

Impact of ecosystem degradation on the Dynamic of vegetation in the Djelfa region- Algeria

Brahim TAIBAOU^{1*}, Abdelkader DOUAOU^{2*}

Abstract

Steppe ecosystems in Algeria, known for their distinctive biodiversity and delicate balance, are facing increasing degradation caused by human activities and climate change. This study aims to analyze the effect of ecosystem degradation on the composition of plant communities. To carry out a detailed floristic and ecological analysis of the vegetation in our study area, we developed a plant typology using two multivariate statistical methods. The first technique used is Correspondence Factor Analysis (AFC), which revealed the phytoecological relationships between the different groups of plants as well as the main ecological factors that explain their differences. This analysis led to the identification of five vegetation units, each corresponding to various plant formations: forest, pre-forest, steppe, degraded steppe and pre-Saharan steppe. These results indicate an evolution towards steppe formations such as those dominated by *Stipa tenacissima* L., which are often accompanied by varying degrees of degradation. The proliferation of species such as *Arthrophytum scoparium* (Pomel) Iljin., *Astragalus armatus* Willd. and *Thymelea microphylla* Coss. & Durieu., which are often considered widespread in these emerging plant communities, demonstrates the resilience and adaptability of some species in response to environmental changes. As a result, some plant species that cannot adapt to new environmental conditions disappear, which upsets the ecological balance.

Keywords: algerian steppe, vegetation; dynamism, degradation.

Impact de la dégradation des écosystèmes sur la dynamique de la végétation dans la région de Djelfa-Algérie

Resumé

Les écosystèmes steppiques d'Algérie, réputés pour leur biodiversité unique et leur équilibre fragile, subissent une dégradation croissante due aux activités humaines et aux impacts du changement climatique. Cette étude vise à analyser l'effet de la dégradation des écosystèmes sur la composition des communautés végétales. Pour effectuer une analyse floristique et écologique détaillée de la végétation de notre zone d'étude, nous avons développé une typologie végétale à l'aide de deux méthodes statistiques multivariées. La première technique utilisée est l'Analyse Factorielle de Correspondance (AFC), qui a révélé les relations phytoécologiques entre les différents groupes de plantes ainsi que les principaux facteurs écologiques expliquant leurs distinctions. Cette analyse permet d'identifier cinq unités de végétation, chacune correspondant à différentes formations végétales : forêt, pré-forêt, steppe, steppe dégradée et steppe présaharienne. Les résultats indiquent une tendance vers des formations steppiques dominées par *Stipa tenacissima* L., souvent associées à divers niveaux de dégradation. La montée en fréquences d'espèces telles que *Arthrophytum scoparium* (Pomel) Iljin., *Astragalus armatus* Willd. et *Thymelaea microphylla* Coss. & Durieu., qui sont souvent considérées comme répandues dans ces communautés végétales émergentes démontre la résilience et l'adaptabilité de certaines espèces face aux changements environnementaux. En conséquence, certaines espèces végétales qui ne peuvent pas s'adapter aux nouvelles conditions environnementales disparaissent, ce qui perturbe l'équilibre écologique.

Mots clés : steppe algérienne, végétation, dynamisme, dégradation.

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INTRODUCTION

The increasing activity of man and his livestock on the vegetation cover of the high steppe plains in Algeria has long since led to the widespread degradation of all the elements of their ecosystems: flora, fauna and their ecological habitats, often described by various authors as an extension of the phenomenon of desertification (**Aidoud et al., 2006; Bedrani & Nedjraoui, 2008**).

Desertification in dry and semi-dry areas is a worldwide environmental issue. The somewhat permanent loss of plant life is causing new desert areas to grow, characterized by rocky plains, stony plateaus, and sand dunes. (**Le Houerou, 1968**). This phenomenon, caused by climate change and human actions, results in the destruction of habitats, recognized as one of the main factors contributing to the decline in

biodiversity. (**Heidebrecht K. B. & Asner, 2005; Taibaoui et al., 2024; Taibaoui, 2008; Taibaoui et al., 2020**)

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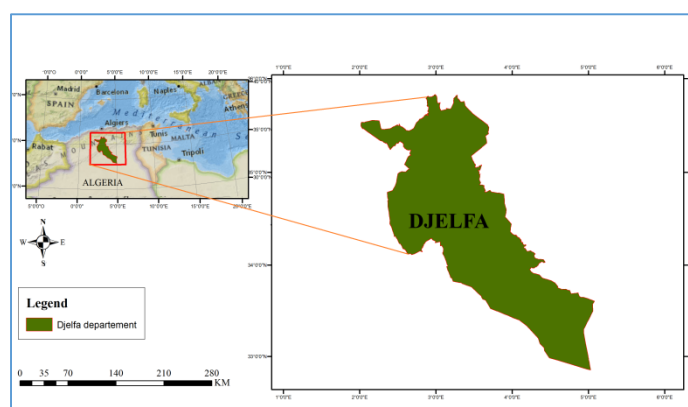
MATERIAL AND METHODS

1. Study area

Our study area is an integral part of the

Algerian high steppe plains. It is located in the wilaya of Djelfa, in central Algeria (Figure 1).

Figure 1: Study area: Djelfa Departement



Based on the climatic data (Table 1), the Emberger's climagram, places our study area in the arid bioclimatic stage, a variant with cool-

winter (Figure 2), and an average annual rainfall of around 243.6 mm.

Table 1 : bioclimatic data

M (C°)	m (C°)	P (mm)	Q2
35.4	1.96	243.6	25

Where:

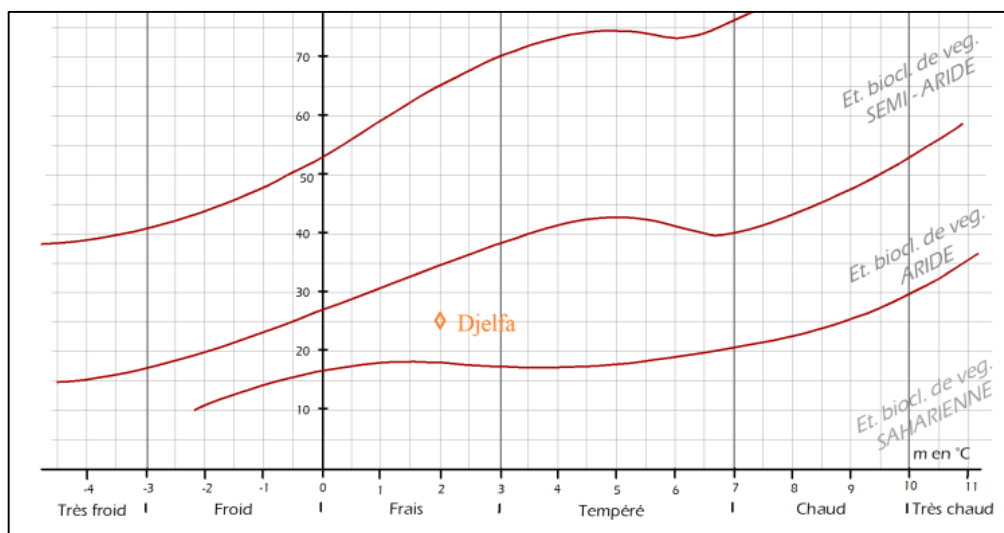
M: Mean temperature of the hottest month

P: Total annual precipitation

m: Mean temperature of the coldest month

Q2: Emberger's pluviothermic quotient

Figure 2 : Bioclimat of our study area



Our study area is characterized by the following ecological features: a geomorphology divided into three main topographic categories: high areas, nearly flat regions, and low-lying zones (Le Houerou, 1968; Taibaoui, 2008; Djebaili, 1978; Pouget, 1980; Taibaoui, 2022), which link to one another: The highest glazes, connected to the Early Quaternary, correspond to the elevated surface of Moulouyan. Another set of glazes, tied to the Middle Quaternary, is primarily characterised by grassland steppe dominated by Alfa (*Stipa tenacissima* L.) and chamaephytic steppes such as white wormwood (*Artemisia herba-alba* Asso), and Recent formations, consisting of

alluvial or colluvial materials, are located in Oueds channels and moist areas, where limestone buildup is considerably less prominent. In the elevated steppe plains of our study area, poorly developed soils, lacking nutrients and organic content. They tend to be thin (shallow), and their spread is closely tied to the existing geomorphological features. These traits complicate agriculture and restrict biodiversity, resulting in an increase of plant species suited to these challenging arid and semi-arid habitats in the area (Djebaili, 1978; Pouget, 1980). We conducted a typology of the vegetation using two multivariate statistical methods:

2. Typology of the vegetation

2.1. Correspondence Factor Analysis

The first method is Correspondence Factor Analysis (CFA), applied to highlight the phytoecological relationships between different plant communities and the main ecological factors that determine their individualization. This approach also allows our study to be comparable to previous studies that used CFA to examine the vegetation of steppe environments (Celles, 1975; Djebaili, 1978; Aidoud, 1984, Kadi Hanifi, 1998). To achieve this, we used SPSS software version 20.0 in conjunction with Excel 2010 to carry out various statistical analyses. We implemented Correspondence Factor Analysis (CFA) on a table containing 50 floristic surveys and 170 species, each assigned a coefficient according to the Braun-Blanquet (1932) scale, representing its Abundance-

Dominance in the surveys conducted in our study area.

To do this, we applied CFA to a table comprising 50 floristic surveys and 170 species, each assigned a coefficient according to Braun-Blanquet's (Braun-Blanquet, 1932) scale, representing its Abundance-Dominance in the surveys conducted in our study area.

2.2. Hierarchical ascending classification

The hierarchical ascending classification (HAC) method is recommended by Roux *et al.* (1967) as an addition to correspondence analysis (CFA) (Lerman I.C., 1977; Meddour, 2011; Vachon *et al.*, 2005). It is carried out according to Ward's technique, which is considered the most appropriate by many researchers (Vachon *et al.*, 2005; Labatte, 2010).

RESULTS AND DISCUSSION

1. Factorial Correspondence Analysis

The results of the factorial correspondence analysis, as shown in Table 2, indicate that the first three axes contribute to over 41.5% of the total inertia. This threshold is considered appropriate for analyzing phytoecological results in the context of similar studies. The dominant axis stands out due to its contribution to inertia, reaching 22.20%, making it the most relevant axis compared to the other axes (2, 3, 4, and 5), which show contributions of 11.29%, 7.98%, 5.25%, and 4.36%, respectively. These values highlight the relative importance of each axis in the

interpretation of the data, thereby providing essential insights for research in this field.

The evaluation of the contribution of the factorial axes to the total inertia, as presented in Table 2, reveals that the first three axes combined account for more than 41.5%. This threshold is deemed adequate to allow for a relevant interpretation of the phytoecological results in this type of analysis. Indeed, the first axis stands out with the highest share of inertia, reaching 22.20%, positioning it as the most influential axis compared to the others (axes 2, 3, 4, and 5), which show inertias of 11.29%, 7.98%, 5.25%, and 4.36% respectively.

Table 2: Cumulative inertia rates for the first 05 factors

Axes	Eigen values (%)	Inertia rates
Axis 1	22.2	0.027
Axis 2	11.29	0.014
Axis 3	7.98	0.01
Axis 4	5.25	0.006
Axis 5	4.36	0.05

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The analysis of the three factorial axes in the 1-2 and 1-3 planes (Figure 3, Figure 4) allowed for the identification of five similar vegetation units, based on their contributions and positions on the factorial axes

Figure 3: Correspondence factor analysis (factorial plan 1-2)

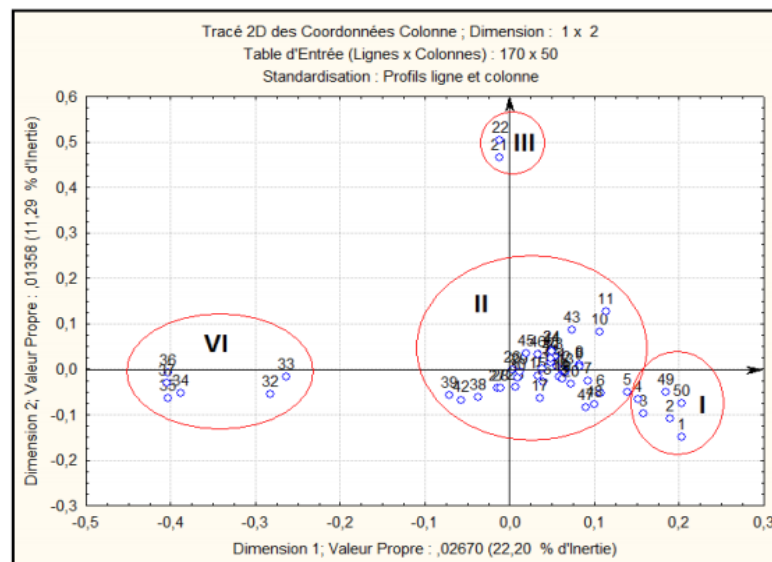
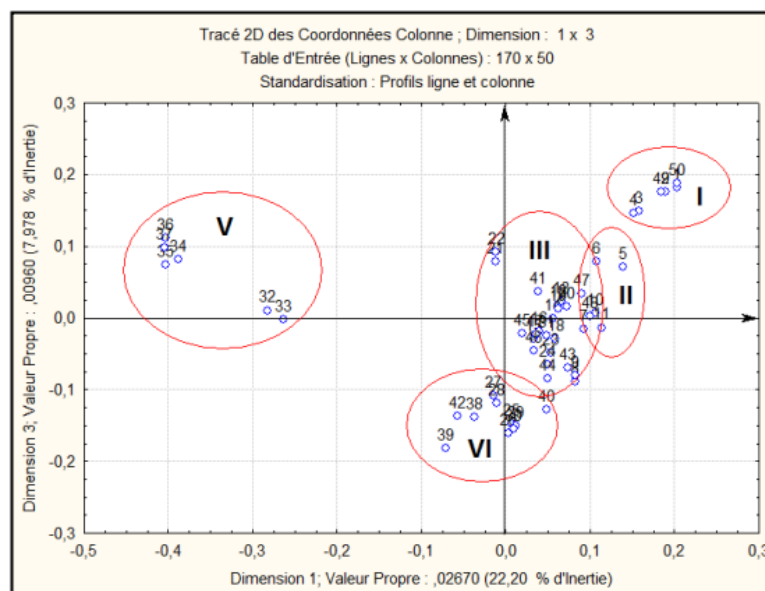


Figure 4: Correspondence factor analysis (factorial plan 1-3)



Factorial axis 3 contrasts two distinct plant groups. Its negative part groups the surveys conducted in the southern pre-Saharan region, characterized by vegetation units dominated by species such as *Astragalus armatus* Willd., *Arthrophytum scoparium* (Pomel) Iljin., and *Thymeleae microphylla* Coss. & Durieu. In contrast, the positive part of this axis encompasses three plant ensembles: forest, pre-forest, and steppe formations. These types of vegetation, although interconnected, are respectively distributed across the northern and central areas of our study zone

2. Analysis of Vegetation Formations in our Study Area

Axis 1 could represent a climatic gradient related to an increase in altitude and latitude when moving from south to north (Figure 3). In contrast, the second axis is distinguished by its opposition to Vegetation Ensemble III, observed in a controlled environment (surveys 21 and 22). Unlike Vegetation Ensembles I, II, and IV, which are subjected to free grazing, this suggests that this axis may be influenced by human activities.

In Plan 1-3, we identify five vegetation ensembles that reflect the various formations

present in our study area: forest, matorral, alfa steppe, degraded steppe, and pre-Saharan steppe.

Axis 03 highlights four vegetation groupings that are organized progressively, moving from the positive side to the negative side (Figure 4). These groupings include forest formations, pre-forest areas (matorral), alfa steppe, and degraded steppe. This axis could be considered an indicator of degradation, reflecting a regressive dynamic of vegetation cover in our study area. It illustrates the transition from forest and pre-forest formations to declining steppe formations.

3. Hierarchical Ascending Classification

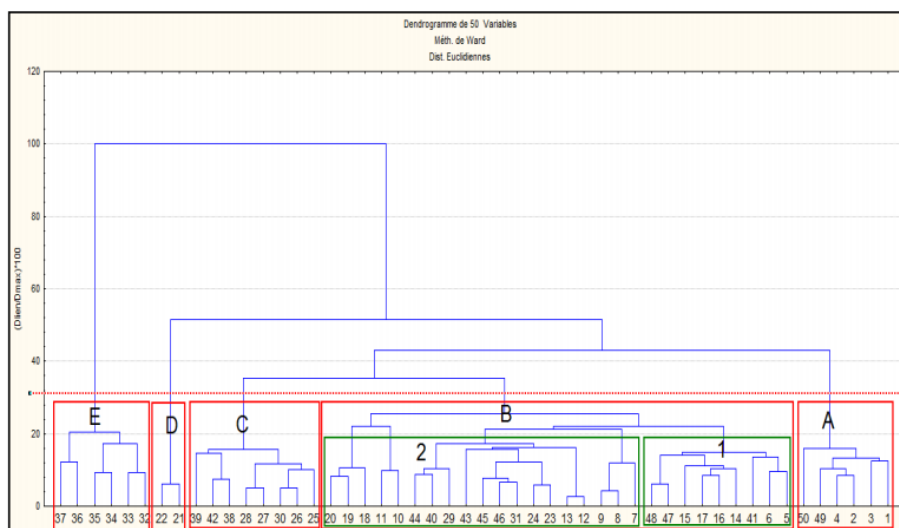
As part of the complementary analysis to the Correspondence Factor Analysis (CFA), Hierarchical Ascending Classification (HAC) is used to segment a set according to defined criteria (Ampapour, 2003).

By making a cut at the upper level (Figure 5), we identify two distinct classes that correspond to the two sets of plants. The first class, located on the left, represents the pre-Saharan steppe, while the second, on the right, groups several subsets composed of different classes, derived from the forest formation

dominated in the Saharan Atlas by the Aleppo pine (*Pinus halepensis* Mill.) and the holm oak

(*Quercus ilex* L.) (Le Houerou, 1969; Celles, 1975; Djebaili, 1978; Aidoud, 1984).

Figure 5: Hierarchical Ascending Classification



Class A: This category encompasses all data that illustrate forest ecosystems.

Class B: This category can be subdivided into several subclasses, which are primarily organized into two major categories: pre-forest vegetation formations (matoral) and steppe-type formations [7].

Class C: It represents the entirety of observations related to the degraded steppe formation located in the pre-Saharan region.

Class D: This category includes all observations that pertain to the protected steppe formation, meaning it is under control. Observations R21 and R22 are representative examples.

Class E: It encompasses all observations that correspond to the steppe formation in the pre-Saharan region.

By making a cut at a lower level (Figure 5), we arrive at a partition that allows us to identify five distinct classes (Table 3).

Table 3: The five vegetation units

Vegetation units	Vegetation formation	State of the formation vegetation	Dominant species
A	Forestry formations	Open forest	<i>Pinus halepensis</i> Mill. , <i>Juniperus phoenicea</i> L. & <i>Stipa tenacissima</i> L.
	Pre-forest formations	Matorral	<i>Juniperus phoenicea</i> & <i>Stipa tenacissima</i> L.
B	Open steppe formations	Open steppe	<i>Stipa tenacissima</i> L., <i>Stipa parviflora</i> Desf., <i>Noaea mucronata</i> (Forssk.) Asch. & Schweinf.
C	Pre-Saharan steppe formations	Pre-Saharan steppe	<i>Astragalus armatus</i> Willd. & <i>Bromus rubens</i> L.
D	Open Steppe formations	Protected steppe	<i>Stipa tenacissima</i> & <i>Stipa parviflora</i> Desf.
E	Degraded pre-Saharan steppe formations	Degraded pre-Saharan steppe	<i>Astragalus armatus</i> Willd. , <i>Arthrophytum scoparium</i> (Pomel) Iljin. & <i>Thymeleae microphylla</i> Coss. & Durieu.

4. Floristic and Ecological

The statistical analyses carried out in our study area produced significant results. We identified a total of five plant communities, representing the different evolutionary phases of a specific series of vegetation degradation, Namely that of the *Pinus halepensis* Mill. Open forest, under the combined climatic influence

accentuated by negative anthropic action. These are forest formations, pre-forest formations (Matorral), degraded Alfa grassland steppe and pre-Saharan steppe with their degradation facies (Le Houerou, 1977; Djebaili S., 1984, Pouget M., 1980, Le Houerou H.N., 1995; Taibaoui et al., 2020; Taibaoui al., 2024; Taibaoui, 2022).

CONCLUSIONS

The steppe ecosystems in our research area, known for their grassy plants and dry climate, are especially at risk from desertification. This process, often exacerbated by human activities such as overgrazing and deforestation, leads to soil degradation and habitat loss. Consequently, some plant species, plant species, unable to adapt to the new environmental conditions, disappear, altering the ecological balance, and the spread of other species such as: *Arthrophytum scoparium* (Pomel) Iljin., *Astragalus*

armatus Willd. and *Thymelaea microphylla* Coss. & Durieu. , often emerge as dominant in these new plant groups, showing the resilience and adaptability of certain species to environmental changes.

This transformation in plant composition disrupts local food chains. Reduced plant diversity can also influence interactions between species, leading to a breakdown in local food webs. The loss of plant diversity can also have harmful consequences for wildlife, which

depends on these plants for food and reproduction.

Desertification has a profound influence on biodiversity by modifying ecosystems, and transforming community composition as this phenomenon progresses, plant communities change, often resulting in the predominance of a

reduced number of species of low ecological and economic value, and a drop in overall diversity.

It is therefore essential to understand the mechanisms underlying desertification and its impact on biodiversity in order to develop effective conservation strategies to preserve these precious steppe ecosystems

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