Chapter 5

THIRTY YEARS OF ECOLOGICAL MONITORING IN ALGERIAN ARID RANGELANDS

Aziz Hirche[1,2,3], Mostefa Salamani[1,2], Boughani Abdelmadjid[1], Dalila Nedjraoui[1], Ratiba Hourizi[1], Youcef Oukil[1], Slimani Hakima[1], Zina Khedache[1], Fahima Belala[1], Tahar Ait Hamouda[1], and Nacer Adi[1]

[1]Laboratory of Vegetal Ecology, Faculty of Biological Sciences, University of Sciences and Technology Houari Boumediene (USTHB), Algiers, Algeria

[2]University of Algiers Youcef Benkhedda, Faculté centrale, Algiers, Algeria

[3]Scientific and Technical Research Center on Arid Regions, (CRSTRA), Biskra, Algeria

ABSTRACT

In 1978, several observatories were settled in the arid high plains of South west Algeria aiming ecological monitoring. These observatories are now integrated in an international network called ROSELT (Long Term Ecological Monitoring Observatories Network) administered by OSS (Observatory of the Sahara and the Sahel). A study area included in one of these observatories was monitored on more than thirty years. It is part of Algerian steppe, the most widespread of the Maghreb. The results showed that this area has undergone profound changes.

These modifications concerned both physical and biological components. The parameters considered include vegetation, flora, and soil surface properties. It appears that land cover has changed and ancient vegetation dominated by *Stipa tenacissima*, *Lygeum spartum* and *Artemisia herba alba* has disappeared. New species, like *Atractyis serratuloides*, *Salsola vermiculata* and *Noaea mucronata*, rare in 1978 are now dominant, in relation with a dynamic degradation. The largest decline is observed for *Stipa tenacissima* vegetation units constituting 2/3 of the landscape in 1978 and occupying just 1/10 in 2010. The vegetation cover has also significantly declined. In 1978, the average cover was more than 34 %, now it is less than 19%. The biodiversity has also changed. The floristic richness has decreased. In 1978, 234 species were inventoried in the study area, for 134 in 2005 and 94 in 2011. On the other side, the family composition and phytogeographical spectra have also changed, in the sens of an adaptation to xeric conditions. This can be explained by severe spells of drought combined by an exponential rise of livestock during the last 30 years. Finally, even if the last years were wetter and a slight improvement in vegetation cover was observed, there is no evidence for a desertification in reverse, as it is considered for the Sahel. On the contrary, we are still in a degradation process on the long term.

INTRODUCTION

The desertification of Algerian rangelands, mainly in arid and semi-arid lands, is a serious problem facing Algeria. The Algerian steppes are the most widespread rangeland of the North African countries. They occupy a pivotal position between the hilly and humid north, called the Tell, composing 5% of Algeria's surface, and the south formed by the Sahara covering 86% of the nation's territory. The demographic and the livestock increase, stepped up the pressure and contributed to the rangelands degradation. This trend seems to be observed not only in Algeria but in the whole Maghreb.

But, at an international level, several studies based on remote sensing data and techniques undertaken with the objective of monitoring land conditions found no evidence for extensive degradation in the Sahelian region (Helldén, 1984, 1991; Prince, Colstoun, Brown, and Kravitz, 1998; Rasmussen, Fog, and Madsen, 2001; Tucker and Nicholson, 1999). On the contrary, recent studies of the Sahelian vegetation based on remote sensing data even emphasize "the greening-up" of the Sahel (Anyamba and Tucker, 2005; Herrmann, Anyamba, and Tucker, 2005). Some authors have extended the desertification study to the whole world and have concluded that greening is now, basically, a universal trend (Helldén, 2008; Helldén and Tottrup, 2008). Recently some recent studies have temperate the previous conclusions and have showed in specific cases a regressive trend (Dardel et al., 2014; Herrmann and Tappan, 2013). At the North African area, specifically at the Maghreb, the results are globally in contradiction with these results. The aim of this study is to provide recent data related to this problematic. It aims also to give some element reflections to this issue by evaluating qualitatively and quantitatively the phenomenon of land evolution in a representative area in the Algerian steppe.

The study area covers approximately 400,000 ha and the time horizon considered is about 30 years. In 1975, the Centre de Recherches sur les Ressources Biologiques et Terrestres (CRBT) carried out a major vegetation monitoring program in the south Oran steppe producing thematic maps of the whole area. Further, permanent observation sites have been set up to collect more accurate data.

We will confront our results with those of neighboring countries. This allows providing a general overview for the North African countries and it would be interesting to carry out some comparisons with landscape changes within the Sahelian region.

Researchers of both the Sahelian and North African regions collaborate presently in the same major research project, ROSELT which constitutes an ideal framework to exchange scientific data and experiences.

1. Material and Methods

1.1. The Study Area

The study region, corresponding to El Biodh department (commune), covers an area of 374,400 hectares and is integrated in the Algeria's south-western High Plateaus. It is administered by the wilaya of Nâama (Figure 1) and the closest important city is Mecheria.

The average altitude is around 1,000 m and it is primarily occupied by the Quaternary polygenic glacis. It includes saline depressions such as the Chott Chergui. The area is surrounded by chain of mountains such as the Antar djebel which culminates at 1,700 m. This area is a part of Algerian ROSELT / OSS observatory.

The ROSELT (*Réseau d'Observatoires* de Surveillance Ecologique à Long Terme) is an international network aiming to monitor ecosystems on the long term implemented since 1994 by the observatory for the Sahara and the Sahel (OSS).

1.2. Climate

Climatic data was gathered from the National Meteorology Office and cover a long period from 1907 to 2013 (ONM, 2014). The climate is characterized by low annual rainfall with averages ranging from 264.21 mm in Mecheria the closest climatic station to 292.34 mm in El Bayadh. Since 1972, the rainfall has decreased and it is observed 229.15 mm in Mecheria to 270.43 mm in El Bayadh (a mountainous area surrounding the north-east). The distribution of rainfall is very irregular. The coefficient of variation reached 36.38% in Mecheria and 34.57% in El Bayadh. Winters are cold and harsh while summers are hot and dry. To illustrate the climatic context, the evolution of rainfall since the beginning of the century is graphed (Figure 2). The rainfall evolution shows an alternation of dry and humid periods with no clear trends during approximately the first half of the century.

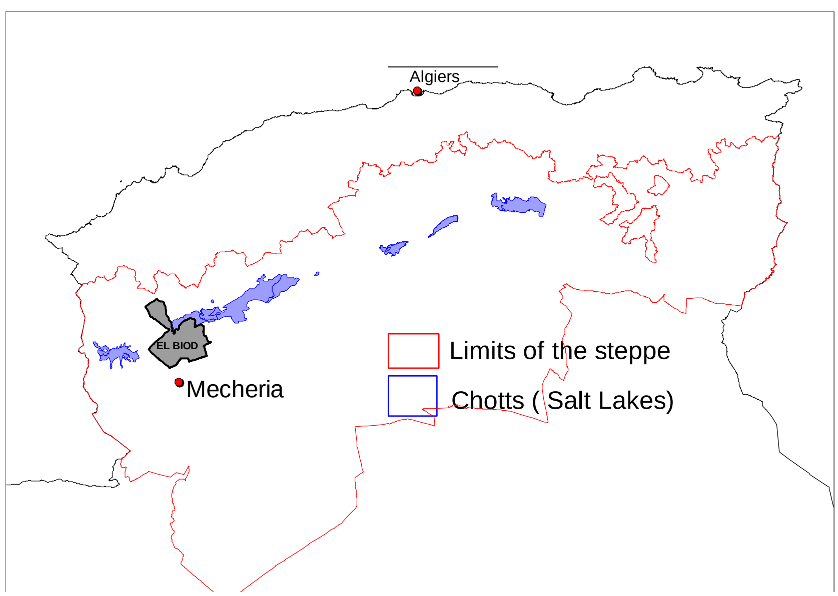

Figure 1. Location of the study area in the South west Algeria (Mecheria).

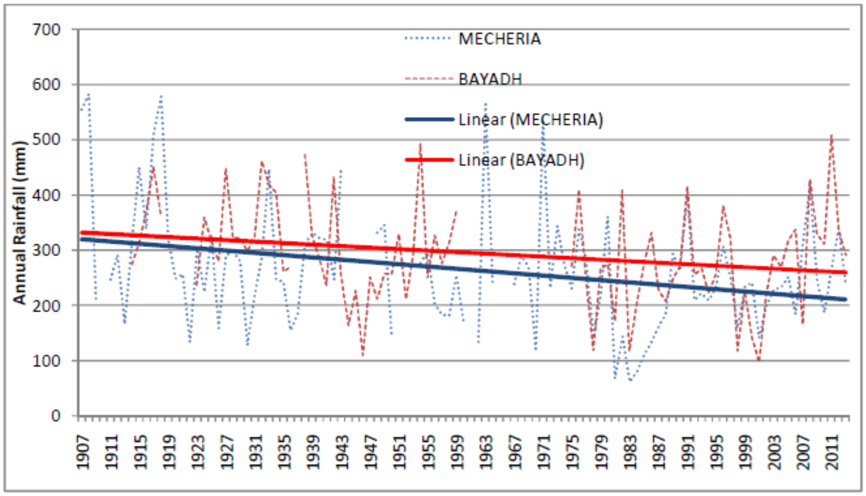

Figure 2. Annual Rainfall evolution since the beginning of the century in Mecheria and El Bayadh.

At the end of the second half, dry periods become notably more frequent and intense, especially during the 1981–1988 years (Hirche, Boughani, and Salamani, 2007) considered being the driest period of the last century. It is interesting to note that this drought period is partially the same as for the Sahel which has been affected by a notable large-scale drought during the 1983–1985 period after the first one that began in the late sixties. Since the end of the seventies, the mobile averages are almost always below the average rainfall.

Temperatures show an average minimum values for January of 1.5°C and −1.8°C for Mecheria and El Bayadh, respectively, and average maximum values of the hottest month (July) of 35.1°C and 33.5°C. For all stations, the dry period (Bagnouls and Gaussen 1953) extends over 6 months and the bioclimate belongs to the medium-arid class with cold winters variant. Dust storms are rare at El Bayadh (3 days year−1) but are more frequent in Mecheria (7.2 days year−1). According to some authors, dust storms would be much more frequent since 1990, but until now, we do not have data before 1990 (Nouaceur, 2001). For the dust days (without storm), an average of 62 dust days per year was recorded in El Bayadh between 1989 and 2013, reaching 119 days per year between 2001 and 2004, considered as a drought period.

The same trend was observed in Mecheria, where 70 days were recorded between 1989 and 2013 and 165 days were observed in 2003 (Figure 3). The increase of dust days correspond globally to a decrease in rainfall.

In any event, if these results are proven over a longer series, they would be very alarming because they are related to the magnitude of soil denudation. The weak recovery of vegetation would then give free way to winds erosion over vast areas of the Algerian steppe.

1.3. Vegetation

The survey area was studied by different works (Aidoud-Lounis, 1997; Aidoud, 1989; CRBT, 1978; Djebaili, 1990; Kadi-Hanifi Achour, 1998; Kadi-Hanifi, 2003) that described the vegetation dynamics in the steppic regions. A synthesis based upon these different studies is given in the following flowchart (Figure 4).

It appears that the Algerian steppe was initially colonized by forests and matorrals. Their gradual deterioration has led to the colonization of xerophytic vegetation consisting in a mixture of herbaceous and perennial plants. The most emblematic is the herbaceous *Stipa tenacissima*, which colonized the majority of stony flat zones, corresponding to the geomorphologic units called "glacis".

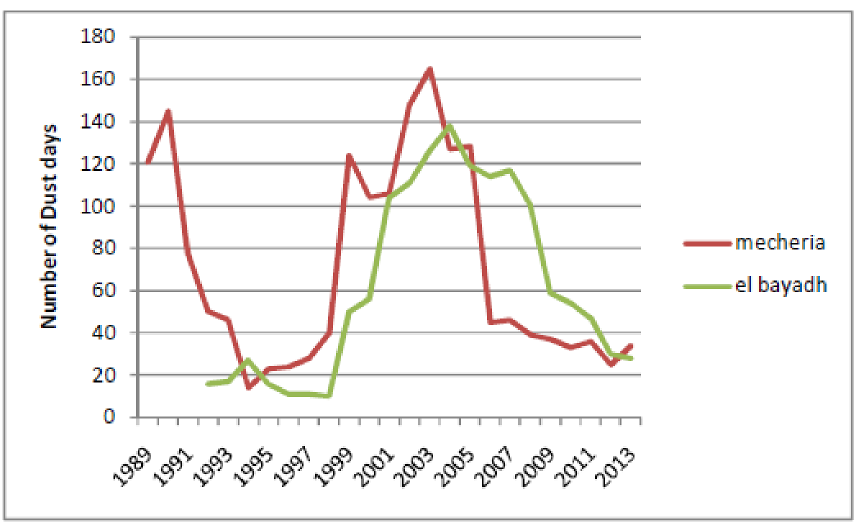

Figure 3. Evolution of the number of dust days in Mecheria and El Bayadh.

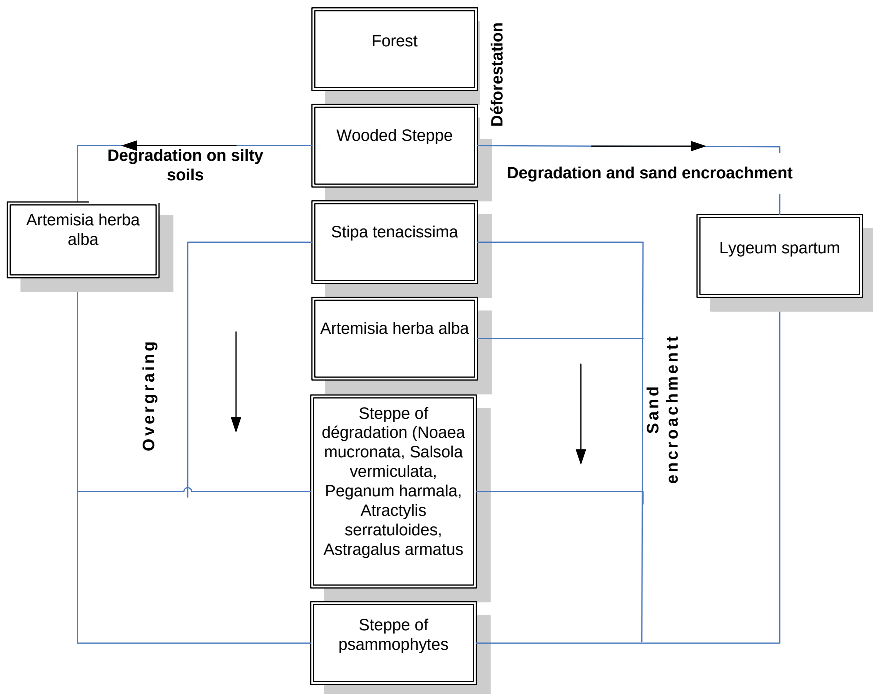

Figure 4. Main directions in the dynamic of vegetation in the study area.

Lygeum spartum, another herbaceous graminoid, appears when sand accumulates, often in depressions.

When degradation occurs, *Artemisia herba-alba*, a chamaephyt, appears on rich silt soils. These three species constituted the framework of the Algerian, and even the North African steppe.

Previous studies also showed that pressure on the environment, mainly by overgrazing, led these formations to disappear. They have been replaced by vegetation units or "formations" resulting from a dynamic degradation with less functional performances, such as *Atractylis serratuloides*, *Salsola vermiculata*, *Peganum harmala*, and *Astragalus armatus*. The conversion of arid grassland to shrublands due to overgrazing and/or drought is a well known phenomenon. Allington and Valone (2010) reviewed the main concerned models and concluded that “current conceptual models of desertification predict that arid grasslands exist in one of two alternate stable states over timescales relevant to management: perennial grasslands or desertified shrubland”. When sand accumulation becomes prominent, psammophytes such as *Thymelaea microphylla* settle.

1.4. Data Collection and Processing

The current work was divided into several stages. The first was to establish land cover maps at different dates, 1978, 2005, and 2011. These maps were realized through a photo-interpretation of Landsat images (TM Landsat) to have a product comparable in its realization to the old land cover maps (1978).

In each map, different units of vegetations were considered and were described by their physiognomic types. Theses ones are defined by the first (up to three) dominant species. Each vegetation unit is also informed by the class cover vegetation.

On the basis of these land cover maps with a temporary key legend, a sampling work was carried at each period. It was a mixture sampling in the sense of Gounot (1969).

In each vegetation unit, were carried out several phytoecological releves, describing vegetation and flora. They was accompanied by information related to the state of the ground surface (coarse elements, pebbles, gravel, sand.). Finally a definitive key legend is established.

2. Land Cover Maps

The land cover maps corresponding to each period are illustrated in the figure 5 a, b, c. The table 1 reports the main vegetation units existing in the study area, with their areas. It shows a clear contrast between 1978 and 2005. Usually, the steppe vegetation was dominated by three species. The first ones are graminaceous; the alfa (*Stipa tenacissima*) and the "sennagh" (local vernacular name) or esparto (*Lygeum spartum*). The third one, the "chich" or wormwood is chamephytic. The green, grey and the orange colors dominate the land cover map of 1978. The green color corresponds to *Stipa tenacissima*, a keystone ecological species. The orange color represent the *Artemisia herba alba* a species appreciated by the cattle. The grey color corresponds to *Lygeum spartum* a psammophyt plant which has a large capacity of recovery. In 1978, these "pseudo "climacic vegetation units, with significant vegetation covers, generally superior to 30 % regressed.

Stipa tenacissma and *Lygeum spartum* vegetation units lost 8/10 of their original area, and it reaches even 9/10 for the *Artemisia herba alba* ones. The average vegetation cover has decreased and reached only 17% on 2005 and 19% on 2011.

Table 1. Evolution of the areas of the vegetation units

Formation	1978		2005		2011	
	Ha	%	Ha	%	Ha	%
Matorral	3908,74	0,56	6849,80	0,98	6849,80	0,98
Stipa tenacissima	313445,08	44,76	46679,52	6,67	11496,93	1,64
Artemisia herb alba	8441,51	1,21	805,58	0,12		
Lygeum spartum	348097,22	49,70	55 607, 60	7,94	111960,74	15,99
Steppe of degradation		0,00	489168,97	69,85	482412,60	68,88
Salty depressions	21030,00	3,00	29609,03	4,23	27625,84	3,94
Crops	419,21	0,06	8880,67	1,27	8366,01	1,19
Psammophyts	5000,94	0,71	59851,71	8,55	48741,06	6,96
Urban			2889,25	0,41	2889,25	0,41

In the same time, new vegetation units called "steppe of degradation", issued from a dynamic degradation have appeared (Figure 4). This units are dominated by species like *Atractylis serratuloides, Peganum harmala and Salsola vermiculata.*

The table 1 also shows that the difference between 2005 and 2011 is not as important as between 1978 and 2005. No new vegetation unit does appear in the meantime. It is just observed a reshuffle in terms of area. The *Stipa tenacissima* vegetation units still decrease and lost the three quarters of their original area. *Artemisia herba alba* finally disappeared completely in 2011. Only the Lygeum spartum amongst the original vegetation, after a drastic fall of its area between 1978 and 2005, increased anew between 2005 and 2011, twice in terms of area. It is interesting to note that, in this last period, the steppe of degradation does not increase more and the vegetal canopy even slightly increases (2005-2011).

3. Evolution of the Biodiversity

Species richness was determined by counting the number of species on the basis of all floristic lists. Species richness does not constitute a reliable indicator if it is not compared and related to rainfall over a long time period.

In our study area, integrated in the ROSELT / OSS network, the established trends showed a qualitative and quantitative decline of vegetation which is also expressed by a decrease in species richness.

The total number of species shows a marked decrease between periods considered. Thus, one passes successively of 234 species in 1978 to 134 species in 2005 and 94 species in 2011. The number of species disappearing is more important for annuals than for perennial and exceeds the half of initial stock.

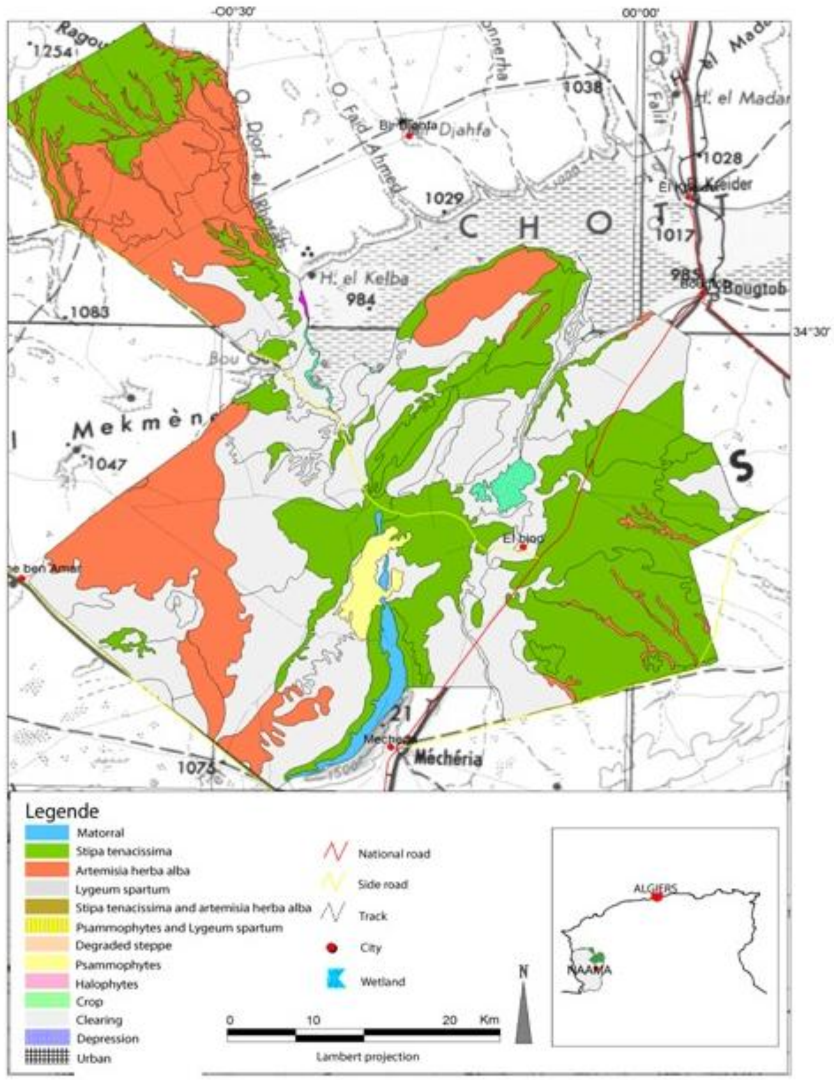

Figure 5 a. Land cover map of El Biodh (1978).

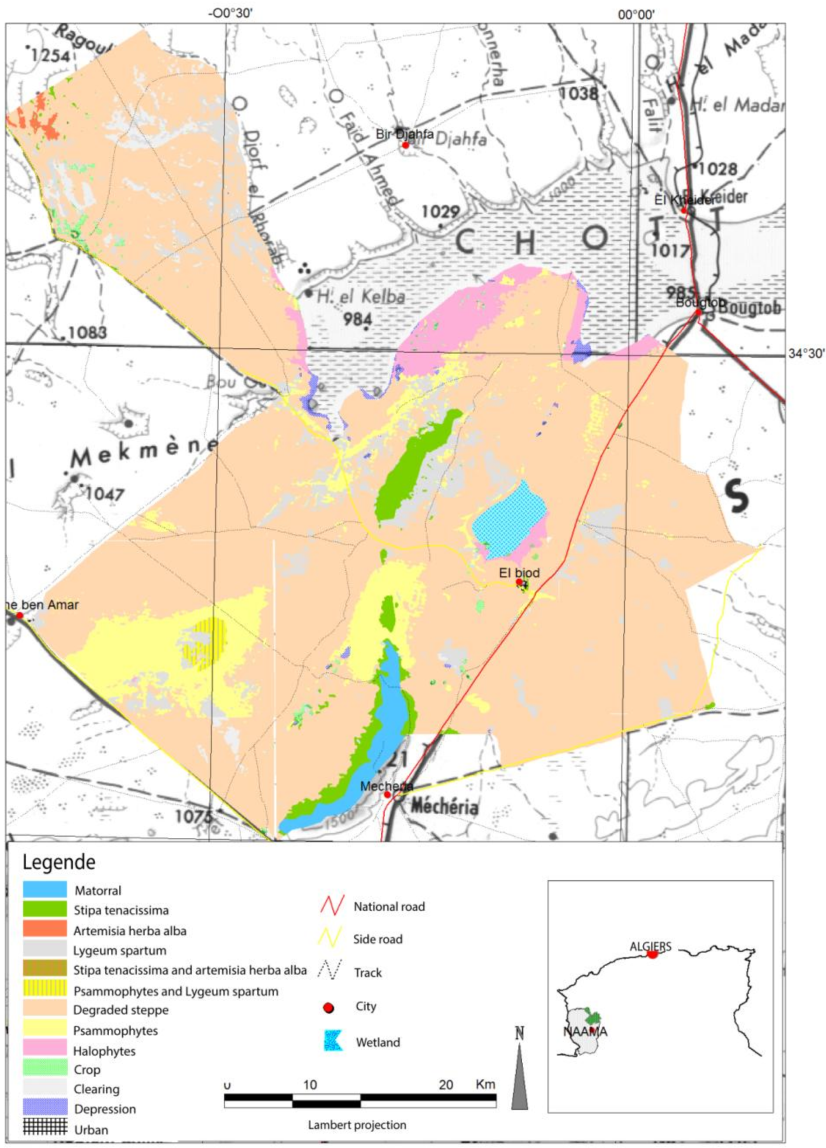

Figure 5 b. Land cover map of El Biodh (2005).

Curiously, The "therophytization", a classical trend which occurs when the desertification is more intense and which means an increase of annuals is not observed in the present study. It could be related to a decrease of seed bank in the soil.

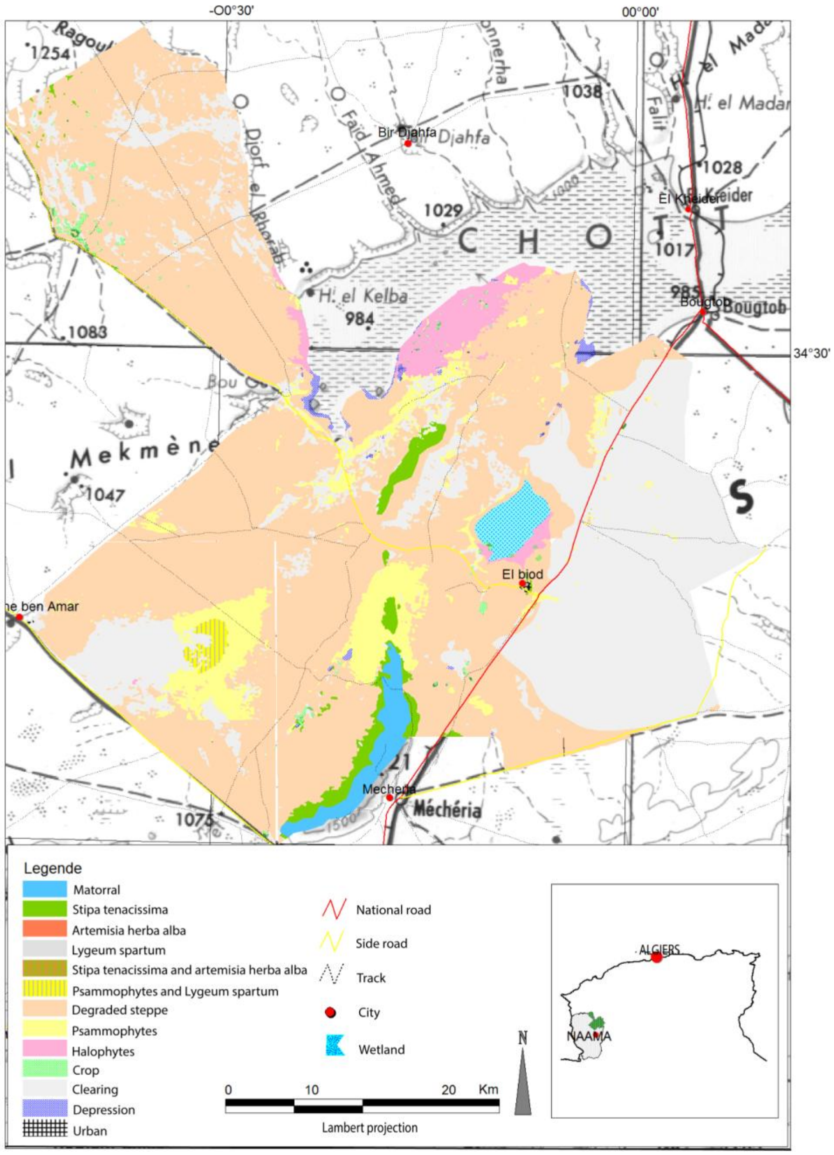

Figure 5 c. Land cover map of El Biodh (2011).

Although little studied in North Africa, the phenomenon of loss of stock in seeds in the soil is a parameter that is commonly given in the Sahel. (Hiernaux, Diarra, and de Leeuw, 1991; Hiernaux et al., 2009) and (Grouzis, 1992) showed that overgrazing tended to decrease the stock seed.

Table 2. Evolution of vegetation covers of the vegetation units

Formation	1978			2005			2011		
	Ha	VC %	VCP %	Ha	VC %	VCP %	Ha	VC %	VCP %
Matorral	3908,74			6849,80			6849,80		
Stipa tenacissima	313445,08	36		46679,52	20		11496,93	20	
Artemisia herb alba	8441,51	28		805,58	12				
Lygeum spartum	348097,22	34		55 607, 60	19		111960,74	21	
Steppe of degradation				489168,97	16		482412,60	19	
Salty depressions	21030,00	38		29609,03	26		27625,84	28	
Crops	419,21			8880,67			8366,01	15	
Psammophyts	5000,94	18		59851,71	23		48741,06		
		30.8	34.62	2889,25	19.33	17.10	2889,25	20.6	18.92

VC: Vegetation covers. VCP: Vegetation cover weighted by area.

Table 3. Comparison in evolution of perennial and annual species through the three periods

Period	1978		2005		2011		Evolution of Total (2011-78)	
	Nbr of species	%	Nbr of species	%	Nbr of species	%	Nbr of species	% diminution
Perennial	129	55,12	76	56,72	63	67,021	66	-51.11
Annual	105	44,87	58	43,28	31	32,98	74	-70.47
Total	234	100	134	100	94	100	140	-59.82

The edaphic aridity could be a second explanation since soils have undergone significant deflation and the rising of temperatures have led to a negative impact on vegetal production. It is noted significant changes in the list of observed species. Some of them are found only in the first period as: *Brachypodium distachyum, Sedum sediforme, Ziziphora hispanica and Xeranthemum inapertum*, and to a lesser extent *Androsace maxima, Bromus squarrosus and Micropus bomycinus*. These species would be indicator of a wetter climate (Aidoud-Lounis, 1997; Aïdoud, Le Floc'h, and Le Houérou, 2006; Aidoud, Slimani, and Rozé, 2010; Le Houérou, 1969). Their absence in 2005 and 2011 would testify also on the degradation of soils (Slimani et al., 2010). These species have been replaced by others indicating degradation as *Atractylis cancellata, Atractylis flava* and *Xanthium spinosum. Salsola kali* appeared only in the third period.

3.1. Evolution of Perennial and Annual Species

Monitoring the perennial species can be a better indicator than the global list of species. Indeed, perennial species are less correlated to climatic hazards as annuals. The results show a significant decrease in the number of perennial species by referring to the first period (1978). The number of perennial species shows a decrease of 53 species during the second period of observation (2005) and a cumulated number of 66 species till the third period (2011). For the total, nearly the two third of initial species has disappeared.

The changes in species composition would affect ecosystem function, but there is several hypothesis about the ecosystems respond to changes in species richness (Naeem et al. 2002). Nevertheless, it appears that keystone hypothesis is particularly relevant in this current case. A rapid decline of ecosystem functions was observed with the loss of crucial species and diversity is consequently reduced below its natural level (Walker, 1992).

The disappearance of a keystone species of the original dominant steppe, namely the alfa has deep impact on the ecosystem (Kadi-Hanifi Achour, 1998; Kadi-Hanifi, 2003; Slimani and Aidoud, 2004; Slimani, Aidoud, and Rozé, 2010). Degradation units like *Salsola vermiculata, Thymelaea microphylla and Peganum harmala* naturally show a lower efficiency in the functioning of ecosystems. They show a lower phytomass and richness than alfa vegetation even if ecological conditions are favorable (rainfall).

3.2. Evolution of the Systematic Composition

The decrease in the overall number of species through 3 periods has resulted in a change in the distribution of the types of families throughout the monitoring period. The evaluation of this change was made taking into consideration the number of species in each family (Table 4).

Figure 6 shows that there is a decrease in the number of species in several families. This reduction does not have the same importance for all of them and allows to rank them in order of importance.

The decline rate is important for three families: Poacea, Brassicaceae, Caryophyllaceae, Apiaceae and Chenopodiaceae (Amaranthaceae), especially during the third period. The diminishing of Asteraceae is real but comparatively to the previous ones, this family seems more stable in its size. It seems more "equipped" to resist to changing conditions and ecological anthropogenic pressures in these degraded environments.

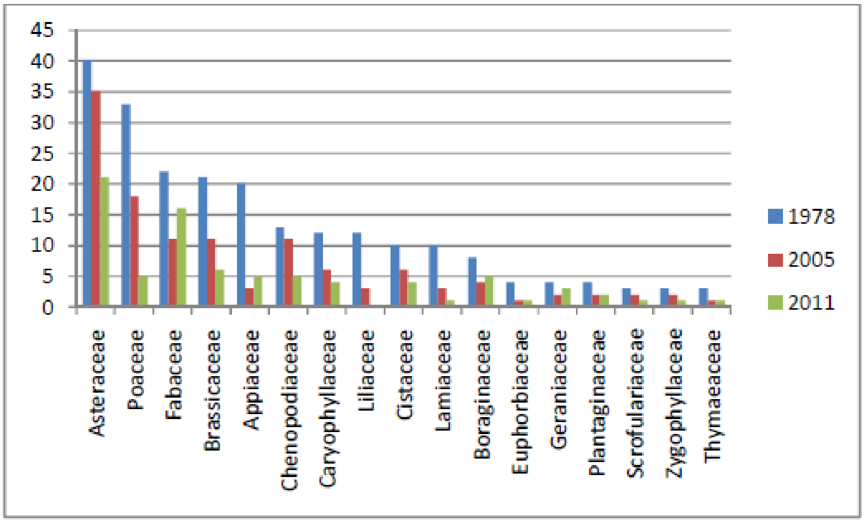

Figure 6. Evolution of the number of species for the main families through the three periods.

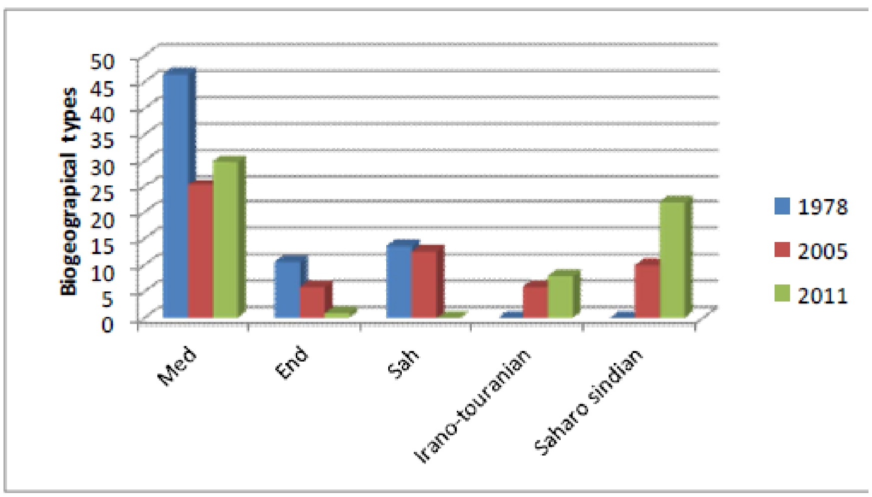

Figure 7. Evolution of some biogeographical elements through the three periods.

3.3. Evolution of Biogeographical Spectra

The study of biogeographical elements is interesting since we can determine through their evolution, the impact of the aridity on the species distribution. Figure 7 represents the evolution of biogographical spectra in the study area during the 3 periods.

It appears that the Mediterranean species are decreasing, since Saharo - Sindian and irano-Touranian, more xeric elements increased.

4. SOCIO-ECONOMIC FEATURES

Mecheria is a pastoral area. The rangelands which constitute the main support to the local economy were recently degraded, especially since the eighties. At the beginning of the century, livestock fluctuated in correlation with rainfall. When droughts occurred, livestock decreased and the cattle were decimated. When the rainfall becomes more consistent, the livestock become more important. A dynamic equilibrium was realized.

After the independence of the country, the improvement of prophylaxis and the using of complementary aliments allowed to a relative independence of climatic conditions for the livestock. So, its size increased exponentially whatever the annual rainfall (Hirche, Salamani, Abdellaoui, Benhouhou, and Valderrama, 2011).

An imbalance between the fodder production and the alimentary needs of the cattle occurred and becomes more and more important. The period 1982-1988, which was among the driest of the century, showed a very strong degradation of the rangelands and led to the progressive disappearance of *Stipa tenacissima and Artemisia herba alba*. These species were certainly weakened by drought, but their disappearance mainly overgrazing. Indeed, the exclosure established in the study area clearly showed that the alfa protected survive and does not disappear.

5. DISCUSSION AND INTERPRETATION

The study of indicators produced from the land cover maps performed on three different dates in the El Biodh ROSELT observatory, highlighted converging trends between 1978 and 2011, showing a very important degradation of vegetation. The dominant formations (vegetation units) such as *Stipa tenacissima* and to a lesser extent *Artemisia herba alba*, a keystone species, disappear progressively and are replaced by new vegetation units resulting from a dynamic degradation like *Atractylis serratuloides* or *Salsola* *vermiculata*. This implies a profound transformation of landscape of the region materializing mainly by fragmentation as shown by (Hirche, Salamani, Abdellaoui, Benhouhou, and Valderrama, 2011). Socio-economic changes, clearing, overgrazing and timber harvesting have led to a significant fall for all the indicators (vegetation cover, phytomass ...).

By cons, between 2005 and 2011, no significant regressive changes were observed and were visible through the indicator set. In contrast, for some of them, the trend has reversed, like cover vegetation which shows a very slight biological recovery and a relative rapid recolonization of *Lygem spartum*.

The main degradation factors, namely the demographic and livestock increase which causes increased pressure on rangelands by overgrazing are always present and don't herald any improvement in the long term. The recent greening would be due to favorable rains in recent years and the slight decrease in livestock in Algeria due to the scarcity of foods, including imported. Our results are corroborated by similar ones led in Tunisa by Hanafi and Jauffret (2008) and the ROSELT synthesis on Ecology for North and West Africa (2013). Benbrahim et al. (2004) and Mahyou, et al. (2010) showed the same trend in Morrocco, in their arid rangelands which represent the western extent of our study area.

The whole North Africa rangelands shows a drastic changes by the disappearing of original dominating species, mainly herbaceous and their replacing by new chamaephyte vegetation with lesser vegetation cover and phytomass.

The degradation rate is much more rapid than the restoration speed. Even, this decade was more or less wet, no significant improvement was observed notwithstanding slight increasing of vegetation cover and a decrease of sand cover. Degradation phases were so intense that today, despite a return of the rains, annual struggling to germinate and return to their original abundance. In this analysis, we must remain vigilant to talk about a total disappearance of a species because only continuous and comprehensive observations can confirm these preliminary conclusions, especially when it comes to annual or short-lived species that are more influenced by inter-annual variations in rainfall. These findings seem to contradict many "remote-sensed" studies around the world, especially in the Sahel region, showing instead a greening up and correspondingly the absence or the stopping of desertification phenomenon. Indeed, based on the images satellite, and studying the evolution of NDVI provided by GIMMS images over the years, Hellden (1984, 1991); Prince et al. (1998), Tucker and Nicholson (1999); Rasmussen et al. (2001), Herrman and Tucker (2005) and (Olsson, Eklundh, and Ardö, 2005) found no evidence of extensive degradation the Sahel. Already, Thomas, in 1993, goes further and published a book in provocative title "Sandstorm in a teacup, taunting and mocking proponents of desertification. Some authors extend their findings, again from satellite image observations, to the whole world (Hellden 2008; Hellden and Tottrup 2008).

We have used the same images and the same methodological approach, and the "remote sensed" results are conforming to the results to the different authors cited above (Hirche et al., 2010) and indicate a rise in NDVI values. The increasing of NDVI refers to the rainfall increase of the last years which induced a vegetation growth and a cover vegetation rise. However, the soils are wetter and no longer subject to wind erosion, inducing a sand coverage decreases. These parameters influence the spectral response and contribute to decrease the value of NDVI. Therefore, the trend shown in a decrease of NDVI spectral response is related to several factors, not just an increase in vegetation cover and phytomass. We have shown through this survey that vegetation shows instead a regressive trend although the desertification seems to have slowed in recent years. Even in the Sahel, recent studies have temperated the previous conclusions of a greening up and have showed in specific cases a regressive trend (Dardel et al., 2014; Herrmann and Tappan, 2013). It is interesting to observe that these recent works address perennial vegetation that is the exception rather than the rule in the Sahel.

It seems crucial when we consider and interpret the desertification to a better understanding to distinguish between dominant annual vegetation such as at the Sahel and dominant perennial vegetation such as the North Africa.

Yet recent famines in the Sahel do not tend to sit the thesis of a biological recovery ("Greening up"). Some author like Ozer et al. (2010) refuted the greening up of the Sahel.

All this discussion, shows that the field work associated to the regular monitoring of rangelands remain indispensable for understanding the functioning of Ecosystems.

CONCLUSION

This study was led at El Biodh, a representative region which summarize the main trends of Algerian rangelands and even North African rangelands. The results show through the study of vegetation and flora that all the results converge and show a degradation trend. But, significant difference exists between 1978 and 2005 and between 2005 and 2011.

The main changes occurred in the first period which is close to 30 years. The second period doesn't show an obvious regressive trend. On the contrary, the cover vegetation is slowly increasing, but our conclusions have to been moderated because the period is too short and the two periods are not completely comparable.

The recent greening-up does not mean a desertification in reverse. In fact, desertification is process on the long term, and recent changes seem to be more a fluctuation than a trend. Only a regular monitoring of the vegetation as major component of the ecosystem, allows a real understanding of desertification process.

REFERENCES

Aidoud-Lounis, F. (1997). Le complexe à alfa-Armoise -sparte (Stipa tenacissima L., Artemisia herba-alba Asso, Lygeum spartum L.) des steppes arides d'Algérie. *Structure et dynamique des communautés végétales* (198 pp.). Doctoral thesis, University of Aix-Marseille III, France.

Aidoud, A. (1989). Contribution à l'étude des écosystèmes steppiques pâturés des Hautes Plaines Algéro-Oranaises. Fonctionnement, évaluation et évolution des ressources végétales. *Doct. Thesis; Uni. Sci. Techn. H. Boumediène. Alger, 253p. + Ann.*

Aïdoud, A., Le Floc'h, É. and Le Houérou, H. N. (2006). Les steppes arides du nord de l'Afrique. *Science et changements planétaires/Sécheresse*, 17(1), 19-30.

Aidoud, A., Slimani, H. and Rozé, F. (2010). La surveillance à long terme des écosystèmes arides méditerranéens: quels enseignements pour la restauration? Cas d'une steppe d'Alfa (Stipa tenacissima L.) en Algérie. *Revue internationale d'écologie méditerranéenne International Journal of Mediterranean Ecology*.

Allington, G. and Valone, T. (2010). Reversal of desertification: the role of physical and chemical soil properties. *Journal of Arid Environments*, 74 (8), 973-977.

Anyamba, A. and Tucker, C. (2005). Analysis of Sahelian vegetation dynamics using NOAA-AVHRR NDVI data from 1981–2003. *Journal of Arid Environments*, 63(3), 596-614.

Benbrahim, K. F., Ismaili, M., Benbrahim, S. F., and Tribak, A. (2004). Problèmes de dégradation de l'environnement par la désertification et la déforestation: impact du phénomène au Maroc. *Science et changements planétaires/Sécheresse*, 15(4), 307-320.

CRBT. (1978). Rapport phytoécologique et pastoral sur les hautes plaines steppiques de la wilaya de Saida. *Algiers. ONRS.*

Dardel, C., Kergoat, L., Hiernaux, P., Mougin, E., Grippa, M., and Tucker, C. (2014). Re-greening Sahel: 30years of remote sensing data and field observations (Mali, Niger). *Remote Sensing of Environment*, 140, 350-364.

Djebaili, S. (1990). Syntaxonomie des groupements préforestiers et steppiques de l'Algérie aride. *Ecologia mediterranea*, 16, 231-244.

Gounot, M. (1969). *Méthodes quantitatives d'étude de la végétation*: Editorial Masson, París.

Grouzis, M. (1992). Germination et établissement des plantes annuelles sahéliennes. L'aridité: une contrainte au développement: caractérisation, réponses biologiques, stratégies des sociétés, E. Le Floc'h, M. Grouzis, A. Cornet, J.-C. Bille, *Editeurs scientifiques*, *ORSTOM*, 267.

Helldén, U. (1984). Drought impact monitoring. A remote sensing study of desertification in Kordofan, Sudan. *Rapporter och Notiser-Lunds Universitets Naturgeografiska Institution* (Sweden).

Helldén, U. (1991). Desertification: time for an assessment? *Ambio*, 372-383.

Helldén, U. (2008). A coupled human–environment model for desertification simulation and impact studies. *Global and Planetary Change*, 64(3), 158-168.

Helldén, U. and Tottrup, C. (2008). Regional desertification: A global synthesis. *Global and Planetary Change*, 64(3), 169-176.

Herrmann, S. M., Anyamba, A. and Tucker, C. J. (2005). Recent trends in vegetation dynamics in the African Sahel and their relationship to climate. *Global Environmental Change*, 15(4), 394-404.

Herrmann, S. M. and Tappan, G. G. (2013). Vegetation impoverishment despite greening: A case study from central Senegal. *Journal of Arid Environments*, 90, 55-66.

Hiernaux, P., Diarra, L. and de Leeuw, P. (1991). Dynamique de la vegetation sahelienne apres secheresse. Un bilan du suivi des sites pastoraux du Gourma en 1990. *ILCA Mali Document de Travail (ILCA). no. 001/91*.

Hiernaux, P., Mougin, E., Diarra, L., Soumaguel, N., Lavenu, F., Tracol, Y., and Diawara, M. (2009). Sahelian rangeland response to changes in rainfall over two decades in the Gourma region, Mali. *Journal of Hydrology*, 375(1), 114-127.

Hirche, A., Boughani, A. and Salamani, M. (2007). Évolution de la pluviosité annuelle dans quelques stations arides algériennes. *Science et changements planétaires/Sécheresse*, 18(4), 314-320.

Hirche, A. (2010). Contribution à l'évaluation de l'apport de la télédétection spatiale dans la dynamique des écosystèmes en zones arides: Cas du Sud oranais. *Doctorate. Thesis. University. of Sciences and Technology Houari Boumediene. 330 p+ ill. Algiers*.

Hirche, A., Salamani, M., Abdellaoui, A., Benhouhou, S., and Valderrama, J. (2011). Landscape changes of desertification in arid areas: the case of south-west Algeria. *Environ. Monit. Assess*., 179(1-4), 403-420. doi: 10. 1007/s10661-010-1744-5.

Kadi-Hanifi Achour, H. (1998). L'alfa en Algérie. Syntaxonomie, relation milieu-végétation, Dynamiqueet perspectives d'avenir. *Thèse. Doct. Es science. Univ. Sci. Tech. H. Boumediene. Alger. 270 p*.

Kadi-Hanifi, H. (2003). Diversité biologique et phytogéographique des formations à Stipa tenacissima L. de l ‘Algérie. *Science et changements planétaires/Sécheresse*, 14(3), 169-179.

Le Houérou, H. N. (1969). *La Végétation de la Tunisie steppique: structure, écologie, sociologie, répartition, évolution, utilisation, biomasse, productivité (avec références aux végétariens analogues d'Algérie de Libye et du Maroc).* Thèse. Doc. D'état.

Mahyou, H., Tychon, B., Balaghi, R., Mimouni, J., and Paul, R. (2010). Désertification des parcours arides au Maroc. *Tropicultura*, 28(2), 107-114.

Nouaceur, Z. (2001). L'évolution des lithométéores en Mauritanie confirme une plus grande efficacité de l'action éolienne. *Cybergéo*.

Olsson, L., Eklundh, L. and Ardö, J. (2005). A recent greening of the Sahel—trends, patterns and potential causes. *Journal of Arid Environments*, 63(3), 556-566.

Ozer, P., Hountondji, Y., Niang, A. J., Karimoune, S., Laminou Manzo, O., and Salmon, M. (2010). Désertification au Sahel: historique et perspectives. *Bulletin de la Société Géographique de Liège*, 54, 69-84.

Prince, S. D., Colstoun, D., Brown, E., and Kravitz, L. (1998). Evidence from rain-use efficiencies does not indicate extensive Sahelian desertification. *Global Change Biology*, 4(4), 359-374.

Rasmussen, K., Fog, B. and Madsen, J. E. (2001). Desertification in reverse? Observations from northern Burkina Faso. *Global Environmental Change*, 11(4), 271-282.

Slimani, H. and Aidoud, A. (2004). Desertification in the Maghreb: a case study of an Algerian high-plain steppe *Environmental Challenges in the Mediterranean 2000–2050* (pp. 93-108): Springer.

Slimani, H., Aidoud, A. and Rozé, F. (2010). 30 Years of protection and monitoring of a steppic rangeland undergoing desertification. *Journal of Arid Environments*, 74(6), 685-691.

Tucker, C. J. and Nicholson, S. E. (1999). Variations in the size of the Sahara Desert from 1980 to 1997. *Ambio*, 587-591.