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ECOLOGICAL DYNAMICS OF THE GREEN DAM BY REMOTE SENSING: THE CASE OF MOUDJBARA (DJELFA, CENTRAL ALGERIA)

KHAOUANI Boumediene [1, 2,] (khaouani11@gmail.com)*
([1]Plant Ecology and Environmental Laboratory - Faculty of Biological Sciences - University of Science and Technology Houari Boumediene | usthb, Alger, Algeria; [2]Scientific and Technical Research Center of Arid Regions - Biskra – Algeria)
HIRCHE Azziz [1] (storaryan@gmail.com)
([1]Plant Ecology and Environmental Laboratory - Faculty of Biological Sciences - University of Science and Technology Houari Boumediene | usthb, Alger, Algeria).
Mostefa SALAMANI [1] (m_salamani@yahoo.fr)
([1]Plant Ecology and Environmental Laboratory - Faculty of Biological Sciences - University of Science and Technology Houari Boumediene | usthb, Alger, Algeria).

Abstract:

The green dam is one of Algeria's greatest environmental achievements. However, few studies have focused on this area and particularly on its dynamics. This study intends to follow the evolution of the green dam since its establishment. We have chosen a typical region where this reforestation was initiated, the forest of Moudjbara, located in Djelfa (department). A visual classification of Landsat satellite images 1972, 1987; 2003 and 2016 coupled with field surveys was carried out. To limit the exogenous variations, the sun-synchronous satellite images were chosen in autumn. Phytoecological surveys based on mixed sampling were performed. In terms of area, reforestation (after planting) reached about 6 500 ha in 1987 and 7985 ha in 2003 while in 2016 it reached 8500 ha, occupying nearly one third of the total study area. Nevertheless, crops, especially in areas where reforestation has declined, are increasing. Phytosanitary status is a concern but natural forests seem less affected with 1.2 nests per tree in natural forest and 1.85 in reforestation.

The comparison between original and reforested forest formations shows that biodiversity is greater in natural forests and the difference between reforestation areas and natural forest decrease with time. The similarity index between the natural forest and reforestation areas for the year 2002 is estimated at 63% reaching 76% in 2018 for perennial species. The most notable changes are observed in the nearby steppe, which is undergoing advanced degradation. The crops which occupied only 1.29% of the study area in the beginning of the study currently cover 12% of the territory.

This work shows that reforestation has relatively maintained their original areas, although crops areas are growing. Contrariwise, the phytosanitary quality and the biodiversity of the reforestation areas are less satisfactory compared to natural ones. The rangelands are

undergone deep changes, which weaken their long-term future and question the survival of livestock farming in these zones.

Keywords: Aleppo pine, Biodiversity, Forest, Green dam, Reforestation, Remote sensing.

1. Introduction

Marginal areas bordering deserts under arid climate are subjected to the combination of episodic droughts and continuous overgrazing which causes desertification through a biomass reduction, soil erosion and biodiversity loss. Among the various measures to combat desertification, the reforestation campaigns across the national territory have been adopted in Algeria. As a pilot wilaya, four reforestation projects in Djelfa during 1968 have been initiated. These reforestation, surround the natural forests of Aleppo pines in the Ouled Nail mountains in order to increase the original extent to 80 000 hectares. Moudjbara was first perimeter to be reforested (Bensaid, 1995). The reforestation have for primary purpose the soil protection and have been implemented on:

- Soils with steep slopes
- The dunes
- The Oueds banks
- As windbreaks in pastoral areas
- Around villages as a green belt (Jacques, 2016).

These hoc efforts have been stitched into a large-scale project called “the green dam”. This leading edge project centers around very ambitious targets, and is consisted of an afforestation of three million hectares located in arid and semi-arid zones stretching over 1000 km length and 20 km width, from the Moroccan to the Tunisian borders (Figure1). Also, it corresponds to the area portion between the isohyets 200 and 300 mm, and incorporates a portion of the Saharan Atlas. This project based on forest approach has been amended in 1982, and its perspective has been broadened towards new goals aimed at (Bensaid, 1995):

- Improve the socio-economic conditions of the population;
- Upgrade the productive potential of the land;
- Reforest pastoral lands and restore extinct stands;
- Develop pastoral and agricultural lands;
- harnessing surface and underground water resources.

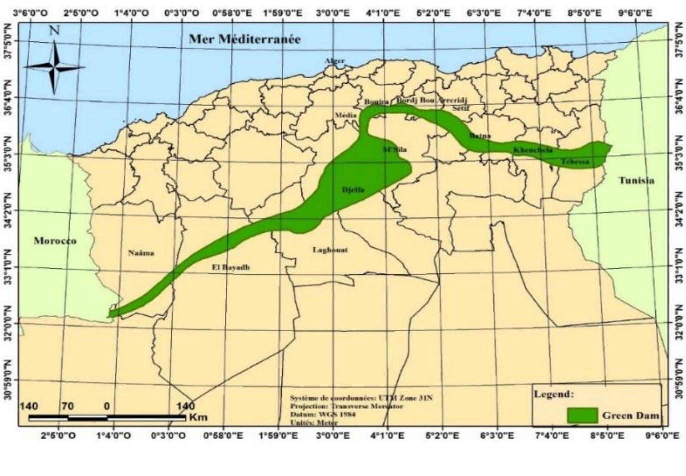

Fig1. Location of the green dam in Algeria (Original).

The main projects are located in Moudjbara and Taadmit with plantations spanning respectively, 13,000 hectares and 10,000 hectares of Aleppo pine (Deroueche, 2015). The region of Moudjbara as one of the first to have been involved makes the study on green dam changes more interesting. Also, this issue is particularly alarming according to (Chakali, 2003), because the Djelfa forests are in steady decline. A diagnosis of forest conditions have been performed at different periods and lead to assess land occupation changes. These maps have been established by visual interpretation of the different Landsat TM color composite (Girard et Girard, 2010). The field work, according to a mixed sampling and bibliographic information's constitutes the basis for the image interpretation. A temporary and stratified key legend as defined by (Long, 1974) have been carried out and then verified and validated in the field. By focusing on a relatively restricted study area, the lessons learned in this project are much more nuanced and accurate than those extended to the whole steppe. The findings of the multi-temporal study and existing data have been integrated and structured in a GIS (Geographic Information System). This research provides not only reliable informations on the spatial and temporal changes of the Moudjbara forest but also anticipates this potential evolution\.

2. Materials and methods

2.1 Presentation of the study environment

The Moudjbara reforestation is characterized by a flat to slightly rolling landform (Chakali, 1985). It is located in an enclave with relatively homogeneous relief and a highly variable vegetation cover fluctuating between 10 and 100%. This reforestation is located five kilometers south-east of Djelfa in the Ouled Nails foothills (Djellal Chergui) and at an altitude ranging between 1200 and 1400m (Figure 2). The bordering areas are in the north of Djelfa, from south the degraded forest of Djellal Chergui, at west the N1 national highway and in East the Moudjbara commune with its large esparto grasslands (DGF, 2010).

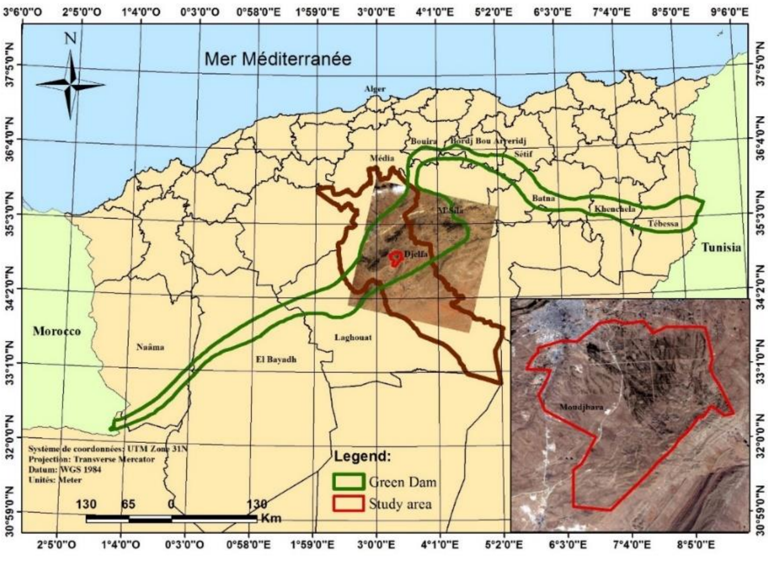

Fig 2. Geographical location of the Moudjbara reforestation (Original).

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2.2 Climate

The most significant climate parameter in arid regions are the total rainfalls and the temperatures (mean, minimum..) that can be combined in a climatic synthesis.

2.2.1 Rainfall

Djelfa climate data spread from 1972 to 2014 were extracted from the National Meteorological Office database (O.N.M., 1975-2015). Means rainfalls are 318 mm and, since 1972, there has been noted a drying climate trend. Nevertheless, replaced in the long term, from the beginning of the century, (Ramade., 1984; Hirche et al., 2007; Belala and al., 2018; Slimani et Aidoud., 2018) have shown that a drying trend is no longer noticeable and rainfall is broadly stable.
The coefficient of variation is 26.5% (Figure 3), is fairly significant but less pronounced variability than in the rest of the arid regions (Toupet., 1990).

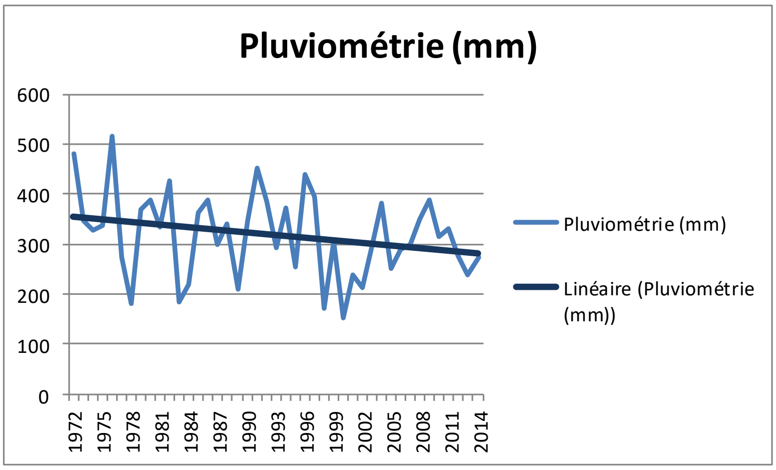

Fig 3. Rainfall evolution since 1972.

2.2.2 Temperatures

The average minimum temperatures of the coldest month is 0.1 C, corresponding to a region with cool winter temperatures, whereas the average maxima temperatures of the warmest month is 33.8 ° C, corresponding to a region with hot summers (Le Houérou and al., 1977**).**
There is therefore a sharp thermal contrast between the seasons as the winters are cold and the summers are warm.

2.2.3 Climatic syntheses

2.2.3.1. Bagnouls and Gaussen Diagram (1953)

The ombrothermic diagram of (Bagnouls et Gaussen 1953) is a climatic diagram representing the monthly variations of temperatures and precipitations (averaged) according to standardized gradations: a gradation of the precipitation scales corresponds to two gradations of the temperature scales (P = 2T).

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The outcomes indicated that there are five dry months in Djelfa with a dry summer period, and humid winter, spring and autumn periods, which makes it a typically Mediterranean climate (Figure 4).

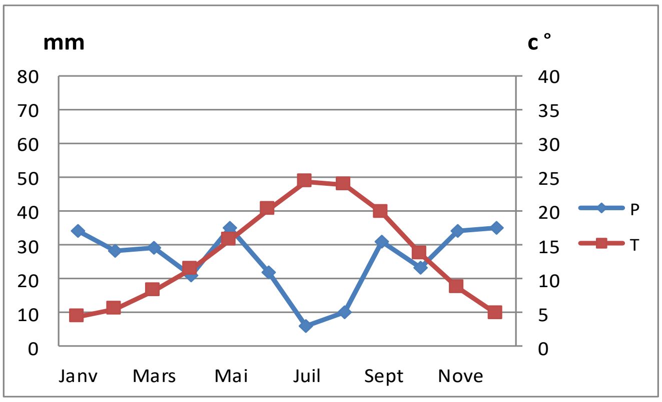

Fig 4. Ombrothermic diagram of Bagnouls and Gaussen.

2.2.3.2. Climagram of Emberger

The EMBERGER Climagram, another climatic synthesis, allowed to determine the bioclimatic zones of a given station and is calculated from the following formula:
Q2 = 2000P / M2 - m, of which:

- P : annual rainfall (mm)
- M : the average maximum temperatures of the warmest month in ° C
- m : the average minimum temperatures of the coldest month in ° C

The Q2 is 33.57 and the m is 0.1 ° C, which places Djelfa station in the cool and low semi-arid type (Figure 5).

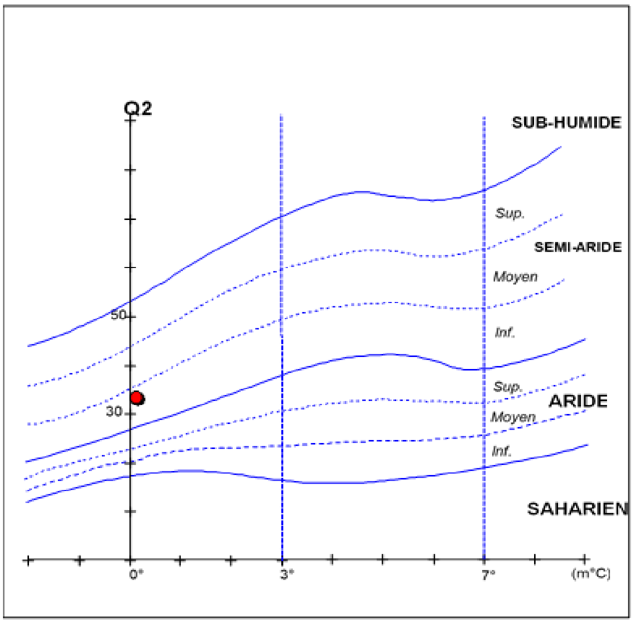

Fig 5. Climagram of Emberger.

2.2. 3.3. Climate data analysis

Djelfa climate correspond to a continental Mediterranean type under xerothermal tendency with a hot and dry summer and a humid and cold winter. The change in annual precipitations as shown in (Figure 6), depicting the variations recorded during these years. The average values of the SPI index highlight the dominance of values close to normal (74%), much less are moderately moist (11%), or moderately dry (7.40%), and very few are humid (3.70%), or very dry (3.70%).

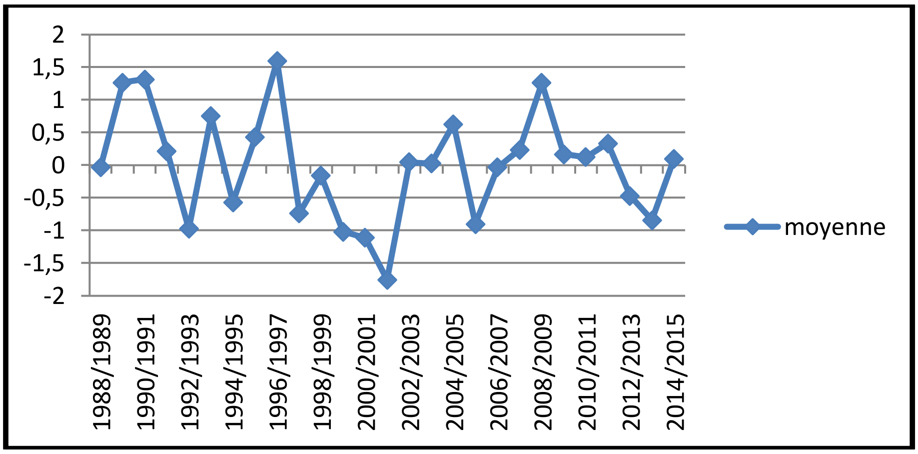

Fig6. Average annual values of the Standardized Precipitation Index (SPI) during the period 1988-2015 in Djelfa.

2.3. Collected satellite image processing

The management of forest resources requires the prior mapping and inventory of the forest estate (Leckie and al., 2002). In this work, the set of cartographic techniques is based on the remote sensing images, which provides information on the forest and its geography through the analysis of remote acquired data without direct contact (Giacobbo, 2000; Bonn, 1996). Collected data will be integrated into the Geographic Information Systems (Provencher et Dubois, 2007; Cerraras and al., 1990).
To study the diachronic evolution of the Moudjbara forest, the use of several Landsat satellite images (Table1) was necessary.

Table 1. Landsat Images 1972, 1987, 2003 and 2016

Image Path/ row	Date	Sensor	Number of channels	Resolution	Level of correction
LANDSAT_1 210/36	13/11/1972	MSS	4	60/80 m	L1T
LANDSAT_5 195/36	02/09/1987	TM	7	30m	L1T
LANDSAT_5 195/36	25/09/2003	ETM	7	30m	L1T

LANDSAT_8 195/36	17/09/2016	OLI_TIRS	11	30m	L1T

They correspond to different dates (1972, 1987, 2003, and 2016) and use various sensors endowed with specific performances.
The study area corresponds to the LANDSAT scene of which path / row is 195/36 or 210/36 and with 30 m resolution for color composite mode (MSS, TM, ETM and OLI) and incidentally 15 m in panchromatic (ETM, OLI). They were chosen according to their quality (cloud-free), their availability and their relevance, due in particular to the existence of bibliographical data allowing to establish the diachrony. The oldest image dates back to 1972 and provides an opportunity to identify forest cover state over at a relatively old period.Some phenomena have no direct relationship with vegetation as, for instance, the illumination conditions and the seasonal effects and are considered as noise. To minimize this last, the images covering the Moudjbara forest in Djelfa taken at different times (1972, 1987, 2003 and 2016) (Figure 7) were chosen in the same season and if possible in a similar dates. The "signal' corresponds to the biophysic elements, especially the perennial species which are crucial for monitoring the intrinsic structural state of vegetation. They are highly correlated to the phytomass conditions. In this season, annual species depending on extrinsic conditions, like the rains, are not sufficiently significant to "blur the signal" because they dominate the landscape only in the spring. Hence, contrary to the widely-held view, the perception of plant changes is more interesting in autumn than spring (Hirche and al., 2018).However, plant monitoring at relatively low phytomass comes as a challenge and raises a real methodological problem in arid zones (Hirche, 2010).

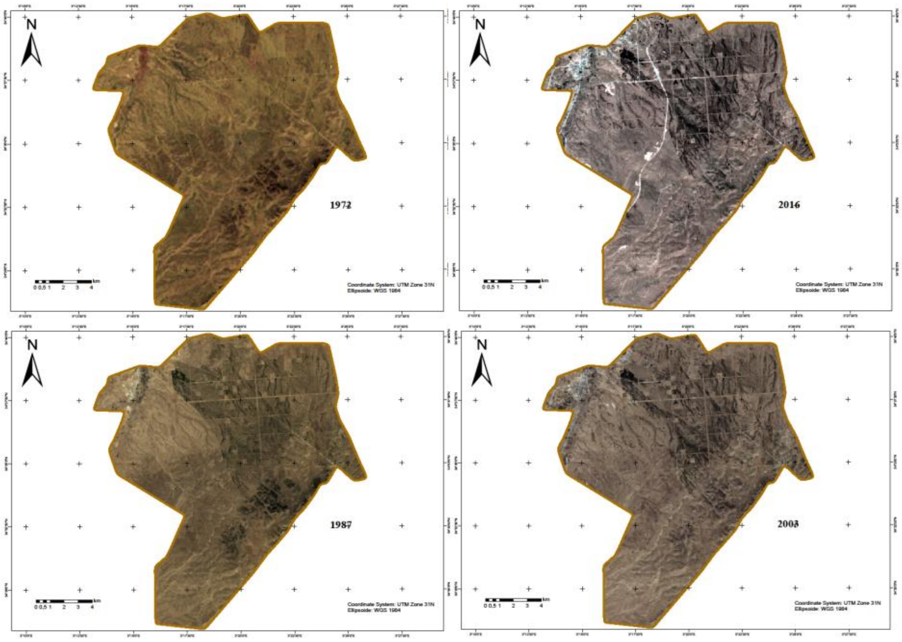

Fig 7. Images covering the Moudjbara forest in Djelfa taken at different times.

Among the most representative channels for the forest discrimination, the channel TM4 (near infrared), TM5 (Infrared medium) and a visible channel (TM1 or TM3) are retained (Girard et

Girard, 2010).The major issue in diachronic studies hinged on the quality of pre-processing, which mainly determined the quality of results. Furthermore, the differences related to illumination conditions as well as for date images, various seasons and atmospheric conditions should be taken into account and involve the radiometric corrections. It means that if the sensor may have technical problems causing systematic errors, as was the case for Landsat (SLCoff), further radiometric corrections will be required. Geometric distortions linked for example to pitch, roll, or yaw effects can induce to geometric deformations, which also imply corrections. The present research has been widely facilitated through the use of latest Landsat imagery (Tier 2) geometrically and radiometrically corrected by the USGS. Regarding the classifications, a visual analysis method was choosen.

2.3.1. Color composite Analysis and study of satellite images

A color composite image was performed by the combination of the channel two for the green, (0.52 - 0.60mm) the channel three for the red (0.63 - 0.69 mm) and the channel four for the infrared (0.75 - 0.90 mm). The combination of these channels emphasized the vegetation of the forest area (Stach et Deshay, 2009).

2.3.2. Sampling

The sampling is of mixed type which combines subjective and stratified sampling (Gounot, 1969). It is based on a prior knowledge of the soil and vegetation throughout prospecting work similar to subjective sampling. The stratification is carried out by an "image interpretations» consisting in an identification of homogeneous entities or strata from a visual analysis. The purpose was to reach a land use map according to Long (1974). It should be underlined that the chosen approach, a "visual" classification, may seem "archaic".

In reality, it is often much more powerful than the numerical classification based on the pixel approach (De Jon, and al., 2001; Hirche, 2010). Indeed, it takes into account not only the texture, but also the structure and the environmental criteria (Rey et Izard, 1969), hardly difficult to identify by software. These homogeneous or “isophenic” zones constituted strata as defined by (Long, 1974). The selected thematic classes were integrated into a GIS to facilitate their manipulation as well as the extraction of surface area data and statistics. Once the classification was settled up, a post classification work was carried out to optimize the first outings and incorporate the field prospecting’s. The information collected through fieldwork is complemented by bibliographic research.

2.3.3. Flora dynamics

Another interesting issue is to assess the evolution of biodiversity for all the vegetation units, in particular the main interest, the forest ecosystems. For this purpose, the global richness of each unit is compared across the time by an similarity index (Sørensen, 1948). It is used to study more closely the floristic resemblance between the two groups.

$$S(s1, s2) = \frac{2a}{2a + b + c}$$

a = common species.

b = species identified in the site one and absent in site two.

c= species identified in the site two and absent in site one.

3 Results

3.1. Land use maps

The visual classification of the various colored compositions enabled to determine the following seven classes; (Natural forest, dense cover reforestation, low cover reforestation; crop, slightly degraded steppe, degraded steppe and agglomeration).
The classification enabled to assign a color to each thematic class (Figure 8). The natural forest is represented by a quite dark bottle green color , the dense reforestation by a moderately green color , the low-density planting correspond to a light green; the dark brown represents the rangelands with " slightly degraded alfa" and the light brown, the rangelands in decline. The crop fields are captured by a white color and the black color represents the agglomerations.

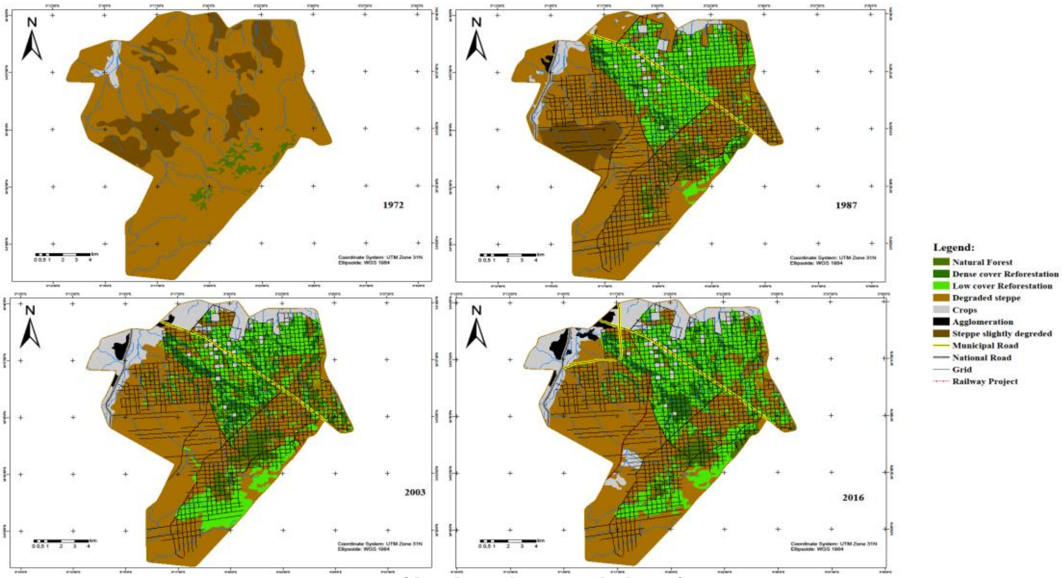

Fig 8. Map of land use by visual classification

1972: The year 1972 is taken as a starting state. The main vegetation unit is a degraded steppe, spreading on about 4/5 of the total area (18872 ha). The remaining area seems occupied by slightly degraded steppes. The natural forest occupies 669.82 hectares (Tab. 2), about 2.80% of the estimated surface area. The phytosanitary state is generally good and the density trees attacked by insects is low. Crops are marginal with 308.40 ha or about 1.29%.
1987: There is a light brown color on the satellite image that characterizes the reforestation of Moudjbara and corresponds to newly settled young stands as well as for the reforestation of Jebel Djellal. In 1987, the land use map indicated a considerable development in terms of reforested forest area; nearly 6500 ha were planted of which 1280 ha seemed in good

condition while 5209 was low-dense reflecting a mitigated success. Nevertheless, there is another part in the same green dam area where the seedling is in decline. The crops were multiplied by three (1065 ha). But the yields are very low (less than 0.5 tonne/ha) having them designated by Le Houérou (1989) as being lottery cultures. Several factors limit the soil fertility like the presence of rather shallow soil, even skeletal (<40 cm).

As the sylvo-pastoral plantations requires a depth soil (> 80 cm) the prior development action was to remove this crust by a digging called "rootage". Thus, the soil was more or less ploughed and loosened, which increased the organic matter exposure to the open air. On the other hand, the augmentation of the soil depth improved the soil storage capacities leading to help a sylvo-culture implementation. The planting period occurred with a relatively dry period and has probably limited the positive impact of plantations. The precipitation amount recorded from 1985 to 1997 is about 350 mm. The steppe, in good state, during the most dry period of the century (Matari, 2008; Bensaid, 2006), has lost about 5000 ha (≈20 %). This decrease affects the slightly degraded steppe, which loses nearly 2/3 of its original surface area from 4080 to 1407 ha. Other authors have worked in this region and pointed out the devastating impact of droughts and overgrazing in rangelands (Aidoud, 1997; Aidoud & al., 2006; Slimani et Aidoud 2018; Nedjraoui et Bedrani, 2008; Bensaid 2006). Even though the steppe is theoretically included in the forest estate, it is practically only poorly protected by the administrative structures.
One of the major deterioration factors is the presence of a plethoric livestock estimated at about two million head (to make the evolution of the livestock in Djelfa) which, contributes consistently in the decline of young plants. Indeed, the guarding of the forest area is not absolute, and the breeders can deceive the vigilance of the forest guards, penetrate in this protected space and then appropriate their high fodder potential. Another factor is the identification of many insect pests. It is relevant to highlight that the pest insect density clearly increased. In fact, most scientific papers about Moudjbara are relevant to entomological studies.

2003 : In 2003, natural forests have a surface area of 729 ha, the reforestation surface area increased to 2584 ha, partly due to favorable climate conditions and replenished by forest services. Thus, the surface area of low-dense planting is 5400 ha (Table2) and the low degraded steppe has disappeared, while the agglomeration and cultures doubled in surface area. Even the dry period, the crops are doubled (12. 46 %). In short, this emphasizes the impact of human being on the landscapes.

Table 2. Surface areas of different types of land use

Classes/Years	**1972**		**1987**		**2003**		**2016**	
	Ha	%	Ha	%	Ha	%	Ha	%
Natural forest	669.82	2.80	862.40	3.60	729.93	3.05	860.40	3.60
Dense cover reforestation	0.00	0.00	1280.68	5.35	2584.26	10.80	2767.50	11.56
Low cover reforestation	0.00	0.00	5209.17	21.77	5400.79	22.57	5738.60	23.98

Crops	308.40	1.29	1065.98	4.45	2982.70	12.46	2925.24	12.22
Slightly degraded steppe	4080.42	17.05	1407.47	5.88	0.00	0.00	0.00	0.00
Degraded steppe	18871.96	78.86	13992.07	58.47	11995.18	50.12	11145.52	46.57
Agglomeration	0.00	0.00	112.83	0.47	237.69	0.99	493.34	2.06
Total	**23930.60**	**100.00**	**23930.60**	**100.00**	**23930.60**	**100.00**	**23930.60**	**100.00**

2016: Natural forests, dense and low-dense planting have slightly changed in surface area on the contrary of the agglomeration that continues to increase to almost 500 ha. This stagnation is caused by the conjunction of several adverse factors. Among them, the discontinuance of the National People's Army in the planting process at the green dam; the prolonged drought since the beginning of the nineties inducing an ecosystem vulnerabity, and the persistence of insect pests attack (Battisti., 1988; Bertella., 1987) contributing to the rapid decline of the stands which underlies the risks of a mono-specific plantation (Table 3). The table three shows that the semi-arid zone is generally less fit to develop processionary caterpillar than sub humid ones. Furthermore, the naturel forest has fewer nests (1.2) than afforestation, which shows that stand diversity favors natural pest control. Bachir & al (2017) have shown that juniper (*Juniperus phoenicea L.* and *Juniperus oxycedrus L.)* stands increase resistance to the processionary caterpillar. SBA and Benrima (2017) show, still in the same area, that for locusts, diversity is minimal in reforestation and systematically greater in natural stands. The study of Bouzekri and al., (2015) concerning ants also shows that the occupation of space depends on the dominant types of plants.

The regressive evolution of the steppe plant communities, especially the former slightly degraded ones (nowadays non-existent), contrasts with the forest units whose progression, although modest, is until 2003, real. Since then, these formations have seen their surface stabilize despite the return of rainy years.

Table 3. Comparison of nesting “D” rates per tree of coniferous processionary caterpillar in the Mediterranean region. (In Mecheri et al., 2018 modified).

Country	Region	Bioclimate (Emberger)	D	Authors
France	Landes of Gascogny	Humid to Mild winter	1.36	Régolini *et al* ., 2014
Italy	Campobasso. Molise	Subhumid to cool winter	2.8	Colacci *et al.*, 2017
Spain	Lleida. Catalonia	Subhumid to cool winter	3.40	Cardil *et al.*, 2017
	Mora de Rubielos	Subhumid to cold winter	3.00	Palacio *et al.*, 2012
	Hoya de Guadix	Semi-arid to cool winter	3.18	Pérez *et al.*, 2014

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Turkey	Kahramanmaras District	Subhumid to cold winter	5.75	Kanat *et al*., 2005
	Bartin	Humid to mild winter	-	Durkaya *et al*., 2009
Algeria	Chréa	Subhumid to mild winter	5.96	Sbabdji *et al*., 2009
	Bordj Bou Arreridj	Semi-arid to cold winter	1.60	Ziouche *et al*., 2017
	Djelfa Reforestation		2.60	Zamoum *et al*., 2016
			1.43	Bachir *et al*., 2017
			1.85	This work
	Djelfa Natural Forest		0.37	Bachir *et al*., 2017
			2.74	Mecheri *et al*., 2018
			1.2	This work

4 DISCUSSIONS

4.1. Spatial dynamics of forest formations

Reforestation has been set up since seventies, and the satellite image of 1987 revealed that the young plantations compiled on 6 500 ha are depicted by a light brown color and showing newly settled areas.

In 2003, these units are depicted by a light green color on the satellite image, indicating dense and low-dense planting of Aleppo pine (*Pinus halepensis L.*). Nevertheless, local degradation appeared in 2003 and affected the reforestation of the southern part, corresponding globally to the Jebel Djellal forest, of which 132.46 ha existing in 1987 disappeared. Aleppo pine has not been spared by frequent pathological diseases, insect attacks, and the periodic severe epidemics such as the pine processionary. The latter *(Thaumetopoea pityocampa D. & S.)* is a Lepidoptera species (butterflies) of the Notodontidae family, known particularly for its caterpillars. Nowadays, lessons have been drawn and plantations with monospecific stands have been prohibited. In addition, more resistant ecotypes were selected according to their resistance to phytopathogenic diseases and in particular to the processionary caterpillar. For this, we must choose the most resistant varieties to phytopathogenic diseases.

Moreover, the recovery in 2016 was not negligible, as we noticed a gain of + 6.21% in reforested surface area in comparison with 1987, of which 11.56% is made up of dense reforestation whereas only 5.35% for 1987.
This increase was due to the improvements and corrections provided into the reforestation in conjunction with favorable rainy period. The replanting and thinning operations and new plantations translate this modest enhancement. However, the results are widely mixed. (Bensaid 1995) has reports that only 160 000 ha were planted over the three million expected, and also 123 000 were treated over twenty years at rate of 77% (Figure 9). He stressed that the success of plantations depends on seed quality, the wrong choice of their provenances (sources), the farming in seedling nurseries and their transportation mode. Planting is also prominent and problematic because success depends on tillage, the dimension of the seed holes, date and planting techniques, maintenance and staff qualifications.

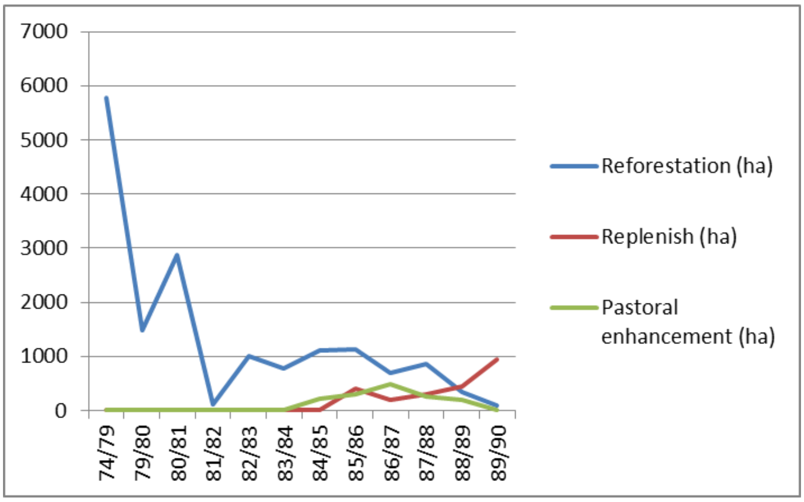

Fig 9. Evolution of plantations in Djelfa. (in Bensaid 1995).

4.2.2. Flora Dynamics

The study pointed out two types of forest units occupied the study area. On the one hand, we find a natural forest based on Phenicia juniper *(Juniperus phoeniciea L.*), and alfa or esparto (*Stipa tenacissima L.*) endowed with a few plants of *Pinus halepensis*, more or less frequent depending on the environment conditions (altitude, preservation ...). On the other hand, exists the reforestation, which is based on Aleppo pine (*Pinus halepensis L.)*, as a dominant species. The other species, when present, are more or less regularly scattered, but remain secondary compared to Aleppo pine.
It is illuminating to compare the floristic wealth of two groups. Does the reforestation outclass today in biodiversity the natural formations?
As matter of fact, the answer is nuanced. The reforestation contains more species about (54) than natural forest (34); however, the sampled area showed that the species number per unit surface area, corresponding to the minimal area (Gounot, 1969) is generally higher in natural forest. Furthermore, reforestation is a relatively protected area unlike natural forests. In addition, the total number of species is very low and indicates intense degradation conditions. Concerning the comparison between the different floristic groups, the results of Sørensen (1948) similarity index are:

88 species in both sites

a = 26 common species in the site one + site two

b = Nine species identified in the site one and absent in site two

c= 27 species identified in the site two and absent in site one

It seems that the overall similarity is moderately high in terms of total flora. It is about 59% whereas as per perennials, this index reaches 76% (Table 4) which shows the relative floristic homogeneity of the local flora.
Nevertheless, field observations revealed that the best species such as thyme *(Thymus ciliatus Desf.), Teucrium polium L.* , are much more present in natural forests and a forest characteristic species like the Globularia *(Globularia alypum L.)* for instance, has only been found in this area. The recovery of these formations is between 30 to 50%, whereas that of natural forests rarely exceeds 30%. Moreover, natural formations are based on phenic juniper *(Juniperus phoenicea L.)* which better protects the soil because the plant emits strains from the bedrock. Reforestation based on Aleppo pine highlights the massive disparities in the soil capping. Natural forests are therefore better protected than those reforested. The insect pest density is lower which indicates a better defense ability. Furthermore, the floristic wealth is, on an equal surface, usually poorer. In fact, our floristic list has been overestimated by an enclave of cultures located in the forest area. This messicole flora is added to the global list in wooded areas. It blurs the information on the real richness of reforested formations.

Table 4. Global Similarity index 2002; 2018.

	Similarity Index					
	Natural Forest	Reforestation	Natural Forest	Reforestation	Natural Forest	Reforestation
	Global	Global	Perennial	Perennial	Annual	Annual
2002	**48%**		**63%**		**40%**	
2018	**59%**		**76%**		**51%**	

The floristic richness between forest formations and those reforested during 2002 and 2018 were compared. It appears that the similarity between the forested and reforested formations is average (48%) in 2002 and has increased to almost two-thirds in 2018 (59%). The homogeneity is higher in 2018 underlined by a higher floristic richness of reforested formations, which reduces the similarities. The similarity increases for the perennials between 63% and 76% respectively, which is remarkable and shows that, with time, the two formation types are increasingly similar. As expected, the similarity between the annuals is lower, given their subordination to random rainfall with rates ranging from 40% in 2002 to 51% in 2018.

5. Conclusion

The current study revealed that reforestation has relatively maintained its original areas at the expense of a decline in reforestation area quality. This degradation is due to crop cultivation, livestock's overgrazing and phytophagous attacks. The health conditions are far from satisfactory in reforestation areas and the soil protection is better in natural forests. However, the original biodiversity dissimilarity between the natural and the reforested areas, decrease with time. Nowadays, the quite significant floristic similarities between reforestation areas and natural forest are attributable to the perennial species. Silvicultural management appears necessary and must involve the rejuvenation and diversification of the settlement.

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