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BIO-DATABASE ARTICLES

Review

Floristic and ecological diagnostic of the Mounts of Saida in the context of ecological restoration: Assessment of six years of field research (2017-2022).

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Abstract

Strategies for the restoration and conservation of degraded natural ecosystems begin by understanding the behavior of vegetation in its composition and dynamism and approaching the process of degradation and assessment of these potentials. The bulk of work, includes six years of filed research, considered in this study involves evaluation and characterization of the vegetation in the Mounts of Saida area, which would allow for the development of efficient restoration plan. This is towards an assessment of the extent, the type of dynamics and degradation of the vegetation using degradation indices, soil quality analysis and vegetation techniques aimed at the regeneration of pioneered plant species. The results of the diagnosis have shown that this region is rich in significant biological diversity. It is estimated for the total of 351 taxa subdivided into 77 families, and 226 genera where *Pinus halipensis, Tetraclinis articulata* and *Juniperus oxycedrus* are pioneer forest species. It also contains 35 rare species, 28 endemics, 9 protected taxa and 73 medicinal plants (local use), as well as 10 Orchids some of which are rare, endemic and protected either by the decree 12/03 of the Algerian Republic and/or by the International Union for Conservation of Nature (IUCN). This diagnosis also showed that human pressure constitute an important factor to be considered in the restoration plan. The overgrazing coefficient and the human action index are very high, 92.3% and 28 without unit. respectively. The application of ecological restoration techniques (soil and vegetation) has shown that soil turning (scarification of soil) is very suitable for the regeneration of these three pioneer forest species that show a density of 34.5 emergence / m^2 / 3 years and a growth of 11 cm / 3 years). Controlled burning is very suitable for the regeneration; a density of 4.9 emergence / m^2 / 3 years and a growth of 3.5 cm / 3 years.

Key words

Floristic, Ecological Diagnostic, Mounts of Saida, Ecological Restoration, Assessment.

Introduction

The flora of the Saida region is little known, in terms of composition. The only inventory carried out by Djebbouri and Terras (2019) during the period 2017 to 2018, was concentrated on rare, endemic and protected species in forest formations pre-forests and the one at Aouadj *et al.*, (2020) during the period 2017 to 2020. The ecosystems of the mounts of Saida like all the composition of the Oriental Tell Atlas (Tlemcen, Sidi Bel Abbes, Saida, Mascara, Tiaret .. etc.) have experienced continuous regression due to fires, anthropogenic actions, inappropriate management and a low rainfall related to its geographical position. This situation requires urgent restoration and rehabilitation strategies (Benabdeli, 1996; Medjahdi et al., 2009; Hasnaoui, 2008; Nasrallah, 2014; Terras, 2013; Babali *et al.*, 2014; Kefifa, 2015; Hasnaoui and Nasrallah, 2013; Nasrallah and Kefifa, 2015, Aouadj *et al.*, 2020a-j, Aouadj *et al.*, 2021 and Aouadj *et al.*, 2022).

In this sense, a phytoecological diagnosis of the ecosystems of the Mounts of Saida area in the first step was carried out in order to develop a strategy of restoration of the degraded ecosystem at a second phase. The phytoecological diagnosis is based on the development of a floristic catalogue and the calculation of biological indices, in order to analyze the evolution of plant cover in study area.

Region of study

The natural forests of Saida are part of the biogeographic subsector of the Tell Atlas (Oran) (O3). They cover an area of 56.31 Km 2 (Fig. 1). She is characterized by a semi-arid climate where the average annual rain fall range from 300 mm to 350 mm. January is the coldest month with a minimum of 2°C, and the warmest month, with maximum averages of 35°C. The area is characterized by a dry and warm period from April to October, and another rainy and cold from November to March. According to the numerical model of the terrain (N.M.T), the area has a very heterogeneous and rugged terrain, its altitude is between 400 m and 1303 m (Aouadj, 2021).

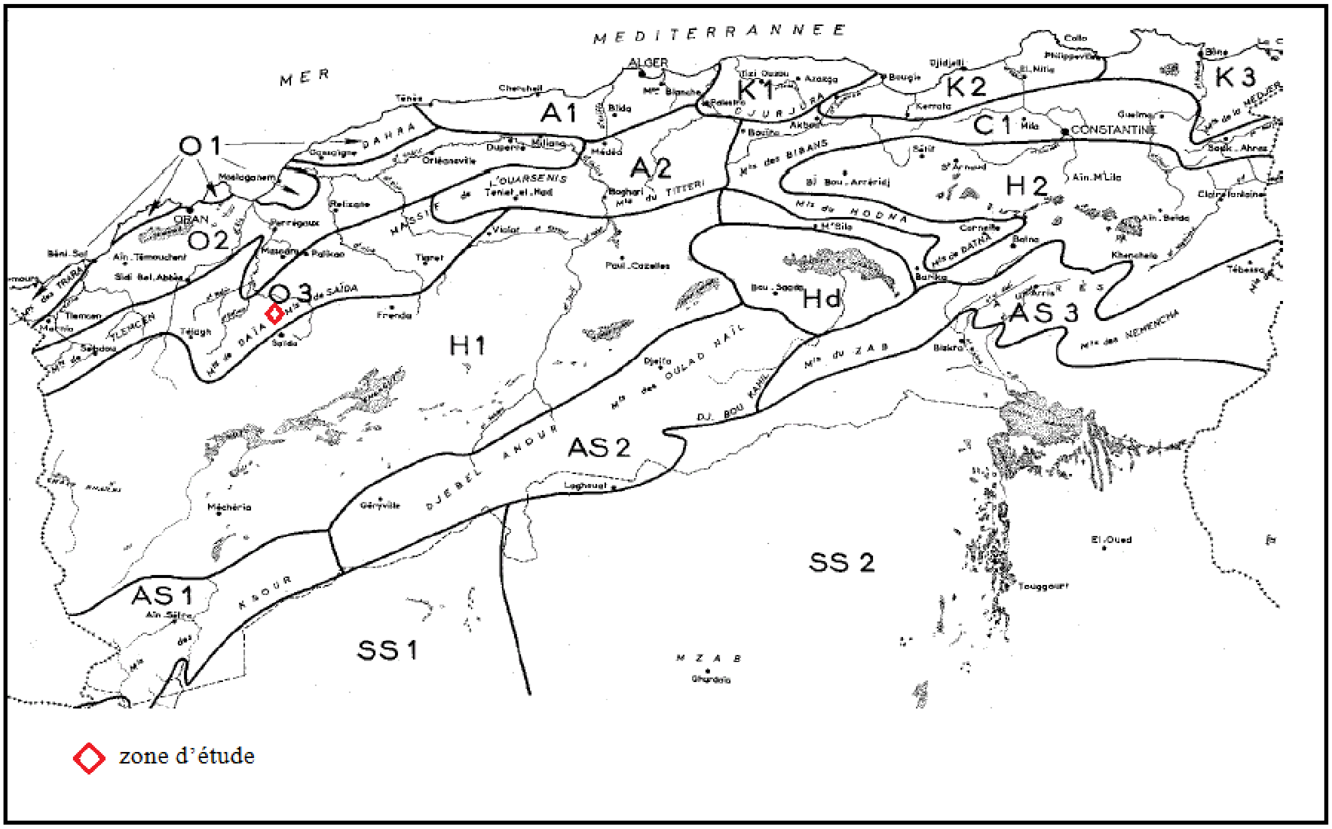

Figure 1. Location of the study area in the map of the main biogeographical territories of Algeria (Quézel & Santa,1962–1963).

Methodology

The autumns and spring sets for the completion of the surveys took place in the years 2017 to 2022. Three hundred and twenty three (323) floristic surveys were conducted in the types of stands covering our entire study area.

The number of surveys conducted in each homogeneous area depends on the diversity of ecological descriptors and the extent of each plant formation (Gehu Rivaz-Martinez, 1981; Aafi et al., 1997; Aafi, 1997).

At the level of each survey, we mentioned geographic coordinates, soil characteristics, orography,

substrate, structure and rate of layer recovery as well as the abundance-dominance coefficient (ADC) and sociability of each species.

The identification of taxa was made at the research Laboratory of Ecology and Natural Ecosystems Management at the university Abu Bakr Belkaid of Tlemcen using several reference books such as: Quézel and Santa (1962-1963), Fennane et al. (1999), Dobignard and Chatelain (2010-2013) for the updating of flora. Regarding protected taxa in Algeria, we consulted the executive decree (12/03) (JORA, 2012) and the IUCN Red List (IUCN version 3.1, 2001) and consultation with our work colleagues: Pr. Mohamed Ibn Tattou and Pr Fennae Mohamed (University of Rabat, Morocco), Pr. Boumediene Medjahdi (University of Tlemcen), Pr. Cyrille Chatelin (Jardin botanique de Genéve) and Dr. Errol Vella (University of Montpellier).

Based on the 323 phytoecological surveys carried out, we have calculated the indices cited below that tell us about the ecological health of our forest:

Specific wealth (S)

$$S = sp_1 + sp_2 + \cdots + sp_n$$

S: Specific wealth;

sp: Taxes observed (Ramade,2003).

Shannon -Wiener index (H')

According to (Blondel, 1979 ; Frontier, 1983 ; Ramade, 2003):

$$H' = -\sum p_i * log_2 p_i$$

H' : Shannon -Wiener index; pi : The number of individuals.

Fair Trade Index of Piélou (E)

According to (Ramade 2003):

$$E = {H'}/{H'max} \text{ with: } H' = -\sum p_i * log_2 p_i \text{ and } H'max = log_2 S$$

Disturbance Index (Loisel and Gamila, 1993)

DI= Number of chamephyte+ number of therophyte / total number of species.

Net Biological Spectrum (NBS) (Raunkiaer, 1934)

The Net Biological Spectrum (NBS) is the rate of each biological type (chamephyte: Ch, therophyte: Th, geophyte: Ge, hemicrypotphyte: He, phanephyte: Ph.).

The Overgrazing Coefficient

The Overgrazing Coefficient can be determined as below. It is expressed in per cent of the balance Load (Le Houerou, 1969):

$$S = 100\,(1 - BL\,/AB\,)$$

where:

S: Overgrazing coefficient;

BL: Balance load;

AB: Actual charge.

Anthropogenic Pressure Index

The method was adopted in Spain by Montoya [9], and this only by determining K constants for each type of livestock according to its weight and displacement in cork oak forests to assess the buffer radius or concentric radius of the pasture animals. To determine the pressure index, we have included in addition to K, the number of inhabitants per Douar (which means a residential grouping mostly from the same family) and the distance between them and the study plots. To calculate this index, we made the sum of each type of cattle by multiplying it by its corresponding coefficient K, the total number of inhabitants and the distance between the douars and the plots. This index is calculated for the entire series and is given by the following equation (Montoya, 1983):

$$API = [(NHd + k\ (\text{Number of cattles}) + k\ (\text{Number of sheep}) + k\ (\text{Number of goats})/D^2)Sz]100$$

where:

API: Anthropogenic Pressure Index;

NHd: number of inhabitants per agglomeration: 4978 [10];

K: herd pressure coefficient (3.7 for cattle, 1.7 for sheep and 1.9 for goats) [9];

D: distance between the agglomeration and the forest calculated as follows:

Sz: Total surface of the pasture area in m^2 simulated to a circle whose radius is the distance from the douar to the square (Rayon 100 m).

In this regard, we have established five classes of pression index as shown in Table 1.

Table 1. Anthropogenic Pressure Index Classes.

Anthropogenic Pressure Index Class	**Class Qualifier**
0-5	Week
5-10	Medium
10-15	Fort
15-20	Strong enough
>20	Very enough

Technique of restoration

An experimental 1hectare field device has been installed on the Doui Thabet forest in an 80-year-old pine forest. Various (technical) treatments of soil and vegetation (for pioneer species) were therefore tested from the period of 2018 to 2020 (Figure 2). Eight (8) soil and vegetation treatment methods were applied: mechanical grinding of vegetation, turning to allow soil work on about 10 cm, deep ploughing to 20 cm, burning, clearing of *Stipa capensis,* seedlings planted in different seasons for certain species, protected by fencing; followed by releases of strains and natural sowing (Control). The treatments were applied on surfaces of 1×3 m^2 m for each treatment and repeated 6 times. The seed harvest of the 5 pioneer species of the Doui Thabet forest is controlled by the biology of each species (physiological maturation period) and on different tree feet (healthy and ripes). To know the mature seeds, we used the technique "floating test" (the planting date for each species and explain if you have been planting for three successive years or just the first year 2018.).

The survival and recovery rate of the plants and releases is counted every month for the three months following the planting. During the counts, a description of the surface of the ground was made by distinguishing the different elements: herbaceous; low woody and assigning them a lap class according to the following Braun-Blanquet [9] scale: 1 present; 2 - 5%; 3 - 5-25%; 4 - 25-50%; 5 - 50-75% and 6- 75-100%.

Growth measures using a tape-put have been: plant growth (made every month), reject growth (made every month of 2018, 2019 and 2020), vegetation description and ground cover (performed every month of 2018, 2019 and 2020). In the end, after recording the number of seedlings per processing type in a notebook, we processed this data using statistica 12 software, and drew the graphs using Excel (ANOVA).

Figure 2. Tracing of the squares; d: Sowing; e: Watering in summer; f: Watering Vehicle; g: Mechanical turning of *Juniperus oxycedrus* L. seeds; h: Fencing; i: grinding; j: Measurements; k: Turning; l: tillage (Deep ploughing).

Results

Floristic catalog

Phytoecological surveys conducted in the field have led to the development of a flora catalog. It contains 344 taxa that are classified by family (subdivided into 77 families and 223 genera) in alphabetical order according to the new nomenclature of Dobignard & Chatelain (2010-2013).

Table 2. Some rare, endemic and protected taxa including Orchids.

Rare taxa	Endemic taxa	Protected taxa
Clematis flammula L	*Rhamnus alternus L*	*Dactylorhiza elata (Poir.) Soó*
Sedum acre L	*Ranunculus millefoliatus auct*	*Anacamptis papilionacea (L.) R. M. Bateman, Pridgeon & M. W. Chase subsp. papilionacea.*
Crithmum maritimum L	*Sanguisorba minor subsp. vestita (Pomel) Maire*	*Teucrium pollium L*
Ranunculus millefoliatus auct	*Anacamptis papilionacea (L.) R. M. Bateman, Pridgeon & M. W. Chase subsp. papilionacea.*	*Biscutella cichoriifolia Loisel*
Sanguisorba minor subsp. vestita (Pomel) Maire	*Thymus numidicus Poir*	*Hieracium humile Jacq*
Cytinus hypocistis (L.) L	*Iris planifolia (Mill.) T. Durand & Schinz*	/
Dactylorhiza elata (Poir.) Soó	*Iris unguicularis Poir*	/
Anacamptis papilionacea (L.) R. M. Bateman, Pridgeon & M. W. Chase subsp. papilionacea.	*Hedysarum aculeolatum Munby ex Boiss*	/
Lythrum acutangulum Lag.	*Helianthemum croceum (Desf.) Pers*	/
Nepeta apuleii Ucria	*Rhamnus alaternus L. subsp. Alaternus*	/
Lamium purpureum L	*Thlaspi perfoliatum L*	/

Laurus nobilis L	*Hieracium humile Jacq*	/
Iris planifolia (Mill.) T. Durand & Schinz	*Hedera helix L*	/
Quercus faginea Lam	*Atractylis caespitosa Desf*	/
Lathyrus tingitanus L	/	/
Cytisus triflorus L'Hér	/	/
Helianthemum croceum (Desf.) Pers	/	/
Magydaris panacifolia (Vahl) Lange	/	/
Echium australe Lam	/	/
Echium confusum Coincy	/	/
Biscutella cichoriifolia Loisel	/	/
Carduncellus pinnatus (Desf.). DC	/	/
Asteriscus spinosus (L.) Sch. Bip	/	/
Atractylis caespitosa Desf	/	/

Biological indices of the study area

On the base plant studies carried out, we determined the rate of each biological type (Figure. 3, Table 3) to determine the physiognomic and biological distribution and which consequently gives an image of the dynamics of the plant cover (progressive/regressive) and calculated the 4 biological indices to quantify the plant biodiversity of the study area.

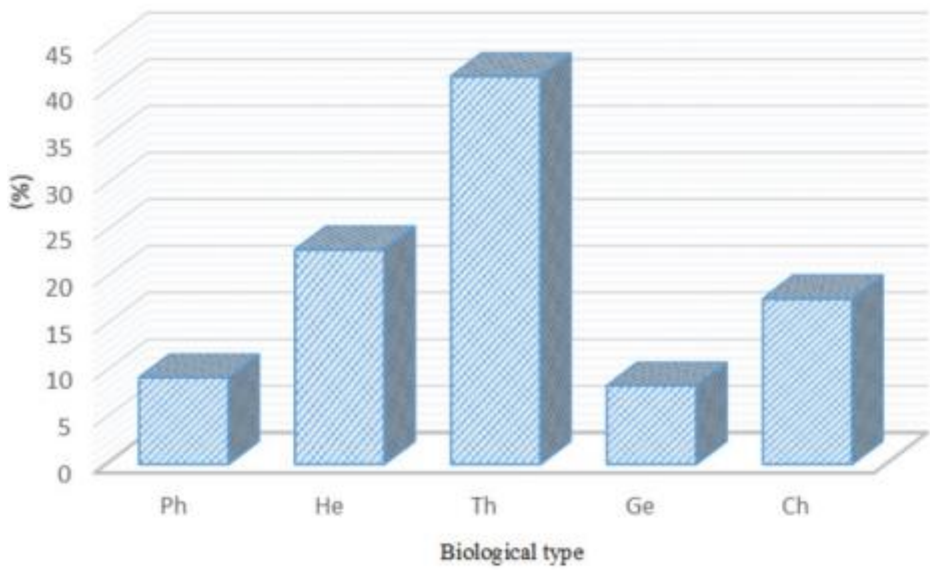

Figure 3. Biological type. Ch: Chamaephytes, Ge: Geophytes, He: Hemicryptophytes, Ph: Phanerophytes, Th: Therophytes. The Net Biological Spectrum of the study area is of type: Therophytes > Hemicryptophytes > Chamaephytes > Phanerophytes > Geophytes.

Table 3. Result of the biological indices of the zone of study.

Index	**(S)**	**(H')**	**(E)**	**(IP)**
Value	344	1.72	2.53	59.30 %

Qualitative and quantitative assessment of anthropogenic pressure exerted in this area zone

In the study area, the annual needs of the herd amount to 8,952,450 forage units. The needs of sheep account for most of them. These needs are in the order of (86.14%), followed by those of goats with (7.5%) and finally cattle with only (6.36%). These needs are derived mainly from forest rangelands whose potential remains below existing capacities, contributing to overgrazing and high pastoral pressure. The forage potential available in the forest ranges of the study area is estimated at (689,990) forage units per hectare per year.

The results of the forage balance sheet, overgrazing coefficient and anthropogenic pressure index in Saida's forest are summarized in Table 4.

Table 4. Quantification of the anthropogenic pressure exerted on the study area.

Indicators	**Values**
Forage needs (FU/Year)	8,952,450
Forest potential in FU	689,990
Forage deficit in FU	- 8,362,460
Actual charge: AC (ULL/Ha)	7,460.37
Balance Load: BL (ULL/Ha)	574.99
Coefficient overgrazing (S)	**92.30 %**
Anthropogenic Pressure Index	**28**

Ecological restoration

The application of soil and vegetation techniques has shown that turning and burning is very suitable for the regeneration of forest species from Doui Thabet. As for grinding, it is an average efficiency, but deep plowing is useless. In addition, regeneration by strain rejection is also suitable for pistachio lentisk and thuja berberie. The cleaning of the tufts of alfa also gave good results (increase in final height of 31 cm) compared to the control (17 cm), as well as the defense gave good results, as regards the recovery rate (80%), the number of varieties (58 taxa for the protected plot and 37 for the unprotected) and the final increase in height by rejection of the strain for the pistachio lentisk (12 cm in the defense) and 7.5 for the unprotected) and the thuja berberie (14.2 cm in the defense and 9.5 for the unprotected).

a.1. Growth of *Pinus halepensis* seedlings

The statistical analysis of the growth of *Pinus halepensis* plants, as a result of the various treatments, was very significant (Table 5). Different treatments influence the growth of this specie.

Turning proved to be the treatment with the greatest height. Deep ploughing and burning had a medium height, as did grinding, while natural sowing (Control) had a low height. This difference between different treatments seems to be increased from year to year. The maximum growth is recorded during the period of maximum biological activity and vegetation from March to May of each year (Figure 4).

Table 5. Average *Pinus halepensis* growth per treatment at the end of each growing period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	4	1,131333	0,282833	45,133	0,000000***
May 2019	4	1,131333	0,282833	45,133	0,000000***
March 2020	4	0,476667	0,119167	35,0490	0,000000***

SC: Sum of squares, ddl: degree of freedom, MC: Average of squares, Fobs: F. observed, P: surplus value, ***: highly significant.

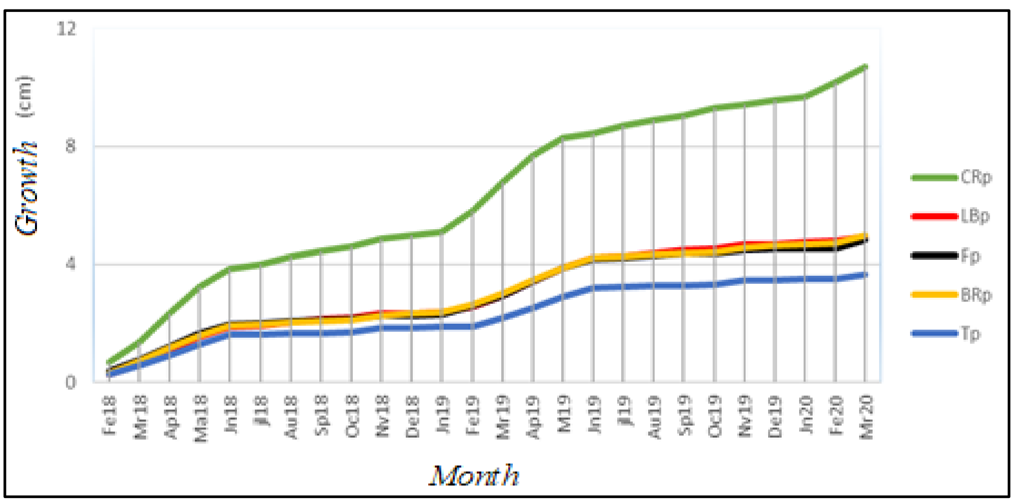

Figure 4. Effect of soil treatments on the height growth of *Pinus halepensis* plants. CRp: turning of *Pinus halepensis*; LBp: tillage of *Pinus halepensis*; Fp: burning of *Pinus halepensis*; BRp: Grinding of *Pinus halepensis*; Tp: Control of *Pinus halepensis*.

a.2. Evolution of the density of *Pinus halepensis* seedlings

The statistical analysis of the density of *Pinus halepensis* plants, as a result of the various treatments, was very significant (Table 6). Different treatments influence the density of Aleppo pine

Once again, turning proved to be the treatment with the highest density. Deep ploughing, burning and grinding had medium density, while natural sowing (Control) had low density. This difference according to the type of treatments seems to be increased from year to year. The maximum density is recorded during the period of maximum biological activity and vegetation from March to May of each year (Figure 5).

Table 6. The average density of *Pinus halepensis* per treatment at the end of each growing period.

Measurement Date	ddl	SC	MC	F	P valuem and meaning
May 2018	4	4587.0970000	1146.7740000	78.0632000	0.000000***
May 2019	4	1326.1250000	331.5313000	175.2527000	0.000000***
March 2020	4	54.6146700	13.6536700	226.3039000	0.000000***

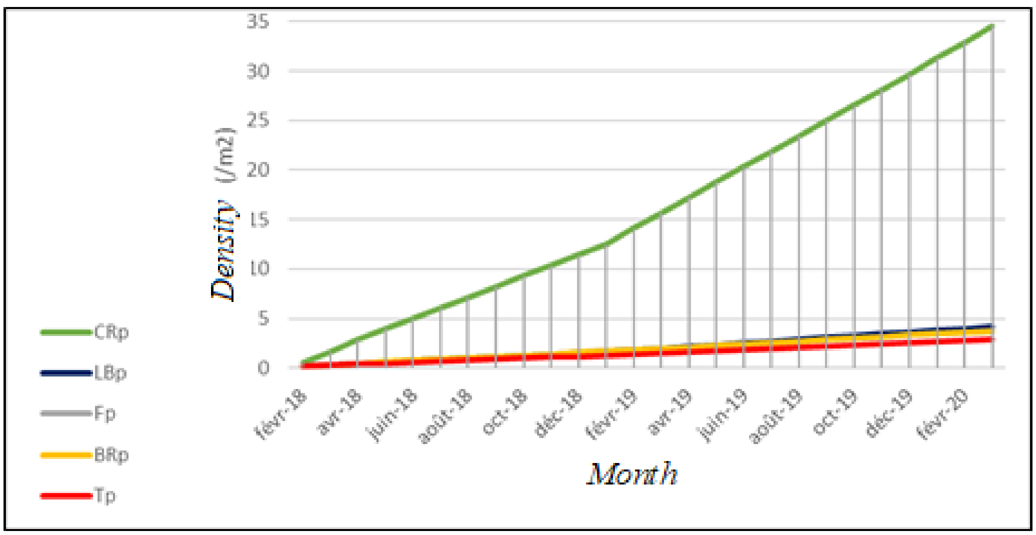

Figure 5. Effect of soil treatments on the density of *Pinus halepensis* plants.CRp: turning of *Pinus halepensis*; LBp: tillage of *Pinus halepensis*; Fp: burning of *Pinus halepensis*; BRp: Grinding of *Pinus halepensis*; Tp: Control of *Pinus halepensis*.

a.3. Growth of *Tetraclinis articulata* seedlings

The statistical analysis of the growth of *Tetraclinis articulata* seedlings under the various treatments was very significant (Table 7). The different treatments have an influence on the growth of this species.

Turning was found to be the treatment with the highest height. Deep ploughing and burning had a medium height, as did chopping, while natural sowing (Control) had a low height. This difference between the different treatments seems to increase from one year to the next. Maximum growth is recorded during the period of maximum biological activity of the vegetation from March to May of each year (Figure 6).

Table 7. The average growth of *Tetraclinis articulata* by treatment at the end of each growth period.

Measurement Date	ddl	SC	MC	F	P value and meaning
May 2018	4	3.1008	3.1008	79.8500	0.000000***
May 2019	4	28.2133	28.2133	70.2410	0.000000***
March 2020	4	63.9410	63.9410	80.2440	0.000000***

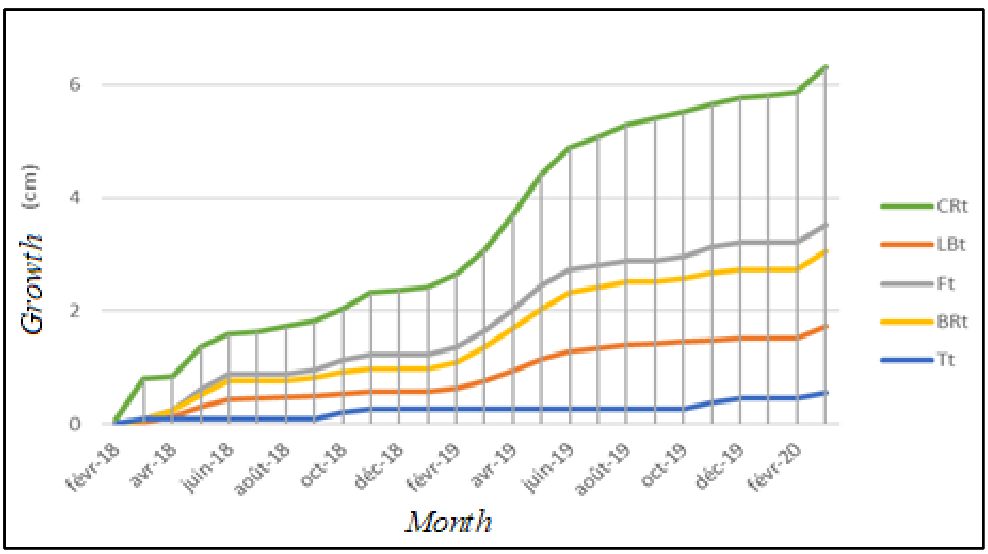

Figure 6. Effect of vegetation treatments on the growth of *Tetraclinis articulate*. CRt: turning of *Tetraclinis articulata*; LBt: tillage of *Tetraclinis articulata*; Ft: burning of *Tetraclinis articulata*; BRt: Grinding of *Tetraclinis articulata*; Tt: Control of *Tetraclinis articulate*.

a.4. Growth of strain rejection of *Tetraclinis articulata*

The statistical analysis of the growth of the *Tetraclinis articulata* strain releases (role of fencing) was very significant (Table 8). Fencing has an influence on the growth of this specie (Figure 7).

Table 8. The average growth in rejections of *Tetraclinis articulata* strains by treatment at the end of each growth period.

Measurement Date	ddl	SC	MC	F	P value and meaning
May 2018	4	3.1008	3.1008	79.8500	0.000000***
May 2019	4	28.2133	28.2133	70.2410	0.000000***
March 2020	4	63.9410	63.9410	80.2440	0.000000***

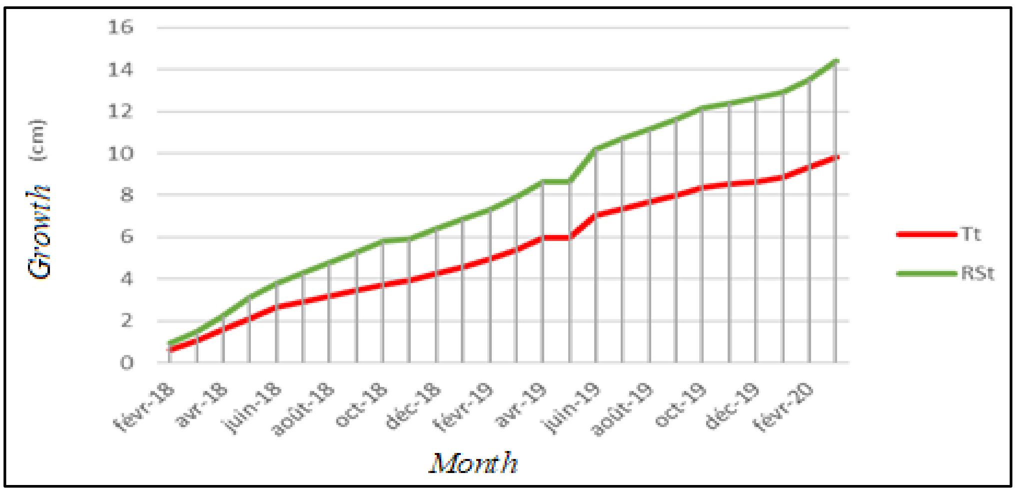

Figure 7. Effect of vegetation treatments on the growth of strain rejection of *Tetraclinis articulata* Tl: Control of *Tetraclinis articulata*; RSL: Rejection of *Tetraclinis articulata* strain.

a.5. Evolution of the density of *Tetraclinis articulate*

The statistical analysis of the density of Berbery Thyua seedlings under the various treatments was very significant (Table 9).

Turning was the treatment with the highest density. Deep ploughing and burning had a medium density, as did grinding, while natural sowing (Control) had a low density.

This difference between the different treatments seems to increase from one year to the next. The maximum density is recorded during the period of maximum biological activity of the vegetation from March to May of each year (Figure 8).

Table 9. The average density of *Tetraclinis articulata* per treatment at the end of each growth period.

Measurement Date	ddl	SC	MC	F	P value and meaning
May 2018	4	4.422	1.1055	7.0926	0.000000***
May 2019	4	72.942	18.2355	6.65028	0.000000***
March 2020	4	216.4113	54.1028	7.56204	0.000000***

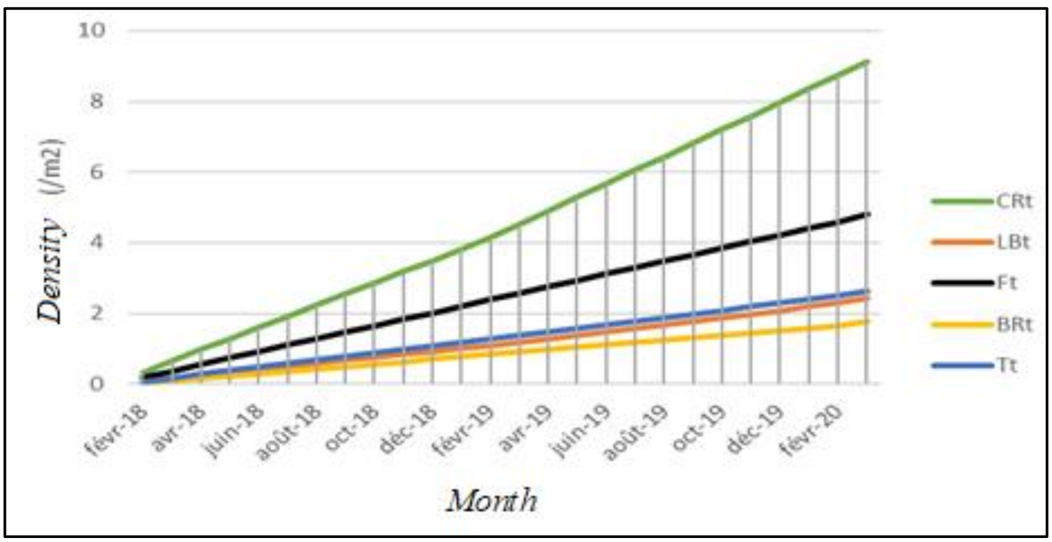

Figure 8. Effect of soil treatments on the density of *Tetraclinis articulata*. CRt: turning of *Tetraclinis articulata*; LBt: tillage of *Tetraclinis articulata*; Ft: burning of *Tetraclinis articulata*; BRt: Grinding of *Tetraclinis articulata*; Tt: Control of *Tetraclinis articulate*.

a.6. Growth of *Juniperus oxycedrus* seedlings

The statistical analysis of the growth of *Juniperus oxycedrus* seedlings under the various treatments was very significant (Table 10).

Turning was found to be the treatment with the highest height. Deep ploughing and burning had a medium height, as did chopping, while natural sowing (Control) had a low height. This difference between the different treatments seems to increase from one year to the next. Maximum growth is recorded during the period of maximum biological activity of the vegetation during the period of March to May of each year (Figure 9).

Table 10. The average growth of the *Juniperus oxycedrus* by treatment at the end of each growing period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	4	2.471333	0.617833	22.82635	0.000000***
May 2019	4	14.44533	3.61133	12.42146	0.000000***
March 2020	4	31.178	7.7945	19.14797	0.000000***

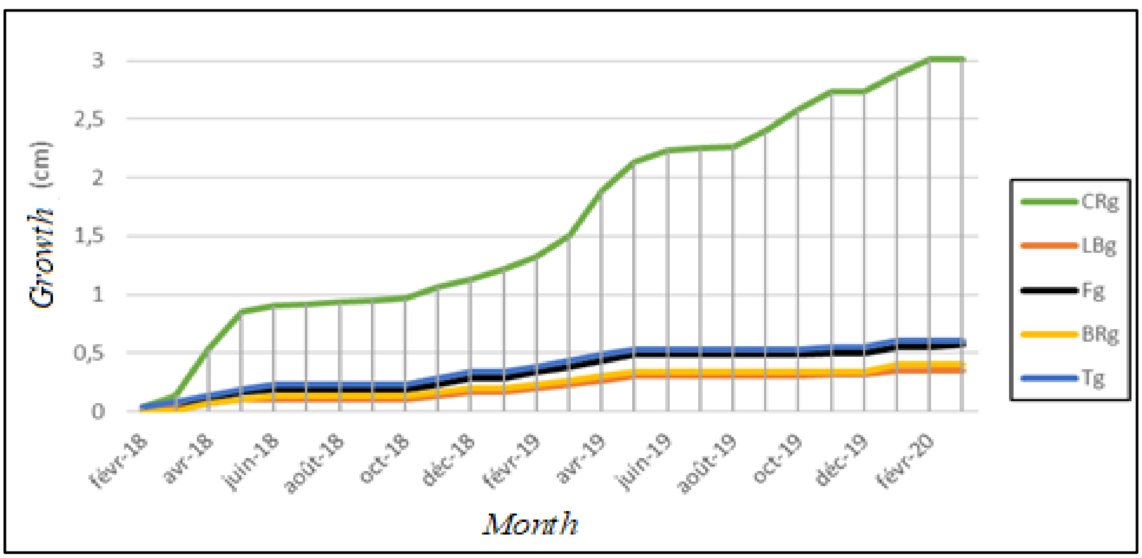

Figure 9. Effect of soil treatments on the growth of *Juniperus oxycedrus* plants. CRg: turning of the *Juniperus oxycedrus*; LBg: tillage of the *Juniperus oxycedrus*; Fg: Fires: burning of the *Juniperus oxycedrus*; BRg: Crushing of the *Juniperus oxycedrus*; Tg: Control of the *Juniperus oxycedrus*.

a.7. Changes in the density of *Juniperus oxycedrus* seedlings

The statistical analysis of the density of cade juniper seedlings under the various treatments was very significant (Table 11). The different treatments had influenced on the growth of the cade Juniper.

Turning was found to be the treatment with the highest density. Deep ploughing and burning had a medium density, as did chopping, while natural sowing (Control) had a low density. This difference between the different treatments seems to increase from one year to the next. The maximum density is recorded during the period of maximum biological activity of the vegetation during the period of March to May of each year (Figure 10).

Table 11. The average density of the *Juniperus oxycedrus* by treatment at the end of each growing period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	4	0.161333	0.040333	2.43952	0.000000***
May 2019	4	3.88800	0.972000	2.19578	0.000000***
March 2020	4	9.40800	2.35200	1.95565	0.000000***

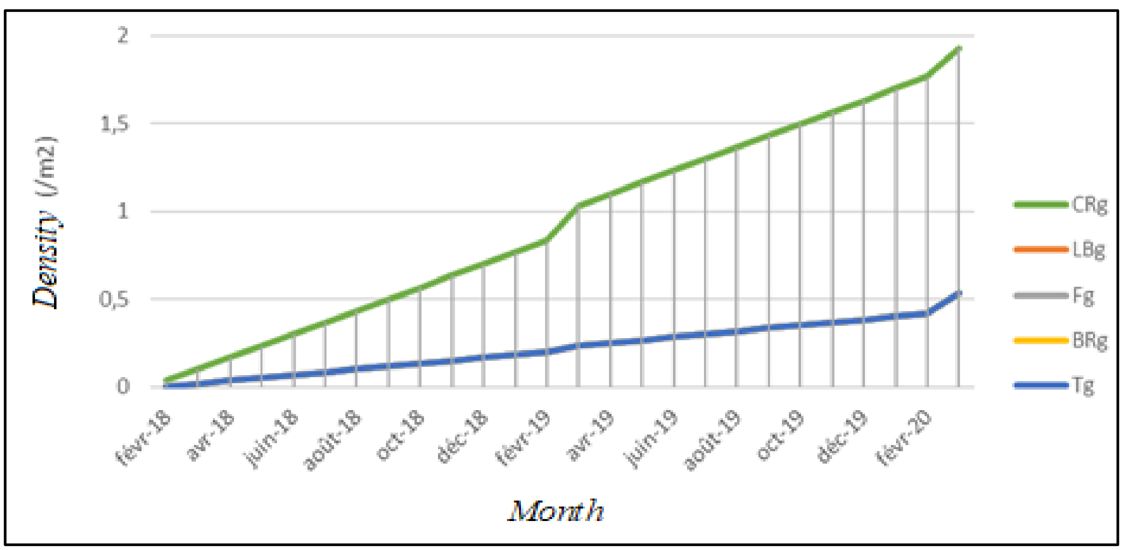

Figure 10. Effect of soil treatments on the density of *Juniperus oxycedrus* plants. CRg: turning of the *Juniperus oxycedrus*; LBg: tillage of the *Juniperus oxycedrus*; Fg: Fires: burning of the *Juniperus oxycedrus*; BRg: Crushing of the *Juniperus oxycedrus*; Tg: Control of the *Juniperus oxycedrus*.

a.8. Growth of *Pistacia lentiscus* seedlings

The statistical analysis of the growth of *Pistacia lentiscus* plants under the effect of the different treatments was not very significant (null results). The different treatments did not influence on the growth of this species.

a.9. Growth of strain rejection of Pistacia lentiscus

The statistical analysis of the growth of the *Pistacia lentiscus* strain releases (role of fencing) was very significant (Table 12). Fencing has an influence on the growth of this specie (Figure 11).

Table 12. The average growth in rejections of *Pistacia lentiscus* strains by treatment at the end of each growth period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	4	5.20083	5.20083	96.015	0.000000***
May 2019	4	29.7675	29.7675	107.270	0.000000***
March 2020	4	71.053	71.053	132.233	0.000000***

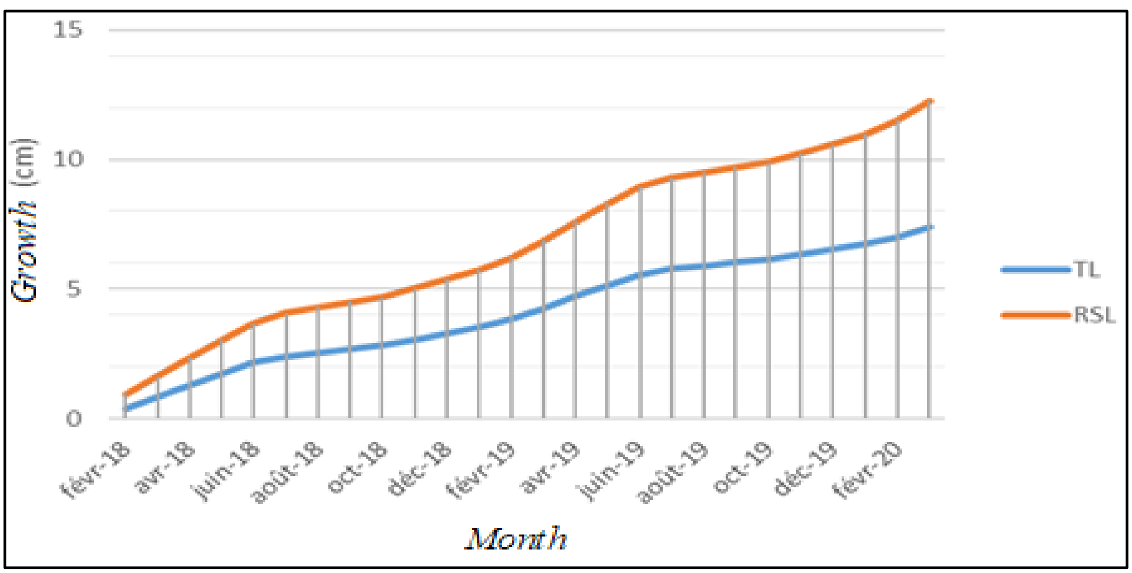

Figure 11. Effect of vegetation treatments on the growth of strain rejection of *Pistacia lentiscus*.

Tl: Control of *Pistacia lentiscus*; RSL: Rejection of *Pistacia lentiscus* strain

a.10. Growth of Alfa seedlings (autumn sowing)

The statistical analysis of the growth of Alfa plants (autumn sowing) under the effect of the different treatments was very significant (Table 13). The different treatments influence on the growth of this species.

Scarification was found to be the treatment with the highest height. Deep ploughing and burning had a medium height, as did chopping, while natural sowing (Control) had a low height. This difference between the different treatments seems to increase from one year to the next. Maximum growth is recorded during the period of maximum biological activity of the vegetation from March to May of each year (Figure 12).

Table 13. The average growth of Alfa (autumn sowing) per treatment at the end of each growth period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2019	4	531.1053	132.7763	15.32306	0.000000***
March 2020	4	2387.965	596.991	39.2071	0.000000***

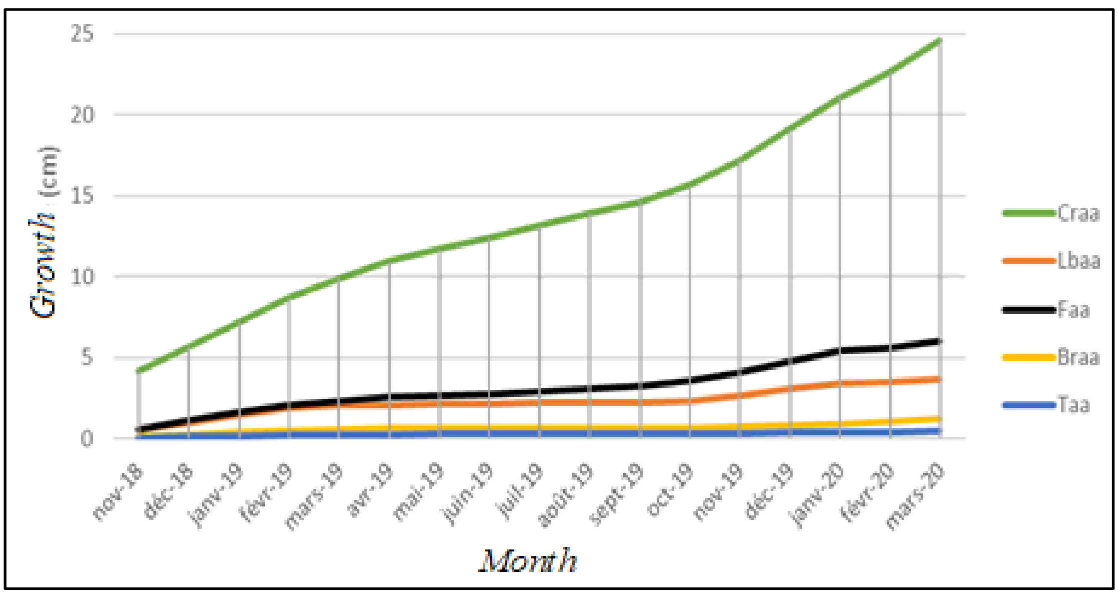

Figure 12. Effect of soil treatments on the height growth of Alfa plants (autumn sowing).

Craa: Alfa turning (autumn sowing); Lbaa: Alfa tillage (autumn sowing); Faa: burning of Alfa (autumn sowing); Braa: Grinding of Alfa (autumn sowing); Taa: Control of Alfa (autumn sowing).

a.11. Evolution of the density of Alfa seedlings (autumn sowing)

The statistical analysis of the density of Alfa plants under the effect of the different treatments was very significant (Table 14). The different treatments have an influence on the growth of Alfa.

Turning proved to be the treatment with the highest density. Deep ploughing and burning had a medium density, as did grinding, while natural sowing (Control) had a low density. This difference between the different treatments seems to increase from one year to the next. The maximum density is recorded during the period of maximum biological activity of the vegetation during the period of March to May of each year (Figure 13).

Table 14. The average density of Alfa (autumn sowing) per treatment at the end of each growing period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2019	4	40.39667	10.09917	32.9178	0.000000***
March 2020	4	465.7180	116.4295	50.6700	0.000000***

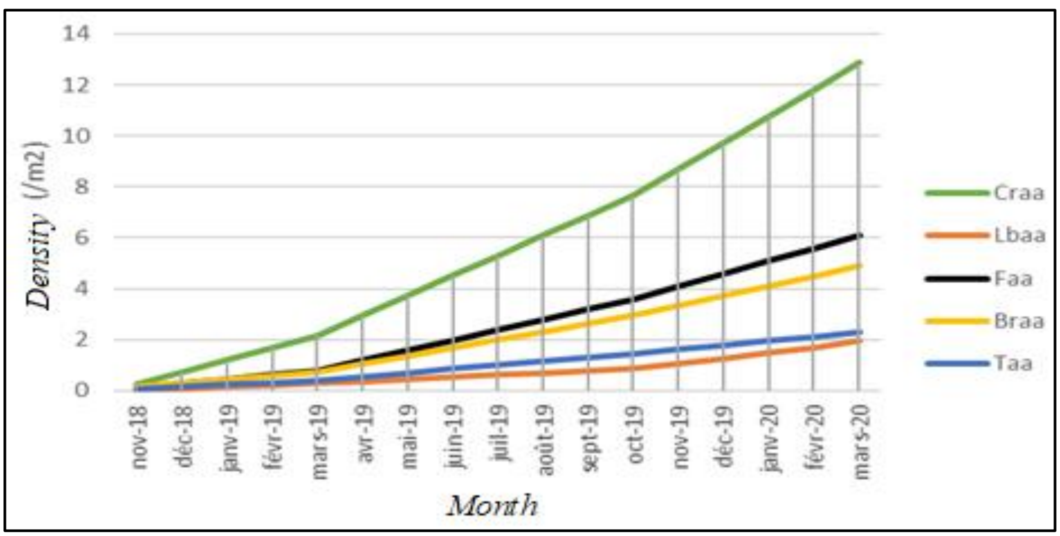

Figure 13. Effect of soil treatments on the density of Alfa plants (autumn sowing). Craa: Alfa turning (autumn sowing); Lbaa: Alfa tillage (autumn sowing); Faa: burning of Alfa (autumn sowing); Braa: Grinding of Alfa (autumn sowing); Taa: Control of Alfa (autumn sowing).

a.12. Growth of Alfa seedlings (spring sowing)

The statistical analysis of the growth of Alfa plants (spring sowing) under the effect of the different treatments was very significant (Table 15). The different treatments have an influence on the growth of this species.

Turning was found to be the treatment with the highest height. Deep tillage and burning had a medium height, as did chopping, while natural sowing (Control) had a low height. This difference between the different treatments seems to increase from one year to the next. Maximum growth is recorded during the period of maximum biological activity of the vegetation during the period of March to May of each year (Figure 14).

Table 15. The average growth of Alfa (spring sowing) per treatment at the end of each growing period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	4	14.96800	3.74200	31.4454	0.000000***
May 2019	4	271.9020	67.9755	8.68112	0.000000***
March 2020	4	688.509	172.127	7.71276	0.000000***

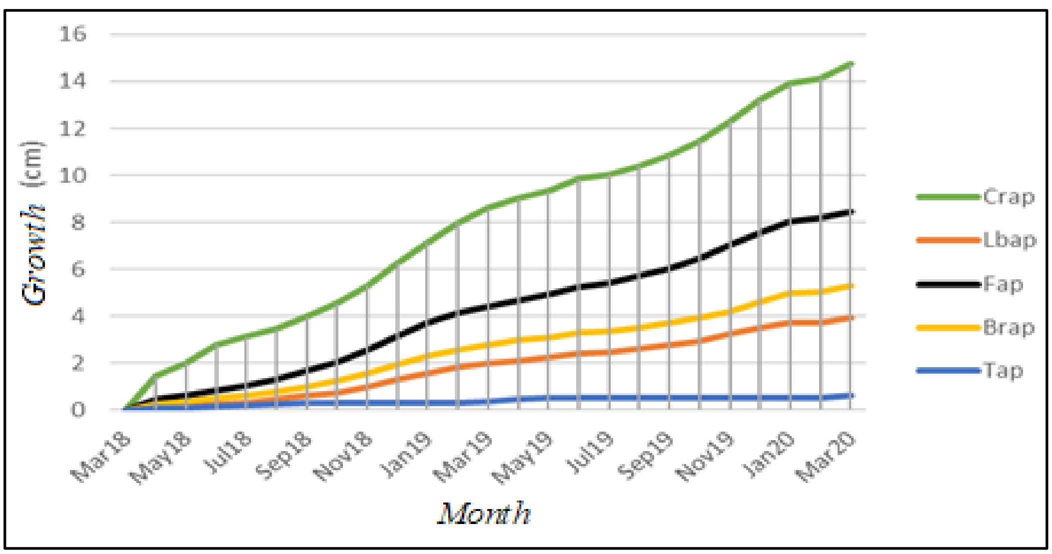

Figure 14. Effect of soil treatments on the height growth of Alfa plants (spring sowing). Crap: Alfa turning (spring sowing); Lbap: Alfa tillage (spring sowing); Fap: burning of Alfa (spring sowing); Brap: Grinding of Alfa (spring sowing); Tap: Control of Alfa (spring sowing).

a.13. Evolution of the density of Alfa seedlings (spring sowing)

The statistical analysis of the density of Alfa plants (spring sowing) under the different treatments was very significant (Table 16). The different treatments have an influence on the growth of Alfa.

Turning was found to be the treatment with the highest density. Deep ploughing and burning had a medium density, as did chopping, while natural sowing (Control) had a low density. This difference between the different treatments seems to increase from one year to the next. The maximum density is recorded during the period of maximum biological activity of the vegetation during the period of March to May of each year (Figure 15).

Table 16. The average density of Alfa (spring sowing) per treatment at the end of each growing period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	4	0.852000	0.213000	28.5268	0.000000***
May 2019	4	51.2653	12.8163	19.2015	0.000000***
March 2020	4	152.972	38.243	20.0071	0.000000***

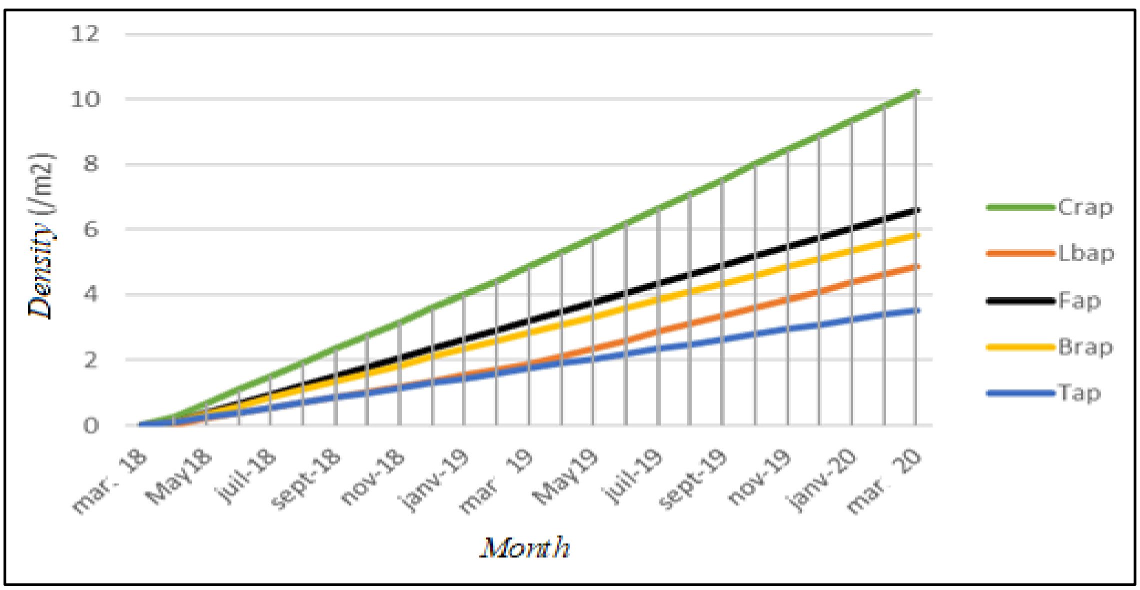

Figure 14. Effect of soil treatments on the density of Alfa plants (spring sowing). Crap: Alfa turning (spring sowing); Lbap: Alfa tillage (spring sowing); Fap: burning of Alfa (spring sowing); Brap: Grinding of Alfa (spring sowing); Tap: Control of Alfa (spring sowing).

a.14. Growth of Alfa tufts (Clearing of tufts)

The statistical analysis of Alfa Tufts growth, due to the clearing effect, was very significant (Table 17). Clearing action has an influence on the growth of this species (Figure 16).

Table 17. The verage growth of Alfa (Clearing of tufts) per treatment at the end of each growth period.

Measurement date	ddl	SC	MC	F	P value and meaning
May 2018	2	12.4033	12.4033	111.075	0.000000***
May 2019	2	269.801	269.801	286.160	0.000000***
March 2020	2	635.108	635.108	259.634	0.000000***

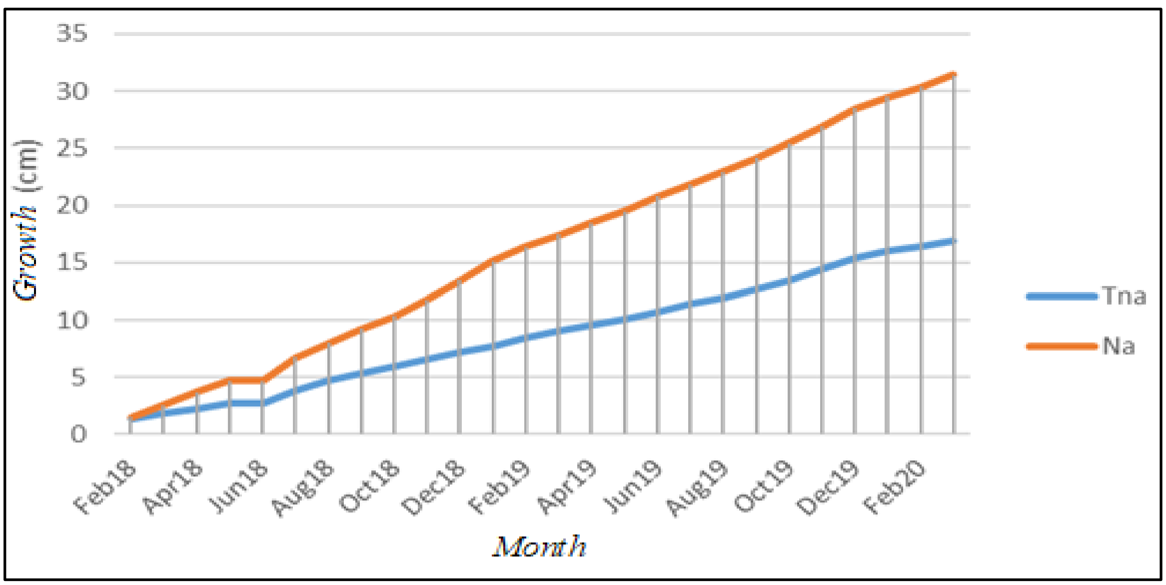

Figure 16. Effect of vegetation treatments (cleaning of tufts) on the height growth of Alfa tufts. Tna: Control to the cleaning of Alfa; Na: cleaning of Alfa.

a.15. Description of the soil surface (importance of the fencing)

The obtained results which are summarized in Table 18, confirm that the effect of fencing in the forest ecosystem over a period of 3 years allows an appreciable increase in the recovery rate compared to the unprotected plot (Figure 17).

Table 18. Recovery rate of the two parcels fenced and unprotected.

Year	**May 2018**		**May 2019**		**March 2020**	
Type	**Parcel unprotected**	**Parcel protected**	**Parcel unprotected**	**Parcel protected**	**Parcel unprotected**	**Parcel protected**
Recovery rate	55 %	55 %	55 %	75 %	50 %	80 %

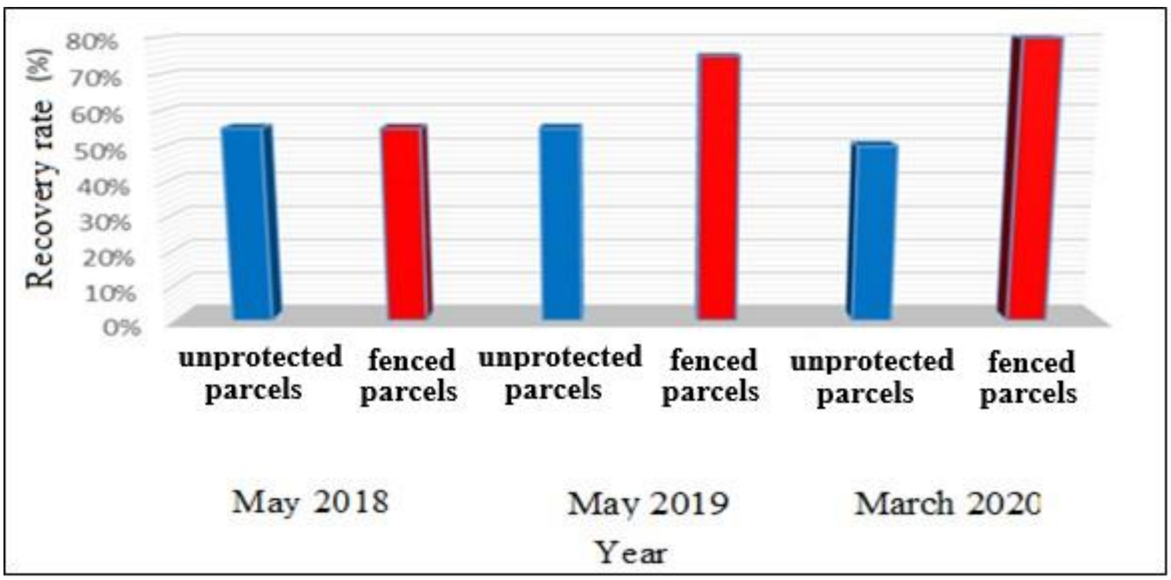

Figure 16. Recovery rate for the two fenced and unprotected parcels.

Discussion

Diagnostic

The present study permitted to diagnose ecologically the area of Mounts of Saida for the first time by : 1 construction of a first floristic catalog highlights its richness of flora ; 2-characterization of the state of vegetation and 3-to match its potential. This ecological diagnosis is a reference for the work of future research (diachronic studies) and decision-makers and managers for landscaping and restoration. The floristic richness of the study area is 344 taxa or 9.18% of the Algerian flora (3744 taxa) (Dobignard & Chatelain, 2010-2013). These species belong to 223 genres and 77 families of which 8 are clearly dominant. This wealth of flora is divided into the family in the following order: Asteraceae, 60 species, or 17. 44%, Fabaceae 42 species, or 12.20%), Lemiaceae (27 species, or 7.84 %), Brassicaceae (20 species, or 5. 81%, Apiaceae 16 species, or 4.65%), Poaceae (13 species, or 3.77%), Cistaceae (10 species, or 2.90%) and Ranunculaceae 09 species, or 2. 61%. Eight (8) families are known by their acclimatization to the arid conditions of the Saida region and total only1, 97 taxa, or 57.26% of the total wealth of forests. The rest of the families contribute 42.73 % of the total workforce.

On a systematic level, this richness is divided among the following groups:

- Pteridophytes: are represented by 3 families: Aspleniaceae with 2 species, Pteridaceae with 2 species and Sinopteridaceae with a single species.

- Gymnosperms: are represented by 2 families: Pinaceae with a single species and Cupressaceae with 03 species.

-Angiosperms: comprise 72 families or 335 species including 324 dicotyledones and 14 monocotyledones.

These data show that, in all the forest massifs of the Algerian tell, the same families of plants dominate in the same order almost. Our results confirm the work of phyto-diversity in the subsector of the Atlas Tellien Ornais (O3) including those of Medjahdi et al. (2007), Hasnaoui, (2008), Babali et al. (2014).

The perturbation index (PI) = 59.30 %, is close to the threshold advanced by El Hamrouni (1992) in Tunisia in his study; which is 70% and which it has described as very important.

Analysis of the results of the biodiversity indices shows an average value of (H’), this magnitude of 1.72 bits, indicates a fairly diverse environment ($0<H<5$) as long as it does not theoretically have a maximum. In this regard, the calculated equitability value (E) is stronger, this size 2.53 bits, means that individuals of different species are more or less in balance.

Analysis of the net biological spectrum in our surveys shows that the rate of therophytes is very high by other biological types and shows that the importance of anthropogenic and climatic action in this forest, like all the forests in the area (Grime, 1977; Daget, 1980; Barbero et al., 1990 and Dahmani, 1997). Hemicrypotophytes are the second most commonly found in moist (humid) habitats such as cliffs and riverine. According to Barbero et al. (2001), the abundance of hemicrypotophytes is related to the presence of moisture and organic matter. The Champhytes occupy the third position. Species of this type are characterized by good acclimatization to aridity by other biological types. Their high rate is a sign of ecosystem disruption and degradation (Danin and Orshan, 1990). Geophytes presents with a low rate. They are characterized by a low germination rate, which poses a real reproductive problem (Verlaque et al., 2001). The Phanerophytes occupy the penultimate place and herald a regressive dynamic of this ecosystem.

The colonization by asylvatic species shows that the regressive dynamics of this ecosystem to be beautiful and well started. The anthropogenic action due to repeated fires in this area during the period : 1992-2015, large-area clearing, over grazing, over exploitation and poor practices of exploitation of medicinal plants by herbalists unskilled and local population. These degradation phenomena are at the origin of the disappearance of many species that have become endemic, rare and protected, as is the case of genera : *Thymus, Teucrium, Phillyrea, Rosmarinus, Thymelaea, Artemisia, Tetraclinis*..

A rarity rate of 35 taxa, representing 10 % of the total flora of the study area and 1.7% of Algeria (1818 rare taxa) is quite important for an area located in semi-arid floor. This rate consists of 7 very rare species (VR), 16 rare species (R), and 8 fairly rare species (QR). The endemism rate is also high, with 29 taxa or 8 % of the total flora of the study area and 5.38% of Algeria (464 endemic taxa, of which 1 endemic taxon (Alg-Lib), 9 endemic taxa (Alg-Mar. Tun. Lib), 8 endemic taxa (Alg. Mar), 1 endemic taxon(Alg), 2 endemic taxons (Alg-Tun),1 endemic taxon (Mar) and 3 endemic taxons (Alg-Mar. Tun). The number of protected taxa is 9, or 2.32% of the total flora of the forest and 1.76% of Algeria (454 taxa protected). 8 taxa are protected in Algeria and 1 taxon almost threatened according to the status of The IUCN. These results open the door to the study of the establishment of a protected area.

In the study area, the annual needs of the herd amount to 8,952,450 forage units. The needs of sheep account for most of them. These needs are in the order of (86.14%), followed by those of goats with (7.5%) and finally cattle with only (6.36%). These needs are derived mainly from forest rangelands whose potential remains below existing capacities, contributing to overgrazing and high pastoral pressure. The forage potential available in the forest ranges of the study area is estimated at (689,990) forage units per hectare per year.

Analysis of the results shows that the forage potential of forest areas does not meet the same food needs of the herd in the same terms. The needs are far greater than the feed supply. Comparison of livestock needs and forage quantities available in the study area shows an average annual forage deficit of (- 8,362,460 FU). In addition, it is noted that the actual load (AL) is greater than the balance load (BL) which indicates an animal overload on the course grounds.

The forage deficit and the high coefficient of calculated overgrazing can only give an idea of the current state of the forest trails, but they confirm the enormous pressure exerted on our ecosystem. The intensity of overgrazing is therefore proportional to the difference between the amount of plant matter collected and the annual increase. When this difference is cancelled out, one is responsible for balance, when it is negative, there is a subgrazing.

For our study area, the pressure index is very high (28) because this forest contains a lot of inhabitants and livestock. It is a crossroads for the people and animals that frequent it from all directions and exert considerable pressure on it. The pressure of the inhabitants on this forest is very strong and translates into clearing, cutting of trees and shrubs and repeated fires.

Forest rangelands are under a great deal of anthropozoogenic pressure that continues to degrade them and expose them to the harms of desertification. The lack of specialized technical frameworks for pastoral research and extension is a hindrance to the development of this sector. However, in order to safeguard this heritage and combat desertification at the country level, it is important to improve vegetation cover through the implementation of the burden, the readjustment of the burden in relation to production capacity. The seeding of the rangelands is related by high-productivity species, the production of forage shrubs, the practice of mineral manure and the complementarily between pastoral production of the rangelands and the production of forage on irrigated perimeters. The establishment of a pastoral strategy, based on legislation or its strict application when it exists concerning the protection of rangelands and natural resources, seems to be of particular urgency and is of urgent necessity.

The analysis of the indicators developed confirms the observation that one can at first glance, shooting while prospecting in the forest, it turned out that the forest of Doui Thabet suffers grossly from a very pronounced overgrazing. Indeed, the sylvo-pastoral balance is seriously compromised: the overall rate of overgrazing recorded is in the order of (92%). It is similar to other Mediterranean forests such as the Tabarka suberay in Tunisia where the rate of overgrazing was 69.3% for Chabane (1982), 77 % for El Hamrouni (1992), (83%) for Sebei (2001), (70%) for Aouadj et al (2018) and (68%) for the Maamora forest in Morocco (2012).

Restoration technique

This study aimed to identify the vegetation and soil treatments (Deep ploughing, chopping, scarification, burning, clearing and fencing) most favorable to the natural regeneration of the 5 pioneer species of the Doui Thabet forest:

Among the different treatments tested, it is the turning which proves to be the most effective for the acquisition of regeneration and its maintenance. In fact, this treatment was widely used in forest regeneration work. However and according to our knowledge, the turning was rarely tested on Mediterranean pines (Le Tacon et al., 1974 ; Prévost et al., 2009).

Turning provides a high percentage of bare soil which will promote a good contact between soil and seed leads to better germination (Prévost et al., 2012).

Soil decompaction also allows easier rooting and a better water supply (Burger et al., 2005; Bockstette et al., 2017), which facilitates seedling growth and survival. The high percentage of pebbles found in this type of treatment due to the fracturing of the shallow rock slab and the upward movement of pebbles by turning may also play a role in limiting evaporation (Bockstette et al., 2017)

However, one important point should be noted for this treatment: - the progression of herbaceous plants is strong. So a study over a longer period of time is therefore necessary to monitor the survival of regeneration in response to the development of competitive vegetation. These results are in agreement with Prévosto et al. (2012) and De Lombaered et al. (2018) studies.

Burning also appears to be one of the favorable treatments allowing the regeneration of pioneer species in the Doui Thabet forest. Considerable regrowth of these species, especially in the 2nd and 3rd year (with the exception of *juniper oxychedron* and *pistachio lenisque*) has been observed. These results are in agreement with Prévosto et al study (2012). Indeed, and according to many authors reviewed by Prévosto et al (2012), burning creates favourable conditions for their growth on an ashy soil highly enriched in nutrients.

Prescribed burning has two contrasting effects on regeneration depending on the presence or absence of slash, since slash determines the intensity of the fire (Tardós et al., 2019). High-intensity slash burning induces total destruction of the soil plant layer in its aerial compartment and partially in its subterranean compartment (roots, seeds). As a result, vegetation recovery is delayed and bare soil may persist longer, which are favorable elements for the acquisition and maintenance of regeneration. These results are in agreement with those of Prévosto et al (2009) and Prévosto et al (2012). In all cases, prescribed burning favored the development of competing vegetation on the ground (Bonin et al 2007). However, prescribed burning promoted the development of competing vegetation on the ground (Bonin et al 2007).

Mechanical grinding of the vegetation (chopping) is also a moderately favorable treatment for regeneration as described previously by Prévosto et al. (2007). That can be explain by the fact that chopping treatment leaves a layer of organic debris on the ground that creates a barrier for soil-seed contact (Wolk et al., 2009). Consequently, thus penalizes the establishment of seedlings, without however prohibiting the regeneration of vegetation whose root part has not been affected by the treatment. It is also possible that certain compounds produced by litter and shredded soil may have a negative influence on seedling germination and growth by allelopathic effect (Bonin et al 2007).. The practice of chopping is beneficial for soil reconstitution, biological recovery of vegetation and repopulation of bare areas (Hellal et al., 1991). Nevertheless, Bourahla and Guittonneau (1978) reported that chopping limits excess temperatures and increases soil water reserves by creating a microclimate favourable to plant germination and growth.

As reported recently by Tony et al. (2017) the deep tillage treatment seems to be not very conducive for regeneration. According to Le Tacon and Malphettes (1974), ploughing, as regular as possible, should be sufficiently deep (30 cm), adapted to the soil structure and the types of plants to be installed. In clayey soils, it is imperative to work the soil in such a way as to minimise the emergence of a plough sole, which is subsequently difficult to detect by tree roots. Ploughing must be carried out early enough to ensure that the soil is stale and that there are no lumps at planting time and to prevent the regrow of competing vegetation (Tony et., 2017). In Mediterranean areas, tillage should be carried out before the autumn rains to avoid any risk of erosion.

The present study consisted also to evaluate the effect of partial clearing of the clump (a mass of leaves that, although dead, still remain suspended from the tufts for a long time) on the regeneration of Alfa tufts for 3 years (2018-2020) in a protected (fenced) site. The obtained data were compared to the unprotected area. This experiment is original in forested areas and stems from an observation made on a cleaned area. Clearing Alfa tufts encourages the buds responsible for foliage to return to activity. The maximum activity of the buds, as determined by Mehdadi (1992), takes place in the spring, during the active period of the Alfa tufts. The increase in green foliar biomass was most likely induced by the clearing of Alfa tufts of their clumps and resulted from the activation of a large number of dormant buds. Removal of the dark, asphyxiating environment created by the clumping of Alfa clumps or tufts can only optimize the conditions for a good vegetative start of esparto (Hellal et al., 1991).

In addition and as reported by Fischer et al. [26], we confirmed that fencing remains one of the best actions allowing appreciable results on the regeneration of the vegetation in general and of the forest plant formation in particular. The comparison between the results obtained in the situation of fencing and those with free access, highlight the effect of the anthropic action. Which makes it possible to appreciate the quantitative and qualitative evolution of the plant cover. However, the beneficial effects of protection are evident in the structure, floristic composition and production of the herbaceous stratum and the dynamics of the woody stratum (Graham et al., 2018; Dey et al., 2019). At the floristic level, these effects are characterized by an increase in floristic diversity.

Conclusion

This work complements the works made by the inventory of Djebbouri and Terras (2019) on the forest region of Saida. It is clear from this study, that the Mounts of Saida area is diverse, with 1.72 bit Shannon-Wiener diversity indices, particularly by the presence of rare species, endemic and protected.

These results open an opportunity to the study of the establishment of a nature reserve. However, that it also deteriorates due to human activities and change, which requires the development of emergency restoration and rehabilitation plans; which we will do in our research that we will conduct in our next publication.

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Appendix: Floral richness of the Mounts of Saida 2017-2022

Ebenus pinnata L.

Teucrium fruticans L

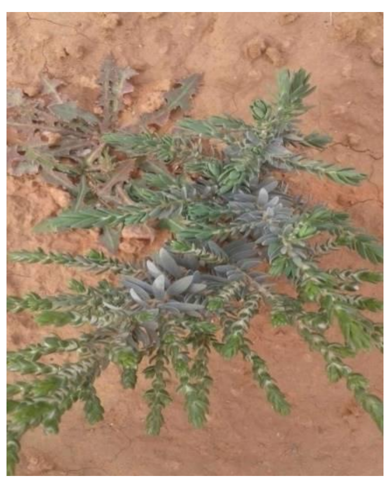
Hedysarum pallidum Desf.

Nepta apulei L.

Lathyrus tingitanus L.

Ranunculus millefoliatus Vahl.

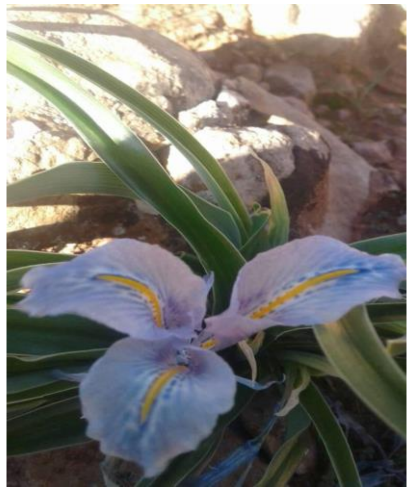
Echium corolle Lam.



Thymelae avirescens Coss. & Dur.

Quercus faginea L.

Crithmum maritimum L.



Iris tingitana (B. & R) B. & T.

Iris unguicularis Poir.

Teucrium pollium L.

Phillyrea angustifolia L.

Clematis cirrhosa L.

Ophrys *tentthredinifera* Wild

Subp. *tentthredinifera*

Sanguisorba minor Scop.

ssp. *vestita (*Pomel). Maire.

Iris planifolia (Mill.) Dur. & Sch.

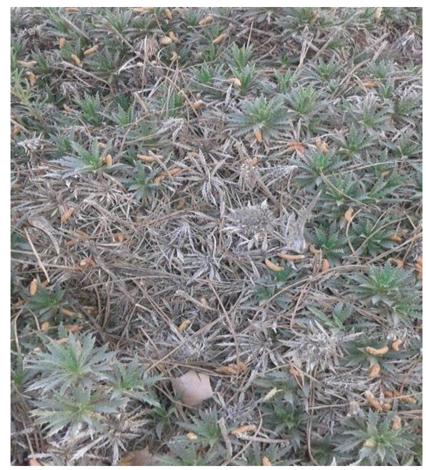
Cytinus hypocistis L.

Artemisia herba alba Asso.

Ailanthus altissima (Mill.).

Carduncellus pinnatus (Desf.) DC.

Retama retam Webb.



Atractylis humilis L. ssp.*caespitosa* (Desf.) M.

Cytisus trifolorus L' Herit.

Centaurea acaulis subsp.*Boissieri* M.

Helianthemum croceum (Desf.).

Thymus munbyanuss (Boiss. & Reuter).

Genista erioclada Spach.

Rosmarinus eriocalyx jord et fourr.

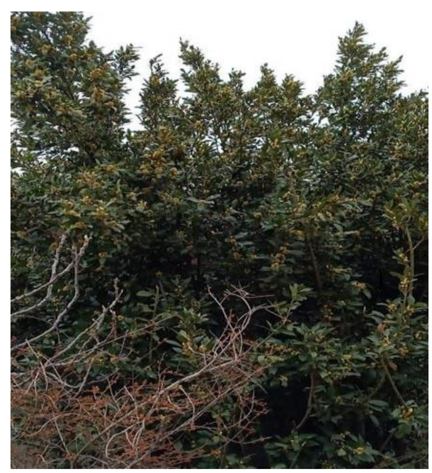
Scrophularia hypericifolia Wudl. Lange.

Magydaris panacifolia (Vahl.)

Echium confusum de Coincy.

Thymus fontanesii Boiss. & Reut

Lamium purpureum L.



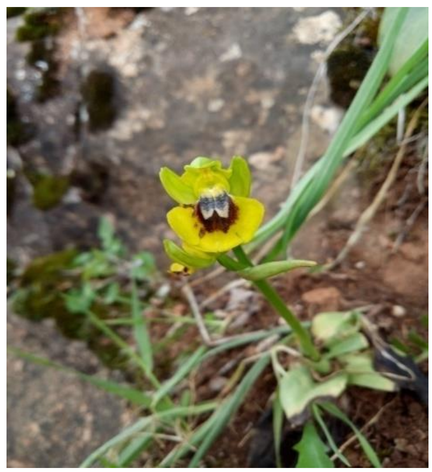
Laurus nobilis L.


Scorzenera laciniata L.


Linum strictum L.


Borago officinalis L.


Echinops spinosus L.


Ophrys lutea (Cav.). Gouan.


Osyris alba L.


Anacamptis papilionacea (L.)


Dactylorhiza elata (Poir.) Soó.


Sedum acre L

Lythrum acutangulum Lag.

Rhamnus alaternus L. subsp. *Alaternus.*

Thymus hirtus Willd.

Helianthemum syriacum (Jacq.) Dum. Cours.

Thymus numidicus Poir.