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STRUCTURE OF VEGETATION IN NORTHERN AND CENTRAL TUNISIA AND PROTECTIVE MEASURES

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ABSTRACT

Vegetation in Tunisia is mainly made up of forests, steppe and pasture land. Anthropic pressures, associated with harsh climatic conditions, have led to the degradation of the ecosystems coupled with a decrease in floral diversity. Many species are threatened with genetic erosion. The founding of 7 national parks and 14 natural reserves represent the first steps taken to protect the ecosystems and maintain their genetic diversity. In Tunisia, these conservation measures, *in situ*, should be associated with *ex situ* conservation programmes in gene banks.

KEY-WORDS

FORESTS, *STEPPE*, PASTURE LAND, GENETIC EROSION

MOTS-CLES

FÔRETS, STEPPES, PÂTURAGES, ÉROSION GÉNÉTIQUE

INTRODUCTION

A precise knowledge of local or regional flora and its evolution makes up the foundation of any phytogenetic resource and natural landscape conservation programmes.

In Tunisia, vascular flora's varied. It comprises 2,103 species grouped into 115 families and 742 kinds which grow in bioclimatic zones ranging from humid to Saharan climate (Cuenod & al. 1954; Poitier-Alapetite 1979; 1981; Nabli 1991a). Endemic species were limited to 34 taxa, of which fourteen have a specific rank and twenty, an infraspecific rank.

The cartography of vegetation structure, already carried out on various scales (Novikoff 1957 ; Schœnenberger 1967; Lehouérou 1969; Gounot 1957,1995), provides valuable information about floral composition, ecogeographic distribution and use of a large number of vegetion groups.

Demographic growth and human activities in Tunisia over the last century have led to a profound transformation of the equilibrium of ecosystems and a significant decrease in floral diversity. Land clearing, deforestation caused by agricultural and industrial exploitation, forest fires, overgrazing (especially in a dry environment) and pollution have led to a degradation of the natural vegetation.

Numerous plants – particularly those related to cultivated forms – have disappeared or are threatened with extinction. But the majority are doomed to disappear because of genetic erosion resulting from the eradication of individuals or populations (Table 1).

This observation invalidates an important number of floral and phytoecological surveys and calls for new observations to update information about the situation and draw up protective strategies.

Starting from a reflection on the state and composition of the natural, forested and pastoral ecosystems in Northern and Central Tunisia, we shall deal with the prospects for preservation of native flora.

FORESTS

Forested vegetation made up of oak and coniferous is relatively well known in Tunisia (Schœnenberger 1957;1962). The nature and surface of forest distribution are determined by rainfall, altitude and the nature of the substratum.

We shall also mention with the main species that make up the forests as well as their floral composition, often a good indicator of the state of the forest and the edaphic and climatic environment.

a. The main forest species

Quercus faginea is limited to certain acid massifs in Khemir and Mogod in wet and sub-wet bioclimatic zones. In 1960, it used to cover 10 000 ha and 30 000 ha when mixed with *Quercus suber*. It grows in the coolest areas above 700 m and where the rainfall is over 800 mm/year. In Ain Zana, Ain Draham and El Fedja it is accompanied by clumps of *Quercus afares* with which it can hybridise .

Decrease in rainfall , altitude and soil depth restricts its localisation along permanent wadi, with *Alnus glutinosa*, *Populus alba*, and *Nerium oleander*. In a normally-constituted forest, *Q. faginea* is accompanied by *Erica arborea*, *Arbutus unedo*, *Ilex aquifolium*, *Rubus ulmifolius*, *Agrimonia eupatoria*, *Brachypodium sylvaticum*, *Cyclamen africanum*, etc.

Quercus suber is mainly situated in the humid zone in Khemir and in Mogod (from Bizerta to Tabarka, Ain Draham, El Fedja) at altitudes over 500 to 600 m on the acidic slopes facing south. Its optimum development lies where there is about 800 mm of rain per year. The existence of small clumps of this plant high up, in the Cap-Bon, in the Zaghouan and Serdj mountains is evidence of its wide distribution. Its area is at present estimated at between 100 000 and 130 000 ha. *Arbutus unedo, Erica arborea, Cistus salviifolius, Cytisus triflorus, Pistacia lentiscus, Myrtus communis, Chamerops humilis and Pteridium aquilinum,* of variable frequency and dominance, depending on the altitude, make up the main floristic cover.

Pinus pinaster, confined to the Algerian border (in the Calle-Tabarka region), covers 6,000 to 10 000 ha. It grows on siliceous soil mixed with the cork-oak (witht 800-1500 mm rain/year and at altitudes less then 600m). *Erica scoparia, Halimium halimifolium, Lavandula stoechas* and species related to them indicate its good development.

Quercus coccifera presents a distribution area between the humid and lower semi-dry zones, with from 400 mm rain/year. Its optimum development is found in the semi-humid zone. The species mainly occupies a littoral situation (altitude < 250 m) on fixed dunes from Tabarka to Nabeul, where it covers 10 000 ha. The species related to it, which differ according to bioclimatic zone, are mainly represented by *Halimium halimifolium, Brachypodium ramosum, Scrofularia sambucifolia, Pistacia lentiscus, Phyllirea angustifolia, Lavandula stoechas* and *Thymus capitatus,etc.* Small bushy clumps exist in the interior (at altitudes of 600-700m) in the Mansour, Zaghouan, Baouala and in Teboursouk mountains. The *Q. coccifera* is associated with *Pinus halepensis* and *Rosmarinus officinalis.*

Quercus ilex covered an area of 80 000 ha. It is mainly restricted to the Tunisian Ridge (the Bargou, Serdj and Fkirine mountains, Kessera and Maktar) where it is dominated by *Pinus halepensis* and related species . The species grows either in hmid or higher semi-dry zones where there is variable rainfall (400 mm in Zaghouan and 1000 mm in Ghardimaou) at increasing altitudes and the further one goes inland (400 m in Zaghouan and 1200 m in Mount Chaambi), forests, in an arborescent state, are rare and situated at altitudes above 900 m (Ghardimaou, Serdj, Bargou) (Shoenenberger 1962; Debazak 1959).

The species which accompany *Q. ilex* vary according to the greater or lesser state of regression of the forest *(Ampelodesma mauritanica, Cistus villosus, Rosmarinus officinalis, Pinus halepensis)* and the bioclimatic zone (*Pistacia terebinthus, Laminium longiflorum, Jasminum fruticans and Centaurea lagascae.*

Pinus halepensis covered an area of 340 000 h in 1960. Its distribution extends from humid to upper dry with an optimum at the level of upper semi-dry (around 400-600 mm rain/year), in the Oued Mellegue basin and at the level of the Tunisian Ridge. The best growing examples are situated in the regions of Kessera (around 900 m altitude) and Thala-Chaambi (around 1400 m altitude). Some of the populations in the North (Fernana, Mount Chemtou) and in the Cap Bon (Mount Abderrahmen,korbous) acquire individual characteristics. The undergrowth is made up of *Rosmarinus officinalis, Globularia alypum* and *Cistus* spp..

Some plant communites of *Pinus halepensis* are formed according to continentality, altitude,the degree of aridity and nature of the substrata.

b. Present state of vegetation

The forests of different species indicate a process of regression, the intensity of which varies according to region. (Shoenenberger 1967; Lefloc'h 1991; Nabli 1995).

Q. faginea, Q. suber and *Pinus pinaster* forests which are situated on broken and not very fertile lands, still present undisrupted climatic vegetation landscapes. Nevertheless, local degradation processes of (suberaie and Zenaie) are evident in the areas of Tamra, Sejnane, Ain Draham, Dj Ghorra, El Fedja. Besides the many different kinds of anthropogenic pressures (such as the use of *Q. faginea* for the manufacture of railway sleepers and pitprops, fires, and overgrazing) have led to a significant alteration of the landscapes and a degeneration of their floral diversity. Maquis of *Arbutus unedo, Erica arborea, Myrtus communis* and *Cistus monspelliensis* evolve progressively into pasture lands with *Pteridium aquilinum, Asphodelus microcarpus, Plantago serraria, Dactylis glomerata* and annual species without a value as fodder or pasture.

Diverse human activity has affected the populations of *Q. coccifera*. Coal-mining, tannin and coal exploitation (in Khemir and Mogod) have transformed the forests into garrigues, of little pastoral value, though regeneration of this species through suckering is perceptible. The forest is increasingly retreating because of the clearing of land for viticulture, fruit and vegetable growing, particularly in Cap Bon in the following regions: El Haouaria-Korbous, Oued El Abid and Abderrahman mountain.

The *Q. ilex* forest, which has from classical times been used for charcoal has been transformed into woods, which shelter *Ampelodesma mauritanica, Cistus villosus, Calycotome villosa.* The degradation is mainly discernible in the Zaghouan aera, at Bir Halima, Maktar and in Kessera.

Restoration of the forest is difficult because stump regeneration is very low and substitutes (*Cupressus, Pinus, Ecalyptus)* have difficulty adapting to the soil and climatic conditions.

The degree of pine forest cover is variable. It is cleared on the borders for the benefit of yearly crops and fruitg rowing in the Cap Bon and at the level of the Tunisian Ridge (Kef-Maktar-Zaghouan ...). The degradation processes transform the landscapes into garrigues of rosemary, *Cistus, Calycotomes* and into steppes of *Stipa tenacissima* and/or of *Arthemesia* at the level of and south

of the Tunisian Ridge. Processionary caterpillar attacks threaten some of the populations (Bergou, Maktar,...)

The best plantations of lentiscus and oleanders with or without carob trees are greatly damaged in Khemir, Mogod,the Medjerda valley, Cap Bon and at Tunisian Ridge level. They have been replaced by cultivated lands. Traces of old oleanders and carob trees in marabou sites show that these species were formerly widely distributed in Northern and Central Tunisia. Almost all the cultivated lands in Northern Tunisia are the result of the clearing of lentiscus and oleanders.

In all forests, destruction of the species is accompanied by soil and herbaceous stratum degradation. A rarefaction or even an extinction of pastoral species populations (*Cytisus triflorus*, *Festuca drymeja*, *Gewm urbanum, Platanthera bifolia*) was reported in Khemir and in Mogod, due to overgrazing (Nabli 1989,1991b; Shoenenberger 1995). Some pastoral species, such as *Hedysarum flexuosum* and *H. humile* have disappeared from the Tunisian Ridge. *Medicago tunetana*, located at the semi-arid stage, is only represented by scattered populations, confined in refuge zones.

In central and Southern Tunisia soil clearing the extension of cereal crops and tree dwelling has led to soil and pastures land degradation.

Overgrazing has led to a rarefaction of perennial species and to a selective elimination of annual plants affected before fructification. Perennial species (fixative sand, pastoral) have progressively been replaced by species indicators of desertification.

Eradication of woods, particularly through coal mining, has led to an excessive degradation of *Acacia raddiana, Calligonum azel, Calligonum arich*, which is overexploited, continuously diminishing.

PASTURE LANDS

These natural vegetal formations are complex and relatively less studied regardless of their important fodder and pastoral potential. Their should be associated with that of weed vegetation (Thiault 1957; Gounot 1957; Schoenenberger 1995).

Their surface, always fluctuating (reduction by clearing for the benefit of cereal cultivation variable according to year and extension to the detriment of forest), cannot be easily assessed. It corresponds to about 150 000 ha in the North of the Tunisian Ridge, deriving from primitive forest.

The pasture lands have the same aspect as the garrigues, maquis or small flat parcels temporarily flooded or broken and cut out by water run-offs.

Thiault (1995) distinguished between the forest-covered pasture lands, unploughed lands, waste lands and the pasture lands of humid and badly-drained depressions. Yet, very few pastoral species are capable of characterizing certain pasture lands. Species are often mixed and each has a large distribution area.

The forested-pasture land pastoral species (dominantly-woody and with mediocre pastoral herbaceous stratum) are derived from the *Quercus suber* forests *(Cytisus triflorus, Festuca coerulescens, Brachypodium sylvaticum,...);* the lentisus and oleander (*Rubus ulmifolius, Phyllirea angustifolia, Dactylis glomerata, Ebenus pinnata, Hedysarum coronarium, ...); Quercus ilex and Pinus halepensis (Stipa retorta, Orysopsis milicea, Dactylis glomerata, Avena bromoïdes, Phalaris truncata,...).*

Grazed unploughed lands in wet or semi-dry environments have a pastoral value and floral diversity influenced by the techniques of cultivation. They are often restricted to poor and eroded soils or those temporarily flooded. In both traditional and modern cultivation, grazed unploughed lands have little pastoral value and are usually a major constraint for the success of

cereal crops: abundance of weed species hard to eradicate *(Avena sterilis, Lolium rigidum)* and the constraints of ploughing and soil preparation.

In the wet and sub-wet stages, soil ploughing has led to a rarefaction of prennials with a good pastoral value *(Festuca elatior, Phalaris coerulescens, Phalaris truncata, Hordeum bulbosum, Dactylis glomerata, Hedysarum coronarium).* Improvement of unploughed lands should be directed towards adapted fodder crops by transforming surfaces into temporary prairies preserved every 2-5 years. This enables the increase of fodder resources over a long period, improvement of soil structure and protection against erosion and absorption of the excess of water.

Local species, exploited unadulterated or mixed, of *Medicago, Hedysarum, Hordeum, Festuca,* with an appreciable winter growth and having already been analysed for genetic variability, could help in the creation or restoration of these pasture lands (Figier & al. 1978; Abdelkefi & al.1992; Harzalli 1994, Boussaid & al. 1995.)

In the semi-arid zone, the grazed unploughed land's productivity is greatly influenced by quantity and regularity of rainfall. The success of unploughed lands is often unfavourable for a good wheat harvest due to exhaustion of soil water reserves and to a belated soil preparation. A choice of species, type of rotation and manner of grazing could lead to some solutions. Perennial and annual local species of *Medicago,* well-adapted to the semi-dry, can constitute good partners in the improvement of these unploughed lands.

CONCLUSIONS

The vegetation formations in Tunisia, represented by forests, pasture land, steppe or by an hydrophilic or halophilous vegetation or weeds are everywhere subjected to degradation processes due to strongly-marked anthropic pressures. Genetic erosion is difficult to measure for all the plant species in the different ecosystems. Forest vegetation and that of pasture lands, highlighted here particularly for their economic and agronomic interest, is a priority for conservation.

The forests (species + floral cover) show signs of variable regression according to region. The conservation of ecosystems, plant groups, species and the most threatened populations is vital.

The conservation modalities and priorities are restricted by the types of environment (defined by climatic and edaphic factors), intensity of genetic erosion and the level and nature of pressures.

Conservation *in situ* (natural reserves and national parks ...) or *ex situ* (gene banks, botanical gardens) are complementary and necessary in different proportions according to the species to be protected.

The creation of seven national parks and fourteen national reserves (Fig. 1) in Northern, Central and Southern Tunisia, has allowed the conservation of the dominant vegetation, the proliferation of endangered species and the emergence of taxa that have not been seen for ages. These protected zones make a good starting point for the conservation of species in relation to the plans for protecting ecosystems . However, they do not necessarily preserve the species' genetic diversity and other interesting species (medicinal-pastoral) that are associated with them. Besides, there are no complete and regular floristic surveys for these reserves that take into account the list of wild plants connected to cultivated forms. Their control objectives (gathering programmes, evolution of protected populations, promotion and education) should be redefined.

The creation of new reserves sheltering different populations (by physiognomy and habitat) should be considered. Genetic diversity can be extended to remote regions. The creation of a network of reserves in North Africa (geographic continuum) deserves further discussion

Forest protection can be supported by research into substitution trees (*Eucalyptus* for example) and their cultivation in groups to limit their being burned as charcoal. Planting fodder crops and setting up artificial grazing lands, underwood, would restore the forested environment and limit the effect of overgrazing.

The methods of conservation of native pastoral species for the improvement of pasture lands can be viewed in more or less the same terms as those for forested vegetation.

The creation of natural reserves and the choice of species and zones should be determined beforehand by an analysis of genetic diversity of species populations in their overall distribution area. Priority given to any particular species should take into account its level of variability (estimated by morphological and biochemical techniques) and the purposes of its use in the short or long term. The creation of genetic reserves, specially designed for wild species related to cultivated forms (e.g. wheat –fodder), should be considered both for forest and pastoral species. These species will provide the basis for selection programmes.

Table 1: List of plants which need to be protected in Tunisia

Species	Category and Criteria[1]
Acacia raddiana	EN, A1a
Ajuga iva	VU, A1
Astragalus gombo	CR, A1c
Astragalus tenufolius	CR, A1c
Calligonum arich	EN, C2a
Calligonum azel	EN, *C2a*
Capparis spinosa	LR
Cornulaca monocantha	EN, A1
Festuca drymeja	VU, B2
Genista saharae	CR, A2
Globularia alypum	VU, A1
Quercus afares	LR
Hedysarum carnosum	EN, A1
Hedysarum flexuosum	EX
Hedysarum humile	EX
Hordeum bulbosum	VU, B2
Juglans regia	EN, A1a
Laurus nobilis	EN, A2
Marrubium deserti	EN, A1
Medicago tunetana	CR, A1a
Oudneya africana	EN, A1
Panicum turgidum	VU, A1
Periploca laevigata	EN
Pistacia atlantica	EN, B2
Prosopis stephaniana	CR, B1
Prunus avium	EN, A1a
Pyrus syriaca	EN, A1a
Traganum nudatum	EN, A1

Abbreviations : EX: extinct, CR: critically endangered, En: endangered, LR: low risk, VU: vulnerable.
[1] Categories and criteria used were those adopted by the IUCN (1994)

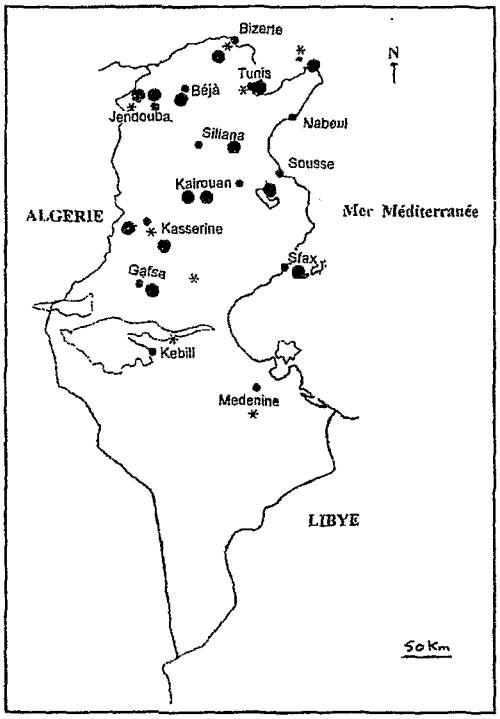

FIG. 1: Tunisian map: Location of national park(*) and natural reserves (•)

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