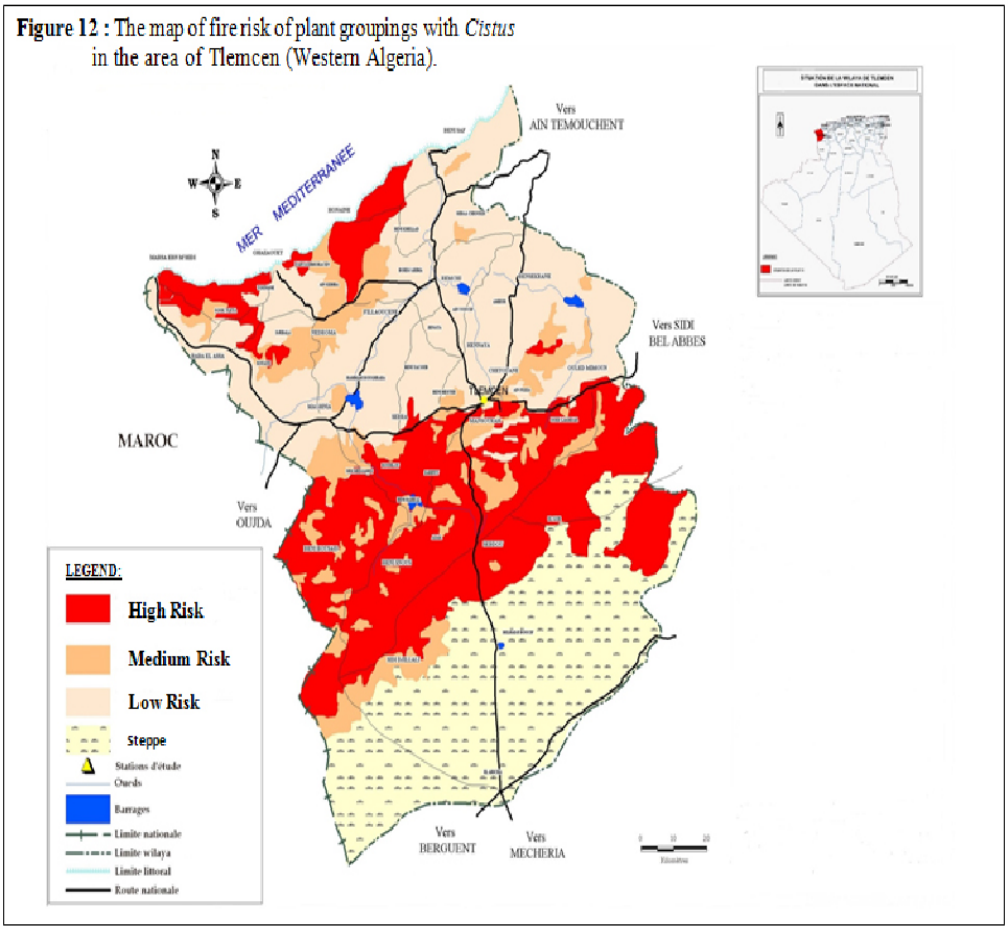


Figure 12 : The map of fire risk of plant groupings with *Cistus* in the area of Tlemcen (Western Algeria).

Conclusion

Tlemcen region is represented by different natural ecosystems (pre-forest, matorrals). These plant communities are occupied by large surfaces based on:

- Plant Groups *Cistus ladaniferus subsp. africanus*;
- Plant Groups *Cistus salvifolius*;
- Plant Groups *Cistus monspeliensis*.

For the entire study area, taxa that have a short ignition delay and a short or long burning (*Erica arborea, Arbutus unedo, Ceratonia siliqua, Lavandula stoechas, Ulex parviflorus, Thymus ciliatus, Lonicera implexa , Cytisus triflorus, Juniperus oxycedrus, Quercus faginea subsp. tlemceniensis, Quercus suber, Pinus halepensis, Cistus ladaniferus subsp. africanus, Calycotome intermedia, Crataegus oxyacantha, Cistus monspeliensis, lavandula dentata, Globularia alypum, Galium verum, Asparagus stipularis, Asparagus albus, Tetraclinis articulata, Olea europaea* and *Chamaerops humilis*). These plants remain extremely susceptible to fire characterizing vegetation degraded with *Quercus suber, Quercus faginea subsp. tlemceniensis* and *Tetraclinis articulata* (Mountains of Tlemcen and Mountains Traras).

The study on the fire risk of plant groupings in the region of Tlemcen allowed us to highlight three classes of plant species according to their degrees for each parameter:

1) Flammability:

- Highly flammable species (86.84%);
- Moderately flammable species (10.52%);
- Low flammability species (2.63%).

2) Combustibility:

- Highly combustible species (42.10%);
- Moderately combustible species (31.57%);
- Little combustible species (26.31%).

3) Intensity of Combustion:

- Strong combustion intensity species (63.15%);
- Moderate combustion intensity species (28.94%);
- Low combustion intensity species (7.89%).

4) Water content:

- Strong water content species (42.10%);
- Moderate water content species (39.47%);
- Low water content species (18.42%).

The tree layer and shrub strata remain the most vulnerable to forest fires in our study area.

It would be desirable to control the fire and avoid repetition, for frequencies too close destroys biodiversity and remote frequencies enriched plant genetic potential.

Ecosystem management based on *Cistus* against devastating fires resulting in the establishment cuts fuel on the ground (Duche and Rigolot, 2000).

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