Ecological Restoration and Floristic Diversity of Steppe Vegetation in El Bayadh Province, Algeria

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Abstract

This investigation focuses on the floristic composition of steppe vegetation formations in El Bayadh province, situated in the western part of Algeria. Our analysis of floristic diversity uncovered 194 taxa distributed across 37 families and 133 genera. Predominant families encompass Asteraceae (59 species), Brassicaceae (20 species), Poaceae (20 species), and Amaranthaceae (13 species). Identification of 15 regional endemic species further highlights the unique biodiversity of the area. Approximately 7% of the studied flora is deemed rare, with 9 species listed on Algeria's register of protected non-cultivated plant species. Examination of biological types reveals the prevalence of annual Therophytes (41%) within the flora. The Perturbation Index (PI) measures around 57%, this confirms the presence of the phenomenon of Therophytization. The results of the comparison between the study stations confirm the positive impact of ecological restoration, such as the techniques of exclosure and forage planting, on floral richness compared to the open grazing station.

Keywords: Endemic, Rarity, Threatened, Steppe, El Bayadh, Algeria

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Introduction

The Mediterranean region stands out for its extraordinary biological diversity, harboring approximately 25,000 vascular plant species, constituting 9.2% of total species diversity within a territory representing merely 1.5% of the terrestrial surface (Médail & Quézel, 1997; Myers, 1988, 1990; Mittermeier et al., 2004). Algeria, owing to its geographical position, encompasses diverse

habitats supporting substantial floral richness (Médail & Quézel, 1997; Véla & Benhouhou, 2007 in Miara et al., 2018).

Several regions in Algeria, classified as biodiversity hotspots (Véla, E. & Benhouhou, S., 2007), remain insufficiently explored. This includes areas within the biogeographic hinge between the Tellian Atlas, the high steppe plains, and the Saharan Atlas, which have been overlooked or forgotten in recent floral inventories (Yahi et al., 2012). In biogeographic transition zones, fluctuations in ecological conditions and habitat heterogeneity play a crucial role in determining floristic richness and genetic diversity (Amirouche et al., 2009).

Prior to establishing any conservation plan—whether for protected areas, species or ecosystem-focused actions, economic considerations, or natural resource management—fundamental knowledge must be generated. This encompasses species inventory, taxonomic and genetic diversity, abundance, traits and functions, ecology, and geographical distribution (Boitani et al., 2011; Cardoso et al., 2011; Crandall et al., 2000; Diniz-Filho et al., 2013; Tamura et al., 2012). Developing a national strategy for conservation and resource development necessitates an in-depth understanding of the flora to effectively guide managerial efforts (Chemli, 1997).

The objective of our study is to characterize the floristic composition of vegetation in the El Bayadh province, analyzing its biological and chorological types. Our focus extends to endemic, endangered, and rare species within the region. This investigation underscores the significance of incorporating ecological restoration techniques for the conservation of floral diversity in the area.

Materials And Methods

Study area

El Bayadh province, situated in the western part of Algeria at coordinates 33° 40′ 49 N and 1° 01′ 13 E, encompasses an area of 71 697 km2, constituting 3% of the national territory. This region is subdivided into eight administrative districts (daïras), housing twenty-two communes (Figure 01). El Bayadh shares borders:

To the north, with Saïda and Tiaret

To the east and southeast, with Laghouat, Ghardaïa, and Adrar

To the west and southwest, with Sidi Bel Abbès, Naâma, and Béchar.

The geographic landscape of El Bayadh comprises three distinct regions: the high steppe plains in the north, the Saharan Atlas, and the Saharan platform in the south. The region experiences irregular precipitation, fluctuating between 200 and 300 mm annually, often accompanied by prolonged periods of drought. Temperature variations are pronounced, with an average winter temperature of 6 °C and a peak summer temperature of 36 °C.

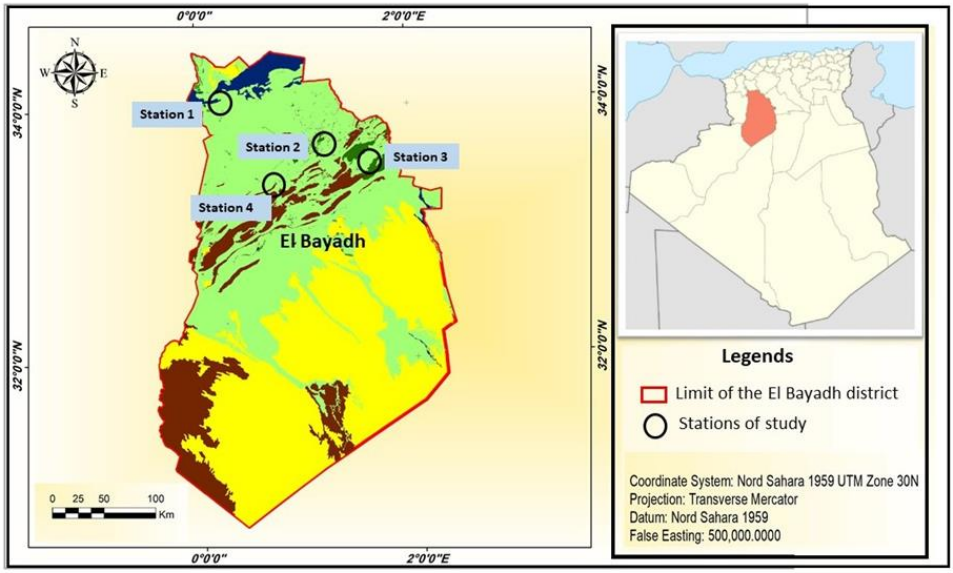

Figure 1. Geographical location of the study area

Sampling

The flora inventory is derived from 60 floristic surveys conducted across four stations within the steppe vegetation formations of the El Bayadh region, spanning the years 2022-2023, during the spring season (March to May). This timeframe is deemed optimal, often marked by antecedent rainfall, facilitating the emergence of annual plants.

The sampling approach adopted for vegetation analysis is subjective, involving the selection of areas deemed homogeneous and representative (Gounot, 1969). At each station, fifteen floristic samples were collected from a 100 m2 area, a surface identified by Djebaili (1984) as the minimum necessary to ensure a representative sample of characteristic flora in Algerian steppe regions. The studied stations encompass the following formations:

Station 1: Located near the Bougtob commune, designated as a Protected Area, by the exclosure technique, featuring formations of Artemisia herba-alba Asso and Retama raetam (Forssk.) Webb.

Station 2: Positioned in the Stitten commune and designated as a protected area by the exclosure technique, comprising formations of Stipa tenacissima L. and Lygeum spartum L.

Station 3: Situated near the Boualem commune, an open grazing characterized by degraded plant formations.

Station 4: Found in the Aïn El Orak commune, distinguished by the plantation of Atriplex canescens (Pursh) Nutt.

Table 1. GPS coordinates of the 4 stations of study

Stations	Longitude	Latitude
Station 1 (Bougtob)	0.14	33.92
Station 2 (Stitten)	1.19	33.88
Station 3 (Boualem)	1.54	33.68
Station 4 (Aïn El Orak)	0.74	33.42

The identified flora underwent classification using the New Flora of Algeria and Southern Desert Regions by Quézel and Santa (1962-1963), and Ozenda (1977), along with reference to the Protection of the Flora. Species classified as quite rare, rare, and extremely rare were documented following the criteria outlined by Zeraia (1983).

Biological types were determined in alignment with the classifications of Quézel and Santa (1962), Dahmani (1997), and supplemented by our field observations.

The species chorology was defined according to Dobignard & Chatelain (2010-13). Chorological types have been grouped according to Benabadji et al. (2007) which comprises the following groupings:

1) Mediterranean species (East-Mediterranean, West-Mediterranean, Center Mediterranean, Ibero-Mauritanian).

2) Widely distributed species (Cosmopolitan, Euro-Mediterranean, Atlantic-Mediterranean, Eurasian-Mediterranean, Irano-Touranian,),

3) Nordic species (European, Paleo-temperate, Boreals-circum, Eurasians and Paleo sub-tropical),

4) Saharan species

5) Endemic species. The nomenclature of the identified taxa was updated using the synonymic index of North Africa (Dobignard & Chatelain, 2010-13).

Species with special status were identified, in part, based on the list of non-cultivated, protected plant species in Algeria (Executive Decree No. 12-03, January 4, 2012).

The Perturbation Index (PI), calculated to quantify the therophytisation of the environment (Loisel et al., 1993), is expressed by the formula:

$$PI = \frac{(Number\ of\ Chamaephytes + Number\ of\ Therophytes) \times 100}{Total\ number\ of\ species}$$

Floristic diversity, along with the presence of endemic, rare, and threatened species, was compared among the studied stations (Exclosure. Open grazing, Forage planting)

Results and Discussion

1. Taxonomic Diversity

In total, we recorded 194 species across 37 botanical families and 133 genera. Notable families include Asteraceae (59 species), Brassicaceae (20 species), Poaceae (20 species), and Amaranthaceae (13 species), with the distribution outlined in Figure 2. Asteraceae emerges as the most dominant family in the study area, aligning with its prevalence in the broader Algerian flora (Quézel and Santa 1962-1963), characterized by adaptations to extreme drought conditions.

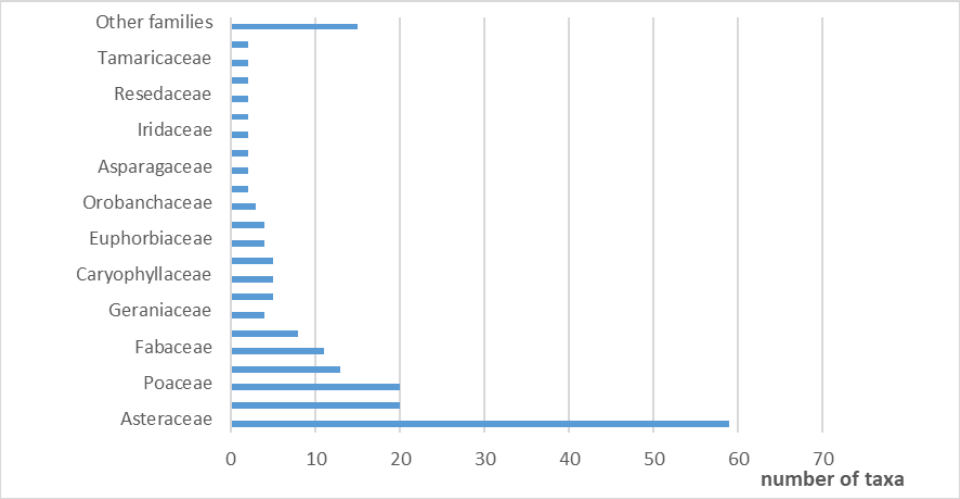

Figure 2. Distribution of plant species by families.

2. Biological Spectrum

We adopted biological types defined according to the Raunkiaer classification (1934) modified by Lebrun (1947). The biological type of each taxon is represented by the following abbreviations: Ph (Phanerophyte), Ch (Chamaephyte), Hem (Hemicryptophyte), Ge (Geophyte), Th (Therophyte).

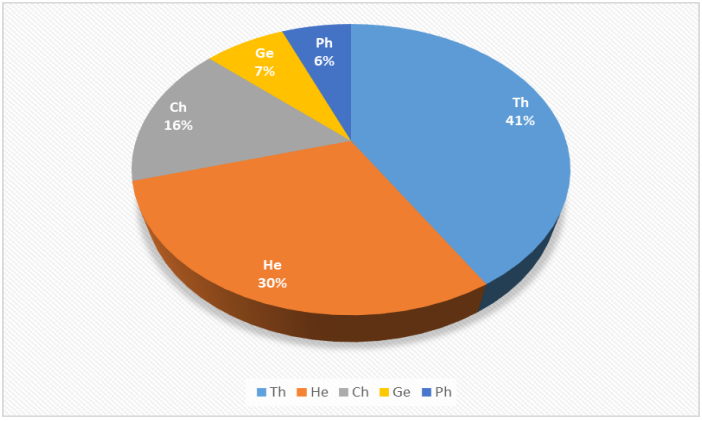

Figure 3.Biological types (Number of taxa).

Biological types reveal that the flora of El Bayadh primarily consists of therophytes, comprising 41% of the inventory with 80 species. Hemicryptophytes follow closely with 30% (57 species), chamaephytes with 16% (31 species), geophytes with 7% (14 species), and phanerophytes with 6% (12 species). The increased therophyte percentage is linked to overgrazing, as suggested by Meddour (2012), while the abundance of annual species is generally associated with clearing activities (Siab-Farsi et al., 2016).

3. Perturbation Index (PI)

For our study area, the perturbation index is approximately 57%, This confirms the presence of the phenomenon of Therophytization in these regions by the dominance of Therophytes annual species more or less needing water resources, trophic and the opening areas (Regagba, 2012). indicating significant degradation of plant formations due to human activities, notably deforestation, overgrazing, and urbanization. Barbero et al. (1989) emphasize that disturbances caused by humans and their herds contribute to increasingly severe situations.

4. Chorological Types

Different chorological types are represented as follows:

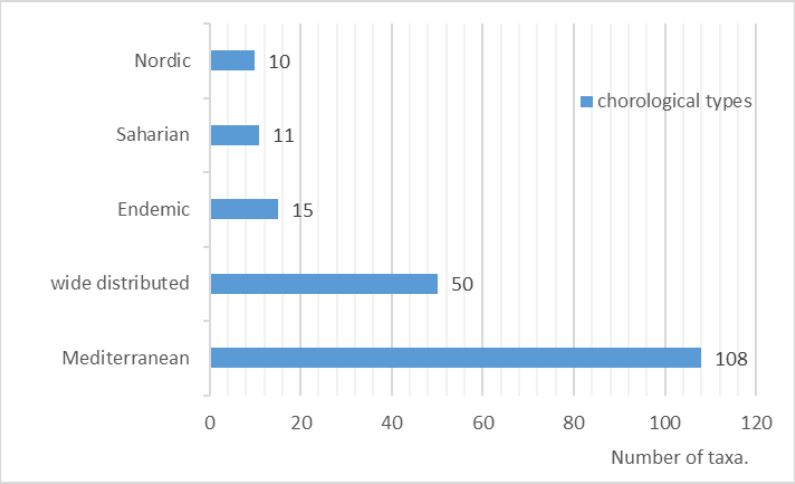

Figure 4. Chorological types (Number of taxa).

Figure 4 shows the predominance of species with a Mediterranean biogeographic type at 55.5% (108 species), followed by wide distributed species at 26% (50 species), and endemic species (North African and Algeria-Morocco, strictly Algerian) at 8% or 15 species. Additionally, there is a notable presence of Saharan type species, accounting for 5.5% (11 species), and finally the Nordic element 5% (10 species), emphasizing the diversity and richness of the region.

5. Endemism

The results reveal the presence of 15 endemic taxa in the studied region (Table 2).

Table 2. List of endemic plants

Endemic species	familie	Chorology(Q.S)	Locality
Stoibrax pomelianum (Maire) B. L. Burtt	Apiaceae	End. Alg. -Mar.	S 2
Cirsium dyris Jahand. & Maire.	Asteraceae	End. Alg. -Mar.	S1,S2,S4
Crepis vesicaria L	Asteraceae	End. Alg. -Mar.	S1,S4
Onopordum algeriense (Munby) Pomel	Asteraceae	End Alg	S2
Picris albida Ball.	Asteraceae	End. Alg. -Mar.	S1
Enarthrocarpus clavatus Delile ex Godr.	Brassicaceae	End. North Afr	S2
Muricaria prostrata (Desf.) Desv.	Brassicaceae	End. North Afr	S2
Astragalus armatus Willd. subsp. armatus.	Fabaceae	End. North Afr	S1,S2,S4
Astragalus gombo Bunge..	Fabaceae	End. North Afr	S4
Crotalaria saharae Coss.	Fabaceae	End. North Afr	S1
Iris tingitana Boiss. & Reut.	Iridaceae.	End. Alg. -Mar.	S2,S4
Maropsis deserti (de Noé) Pomel .	Lamiaceae.	End. North Afr	S1,S4
Rosmarinus eriocalyx Jord. & Fourr	Lamiaceae.	End,Alg-mar-lip	S2
Cistanche lutea (Desf.) Hoffmanns. & Link	Orobanchaceae .	End. North Afr	S2
Thymelaea microphylla Coss. & Durieu ex Meisn	Thymelaeaceae	End. North Afr	S4

End: Endemic.North Afr: North Africa.Alg: Algeria.Mar: Morocco.Lib: Libya

(Q.S): Chorology according to Quézel & Santa (1962)

D-CH (2010–2013): Revised chorology according to Dobignard & Chatelain (2010–2013).

6. The Rarity: The analysis reveals that approximately 7% of the studied flora is classified as rare, distributed as follows (Table 2):

Table 03.List of rare plants.

Rare species	Rarity	Locality
Bassia muricata (L.) Asch.	AR	S2
Carthamus pinnatus Def	R	S4
Centaura melitensis L	AR	S2
Launaea nudicaulis (L.) Hook. f.	R	S1,S4
Onopordum acanthium L.	RR	S1,S2,S4
Echium humile subsp. pycnanthum (Pomel) Greuter & Burdet	R	S2
Eruca vesicaria (L.) Cav.	AR	S2
Lepidium draba L.	AR	S1
Astragalus armatus Willd. subsp. armatus.	RR	S1.S2,S4
Erodium cicutarium (L.) L'Hér.	AR	S4
Rosmarinus eriocalyx Jord. & Fourr	R	S2
Reseda phyteuma L	R	S1
Tamarix gallica L	AR	S4
Stipa parviflora Desf,	AR	S2

AR: Fairly rare. **R:** Rare. **RR:** Very rare.

7. Threatened Plants

From the recorded taxa in the studied province, 9 are considered protected species, listed in the Algerian register of non-cultivated plant species protected by Executive Decree No. 12-03 of January 4, 2012.

Table 04. List of protected plants in Algeria

Protect species	Locality
Catananche caerulea L	S1
Cotula anthemoides L.	S4

Crotalaria saharae Coss.	S2
Limonium virgatum (Willd.) Fourr	S4
Moricandia arvensis (L.) DC.	S2,S4
Ononis natrix L.	S4
Onopordum algeriense (Munby) Pomel	S2
Plantago crassifolia Forssk	S2
Rhaponticum acaule (L.) DC.	S2

Maropsis deserti (de Noé) Pomel .

Astragalus armatus Willd. subsp. armatus.

Enarthrocarpus clavatus Delile ex Godr.

Figure 5. Some endemics from the El Bayadh region (Photo:Chelali .A).

Bassia muricata (L.) Asch

Echium humile subsp. pycnanthum (Pomel) Greuter & Burdet

Figure 6. Some rare species from the El Bayadh region (Photo:Chelali .A).

Moricandia arvensis (L.) DC.

Rhaponticum acaule (L.) DC.

Figure 7. Some Protect species from the El Bayadh region (Photo:Chelali .A).

8. Effect of techniques the exclosure and forage planting on floristic diversity

Comparison of floristic diversity and the presence of endemic, rare, and threatened species among the studied stations yields the following results (Table 05):

Table 05. Distribution of floristic diversity in the studied stations.

Number of species	Station 1 (Exclosure)	Station 2 (Exclosure)	Station 3 (Open Grazing)	Station 4 (Forage planting)
Total number of Species	71	86	27	65
Endemic species	6	9	1	7
Rare species	5	8	0	6
Threatened Plants	1	5	0	4

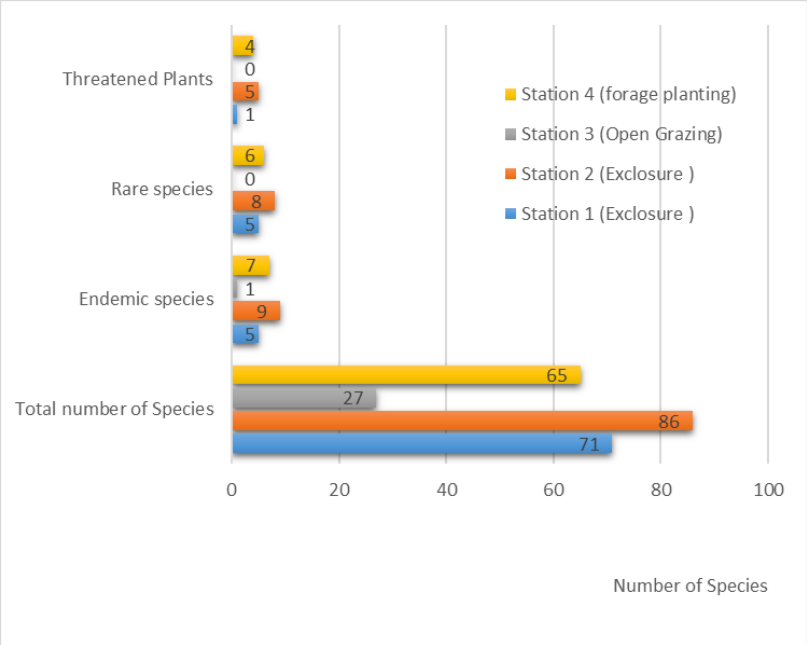

Figure 8. Distribution of floristic diversity.

These stations exhibit varying numbers of recorded species, with Station 2 having the highest (86), followed by Station 1 (71), Station 4 (65), and Station 3 recording the lowest (27). Notably, Station 3 lacks any rare species, with only one endemic species compared to the other stations, emphasizing the positive impact of protection and planting projects on steppe regions' floristic diversity and richness.

Several studies have substantiated the ecological advantages attributed to the exclosure method in pasture rehabilitation. Extensive research, exemplified by (Amghar et al., 2016, Bouchertit et al., 2017; Moukrim et al., 2019; Asmare and Gure, 2019).has demonstrated its capacity to markedly augment pasture quantity and quality. This is achieved through the promotion of substantial plant cover growth and the regeneration of vegetation, effects sustained for a period exceeding three

years. In accordance with observations made by Visser (2001), overgrazing practices impede the flowering and fruiting processes of palatable annuals, precipitating the disappearance and elimination of species that significantly contribute to pasture quality.

Conclusion

This study has unveiled a diverse botanical landscape in in El Bayadh province, documenting 194 species across 37 families and 133 genera. Among these, 15 endemic species were identified, underscoring the province's unique biodiversity. The presence of rare and threatened species, aligned with Algeria's list of protected plants, emphasizes the need for conservation efforts. Notably, the findings highlight a decline in floral diversity within degraded steppe regions, emphasizing the imperative role of ecological restoration techniques in safeguarding plant species, particularly the endemic and rare ones. These insights contribute to the broader discourse on sustainable conservation strategies for the unique ecosystems of El Bayadh.

References

[1] Amghar F., Langlois E., Forey E. et Margerie P.E, 2016. La mise en défens et la plantation fourragère : deux modes de restauration pour améliorer la végétation, la fertilité et l'état de la surface du sol dans les parcours arides algériens. Biotechnol. Agron. Soc. Environ. 20(3), 386-396.

[2] 2.Amirouche R. & Misset M-Th., 2009. Flore spontanée d'Algérie : Différenciation écogéographique des espèces et polyploidie. Cahiers d'Agriculture 18 : 474-480.

[3] 3.Asmare M. T. & Gure A., 2019. Effect of exclosure on woody species diversity and population structure in comparison with adjacent open grazing land: the case of Jabi Tehnan district north western Ethiopia. Ecosystem Health and Sustainability, 5:1, 98-109.

[4] 4.Barbero,M.and Quézel, P., 1989, Contribution à l'étude phytosociologique des matorrals

[5] 5.Benabadji, N., Benmansour, D. & Bouazza, M. (2007). La flore des monts d'Ain Fezza dans l'ouest Algérien, biodiversité et dynamique. Sciences & Technologie. C. Biotechnologies, 26: 47-59.

[6] 6.Boitani L, Maiorano L, Baisero D, Falcucci A, Visconti P, Rondinini C (2011) What spatial data do we need to develop global mammal conservation strategies? Philosophical Transactions of the Royal Society B: Biological Sciences 366:2623-2632

[7] 7.Boucherit, H., Benabdeli K., Benaradj A. 2017: Biological recovery the steppe of Hammada scoparia after enclosure in the region of Naama (Algeria). Ekologia (Bratislava), 36(1): 52–59.

[8] 8.Cardoso P, Borges PA, Triantis KA, Ferrández MA, Martín JL (2011) Adapting the IUCN Red List criteria for invertebrates Biological conservation 144:2432-2440

[9] 9.Chemli,R., 1997, Plantes médicinales et aromatiques de la flore de Tunisie. In: V. de Méditerranée orientale. Lazaroa 11 37–60.

[10] 10.Crandall KA, Bininda-Emonds OR, Mace GM, Wayne RK (2000) Considering evolutionary processes in conservation biology Trends in ecology & evolution 15:290-295

[11] 11.Dahmani M., 1997 - Le chêne vert en Algérie, Syntaxonomie, phytoécologie et dynamique des peuplements. Thèse de doctorat, Université H. Boumediene, Alger, 383 p.

[12] 12.Diniz-Filho JAF, Loyola RD, Raia P, Mooers AO, Bini LM (2013) Darwinian shortfalls in biodiversity conservation Trends in Ecology & Evolution 28:689-695

[13] 13.Djebaili, S. (1984). Algerian steppe, phytosociology and ecology. O.P.U. Algiers. 171p.Dobignard, A. & Chatelain, C. (2010-2013). Index synonymique de la Flore d'Afrique du Nord, V: 1-5. Genève.

[14] 14.Dobignard, A. & Chatelain, C. (2010-2013). Index synonymique de la Flore d'Afrique du Nord, V: 1-5. Genève.

[15] 15.Gounot, M. (1969). Méthode d'étude quantitative de la végétation. Masson, Paris, 308p.

[16] 16.Loisel, R. & Gamila, H. (1993). Traduction des effets de débroussaillement sur les écosystèmes forestiers et pré-forestiers par indice de perturbation. Ann. Soc. Sci. Nat. Arch. Toulon: 123-132.

[17] 17.Médail, F. & Quézel, P. (1997). Hot-spots analysis for conservation of plant biodiversity in the Mediterranean basin. Ann. Missouri Bot. Gard, 84: 112-127

[18] 18.Meddour R (2012) Bioclimatologie, phytogeographie et phytosociologie en Algerie: Exemple des groupements forestiers et preforestiers de kabylie djurdjureenne. Universite Mouloud Mammeri

[19] 19.Miara, MD., Ait Hammou, M., Dahmani, W., Negadi, M. & Djellaoui A. (2018a). Nouvelles données sur la flore endémique du sous-secteur de l'Atlas tellien Oranais "O3" (Algérie occidentale). Acta Botanica Malacitana, 43: 63-69. https://doi.org/10.24310/abm.v43i0.4453

[20] 20.Mittermeier, R.A., Robles Gil P., Hoffmann M., Pilgrim J., Brooks T., Mittermeier C.G., Lamoreux J., Da Fonseca, G.A.B. (2004). Hotspots revisited: Earth's biologically richest and most endangered terrestrial ecoregions, Preface by Peter A. Seligmann, Forewordby Harrison Ford. Cemex, Conservation International, Agrupacion Sierra Madre, Monterrey, Mexico, p. 392.

[21] 21.Moukrim S., Lahssini S., Naggar M., Lahlaoi H., Rifai N., Labbaci A., Arahou M. et Rhazi L., 2019. Compensation pour mises en défens forestières et réhabilitation des écosystèmes par l'implication de la population. Alternatives Rurales. 1-16.

[22] 22.Myers, N. (1988). Threatened biotas: Hotspots in tropical forests. Environmentalist, 8, 178-208.

[23] 23.Myers, N. (1990). The biodiversity challenge: Expandedhotspots analysis. Environmentalist, 10: 243-256.

[24] 24.Ozenda, P. (1977). Flore du Sahara (Deuxième édition revue et complétée). CNRS, Paris, 622p. Quézel, P &. Santa, S. (1962,1963). Nouvelle flore

[25] 25.Quézel,P.and Santa,S., 1962–1963, Nouvelle Flore De l'Algérie Et Des Régions Désertiques Méridionales.Tome IEtTome II (Paris: Centre national de la recherche scientifique).

[26] 26.Raunkiaer c. (1934) - The life forms of plants and statistical plant geography. Édit. Oxford. University Press, Londres (GB), XI + 632 p.

[27] 27.Regagba, Z. (2012). Dynamique des populations végétales halophytes dans la région sud-est de Tlemcen. Aspects phytoécologiques et cartographiques. Doctorate thesis. Univeristy of Tlemcen, 179p.

[28] 28.Siab-Farsi, B & Yamina, K & Khelifi, H., 2016 , La flore vasculaire du massif du Mont-Chenoua (Algérie). Revue Forestière Française. Vl 68 . 10.4267/2042/61592.

[29] 29.Tamura K, Battistuzzi FU, Billing-Ross P, Murillo O, Filipski A, Kumar S (2012) Estimating divergence times in large molecular phylogenies Proceedings of the National Academy of Sciences 109:19333-19338.

[30] 30.Véla,E.and Benhouhou,S., 2007,Evaluation, d'un nouveau point chaud de biodiversité végétale dans le bassin méditerranéen(Afrique du Nord). Comptes Rendus Biologies 330 (8), 589–605. doi: 10.1016/j.crvi.2007.04.006.

[31] 31.Visser M., 2001. Produire des semences autochtones pour réhabiliter des terres dégradées. Le cas de Stipa lagascae R. & Sch. en Tunisie présaharienne. Thèse de Doctorat, Université de Gand, Belgique.

[32] 32.Yahi,N.,Vela, E.,Benhouhou, S.,De Belair, G., and Gharzouli, R., 2012, Identifying important plants areas (key biodiversity areas for plants) in northern Algeria. Journal of Threatened Taxa 4 (8), 2753–2765. doi: 10.11609/JoTT.o2998.2753-65

[33] 33.Zeraia L (1983) Protection de la Flore, Liste et Localisation des Espèces Assez Rares, Rare et Rarissimes Station Centrale de Recherche en Ecologie Forestière, Alger.