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Importance of low perennial plant formations to the sustainability of forest ecosystems in the Saida Mountains (Algeria)

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ABSTRACT

The forest ecosystems of the Saida Mountains are subject to several pressures (range, cut, fire) inducing a strong presence of low formations. Out of a total area of 174,300 hectares or 26.17% of the total area, matorrals represent 73% of the total forest area. Adaptation to edaphic, climatic, and pressure conditions has resulted in low forest formations composed of resistant and strain-rejecting species. The light matorral dominates about 30% in the area and evolves towards the disappearance of all the forest cover. All forest groups are: Pinetum halepensis, Tetraclinis articulata, Quercetum ilicis, Olé-lenticetum, and Juniperus oxycedrus. Forest cover rehabilitation involves the selection of resilient and resistant species such as Quercus rotundifolia, Tetraclinis articulata, Olea europaea, Quercus coccifera, and Phillyrea angustifolia.

Keywords: *forests, pressures, degradation, rehabilitation, Saida (Algeria), ecosystem, mountains*

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1. INTRODUCTION

At present, the reasoned and sustainable management of forest formations requires a perfect knowledge of the state of their dynamics (Alecseev and Ruchin, 2020; Sebua and Nuñeza, 2020). At the level of the Saida Mountains, there are several pressures on forest ecosystems and can only be properly protected to ensure their sustainability through an understanding of the degradation process that allows for the rehabilitation of forest formations.

All forest formations in the region have a certain heterogeneity in their structure and composition, which require an approach based on the concept of eco-landscape. This complexity and the absence of typology are a major obstacle that does not allow for adequate accommodation. The ecological lack of knowledge of forest ecosystems and the various anthropogenic pressures have made numerous problems for these forest formations, both theoretical and practical. On this subject (Quezel, 1976) stressed: "Their heterogeneity, both floristic-structural and bioclimatic, does not simplify things. No general scheme can be reasonably proposed. The Algerian forest was excluded from the effort to think about management and development because its economic interest seemed negligible to managers."

The forest massifs of the Saida Mountains are dominated by five species imposing their appearance: The Green Oak, Pine of Aleppo, Thuya of Berberie, oxidized juniper, and Pistachio of the Atlas. But it is the floristic procession composed of perennial species and resistances colonizing the undergrowth and ensuring a significant rate of recovery that should serve as a natural tool for the rehabilitation of these forest ecosystems.

2. MATERIAL AND METHODS

Ecological characterization of Saida Mountains

Spanning about 20 kilometers west of the city of Saida, the study area is located according to the longitude/latitude-type projection (WGS84) between: (34,9674 degrees north), (34.8068 degrees South), (0.14949 degrees East), and (-0.1120236 West);

The forest area occupies a total area of 174,300 hectares or 26.17% of the total area. The matorrals account for 73% of the total forest area and bear witness to the pressure on forest formations and their adaptation to edaphoclimatic conditions. Reforestation is only around 4%, while forest areas are important in the light of fires and sloping rangelands. They are mainly pine-based from Aleppo, remain very limited in area, and with an extremely low success rate.

The dominant countenance remains in a decreasing chronological order clear matorrals, dense matorrals, clear forests, and dense forests. The regressive situation in which these forest formations are located is mainly induced by overgrazing, fires, and the lack of a management plan (Benabdeli 2016, 1996; Borsali et al., 2019; Terras, 2011).(Fig.1)

Figure 1. Location of the study area

- **Climate and bioclimate**

The exploitation of the work of (Hirche et al., 2007; Seltzer, 1946; Meddi and Meddi, 2009; Labani et al., 2006; Terras, 2011; Meterfi et al., 2011; O.N.M, 2015) help to characterize the climate of the region. The average annual precipitation from north to south fluctuates from 400 to 325 mm, an average of 355 mm over a 40-year period. The average minimum temperatures for the coldest month (m) are between 3 and 6 and the average maximum temperature for the warmest month is between 32 and 36 degrees Celsius. The prevailing rainfall pattern is HPAE characterized by an 891.4 mm FTE, a 354.8 mm ETR and a rainfall deficit of 536.6 mm. The region is a semi-arid bioclimatic floor with a fresh variant.

The decrease in rainfall to close to 25%, it is also characterized by a large interannual fluctuation. Temperatures changed irregularly from the beginning to the end of the last century but increased by 1 to 1.5 degrees Celsius in winter and 2 degrees Celsius in summer.

- **Soils**

According to (B.N.E.D.E.R, 2008), the main types of dominant soils in the Saida Mountains are lithosols located on bare slopes with a thickness of less than 25 cm; reddish-brown soils with sandy texture or humiferous horizon. They occupy the hills and are located on limestone or dolomite. Their rubefaction corresponds to a warmer phase with sclerophyll vegetation and gave iron-red soils or "Terra r ossa". The average rainfall in the region has declined annually between 57 and 71 mm on average.

- **Overview of anthropogenic pressures**

The main anthropogenic pressures are fires, overgrazing, land clearing, and cutting offenses (Zhangozhina et al., 2019). An analysis of forest space dynamics by comparing the 1953 staff maps with those of the studies conducted by (S.A.T.E.C, 1976; A.N.A.T, 1989; B.N.E.D.E.R, 1992; Labani et al. 2006; Terras, 2011) makes it possible to draw several conclusions. A slight decline in forest cover was estimated at an annual average of 230 hectares. Management operations have only served to maintain an area with an acceleration of the degradation process (Bakhir and Pogorelov, 2018). Stands were characterized by a lack of natural regeneration threatening the sustainability of ecosystems. A marked increase in low formations where the matorral dominates confirming the intensity of the degradation of the forest space as a whole and the trend towards unbalanced formations.

Fires: The 30-year toll (1985-2015) shows an average annual fire loss of 2,260 ha; this figure fluctuates between a minimum of 469 and a maximum of 4180 hectares. Forest fires are the largest compared to brush and alfa fires; they account for 81% of the total area. At this rate, the area would lose all its forest cover in less than a century.

Overgrazing: The estimated 15 million forage resources are failing to meet the needs of the herd. They are homes of an estimated 420,000 sheep, 15,000 cows, and 45,000 goats, a need for 870 million forage units. The pastoral load in forest formations is 3.5 large livestock units with a maximum capacity of 0.5. The state of advanced degradation of forest formations is mainly due to grazing and the high and intense frequency of fires that limit economically profitable exploitation without disrupting the ecological objectives that remain priorities in this region threatened by erosion, seeding, and desertification.

Clearing and cutting: for lack of data are estimated respectively in the Dhaya Mountains, which are bordered by (Benabdeli 1983, 1996) at 6 hectares and 230 steres annually.

3. RESULTS

The exploitation of a doctoral thesis work (Terras, 2011) facilitated the approach as it identified the main forest stations for these formations. There have been 5 forest groups with their different stages of degradation; ten phytoecological surveys were carried out and synthesized in a summary table. Thus, it was possible to give an overview on the importance of low forest formations resulting from the degradation of these five forest groups: *Pinetum halepensis, Tetraclinis articulata, Quercetum ilicis, Olé-lenticetum and Juniperus oxycedrus.*

The survey consists of a description of floristic composition by type of plant formation (in the sense of IONESCO and SAUVAGE, 1962) by retaining only perennial woody species and assigning by stratum the abundance-dominance coefficient according to the BRAUN BLANQUET scale.

Composition of the main low-lying forest formations

The work of (B.N.E.F, 1983; B.N.E.D.E.R, 2008; D.P.A.T, 2011) on forest vegetation types points out that matorrals occupy 35% and the forest mainly based on *Pinus halepensis* 45% followed by geophysical-based formations estimated at 15%.

- **Spatial dynamics of the main forest formations**

A retrospective of the area occupied by the various forest formations gives a detailed overview of the evolution of forest cover. (Table 1)

Table 1: Forest Space Dynamics

Typology	1950-1970	1995-2015	Difference	Rate
Dense forests	37 300	19 600	- 17 700	11.35
Clear Forests	36 800	30 300	- 6 500	4.15
Dense Matorrals	45 300	22 200	- 23 100	14.80
Clear Matorrals	32 600	78 100	+ 45 500	29.20
Total	155 900	155 200		

In the last 45 years, the forest space has undergone an upheaval; the exploitation of the areas occupied between 1970 and 2015 by the various forest formations allows the following observations in terms of the dynamics of the area and the future of this vegetation.

Dense forests are experiencing a significant decline from 37,300 to 19,600 hectares, while clear forests follow the same route and cover only 30,300 instead of 36,800 hectares, showing a decline of 15.50%.

Dense matorrals have decreased from 45,300 to just 22,200 hectares and clear matorrals from 32,600 to 78,100 hectares, an increase of 44%, indicating the uncertain future of this vegetation.

The forest covers only 24,200 hectares or 15.50%, while the matorrals occupy 47,300 hectares or 44%. The main causes of this regressive situation are in decreasing order the pressure of the herd throughout the year, a lack of sustainable development, fires, global warming, and illegal cuts. The spatial dynamics highlight the importance of the degradation of the main groups of the *Pinetum halepensis*, the *Quercetum illicis,* and the *Tetraclinis articulata* constituting the basic backbone of the forest heritage of the Saida Mountains.

- **The area occupied by major species**

The spatial dynamics of the major tree species of the forest were assessed using the most recent work of (Labani et al., 2006; Terras, 2011), the area assigned to each species is summarized in the following Table.(Table 2)

Table 2: Area Occupied by Dominant Species/Species Area in hectares Percentage

Species	Area in hectares	Percentage
Green oak	56 920	35%.
Aleppo Pine	44 740	30%.
Thuya of Berberie	15 640	10%.
Oak Kermes	12 820	5%.
Juniperus oxycedrus	7 820	4%.
Pistacia atlantica	950	1%
Other species	17 000	15%.
Total	155 890	

Aleppo Pine is strongly competing with green oak, in third place are thuya, oak kermes, Pistachio of the Atlas followed by oxidized juniper. Any intervention in the management or rehabilitation of these ecosystems must take into account the impact of these species in the near future of these forest formations.

- **Plantological aspects**

The analysis of the net biological spectrum of the study area is of the type: Therophytes > Hemicryptophytes > Chamephytes > Phanerophytes > Geophysicists according to (Aouadj et al., 2020); it is induced by severe anthropogenic and climatic actions. Chamephytes occupy the third position and adapt to aridity compared to other biological types. Their presence is high and is a sign of disturbance and degradation of this ecosystem. Geophysics occur in small proportions; these species are characterized by a low rate of germination that arises as a real reproductive problem. The Phanerophytes occupy before the last position shows the regressive dynamics of this ecosystem. All these results are in line with those of (Barbero et al., 1990; Vela and Benhouhou, 2007).

In this regard, (Benabdeli 1998) pointed out that: the vegetation cover is constantly subjected to human aggressions especially, in which the rustic vegetation, despite its resistance, is no longer able to resist and maintain itself and that the plant formations are represented only by degraded groups as a whole to the point that under the multiple and permanent aggressions the vegetation cover is seriously threatened with extinction.(Table 3)

Table 3 : Presence of species

Species	Aleppo pine	Holm oak	Thuja	Oleo-lentisk	Juniper	Score	Presence
Tree stratum							
Pinus halepensis	3.1	+	+	1.1	1.1	2.1	3/5
Tetraclinis articulata	1.1	+	1.1	+	-	1.1	2/5
Quercus rotundifolia	+	1.1	-	1.1	-	+	2/5
Juniperus oxycedrus	+	-	+	+	1.1	+	1/5
Pistacia atlantica	-	+	-	+	-	+	
Shrub layer							
Quercus rotundifolia	2.1	3.2	+	1.1	1.1	2.2	4/5
Pistacia lentiscus	1.1	1.1	2.1	2.2	2.2	2.1	5/5
Phillyrea angustifolia	2.1	1.1	1.1	2.2	1.1	2.1	5/5
Olea europaea	1.1	-	2.1	1.1	+	2.1	3/5

Quercus coccifera	2.1	2.2	-	1.1	+	2.1	3/5
Tetraclinis articulata	1.1	+	2.1	1.1	-	1.1	3/5
Under-shrub stratum							
Genista cinerea	2.2	1.1	2.2	+		1.1	3/5
Rosmarinus tounefortii	3.1	1.1	2.1	1.1	2.1	2.1	5/5
Stipa tenacissima	1.1	+	2.1	1.1	2.2	2.1	5/5
Calicotome villosa	2.2	+	1.1	2.1	1.1	2.1	4/5
Genista quadriflora	2.1	1.1	+	+	-	1.1	2/5
Chamaerops humilis	1.1	+	1.1	1.1	2.2	2.1	4/5
Cistus villosus	2.2	+	2.2	2.1	1.1	2.1	4/5

- **Importance of low-level formations**

Dense matorrals decreased from 45,300 to just 22,200 hectares and clear matorrals from 32,600 to 78,100 hectares, an increase of 44%, indicating the uncertain future of this vegetation.

The dominant species in the shrub and sub-shrub strata total 60% and are so important from the point of view of physiognomy, covering of the soil, or ability to resist.

The exploitation of the results obtained on species that can be described as keystones in the concept of ecosystem rehabilitation allows two options:

-An indiscriminate classification of stratum according to the coefficient of abundance dominance and presence that allows targeting in decreasing chronological order the following dominant species: *Pistacia lentiscus, Phillyrea angustifolia, Rosmarinus tournefortii, Stipa tenacissima*. They are followed by *Quercus rotundifolia, Chamaerops humilis Cistus villosus, Calicotome villosa.* In dernier come the following species: *Pinus halepensis, Tetraclinis articulata, Olea europaea, Quercus coccifera*

-Classification of species at the level of each stratum where the following species are selected with a distinction of strata for the arborescent stratum: *Pinus halepensis and tetraclinis articulata* followed by *Pistacia lentiscus* and *quercus rotundifolia*. For the shrub layer: *Pistacia lentiscus, Phillyrea angustifolia*, and *Quercus rotundifolia* followed by *Olea europaea*, *Quercus coccifera* and *tetraclinis articulata*, the sub-shrub stratum remain dominated by *Rosmarinus tournefortii* and *Stipa tenacissima* followed by *Chamaerops humilis*, *Cistus villosus* and *Calicotome villosa*.

Faced with the constant pressures experienced by these forest groups, it is illusory to be able to continue to make reforestation based on *Pinus halepensis* in view of the risk of failure induced by the quality of the plants, their adaptation to natural and anthropogenic constraints, and the invasion of species of shrub and sub-shrub strata. In this context, (Barbero et al., 1990) report that: the disturbances caused by man and his flocks are numerous and correspond to two increasingly severe situations ranging from materialization to desertification through steppization;

The future in species inducing materialization is necessary in the first place to prepare the environment to receive species from the tree stratum. Based on the species stability index in their environment defined by (Benabdeli, 1996), it gives the following ranking for shrub and sub-shrub stratum; *Quercus rotundifolia*, *Tetraclinis articulata, Juniperus oxycedrus, Pistacia lentiscus, Phillyrea, Quercus coccifera, Genista, Calycotome, Chmaerops, Stipa tenacissima,* and *Rosmarinus tournefortii* long before forest species.

4. DISCUSSION

Safeguarding and Rehabilitation Strategy

The results obtained and highlighted allow the choice of species adaptable and profitable in the face of this ecological, forest, and socio-economic situation that can be described as disastrous. In this choice, all perennial plant species with stress-resistance powers are accepted. This assessment suggests that shrub and shrub strata must play a key role in the sustainability of ecosystems. This finding puts on the agenda the management of all low-level training in any sustainable forest management program in view of the ecological and economic role they play.

Keeping natural attributes first

It is always more effective to maintain natural attributes already in place than to have to restore them. Where, in a development unit, portions of the land represent remnants of the natural forest, every effort should be made to preserve the desired attributes. For example, pre-industrial softwood forests generally had a high proportion of complex internal structure stands that are becoming scarce under management regimes. Detecting stands (or massifs) that still have complex internal structures allows quantitative targets to be set and geographically circumscribe. This type of target is usually part of an ecological restoration plan.

Encouraging Keystone Species

These are species whose presence, at sufficient density, is necessary to maintain the structure and functioning of the ecosystem. The concept, which was first used in the work on conservation biology, also seems adapted to the ecology of restoration and rehabilitation. The attempt to reorient the trajectory of degraded ecosystems such as those of the Saida Mountains may be facilitated by the careful reintroduction of key vault species and when necessary by the eradication of "exotic" species introduced voluntarily or inadvertently. (Simberloff, 1990). The preservation of forest ecosystems requires a mastery of biological potential that allows the population to be maintained as to itself over time and in space while ensuring a more or less constant annual production of woody matter.

Fundamentals of the development of degraded formations

"Developing a forest is decoding what you want to do with it, given what you can do about it and deduce what you need to do about it, summing up the so broad concept of development." (Jacquiot, 1970). The purpose of the development is to quantitatively fix the forestry operations to be implemented in order to obtain a constant production of woody material. An ideal development tends to determine an annual production value or possibility that corresponds to biological potential but taking into account the ecological role that remains decisive in arid and erosion-threatened areas. The cultivation of the forest depends on the quality of its knowledge.

5. CONCLUSION

The problem arises in terms of identifying the state of degradation of forest formations and analyzing their trajectory. The latter is strongly oriented towards a process of degradation that will lead inexorably to the dominance of ermes if nothing is done.

The response of perennial vegetation with resilience powers must play a decisive role in the management of these natural spaces. The results support the rehabilitation of the low-lying formations, which dominate the following species: *Quercus rotundifolia, Quercus coccifera, Tetraclinis articulata,* and *Pistacia lentiscus*, which play a role in protecting soil, biodiversity and providing significant recovery.

Only a development program, taking into account both the physical parameters of the environment and socio-economic conditions, can slow down the process of degradation that has already begun. It should be based on the development and protection of low-lying formations in the first place to establish conditions conducive to other tree species.

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