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RESEARCH ARTICLE

CHRONOLOGY OF PLANT FORMATIONS SETTLED ON BANKS OF "OUED" TAFNA (Oran-Algeria)

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ABSTRACT

Diachronic mapping (2004 and 2013), conducted as part of a program of phytoecological studies on "Oued" Tafna stations, illustrated a heterogeneous physiognomy of Tamaricaceae vegetation. The presence of salts and the appearance of a degraded structure affected the physiognomy of vegetation which is often organized according to a gradient of the soil substrate. Sequential dispersion of these populations was observed spatially. The Tamarix, the Atriplex and bioclimate also contributed to changes in environmental variables, including salinity, which are partly responsible of the large installation of halophytes, such as *Atriplex halimus*, *Salsola vermiculata* or *Tamarix africana,* on banks of "Oued" Tafna. Other formations also changed between 2004 and 2013. Installation of food crops was sometimes excessive; their surfaces generally exceeded 45% of the plots mapped. Thus, this study highlighted the evolution, over nearly 10 years, of the vegetation aspect on "Oued" Tafna banks and more specifically Tamaricaceae' formations.

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INTRODUCTION

Combourieu Nebout *et al.* (2009) point out that it is certain that the succession of intense droughts will affect the Mediterranean environments, marine as well as continental and thus will influence the future of mankind in these regions. In Algeria the arid zone accounts for nearly 95% of the country with 80% in the hyper-drought domain (Halitim, 1988).The particularity of the arid environment is water failure, low rainfall, soil erosion by wind or water and its vulnerability to these factors of degradation. Moreover, the problem frequently encountered in various arid environments is a soil degradation, which can be caused by human activities and climatic changes (Sheridan, 1981).The total area threatened by water erosion is estimated at nearly 10 million hectares. Disturbing results of wind erosion are achieved through the realization by teledetection of sensitivity map to desertification by the Arzew Space technology Center in Algeria; nearly 600 000 hectares of land in steppe zones are completely desertified with no possibility of biological recovery, and nearly 6 million hectares are hardly threatened by the desertification phenomenon. About 1.2 million hectares of land plowed annually are subject to desertification following inappropriate farming practices in the steppe environment. The Atriplexeae and Tamaricaceae appear to have the characteristics of an effective weapon against desertification, while maintaining a minimum productive level of livestock foodand sometimes to permit higher incomes than traditional forage systems (Le Houerou, 2000). In arid and semi-arid regions, Tamaricaceae possess great interest as conservative soil plants against various physical phenomena of erosion. Hardiness acquired by resistance to drought gives them a special interest in the floristic composition of the study area (Ghezlaoui, 2011). *Tamarix africana* Poiret is a very abundant plant especially on the Mediterranean coast in the beds of the "oued" and this, because of the humidity and salinity of the medium (Bendaânoun, 1981).The settlement of *Tamarix africana* reflects the typical facies of "oued" borders, characterizing salty environments "oueds" with equilibrated texture (El-Afifi, 1986 *in* Ghezlaoui, 2011). Also the presence of single-species settlement as *Atriplex halimus* or *Tamarix africana* may be an indicator of the environment (Sari-Ali *et al.*, 2011).Vegetation units once identified and determined with their physical and floristic characteristics should be made available to users whose technical nature does not always allow them the use of text and tables. To overcome this deficiency, and for more convenience, mapping is required and is an irreplaceable tool in this domain (Steinberg, 1996). According to Benmehdi

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(2012), mapping approach is a mirror that reflects the state of the vegetation at time x. It is a logical and scientific simplification of a much more complex reality, while highlighting the most relevant facts (Carreras *et al.*, 1990).The ability to monitor the quality and quantity of vegetation and to map the evolution of plant communities permit to estimate the nature, extent and speed of territory' phytoecological changes (Bouazza *et al.*, 2004). Many authors have studied the diachronic study, among them: Nedjraoui *et al.* (1999), Benabadji *et al.* (2009), Haddouche (2009), Aboura (2011), Regagba (2012), to name a few. The objective of this study is to follow the diachrony from 2004 to 2013 of all existing settlement and especially those of Tamaricaceae, on 02 stations located on banks of "Oued" Tafna (North of Tlemcen). What could be observed, on a physiognomic plan, in nearly 10 years in these stations?

MATERIALS AND METHODS

Physical characteristics of stations

In order to answer the posed topic, our choice of stations was guided by the presence of salt-tolerant species and more precisely by the Tamaricaceae settlements that are the subject of our study and that, on banks of "Oued" Tafna.

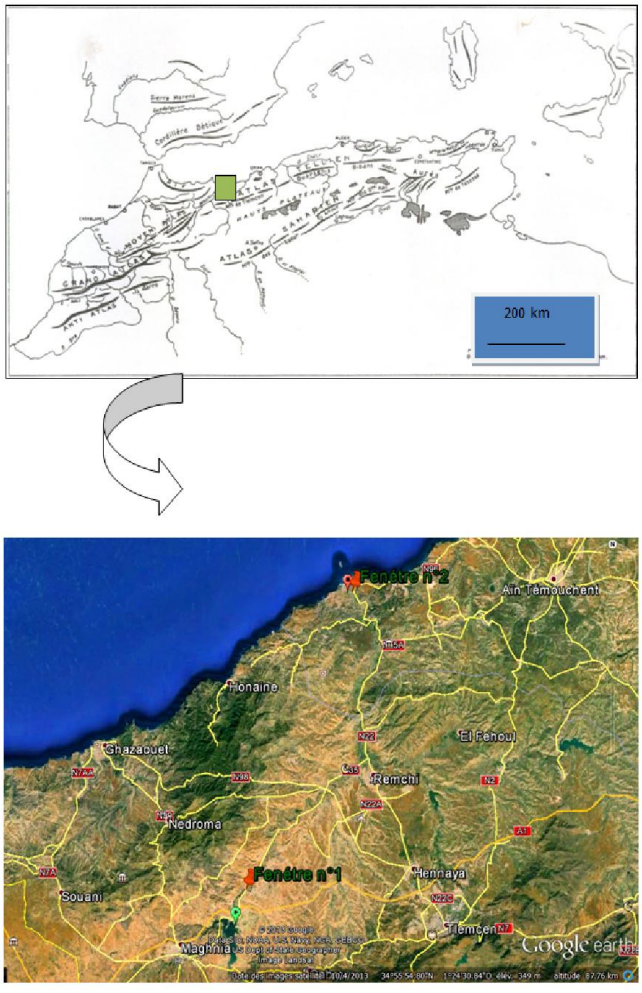

Figure 1. Location of study sites

Our study area is located in the western part of the North-West Algerian, extending over part of the "Oued" Tafna; it corresponds to the sites of "Hammam Boughrara and Béni-Saf". The study site is in fact called "window", term that we have attributed to the two concerned sites.

The "Oued" Tafna' watershed, located in the north west of Algeria, covers the entire province of Tlemcen in an area of 7245 km2. Under the new structure of hydrological units in Algeria, the watershed of Tafna belongs to the set of Oran – Chott Chergui. According to Elmi (1972), the plain of Maghnia coincides with the Tafna Valley and"Oued" Mouilah that originates in Morocco (at 40km North of Oujda) as the "Oued" Issly. "Oued" Tafna is a river of 170 km long, which is divided into three parts: the upper Tafna, middle Tafna and lower Tafna. The bioclimatic synthesis, in the sense of Emberger, of the study area allows us to advance the following remarks: our studies sites ("Hammam Boughrara" and "Béni-Saf") are respectively located in semi arid superior bioclimatic stage with warm winter and semi arid inferior stage with temperate winter. According to the Debrach thermal classification (1959), we have two types of climate: semi-continental for "Hammam Boughrara" site and coastline for the "Béni-Saf" site. This difference is due to the combined influence of the sea, topography and altitude.Bioclimatic classification based on the annual average temperature and "m" shows that "Béni-Saf" site belongs to the thermo-Mediterranean level and "Hammam Boughrara" to the meso-Mediterranean level.

Chronology of vegetation

Sampling is the operation that takes a number of elements that can be observed or treated (Dagnelie, 1970). It is the method to study large extent phenomena such as vegetation, soil and eventually their relationships. To follow the dynamic of vegetation in the study area, we have considered the method of Dutoit (1996). It is a direct and experimental diachronic study method: it is the study of a site at an initial state at a time called "T0". On this same site, we studied the changes that may arise, in the floristic composition. An accurate survey of the plant physiognomic composition is done at time T0; it is a quantitative method (change in the frequency of species in a given area). Compared to a time T0 + n, the operated fluctuations are studied, for example, during various weather conditions or human action (plowing, overgrazing). First, we chose two windows considered as study sites on our database; one located in "Hammam Boughrara" and one in "Béni-Saf".
Then we went on the site and within each window, the physiognomic units are reported. Each dominant settlement is in a significant degradation or in an appreciable physiognomic state. It led us to take a variability scale from 1 to 3, which are assigned to each settlement.

- 1: good condition
- 2: moderately degraded
- 3: very degraded.

After making the new amendment of physiognomic maps, we evaluated surfaces in m²,and then quantified them as a percentage. The field trips and exploitation of documents (satellite images and maps) have enabled us to draw the different physiognomic sampled surfaces (16.8719 Ha for site 1 and 25.1677 Ha for site 2) measured in unit area as follows:

Ta1: Settlement of *Tamarix africana* dense,
Ta2: Settlement of *Tamarix africana* moderately dense,
Ta3: Settlement of *Tamarix africana* degraded,

Figure 2. Satellite image and overview of plant formations of the first window Study site N°1: "Hammam Boughrara"

Its coordinates correspond to longitude 1 ° 38 ' West and latitude 34 ° 55' North. It rises at an altitude of about 200 m; it's localized on the eastern side and settled on a slope that varies from 10 to 15%. • The average recovery rate by vegetation is relatively low between 30 to 35%. • The average vegetation height can reach 50 to 60 cm. • The flora includes species from "matorral" like *Lavendula dentata* , *Cistusalbidus* ... Forestand pre- forest remains still exist, such as *Calycotome spinosa* , *Pistacia africana* and others.

Figure 3. Satellite image and overview of irrigated crops and *Tamarix africana* of the second window, study site N°2: "Béni-Saf"

This site is located near the road intersection (Tlemcen - Rachgoun, Tlemcen - Béni-Saf, Tlemcen - Siga). It is positioned on a longitude 1 ° 26 ' West and a latitude of 35 ° 16' North. Exposed to the North-West, this site is located at an altitude of about 40m. Its recovery rate is 30 to 40%. The slope varies between 20 and 25% near the "Oued" and far from it, it becomes low (5 %). The site is based on a siliceous substrate. The vegetation is dominated by herbaceous species, "therophytes", at the expense of tree and shrub species, its average height varies between 1, 5 to 2 m.

At1: Settlement of *Atriplex halimus* dense,
At2: Settlement of *Atriplex halimus* moderately dense,
At3: Settlement of *Atriplex halimus* degraded,
At1 + Pi:Settlement of *Atriplex halimus* dense + *Pistacia lentiscus*,
At1+ As: Settlement of *Atriplex halimus* dense + *Asparagus acutifolius*,
At1 + Fr + Sa: Settlement of *Atriplex halimus* dense +*Frankenia corymbosa* +*Salsola vermiculata*,
At1 + As + Pi: Settlementof*Atriplex halimus* dense +*Asparagus acutifolius* +*Pistacia lentiscus*,
At2 + Wi: Settlement of *Atriplex halimus* moderately dense + *Withania frutescens*,
At2 + Zi: Settlement of *Atriplex halimus* moderately dense + *Ziziphus lotus,*
At2 + Pi: Settlement of *Atriplex halimus* moderately dense + *Pistacia lentiscus*,
At2 +As + Pi: Settlement of *Atriplex halimus* moderately dense + *Asparagus acutifolius* + *Pistacia lentiscus,*
At2 + Ta2+As:Settlement of *Atriplex halimus* moderately dense +*Tamarix gallica* moderately dense+*Asparagus acutifolius*,
At 2+ Fr +Sa: Settlement of *Atriplex halimus* moderately dense + F*rankenia corymbosa* + *Salsola vermiculata*,
Ta1 + Ph: Settlement of *Tamarix gallica* dense + *Phragmites communis*,
Ta2 + At1: Settlement of *Tamarix gallica* moderately dense + *Atriplex halimus* dense,
Ta2 + Pi: Settlement of *Tamarix gallica* moderately dense + *Pistacia lentiscus*,

Ta2 + Ac: Settlement of *Tamarix gallica* moderately dense + *Acacia albida*,
Ta3 + At2: Settlement of *Tamarix africana* + *Atriplex halimus* moderately degraded,
At3 + Pi: Settlement of *Atriplex halimus* degraded + *Pistacia lentiscus,*
At3 + Zi: Settlement of *Atriplexhalimus* degraded + *Ziziphus lotus,*
At3+ Zi + Pi Settlement of *Atriplex halimus* degraded + *Ziziphus lotus* +*Pistacia lentiscus,*
Pi + Wi: *Pistacia lentiscus* + *Withania frutescens,*
Ca + Pi + *Calycotome spinosa* +*Pistacia lentiscus,*
Cis + La: *Cistus villosus* + *Lavandula dentata,*
Ne: *Nerium oleander,*
Ju: *Juncus maritimus,*
Ph: *Phragmites communis,*
Ac: *Acacia albida,*
Sn: Bare soil,
Eu: *Eucalyptus globulus,*
P: Lawn,
Ci: Irrigated crops.

RESULTS AND DISCUSSION

First site "HammamBoughrara"

Comparison of results in both periods (2004 and 2013) for the site 1 permits to note: irrigated crops dominate the surface (8.9389 Ha) with a percentage that remains the same (52.98% in 2004 and 2013). *Tamarix africana*, medium quality (Ta2), do not seem to have modification surface but Ta1 slightly decreases between the two periods (2004: 0.4381 Ha or 2.60% and in 2013: 0.4185 Ha or 2.48%). As for *Atriplex halimus*, it stayed almost stable in its moderately and degraded density, with very low values, while the dense form (At1) increases from 0.5840 Ha (3.46%) in 2004 to 0.8054 Ha (4.77%) in 2013.

The *Atriplex halimus* with *Ziziphus lotus* (At2 + Zi) regress considerably 2.3664 Ha (14.02%) in 2004 and 1.0850 Ha (6.43%) in 2013.Lawns (P) show an increase, they rose from 0.7298 Ha (4.32%) in 2004 to 1.2506 Ha (7.41%) in 2013, while the mosaic formations show some significant changes between the two periods.

Table 1. Floristic stands areas for study site N°1 in 2004 and 2013

Stands in 2004	Areas		%	Stands in 2013	Areas	%
	Areas on land in m^2	Areas on land in Ha		Areas on land in m^2	Areas on land in Ha	
Ta1	4185	4.185	Ta1	4381	0.4381	2.60
Ta2	4070	0.4070	Ta2	4070	0.4070	2.41
At1	8054	0.8054	At1	5840	0.5840	3.46
At2	6749	0.6749	At2	6949	0.6949	4.11
At3	2853	0.2853	At3	2853	0.2853	1.69
At2+Zi	10850	1.0850	At2+Zi	23664	2.3664	14.02
At2+Pi	2162	0.2162	At2+Pi	2377	0.2377	1.46
Ta2+At1	14764	1.4764	Ta2+At1	15373	1.5373	9.11
At3+Pi	5038	0.5038	At3+Pi	4200	0.4200	2.49
At3+Zi	729	0.0729	At3+Zi	769	0.0769	0.45
At3+Zi+Pi	556	0.0556	At3+Zi+Pi	1556	0.1556	0.92
P	12506	1.2506	P	7298	0.7298	4.32
Ci	89383	8.9383	Ci	89389	8.9389	52.98
Ne	1788	0.1788	Total	168719	16.8719	100
Ju	1056	0.1056	0.62			
Ph	3955	0.3955	2.34			
Ac	750	0.0750	0.44			
Total	168719	16.8719	100			

Table 2. Floristic stands areas for study site N°2 in 2004 and 2013

Stands in 2004	Areas		%	Stands in 2013	Areas	%	
	Areas on land in m^2	Areas on land in Ha		Areas on land in m^2	Areas on land in Ha		
Ta1	6690	0.6690	Ta1	7165	0.7165	2.84	2.66
Ta2	8530	0.8530	Ta2	8530	0.8530	3.39	3.38
At1	27112	2.7112	Ta3	1899	0.1899	0.75	10.77
At2	4304	0.4304	At1	29157	2.9157	11.58	1.71
Ta2+Pi	2349	0.2349	At2	4304	0.4304	1.71	0.93
Ta2+Ac	1899	0.1899	At3	1701	0.1701	0.68	0.75
Ta2+At1	8213	0.8213	Ta2+Pi	2349	0.2349	0.93	3.26
Ta1+Ph	10906	1.0906	Ta2+At1	6802	0.6802	2.70	4.33
At1+Pi	6665	0.6665	Ta1+Ph	10906	1.0906	4.33	2.65
At1+Fr+Sa	10023	1.0023	Ta3+At2	1411	0.1411	0.56	3.98
At1+As+Pi	2844	0.2844	At1+Pi	4892	0.4892	1.94	1.13
At1+As	2264	0.2264	At1+Fr+Sa	7593	0.7593	3.02	0.90
At2+Wi	2421	0.2421	At2+As+Pi	2844	0.2844	1.13	0.96
Pi+Wi	2658	0.2658	At2+Ta2+As	2264	0.2264	0.90	1.06
Ca+Pi	2592	0.2592	At2+Wi	2421	0.2421	0.96	1.02
Cis+La	4661	0.4661	At2+Pi	1773	0.1773	0.70	1.85
Ph	9594	0.9594	At2+Fr+Sa	2430	0.2430	0.96	3.81
Sn	10917	1.0917	Pi+Wi	2658	0.2658	1.07	4.34
Ci	127035	12.7035	Ca+Pi	2592	0.2592	1.03	50.47
Total	251677	25.1677	Cis+La	4661	0.4661	1.85	100
			Ph	21209	2.1209	8.43	
			Eu	1695	0.1695	0.67	
			Sn	10917	1.0917	4.33	
			Ci	109504	10.9504	43.50	
			Total	251677	25.1677	100	

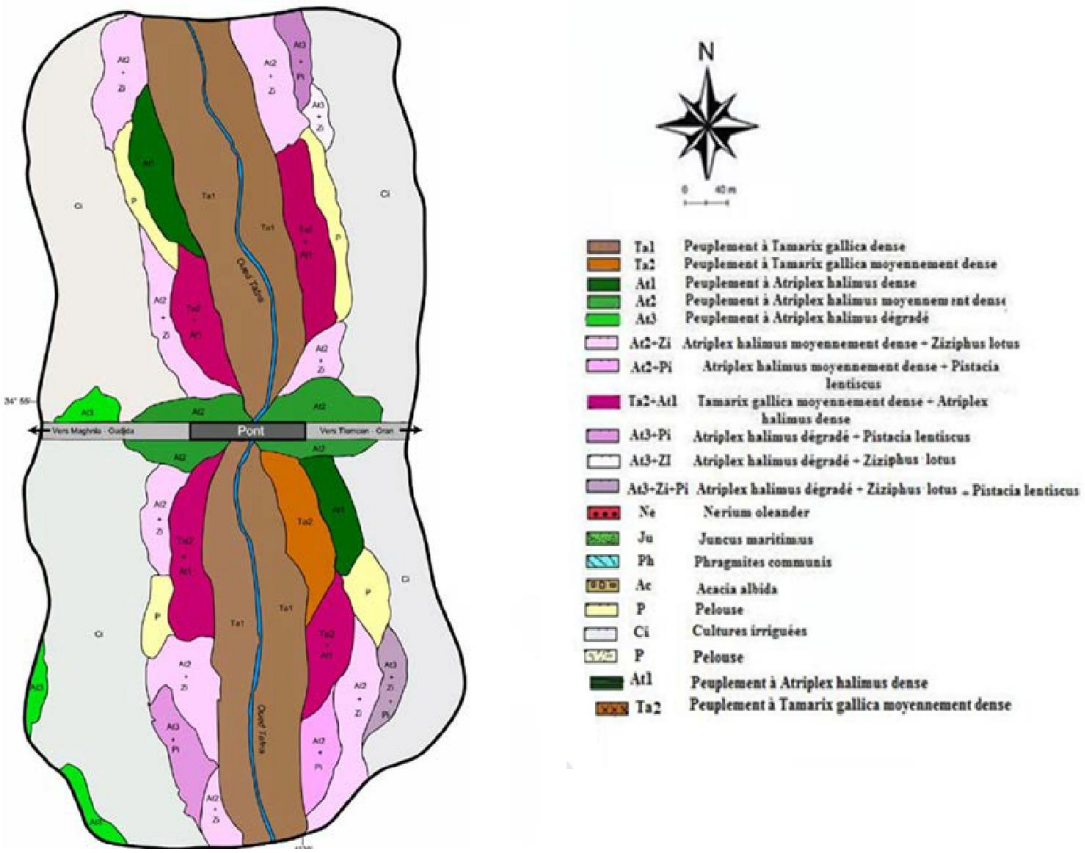

Figure 4. Vegetation physiognomy in 2004 and 2013 of study site N°1 "Hammam Boughrara"

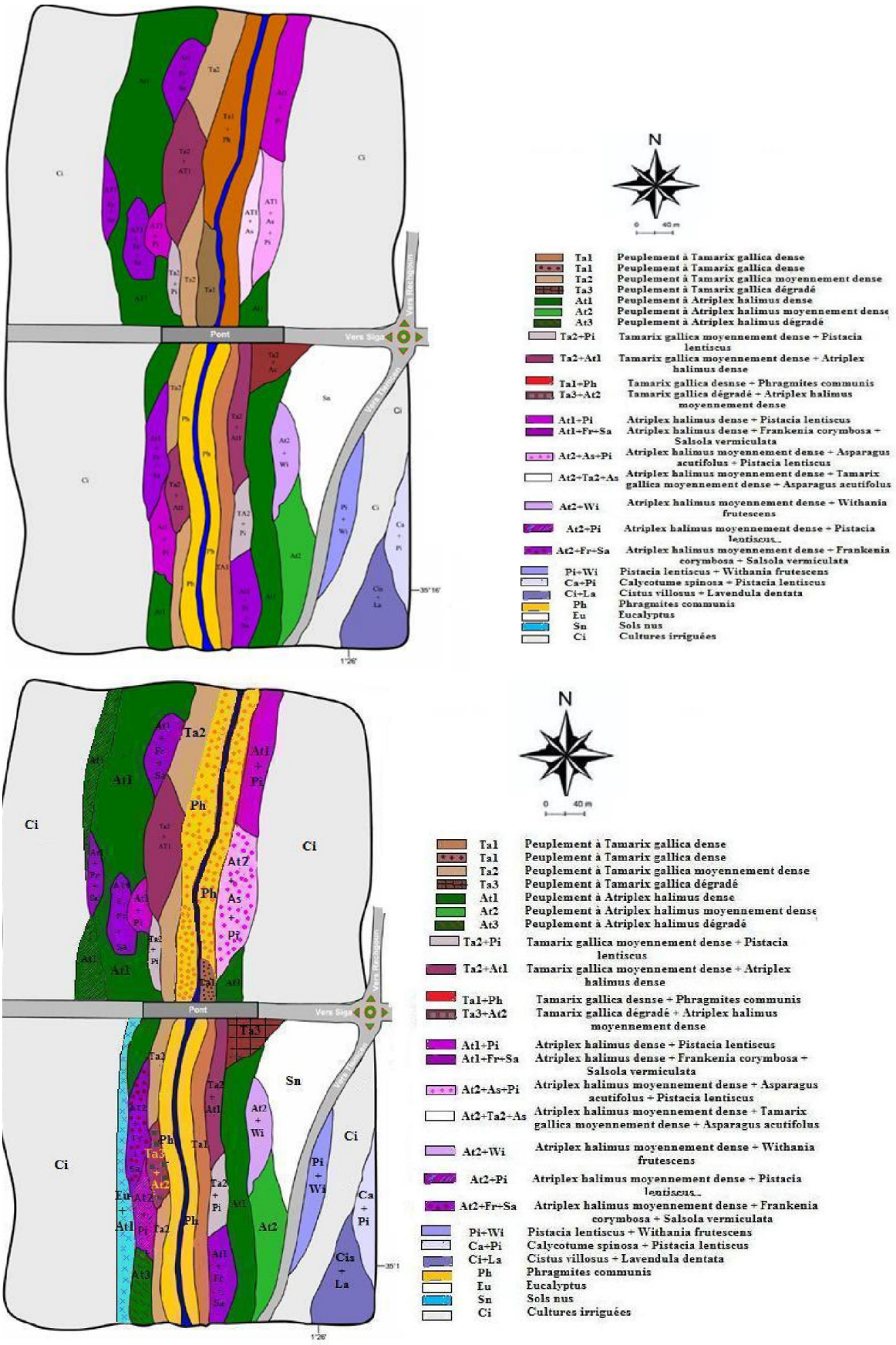

Figure 5. Vegetation physiognomy in 2004 and 2013 of study site N°2 "Béni-Saf"

Furthermore, it should be noted the new formations emerged in 2013 as *Nerium oleander* (0.1788 Ha or 0.11% of the total area), *Juncus maritimus* (0.1056 Ha or 0.62%), *Phragmites communis* (0.3955 Ha or 2.34%) and finally *Acacia albida* (0.0750 Ha or 0.44%). Irrigated crops occupy large areas, this agricultural activity appears to be facilitated by the proximity of the "Oued" (8.9389 Ha or 52.98% in 2004 and 2013).The natural landscape of the Northern Plains of Tlemcen consists essentially of a plant formation quite characteristic of the Algerian northern areas: *Tamarix africana* and *Atriplex halimus* . Among the works done, on these woody and herbaceous vegetation formations, here are a few of them: Djebaili (1978), Aimé (1991), Merzouk (2010). This entire works were conducted mainly on *Tamarix africana*, *Atriplex halimus*. Their temporal dynamic within this manmade ecosystem, as well as the descriptors, were masters of work; they reveal unsurprisingly natural degradation of this landscape (foothills, mountain slopes and settlements of Tamaricaceae).

Second site"Béni-Saf"

The physiognomic examination of 2004 and 2013 periods reveals on this site (larger than the previous one), very close to the Mediterranean Sea, a holding of Tamarix surfaces Ta1 (0.6690 Ha or 2.66 % in 2004 and 0.7165 Ha or 2.84 % in 2013). The degraded settlement of Tamarix appears in 2013 Ta3 (0.1899 Ha or 0.75 %).The Atriplex (At1 and At2) do not show important changes between 2004 and 2013 (At1 : 2.7112 Ha or 10.77 % in 2004 and 3.1271 Haor11.58 % in 2013; At2 : 0.4304 Ha or 1.71 % in 2004 and in 2013). All mosaics formations do not evolve in the same way between the two periods, Ta2 + Pi (*Tamarix gallica* and *Pistacia lentiscus*) maintain at a stable level (0.2349 Ha or 0.93%). Tamarix with *Phragmites communis* do also recorded no changes (1,899 Ha or 0.75% in 2004 and 2013). The new mosaics settlements found in 2013 are:

- Tamarix africana moderately degraded + Atriplex halimus moderately dense (0.55%).
- Atriplex halimus moderately dense + Pistacia lentiscus (0.7%).
- Atriplex halimus moderately dense + Frankenia corymboza + Salsola vermiculata (0.95%).

Atriplex halimus + *Frankenia corymbosa* + *Salsola vermiculata* mosaic settlement see their area decrease (1.0023 Ha or 3.98% in 2004 against 0.7593 Ha or 3.02% in 2013). Other mosaics settlements like *Calycotome spinosa* + *Pistacia lentiscus* or *Cistus* + *Lavendula dendata*) show no significant changes in their areas between the two periods. *Phragmites communis* doubles his area in nine years (0.9594 Ha or 3.81 % in 2004 and 2.1209 Ha or 8.43 % in 2013). *Eucalyptus globulus* is a new formation that appeared in 2013 (0.3695 Ha or 0.67 %), it consists, in this site, of young reforested subjects. If no changes are observed on bare areas, on the contrary, irrigated crops accuse some regression (12.7035 Ha or 50.47 % in 2004 and 10.9504 Ha or 43.50 % in 2013).

Conclusion

The mapping is intended to inform us about the potential of a territory, its use and abilities. This method allowed a space-time monitoring of the dynamic of vegetation. The diachronic study of land use from these dated documents allowed us to analyze and quantify the changes between 2004 and 2013.The diachronic analysis highlights the changes in our environment over time. The landscape analysis is particularly important in the field of restoration in order to know in detail factors structuring the resilience of vegetation. It is not surprising to see irrigated crops and land clearing to take more and more importance (1% increase per year).

Site 1: "HammamBoughrara"

Atriplex with *Ziziphus lotus* (At2 + Zi) have their areas decrease significantly 2.3664 in 2004 against 1.0850 Ha in 2013.The areas of lawns (P) increase, they move from 0.7298 Ha in 2004 to 1.2506 Ha, while the mosaic formations show little significant changes between the two periods. Well preserved in comparison with the second station, *Tamarix africana* is less degraded; but the manifestation of an imbalance, marked by the absence of "Oued" ' flooding which is probably due to drought, may explain, the partial disappearance of *Tamarix africana*. The "therophytisation" seems to be more important. We noted in 2013 the apparition of new formations such: *Nerium oleander* (0.1788 Ha), *Juncus maritimus* (0.1056 Ha), *Phragmites communis* (0.3955 ha) and *Acacia albida* (0.0750 Ha).

Site 2: "Béni-Saf"

Phragmites communis double his area between 2004 and 2013 (0.9594 Ha in 2004 against 2.1209 Ha in 2013). *Eucalyptus globulus*, new species appeared in 2013 (0.3695 ha), correspond to young reforested subjects.

However, a change of the scaly structure of the soil in these immersion areas (due to the episodic drought) was observed; it is a frequent phenomenon. The difference of 9 years for the chosen study period is insufficient. This spatio-temporal vegetation' dynamic of Tamaricaceae needs to be followed by multiplying the number of observation sites along the "Oued" Tafna and by increasing the period time study.

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