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Effect the exclosure on plant diversity of the *Hammada scoparia* steppe in the Naama steppe courses (Algeria)

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Abstract
The analysis of ecological data is certainly a preliminary for first class understanding of ecosystem functioning and environmental design. Our work is to provide a fine phytoecological analysis based on the dynamics of vegetation and floristic inventories. The Steppe south Oranian of Naama (Algeria) at Remth (*Hammada scoparia*) is a representative example of arid threatened areas by the scourge of desertification, a strong human pressure and climatic constraints. It occupies the southern foothills of the Saharan Atlas, glacis and hamadas of the northern part of the Sahara where this species seems to find an optimum development in shallow soil, mostly in sandy loam texture, under lower arid and Saharan climate (isohyet between 100 and 150 mm). To overcome the degradation, actions and measures for rehabilitation and restoration will be considered using the most appropriate techniques of pastoral arrangements. Among these pasture improvement techniques, there is the exclosure technique (fencing). The objective of this latter is to encourage natural regeneration, the best to induce the recovery of natural biological steppe. Following this assessment, rehabilitation by the technique of exclosure the *Hammada scoparia* steppe has a positive impact on biological recovery by quantitative and qualitative increase in the rate of recovery of vegetation, flora richness and of phytomass. Floristic diversity of the *Hammada scoparia* steppe is very special because of its biological, systematic and phytogeographic characterization. This review underscores the importance of Saharan-endemic species thanks to a more favorable adaptation and resistance under arid bioclimate.

Keywords: Steppe, Naama, Algeria, Hammada scoparia, Biological recovery, Exclosure, Desertification.

1. Introduction
Algeria has ratified the UN Convention on Biological Diversity, which represents the first international treaty on the protection of living beings and their ecosystems in which the community of nations recognized that biological diversity became impoverished considerably due to human activities, that its preservation was a common concern of humankind and that the countries were responsible for the conservation of their biological diversity and of the sustainable use of these constituent elements. Signed in 1992 in Rio de Janeiro at the Earth Summit and ratified quickly by more than 170 countries, the outline agreement (convention) sets out universal principles and objectives to achieve.
The ecology of restoration and rehabilitation is part of the possible actions more to limit the extansion of these misdeeds than to erase or mitigate the consequences. First of all, it is necessary to know the steppe ecosystem performance (Le Floc'h, 2000). The aim of restoration is the natural resources sustainable management in areas heavily damaged by desertification in order to safeguard the land courses.
To remedy the situation, the Algerian state (through the Office of Development of the Steppe "HCDS") has undertaken various measures of restoration or rehabilitation that fit into the framework of a national strategy for improving pastoral of degraded steppe and the fight against silting to combat desertification.
The rehabilitation includes repair of damage that did not alter an ecosystem in depth with a minor operation, such as by removing the causes of deterioration and restoring the free way of natural processes. In this case, a simple exclosure is sufficient for reconstitution of the media, with the proviso that the misdeeds of the disturbances are not very pronounced (Moulis, 2001).

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According to Le Houérou (1995) exclosure is a natural technique that helps protect a territory or a plot against the man and/or pets, is a known technique which has been practiced for centuries by our ancestors like that of "Agdal" in North Africa or the system of "Hema" in the Middle East and Arabia.

2 - Objectives:
This present work is part of preserving courses in the steppe south-Oranian. It aims the study of the exclosure role and effect and the rise of biological steppe vegetation protected in relation to climate and habitat use. Our approach results in a floristic and ecological assessment and quantification of changes in the rate of recovery of vegetation after a period of exclosure.

2.1-Establishment of areas of dissemination of seeds:

To foster the improvement of pastoral resources in the exclosure plots, it is necessary to consider the establishment of "Improving Pastoral Perimeters" favoring a biological recovery by manual dispersal of steppe seeds. The location of these areas will be taken into account with the objective of promoting maximum seed dispersal of steppe plants via wind or runoff (Kaabeche, 2005).

2.2. Desired conservation and restoration actions:

The main objective is part of a fight option against the degradation of natural pastoral resources of the site by the implementation of pastoral rehabilitation actions able to create a dynamic allowing a biological recovery. This object is therefore the restoration of ecological systems under the definition adopted by the Society for Ecological Restoration "Restoration is the" intentional conversion from one medium to restore the ecosystem regarded as indigenous and historic. The aim of this intervention is to return "to the structure, diversity and dynamics of this ecosystem". It should be noted that the improvement of plant also comes in a context of struggle against desertification processes in the area of the site (Kaabeche, 2005).

3 - Materials and methods

3.1-Presentation of the study area

In the area of Naama, land clearing, overgrazing and overexploitation of vegetation exposes the soil surface of the wilaya pastoral rangelands to an intense desertification. Control of this phenomenon requires facilities that promote the recovery and restoration of biological soil covers. These include the exclosure is a technique that is to put at rest, by periodical rotations, degraded areas in order to promote the restoration of the ecosystem.
The study area is part of the high steppe plains south of Oran, it lies between 32 ° 08'45 "and 34°22'13" north and 0°36'45 "is at 0 ° 46 '05" West. The wilaya of Nâama covers an area of almost 3 million hectares in the south-west Highlands.
The wilaya of Nâama has a large array of ecosystems and biodiversity. It is located on Quaternary glacis belonging to sub-sector of the Saharan Atlas Oran. It is situated between the Tell Atlas and Saharan Atlas in its western part. It is bounded on the north by the wilaya of Tlemcen and Sidi Bel Abbes, on the east by the wilaya of El-Bayadh, south by the wilaya of Bechar and west at the Moroccan-Algerian border by a 275-km long strip; it covers an area of 29 825 square kilometers with a population of 225 530 inhabitants (2010).
It has experienced strong growth of population and number of sheep flocks. This trend is the main cause of degradation of pastoral ecosystems.

3.2-Choice of study site:

In the wilaya of Naama, HCDS achieves the 32 sites of exclosure, or 18% of the grazing courses of the wilaya. This exclosure showed a form of struggle against the degradation of rangelands. We have chosen eight sites to achieve our study in the area the most affected by desertification and silting.
The choice of station Zeboudja (Figure 1) which corresponds to the steppe has been done to assess biodiversity of Remth (*Hammada scoparia*) groupings. It was founded on the following criteria: the station must be accessible, identifiable and recognizable on maps and aerial photographs.
The exclosure of Zeboudja (Tiout) spread over an area of 19,000 ha and is located in the southeastern part of the wilaya of Naama. It forms a seamless topographic without any major irregularity. This exclosure was established in early July 2003.

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Geologically, the area corresponding to the conditions of Oran high plains whose evolution has been consistent over geologic time and that is a whole transition zone of the Tell Atlas and that of Saharan Atlas formations. It is a Saharan interface area.

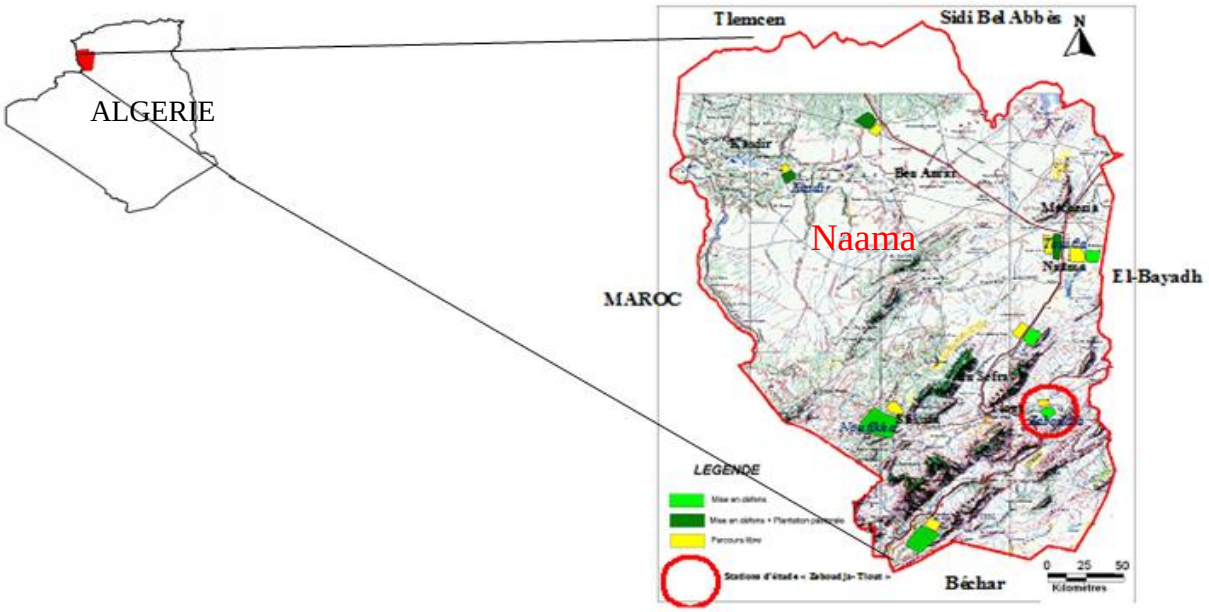

Figure 1: Location of the study area.

3.3- Methodological approach:

The Remth (*Hammada scoparia*) groupings settles the foothills south of the Saharan Atlas, the northern part of the Sahara glacis and hamada where it seems to find an optimum development (Achour et al., 1983). This grouping grows on regs, bare glacis, on covered by sand glacis of erosion with shallow soil, mostly in sandy loam texture. Its physiognomy (as defined by Bouzenoune, 1984 and Le Houérou, 1969), is characterized by diffuse shrub steppe.
In terms of climate, its northern limit follows quite faithfully the 150mm isohyet; its southern boundary only rarely transgresses the 100mm isohyet.
This group characterizes the bioclimatic lower arid and Saharan with cold variant corresponding to a desertic and sub-desertic climate. Thus, it urges the transition between the arid stratum and the Saharan stratum (Djebaili, 1978). It has been described by several authors like Pouget (1977) in Southern Algiers region and Bouzenoune (1984) in southern Oran.
At the physiognomic and floristic levels, Djebaili (1978) defines the variation in floristic composition of this grouping based on the lithological substratum nature. When grown on heavily silted erosion glacis, this group forms facies with psammophytes species such as *Thymelaea microphylla*, whereas on bare glacis to poor soil, it forms a facies with *Anabasis aretioïdes*, etc.

3.3.1. Methodology

In this work, we consulted several works on the flora:

- New flora of Algeria and southern desert regions (Quezel P, Santa S. 1963)
- Flora of the Sahara (Ozenda, 1977)
- Medicinal plants in Algeria (Beloued A., 2001)
- The medicinal plants of arid regions (UNESCO, 1960)
- Encyclopedia of useful plants, flora of Algeria and the Maghreb, Vegetal substances of East and West Africa (Baba Aïssa, F., 2000)

3.3.3-Choice of transect and sampling structure

After the description of the vegetation and inventory and statement of state of the vegetal cover, we developed a survey form for surveying the vegetation inside and outside the exclosure, corresponding to a plant survey and the measurements or estimates of ecological site types (geomorphology, topography, lithology and altitude). To give this work a participatory

approach, we went up to the indigenous population for its views on the concept of natural resources exclosure (medicinal and aromatic plants, and their uses) and, by showing the consequences of unsustainable exploitation of rangelands to maintain this ecosystem, make them react to that fact.
We launched a sampling campaign in spring 2007 to determine the effect of that experimental practice on plant diversity and the soil surface condition at this station in the Naama steppe south of Oran.
We selected by systematic sampling the transect method. This sampling technique, very suitable for our work, allows on one hand to relate the vegetation and the environment by using gradients of environmental sustainability such as micro-topography, substratum, salinity, etc.., and on the other hand to study the horizontal and vertical structure of vegetation. This method sets the size of the vegetation elements that could provide a working scale.
After detecting variability of vegetation (zoning), the methodology used includes a device consisting of a series of transects located in different topographic units of the study area. Thus the number of transects is a grid that can scan the whole exclosure site and in some grazing courses nearby. These transects implanted with different orientations can overlap with more altitudinal and geomophological gradients (tops, sides, flat terrain, troughs ...).
These transects are collected every 200 m depending on the variability of vegetation and ecological conditions (topography, exposure). The station, an area of 100m^2, is delimited with a rope.

4 - Results and discussion of application:
This study has been based and undertaken on comparative analysis of two states (exclosure and open range). It is performed by comparing the results obtained on the exclosure site in the Naama steppe south -Oranian and the other as a witness; a neighboring site located outside the exclosure (free courses "FC").
From the obtained results, the analysis is done by calculating the variation of different parameters (recovery rates, biological spectrum and systematic inventory of species) by comparing data of the two-state study.
We found a significant difference between the exclosure and the open range conditions (species survival) because the uncontrolled anthropogenic fraction and the poorly developed management courses, after opening to grazing, threatens the entire ecosystem of the Naama steppe despite all the efforts done by the HCDS (High Commission for the development of steppe) to preserve natural resources to preserve them for the coming generations.
This study allowed us to obtain results in terms of biological and systematic station characters.

Parametres	***Exclosure***	***Free courses***
overy %	40%	20%
nber of species	108 species	44 species
ogical types		
Phanerophytes	03	01
Chamœphytes	32	15
HemiCryptophytes	20	08
Therophytes	46	16
Geophytes	07	04
ogical Spectrum	Th > Ch > He > Ge > Ph	Th > Ch > He > Ge > Ph
ematic		
Families	30	18
Genius	84	37
Number of species	108	44

Table 1: Comparison of different parameters between the two states (*exclosure & Free courses*)

4.1 Improved recovery rates:

We note that the recovery is higher in the first situation; it is twice that of the free path. Thus, we can say that the exclosure has improved the recovery rate of vegetation. In the exclosure, the recovery is between 25 and 40%, but varies in space. Indeed, it is different in the free path, and does not exceed 20%.
This improvement in recovery rate is due to the biological recovery process. According to Le Houérou (1995) "The biological recovery is the set of inverse biological processes to those of the steppe and desertification. The recovery is characterized by the organic growth rate of perennial biomass recovery, the rate of organic matter in soil, structural stability, permeability and water balance, biological activity and primary productivity, while the variability of annual production declines. "

4.2-Improvement of plant species richness:

Indeed, the species recorded within the exclosure are higher than outside (free range). The difference in the number of species between the inside and outside the exclosure shows the beneficial effect of fencing on the floristic richness.
The exclosure promoted several species by the biological process of recovery: *Stipa parviflora, vermiculata Salsola, Anabasis articulata, Helianthemum lippii, Launaea nudicaullis ...*
In the free courses (FC) species become more abundant, such as: *Atractylis serratuloïdes Zilla macroptera, Peganum harmala, Ferula cossoniana, Euphorbia Guyoniana, Thymelaea microphylla,* while other species are in decline or even disappear, among others: *Stipa parviflora, Artemisia herba-alba, Salsola vermiculata ...*
It appears that the protection by the technique of fencing has a positive impact on the enrichment of flora and the return of endangered vegetation, so the art of fencing, which aims to reactivate the biological recovery of endemic species (Saharan and pastoral) will be applied primarily to the types of courses with regeneration abilities and quick return of species of great pastoral value.

4.3-Effect of exclosure on the floristic composition (Biological and systematic)

In terms of floristic composition, the exclosure has enriched flora from more than 50%. Several pasture species have reappeared in the exclosure area, such as *Artemisia campestris, Artemisia herba-alba, Rhanterium suaveolens, Ephedra alata ...*
This therophytisation is related firstly to the harsh climate and other human actions that degrade more and more the new species settlement conditions (Benaradj A, 2009). Emberger (1939) asserts that the rate of therophytes increases with the aridity of the environment. For Daget (1980), the therophytisation is a characteristic of arid; it expresses a strategy of adaptation in relation to the adverse conditions and a form of resistance to climatic extremes.
We also note that this station is characterized systematically by two cases, where as we are in a free path (PL) or a term exclosure. In the latter, there are 30 families, 84 genera and 108 species, and in the second situation (PL), we find only 18 families, 37 genera and 44 species.

It appears from these systematic reviews a variety of families and genera in the more nuanced situation after exclosure compared to the previous situation.

The Asteraceae, Poaceae and Fabaceae are three families common to both situations with predominance in both floristic lists. These three families represent 35 to 40% of the flora in each Saharan sector (Ozenda, 1977). This dominance is justified because they are cosmopolitan families widespread throughout the globe.
Given these observations, the 108 selected species (Table 2) for the implementation of measures to improve routes are part of the floristic Remth steppe (*Hammada scoparia*).

Situation		***Exclosure***			***Free courses (FC)***		
N°	***Families***	**Cortège floristique**	**G**	**sp**	**Cortège floristique**	**G**	**sp**
1	Asteraceae	*Atractylis serratuloides, Atractylis humilis, Carduncellus eriocephalus, Cotula cinerea, Echinops spinosus, Ifloga spicata, Launaea arborescens, Launea resedifolia, Launaea nudicaulis, Scorzonera undulata* *Anacyclus cyrtolepidioides, Anvillea radiata, Artemisia campestris, Artemisia herba-alba, Atractylis carduus, Calendula aegyptiaca, Chrysanthemum macrocarpum, Evacidium discolor, Ifloga spicata, Koelpinia linearis, Lasiopogon musticoides, Launea acanthoclada, Rhantherium suaveolens, Matricaria pubescens, Picridium orientale*	19	24	*Atractylis serratuloides, Atractylis humilis, Carduncellus eriocephalus, Cotula cinerea, Echinops spinosus, Ifloga spicata, Launaea arborescens, Launaea nudicaulis, Launea resedifolia, Scorzonera undulata*	08	11

					Perralderia carponopifolia		
2	Brassiceae	*Malcolmia aegyptiaca, Zilla macroptera, Zilla spinosa* *Diplotaxis acris, Diplotaxis pitardiana, Farsetia aegyptiaca, Sisymbrium reboudianum, Mathiola livida, Eruca vesicaria, Moricanda spinosa, Moricandia foleyi, Moricandia suffruticosa, Pseudoerucaria clavata,*	11	14	*Malcolmia aegyptiaca, Zilla macroptera, Zilla spinosa*	03	03
3	Poaceae	*Stipa tenacissima, Stipa parviflora, Aristida pungens, Avena sterelis, Bromus rubens, Cynodon dactylon* *Aristida acutiflora, Avena alba, Cutandia dichotoma, Eremopyrum bonaepartis, Schimus barbatus, Stipa lagascea, Lygeum spartum*	09	13	*Stipa tenacissima, Stipa parviflora, Aristida pungens, Avena sterelis, Bromus rubens, Cynodon dactylon*	05	06
4	Fabaceae	*Medicago laciniata, Retama retam Astragalus mareoticus, Astragalus armatus* *Trigonella stellata, Astragalus caprinus, Astragalus Gombo, Astragalus vogelit, Lotus jolyi*	05	09	*Medicago laciniata Retama retam, Astragalus mareoticus, Astragalus armatus*	03	04
5	Chenopodiaceae	*Anabasis aretioides, Hammada elegans* *Hammada scoparia,* *Anabasis articulata, Bassia muricata,*	04	06	*Anabasis aretioides, Hammada elegans,* *Hammada scoparia, Salsola vermiculata*	03	04
6	Liliaceae	*Allium roseum, Alyssum granatense, Iris sisyrynchium, Muscari commosum, Urginea noctiflora,* *Asparagus altissimus, Urginea maritime, Asphodelus tenuifolius*	05	06	*Asparagus altissimus, Urginea maritime,* *Asphodelus tenuifolius*	03	03
7	Caryophyllaceae	*Sclerocephalus arabicus, Hernaria mauritanica, Polycarpaea repens*	03	03		-	-
8	Zygophyllaceae	*Fagonia glutinosa, Fagonia latifoli,* *Pegannum harmala*	02	03	*Pegannum harmala*	01	01
9	Borraginaceae	*Echium trygorrhizum,* *Elizaldia violacea*	02	02	*Echium trygorrhizum*	01	01
10	Apiaceae	*Ferula cossoniana,* *Eryngium ilicifolium*	02	02	*Ferula cossoniana*	01	01
11	Cistaceae	*Helianthemum hirtum , Helianthemum lipii*	01	02		-	-
12	Euphorbiaceae	*Euphorbia calyptrata*	01	01	*Euphorbia Guyoniana, Euphorbia retusa*	01	02
13	Géraniaceae	*Erodium glaucophyllum, Erodium triangulare*	01	02			
14	Malvaceae	*Malva parviflora*	01	02	*Malva parviflora*	01	01

		Malva aegyptiaca					
15	Plombaginaceae	*Daucus biseriantus*	02	02	*Daucus biseriantus*	01	01
		Limoniastrum feei,					
16	Resedaceae	*Reseda decursiva, Reseda villosa*	01	02		-	-
17	Capparidaceae	*Cleome arabica*	01	01	*Cleome arabica*	01	01
18	Convolvulaceae	*Convolvulus supinus*	01	01		-	-
19	Dipsacaceae	*Scabiosa stellata*	01	01		-	-
20	Lamiaceae	*Marrubium desertii*	01	01		-	-
21	Onagaceae	*Ononis natrix*	01	01		-	-
22	Orobanchaceae	*Cistanche violacea*	01	01		-	-
23	Palmaceae	*Phoenix dactylifera*	01	01		-	-
24	Plantaginaceae	*Plantago albicans*	01	01	*Plantago albicans*	01	01
25	Rhamnaceae	*Zizyphus lotus*	01	01	*Zizyphus lotus*	01	01
26	Rosaceae	*Neuroda procumbens*	01	01		-	-
27	Ephedraceae	*Ephedra alata*	01	01		-	-
28	Thymeleaceae	*Thymelaea microphylla*	01	01	*Thymelaea microphylla*	01	01
29	Polygonaceae	*Rumex vesicarius*	01	01	*Rumex vesicarius*	01	01
30	Scrophulariaceae	*Scrophylaria saharae*	01	01	*Scrophylaria saharae*	01	01
Total			**84**	**108**		**37**	**44**
G: Genius, sp: species							

Table 2. List of vegetation in the surveyed station Zeboudja after a period of exclosure

Conclusion

This article has been made in the Zeboudja (Tiout) station, for improving pastoral conditions. The objective of this study is to demonstrate the technique for pasture improvement (exclosure) which can assist and encourage natural regeneration. This involves stopping all forms of human and animal pressure. The vegetation and environment begin a gradual move towards the regeneration of Remth (*Hammada scoparia*).

The steppe ecosystem is now more alarming, the wealth of landscapes and habitats are often subject to damage at the edge of no return. Desertification is gaining ground and the main economic activity of the wilaya, that pastoralism is in decline.

In Algeria, the degradation of *Hammada scoparia* steppe is observed by a change in the physiognomy and the declining of the pastoral quality, the loss of woody species of high grazing value.

The technique of exclosure is a strategy for improving pastoral, conservation, rehabilitation and reconstruction of steppe species threatened or those of an heritage interest. This requires above all a good knowledge of their ecology and biology.

The exclosure allows a quantitative and qualitative increase in floristic richness, a development of pasture species including therophytes. This gives a significant plant biomass, and a relatively high vegetation cover. The floristic composition is very diverse. It encouraged the relocation and re-emergence of species threatened with extinction.

Following this assessment, the positive impact of fencing on biological recovery has been well demonstrated.

Managing our natural resources must necessarily go through a development strategy that will allow the preservation of ecological balance.

The technique of exclosure is the very encouraging results obtained by the operations of fencing. Indeed, we see that, through the exclosure made in the wilaya, especially in border areas, the drought has little effect on the environment. The degradation of steppe vegetation is mostly due to human activity.

This finding suggests that a restructuring of economic activities of the wilaya, based on reducing the pressure on rangelands, the exclosure and the development of multiple activities, may be a solution to stem the degradation process and desertification.

In light of this, it is imperative to put in place a comprehensive program to organize a rational exploration, inventory and valuation of plant genetic resources at local and national levels.

These natural resources are a potential, it must be clear and remember, to preserve natural resources against all these disappearing factors, to integrate these resources in the list of protected species.

We need, by the compliance burden, a rational management of exclosure courses after they are open. With these requirements solutions of jobs are offered to locals on conditions to keep the course in good state for future generations.

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