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Chapter 5

THE CORK OAK, A NEGLECTED TREE RESOURCE IN ALGERIA

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ABSTRACT

This chapter is intended to address some key questions about *Quercus suber*, such as updating some information on the tree and its distribution by spotting where the species grows and prevails. Despite

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economic importance of Cork Oak, these last decades, the *resource* is *neglected* and underexploited. As a result, cork production is decreasing and natural habitats are more and more fragmented. This work may serve as guide to understand the adaptability and responses to various threats of the tree and select the most appropriate available techniques to ensure a long-term survival of the tree.

Keywords: *Quercus suber*, distribution, industry, threats, conservation, North Algeria

BACKGROUND

Knowledge on diversity, threats and particularly spatial distribution patterns of forest tree species in Algeria has not been enough documented in the last decades. It is true that it is difficult to establish a reliable database owing to the lack of technical personnel and appropriate technology in the country. National Forest inventories showed a justifiable discrepancy in data throughout the estimation reports on forest cover and loss. As it was written literally in the report of FAO's FRA (2000): "The Algeria data set is obsolete. Information used by FRA 2000 was generated from a countrywide inquiry led by a local consultant. It was a simple updating of the 1982 inventory on the basis of local knowledge." This Inconsistency and imbalance of available information comparing to Northern Mediterranean countries encouraged us to re-examine ancient and recent available literature. It is important to mention that various facts on Cork oak tree (i.e., pest threats) described here are not exclusive to Algeria. They are only lesser known due to the nature and availability of literature but in term of responsibility, i.e., international cooperation through *exchange of information* on *invasive pest* attacks must be a *shared concern* at the global level as bugs have no frontiers.

1. INTRODUCTION

The Mediterranean Basin is one of the world's major centers for plant diversity (Médail and Quézel, 1997). It is home to a large

diversity of species and habitats. Its flora diversity is outstanding with ca. 25,000 species of which 60% are unique to a region recognised as an exceptional biodiversity hotspot making it one of the highest concentrations of endemic plants worldwide (Myers et al., 2000). However, with rapid habitat loss and continuous species extinction, there is a serious concern about the effectiveness of existing strategies for minimizing biodiversity loss. Forests and woodlands tree species are also affected, as they are other key components of our landscapes. The number of tree species (around 100) in *Mediterranean countries* is three times more than central Europe (30 species), with the genus *Quercus* alone presenting more than 20 species in the region. Forests support approximately 80% of the world's terrestrial biodiversity and provide key services to humanity such as: timber, food, recreation, and climate and water regulation (Balvanera et al., 2014). *Tree*-mediated ecosystem *services* are also recognized as key features of more sustainable agro ecosystems by contributing to more resilient rural livelihoods (Prabhu et al., 2015; Balvanera et al., 2016). It is difficult to establish a reliable chronology on the states of either conifer or broadleaf forests in North Africa but few past and recent literature reported intense forest degradation. Currently, the Algerian forest area occupies about 4,525,000 ha (FRA 2015). Boudy (1950) listed 17 main forest tree species for North Africa forming pure or mixed stands over large areas and 51 being scattered geographically surviving in small, isolated locations such as relict stands and Alder grooves.

We collected data on cork tree species *Quercus suber* taking into account some conservation, social and economic values. In other terms, this work can help identify knowledge gaps and highlight where improved information on cork oak forest resources is needed. Managing trees for ecosystem services requires understanding, which tree species to include and how to manage them for different socio-ecological contexts (Barriosa et al., 2017).

2. CLIMATE AND TOPOGRAPHY

Algeria occupies an *exceptional geographic location* with a total area of 2,381, 741 km². It is the largest country on the African continent, bordered to the North by the Mediterranean Sea and to South by the large Saharan desert giving thus rise to different *climate* types. Except the Saharan desert, climate is typically Mediterranean over almost all the northern parts of the country with rainfall concentrated during winter and dryness occurring during summer. The average level of annual precipitations is changing from year to year and subjected to profound local influences (altitude, continental gradient). The rainfall is ranging from less than 100 mm in the Sahara to nearly 1500 mm in the upper northern mountains (Seltzer, 1949). In this work we will be interested only to Tellian zones circumscribed within the Mediterranean bioclimatic to understand where the main tree resources are distributed (Figure 1). The targeted zone is subdivided geographically as follows: The western Tell, a series of Jurassic and Cretaceous limestone massifs of average height (mounts of Tlemcen, Dhaya and Beni-Chougrane). The western Tell is interspersed by large depressions (Oran and Chlef lower plains). The central Tell consists of a series of massifs of sedimentary sandstone, dolomite, limestone and marl rocks. The massifs of Djurdjura are the most prominent ones of which altitude rises to 2300 m. The littoral border is dominated by a large depression forming the alluvial plain of Mitidja. The eastern Tell represents the most mountainous part of Algeria chains consisting of gneiss and granite, which extend those of the Djurdjura. The eastern Tell is a complex series of massifs (Little Kabylie, Babors, Hodna, Belezma, Aurès, and Némemchas) where we can find one of the richest floristic panoramas of Algerian forests. This very decisive geographical and topographical variability is shaping the vegetation composed of natural

formations distributed among the different bioclimatic levels from semi-arid to humid such as Aleppo pine and Thuya. Some other typical conifers: *Cedrus atlantica*, *Pinus nigra*, *Taxus baccata*…etc. are growing under humid and very humid bio climate on higher elevations (Ozenda, 1975). Many leafy trees species occupy the plains and piedmonts of mountains. Few Oak species are widespread dominants throughout the northern forest covers: *Quercus ilex* (holm oak) is one of the most common oaks spreading inland and replaced in the northern coastlines by *Quercus suber*. The rest of the species are *Quercus canariensis, Quercus afares* and *Quercus coccifera.*

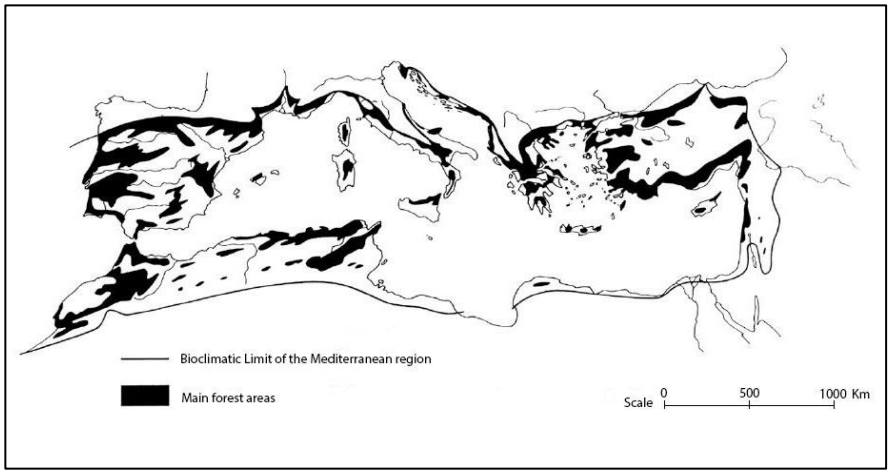


Figure 1. Shrubs and trees distribution in the Mediterranean Basin (Ozenda, 1975).

3. FOREST RESOURCES

There are known limitations of collecting and synthesizing information on Algerian forest resources owing to many factors such as missing or old data that require caution in analysis and interpretation.

Table 1. Some selected variables throughout 4 national forest inventory periods*

Question 1: what is the area of forest and other wooded land and how has it changed over time?					
Variables/Years	1990	2000	2005	2010	2015
Extent of forest area (1000 ha)	1667	1579	1536	1918	1956
Other wooded land area (1000 ha)	2063	2374	2529	2457	2569
Forest expansion (1000 hectares/year)	13.4	0.0	18.8	28.0	-
Deforestation (1000 hectares/year)	11.6	18.0	11.0	18.0	-
Reforestation (1000 hectares/year)	25.0	14.4	29.8	46.0	-
Question 2: what is the area of natural and planted forest and how has it changed over time?					
Planted forest (1000 ha)	333	345	370	498	556
Question 4: what is the status of forest production and how has it changed over time?					
Forest area designated for production (1000 ha)	596	562	544	526	526
Question 6: how much forest area is protected and designated for the conservation of biodiversityand how has it changed over time?					
Forest area within protected areas (1000 ha)	119	119	119	119	119
Forest area designated for conservation of biodiversity (1000 ha)	165	165	165	165	165

*Source: Global Forest Resources Assessment (2015). Desk reference.

The FRA 2000 and 2005 national reports were made on the basis of forest inventory data of 1984. Data from 2005 were only validated in 2008. As a result, in this work we used some global datasets from an updated field-based forest national inventories compiled in Global Forest Resources Assessment (FRA, 2015) organized around 21 key questions grouped into eight topical categories. A selection of some variables are included, most of which covered the period 1990–2015 (Table 1). Forests and other wooded land cover an estimated total surface of 4,525,000 ha representing less than 1% of the total area of the country (FRA 2015). The forests and other wooded land represent respectively 1,956, 000 ha (43.22%) and 2,569,000 ha (56.78%). The average rate of afforestation of the country is quite significant and yet still far for the socio-ecological and environmental balance requirements. The last FAO's FRA (2015) reportmade it possible to better apprehend some key variable where we can yet note rather

positive values such as the extension of the forest area at rates of 2% and 0.4% respectively for the periods 2000-2010 (44, 000 ha/year) and 2010-2015 (76,000 ha/year). Except cork production, other wood derived production type capacities of Algeria are relatively limited compared to European neighbour countries. It is certain that the most important contribution of the Algerian forest ecosystems to the national economy resides more in its protection and recreation roles than in its function as wood productive resource. This conservation vocation is expressed through the existence of forest area designated for conservation of biodiversity (165,000 ha) of which most area parts (119,000 ha) are circumcised within protected areas such as national parks.

4. TREE ORIGIN

Cork oak is one of the major components of northern Algerian forests. This medium-sized tree with an average height of 15-20 meters and the possibility of life span of up 350 years has shaped for centuries our natural landscapes. The tree presence is more and more remarkable travelling eastwards. As an evergreen broad-leaved tree, it may offer shade and shelter or income to their owners by making a wide range of products. Culturally, it is a symbol of strength, morale and resistance. Many studies on section *Cerris* distributed in Europe (Iberian Peninsula), North Africa (Morocco) and Asia (Japan) attested that phylogenetically, cork oak is considered to be closely related to three Asian oak species, all of which are deciduous: the Turkey oak or Austrian oak (*Quercus cerris*) from south west Asia, the saw tooth oak (*Quercus acutissima*) from eastern Asia, and the Chinese cork oak (*Quercus variabilis*) (Manos and Stanford, 2001). According to Sauvage (1961), *Quercus suber* originated from the Iberian Peninsula and extended its area through the straits of Gibraltar at the end of the

Miocene. The center of origin of cork oak has been the subject of controversy for many decades and still under debate (Magri et al., 2007). Indeed, the fossils of the cork oak ancestors in the *Quercus sosnowsky* group have been found in France, Poland, Romania, Bulgaria, Turkey and Georgia (Bellarosa, 2000). The venue of newer scientific tools and technics reinforced the Iberian origin of the tree. Using molecular *analyses* to reconstruct the evolutionary history of closely related oak species (*Quercus trojana*, *Quercus laevis*), Lumaretet al. (2005) brought decisive evidence concerning the so acclaimed geographic origins of cork oak. The genus *Quercus* contains over 500 species, mainly distributed in the northern hemisphere. High diversity of the species is found in Mexico with around 160 species, 109 of which are endemic representing 67.7% of the total species of the genus in the country (Valencia, 2004). *Quercus suber* is not the only representative of its genera of Fagaceae family in the country. Indeed, there are other *Quercus* species occurring in Algeria such *Quercus canariensis, Quercus coccifera* and *Quercus afares*. The latter is an endemic to North Africa and considered as a stabilised hybrid species genetically differentiated from cork oak (Mir et al., 2006).

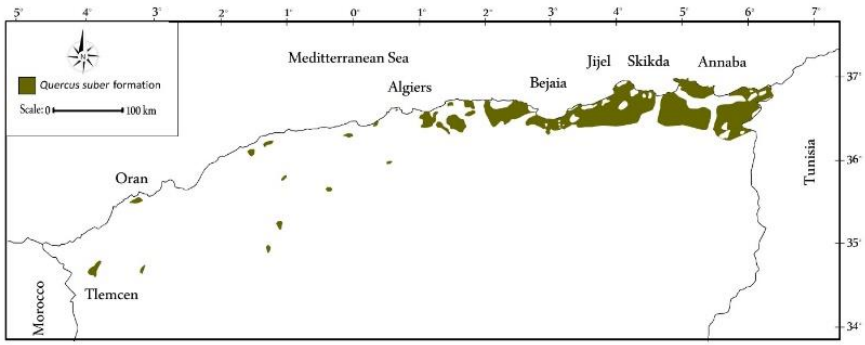
5. TREE DISTRIBUTION

The cork oak forests (*Quercus suber*) cover approximately 2,687,000 hectares (Pausas, 1997). According to other authors (Varela, 2000) the area evaluation is less than 2 million hectares distributed across the western Mediterranean basin having as natural range Algeria, France, Italy, Morocco, Tunisia, Portugal and Spain. The last two cited countries represent more than 50% of the world distribution area (Table 2). The cork oak is circumscribed in the western Mediterranean region

(Quézel, 1976) where positive response to the *influence* of the *Atlantic is more prominent in* Portugal and Morocco. Well known under terms *Dehesas* in Spain, *Montados* in Portugal, *Azaghar* in Morocco (Aronson et al., 2009), cork stands landscapes evolved and their resources have *been* always utilised for many purposes *throughout* generations.

In Portugal, the trees spread over vast plains and plateaus totalling 730,000 ha where most of areas have been under extensive management. As a result, the country is presently the leader of cork production in the world (Table 3). Spain has a very significant area of half a million hectares (Silva and Catry, 2006). Italy represents the eastern limit of the tree covering a total area of 90,000 ha in a very dispersed state. According to (Eduardo, 2001) the species covers more than 225,000 where the island of Sardinia is the biggest producer of cork in the country (Vogiatzakis and Careddu, 2003). The estimates of areas among authors (Gonçalves, 2000; Vogiatzakis et al., 2003) and land planners are still a controversial. The available information on the tree distribution for each country must be carefully exanimated. The delimitation of areas based on different criteria or definitions, of what is i.e., a garrigue, seems to be the main source in *inconsistency and imbalance* of available information. This may also results from the continual regression areas of this ecosystem. In Morocco, the cork oak covers an area of nearly 340,000 ha representing 15% of the world area mainly distributed in Central Plateau and Rif. Mamora is the world's largest extent (Natividade, 1956). The distribution of the cork oak in Tunisia is represented by a continuous northern band occupying almost all the region of Kroumirie - Mogods, about 99, 000 ha bordering Algeria (Silva and Catry, 2006). In Algeria, the Oak is spread along large coast band. However, the most important stands are located eastwards i.e., in the departments of El-Taref, Skikda, Jijel, Annaba, Béjaia and Tizi-Ouzou. The eastern region includes the largest areas (Figure 2) distributed in a rather continuous band along the coastlines mainly growing on siliceous substrates forming the so-called “cork oak region.” In the center of the country, cork oak stands are mainly

distributed in Chlef, Algiers and Delys. In the western part, it remains scattered and constitutes islands of less importance. The less defined areas are mainly concentrated in the region of Tlemcen. A map redrawn (Figure 2) after a rather ancient phytogeographical map of Algeria and Tunisia shows the distribution of cork oak stands with remarkable areas in north-eastern of Algeria. The document is part of a series of thematic maps. Fascicle IV published in 1925, is devoted to phytogeography including a map at a scale of 1: 1,500,000 conceived by R. Maire and his collaborators (1925): J.M. Battandier, G. Lapie, P. de Peyerimhoff and L.C. Trabut. For clarity, the map is intentionally adapted to show only the distribution of cork oak while the document originally represents the distribution of fifteen major species of Algeria and Tunisia (Lespès, 1931). This phytogeographic document, in spite of its epoch, remains one of the most original and detailed distributions of the major trees in Algeria. The results of the last forest inventory (FRA, 2015) attested that Cork oak is nevertheless one of the most widespread tree species in the country, occupying a total area of ca. 357, 000 ha.



Source: Map redrawn after phytogeographical map of Algeria and Tunisia by R. Maire and his collaborators (1925).

Figure 2. Distribution of cork oak in Algeria. *Small patches especially in the western regions are not represented.

Table 2. Geographic distribution of cork oak woodlands worldwide (Silva andCatry, 2006)

Countries	Area (in Hectares)	%
Portugal	730.000	32.2
Spain	500.000	22.0
Algeria	410.000	18.1
Morocco	340.000	15.0
France	100.000	4.4
Tunisia	99.000	4.3
Italy	90.000	4.0

Table 3. Cork production worldwide

Countries	*Average annual production (tonnes)*	*Percentage*
Portugal	100,000	49.6%
Spain	61,504	30.5%
Morocco	11,686	5.8%
Algeria	9,915	4.9%
Tunisia	6,962	3.5%
Italy	6,161	3.1%
France	5,200	2.6%
Total	201,428	100%

Source: FAO, 2010. Global Forest Resources Assessment 2010. Country reports.

6. Structure and Plant Composition

Cork oak can form homogeneous formations or rarely mixed stands with other closely related species such as Algerian oak (*Quercus canariensis*) and Afares oak (*Quercus afares*) where climate is humid with a rainfall up 1,000 mm/year. Akfadou massif is an example of a lush mixed forest (Figure 3) representing 18% of the country's deciduous oaks (Messaoudene, 1996). Cork oak woodlands may vary in herb and grass species composition depending on soil, climate conditions and human influences (Figure 4). Cork Oak formations result primarily from the association between *Quercus suber* and *Erica*

arborea. These are the two most characteristic species of an acidophilic group with a large distribution on siliceous soils and in a humid to sub-humid bioclimate. In more degraded oak woodlands Strawberry tree (*Arbutus unedo*), Spiny broom (*Calycotome spinosa*), Sage-leaved rockrose (*Cistus salviifolius*), Elm leaf blackberry (*Rubus ulmifolius*), Myrtle (*Myrtus communis*) and Mastic tree (*Pistacia lentiscus*) are the more common plants to develop. Considering prevalent physiognomy, basic climatic variables and species composition of cork forests, we can discriminate three large groups occurring in two *altitudinal* vegetation *'étages'* (Bekdouche, 2010):

Figure 3. Mixed stands of *Quercus canariensis* and *Quercus afares.* Akfadou, Bejaia. In foreground *Lac Noir*.

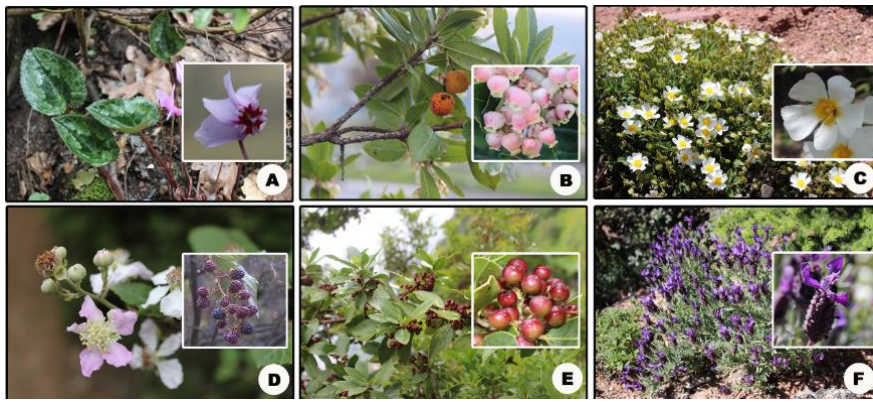


Figure 4. *Plant species* diversity in cork forests (A) *Cyclamen africanum*; (B) *Arbutus unedo*; (C) *Cistus salvifolius*; (D) *Rubus ulmifolius*; (E) *Pistacia lentiscus*; (F) *Lavandula stoechas*.

A mesomediterranean *Laburnum* group, which prevails on slopes distributed most often at hilly and submontane altitudes over 500 m. The group develops in less pronounced summer drought. It is characterized by the presence of *Cytisus villosus, Galium rotundifolium, Rhaponticoides africana, Chrysanthemum fontanesii*…etc. *In cork oak* forests with appreciable tree *density* and a dense shrub cover, the presence of some species have a significant impact on *the formation* of more or less thick soil rich in organic matter favouring the installation of rich *floristic cortege*: *Viburnum tinus, Smilax aspera, Crataegus monogyna, Discorea communis, Lathyrus tingitanus, Rubus ulmifolius, Melica minuta, Pteridium aquilinum, Trifolium bocconei, Brachypodium sylvaticum, Rubia peregrina, Asplenium adiantum-nigrum* and *Cyclamen africanum.* In coolest transitional stations abound *Quercus canariensis, Prunella vulgaris, Ranunculus ficaria* and *Luzula forsteri*.

The second group is thermomediterranean characterized by a strong presence of *Erica arborea* and *Pistacia lentiscus* with sporadic or lacking oak-kermes. A group mainly present in sub-littoral regions covering hilly areas with altitudes under 500 m. We note a balanced presence of mesophilous and thermophilous species: *Cistus salviifolius, Arbutus unedo, Lavandula stoechas, Tuberaria commutata, Erica scoparia* and *Daphne gnidium.* Degradation also favors the following species characteristic of the stripped soils: *Cistus monspeliensis, Bellis sylvestris, Ampelodesmos mauritanicum, Hypochaeris radicata, Briza maxima, Aira tenorei, Festuca coerulescens, Hedysarum coronarium, Cynosurus echinatus* and *Stachys ocymastrum.* In conditions more marked by drought: *Hypericum humifusum, Hyparrhenia hirta, Erica multiflora* and *Fumana thymifolia* are more frequent.

The last groups is another representative of the thermomediterranean with mixed Mastic *Pistacia lentiscus* and Oak-kermes *Quercus coccifera* extending under maritime influencesat low elevations in the littoral to sub-littoral regions. A typical spectrum of

species characterize these locations: *Phillyrea latifolia*, *Chamaerops humilis*, *Myrtus communis*, *Teucrium fruticans*...etc.

7. CORK INDUSTRY

The cork oak (*Quercus suber*) is an exceptional tree, as it is the unique stand in Algeria and Mediterranean basin with the ability to produce a commercially exploited bark, the cork (Figure 5). A material widely used to manufacture a wide range of products, including sound and thermal insulators. Wine bottle stoppers are one of the main end-products. The exploitation of cork oak forests is not recent in Algeria as it started extensively at the beginning of the 17th century during the colonial period when the French administration at that time had according to (Saccardy, 1938) delimited 440, 000 ha of cork oak and an estimated productive area valued at 200,000 ha. For Algeria and Italy, cork production reached their highest levels around the 1940s (Xuejing, 2010). Cork oak forests would have occupied a much larger area since that period but remains nowadays as it was in the last century with only 229, 000 ha considered as productive: the area in production fell significantly to 220, 000 ha and production decreases from one year to the next (Dehaneet al., 2013). Statistics of FAO (2010) shows Algeria as the fourth producer of cork in the world with 4.9% (9,915 tonnes) after Portugal 49.6% (100,000 tonnes), Spain 30.5% (61,504 tonnes) and Morocco 5.8% (11,686 tonnes). Moreover, from an unprecedented record of 55.300 tonnes in 1937, production in 2010 did not exceed 10,000 tonnes (Table 3). There have been important changes regarding management of the Algerian oak forests since the rise of oil prices. For Algeria, *downward production trends* started since decades and while Portugal becomes more and more the world's largest *country* for cork, production fell in some *countries like France and Italy*. The decline of the Oak production is not country specific.

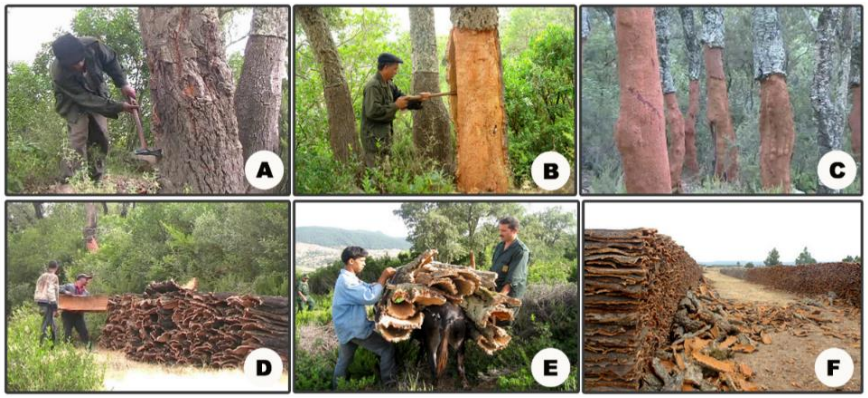


Figure 5. Cork oak exploitation in National Park of El Kala. (A-B) Stripping cork from the trunk (National Park of El Kala, Northeast Algeria); (C) Recently striped cork oak; (D) Stacking and sorting of barks *in situ*; (E) A donkey hauling stacks of freshly cut barks, in inaccessible areas; (F) Stacked barks ready for processing.

8. Disturbance Impacts

Cork is known for its insulating properties which are the result of millions of years of evolution and an advantage for survival after fire occurrence. Most oak species including Cork oak have the capacity to resprout (Figure 6) after a severe fire from basal buds or quickly from stem and crown buds (Pausas, 1997). In post fire, some young trees may suffer or die from because their bark is still too thin to provide thermal protection to the stem buds (Aronson et al., 2009). Even the species is well adapted to persist after recurrent fires and regenerates remarkably quick, we can note ignore other limiting factor for the sustainability of cork oak stands. In Algeria, livestock include sheep, cattle and more recently goats. So far, it is common to associate grazing of oak woodlands as one of the main decline drivers worsened in recent years with intensive burning and tree cutting to free areas for subsidence agriculture. Decline in cork oak due to pests has also increased. There are many insects living in oaks where some are considered harmful while others can only be a great threat if they act

simultaneously with other pathogens or coinciding with some stress conditions (Gónzalez, 2008). Generally, these pests are not considered responsible for the death of the oaks but it is important to mention that especially, defoliator insects such as *Tortrix viridana* and *Lymantria dispar* can play an important role in causing decline (Thomas et al., 2002). The Latter, the Gypsy moth is considered as one of the main pests of northern African oaks widely distributed on Fagaceae in Tunisia, Algeria and Morocco feeding preferentially on leaves causing remarkable defoliations (Villemant, 2006). *Lymantria dispar* is reported among the ten most prevalent insect pests in the country (FAO, 2010). Even the pest is Known as a defoliator feeding on very large number of species, in Algeria its seems to preferentially search cork oak as host plant offering him optimum development (Mecellem et al., 2016).

Figure 6. Cork oak stands in eastern Algeria. (A) Post-fire tree responses in a degraded cork oak forest (Crown resprouting); (B) Unmanaged cork oak forest.

9. MANAGMENT AND CONSERVATION

In Algeria, most cork oak formations are public. Changes in *socio-economic status* induced in part by the rise of oil prices, have led to the overlooking of the sericulture sector. This is noticeable by recurrent abandonment of small patches and low management of other larger cork oak woodlands promoting thus the installation of invasive undergrowth which represent a serious fire hazard. Of course there are other drivers speeding up the decline of the neglected tree resources. Some of the decline symptoms which are common to all cases in Algerian oak stands are associated to the absence or inappropriate silvicultural management, failure of reforestation, aging of the trees, regeneration becoming very difficult, recurrent fires and overgrazing. In the same sense, Pausas et al. (2009) note that the continuous compression of the forests area in Spain is more the result of management, pest attacks, overgrazing and possibly climate change than fires. We cannot ignore some efforts and programs undertaken for conservation and enhancement of genetic resources but it is not clear how much management our country is doing as policies change. This is the case of National park of El Kala (Figure 7) where there are some collaborative programmes with FAO aimed at ensuring an effective reforestation and conservation of existing areas and at the same time protecting and maintaining threatened biodiversity but it is not enough. The *Barbary stag*: *Cervus elaphus barbarus* native to North Africa is an example of animals perfectly adapted to such habitats where dense vegetation provide them food, security and shelter. Absence of managements systems, real policies and secure employment for long-term has contributed to the decline of the resource as we are not yet coming to realise how crucial it is to conserve what remains of our forests. Though very flourishing in the past, the regression of the oak

forest in Algeria can't be overcome without having recourse to a serious revision of existing policies and management systems allowing the return of the oaks.

Figure 7. Propagation of Cork Oak in National Park of El Kala. (A) Freshly gathered acorns; (B) Filling pots with acorns in potting soil; (C) Nursery care; (D) Ready seedlings; (E-F) Planting a new generation of trees.

REFERENCES

Aronson J., Pereira J.S. and Pausas J.G. 2009. Introduction. In: Aronson J., Pereira J.S. and Pausas J.G. (Eds). *Cork oak woodlands on the edge*. Washington, DC: Island Press.

Balvanera P., Siddique I., Dee L., Paquette A., Isbell F., Gonzalez A. and Griffin J.N. 2014. Linking biodiversity and ecosystem services: Current uncertainties and the necessary next steps. *Bio Science, 64*(1), 49-57. https://doi.org/10.1093/biosci/bit003.

Balvanera P., Quijas S., Martín-López B., Barrios E., Dee L., Isbell F., Durance I., White P., Blanchard R. and De Groot R. 2016. *The links between biodiversity and ecosystem services.* In: Potschin M, Haines.

Barriosa E., Valenciab V., Jonssonc M., Braumand, A. Hairiahe K. and Peter E. 2017. Mortimerfand Satoru Okubo-Contribution of trees to

the conservation of biodiversity and ecosystem services in agricultural landscapes. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 14:1–16.

Bekdouche F. 2010. *Evolution après feu de l'écosystème suberaie de kabylie (nord Algérien).* Thèse de doctorat d'état en sciences agronomiques [*Post-fire evolution of cork* oak *stands (Kabylie, north Algeria)* State doctoral thesis in agronomic sciences]. Option: écologie forestière-Tizi ouzou-175 pp.

Bellarosa R. 2000. Introduction: brief synthesis of the current knowledge on cork oak. Pp. 11 – 21, In: M.C. Varela (ed.), Evaluation of genetic resources of cork oak for appropriate use in breading and gene conservation strategies. *Handbook of the concerted action FAIR 1 CT 95 – 0202.* INIA – Estação florestal national, Portugal.

Boudy P. 1950. *Economie forestière Nord-Africaine. Monographie et Traitement des essences forestières.* [*North African forest economy. Monograph and treatment of forest tree species*]. Ed. Larose, T.2.

Eduardo G. 2001. *The Cork Report: A Study on the Economics of Cork.* The Lodge, Sandy, Bedfordshire, SG19 2DL.

FAO 2010. *Global Forest Resources Assessment 2010*. Country reports.

FAO 2015. *Global Forest Resources Assessment 2015*: How have the world's forests changed? Rome, Italy.

Gónzalez C. 2008. *Analysis of the oak decline in Spain; la seca*. Swedish University of Agricultural Sciences SLU, Uppsala.

Lespès R. 1931. *L'Atlas d'Algérie et de Tunisie*. [*Atlas of Algeria and Tunisia*]. In: Annales de Géographie, T.40, N°227. pp. 519-526.

Lumaret R., Tryphon-Dionnet M., Michaud H., Sanuy A., Ipotesi E., Born C. and Mir C., 2005. Phylogeographical variation of chloroplast DNA in cork oak (*Quercus suber*). *Ann. Bot.*, 96: 853 – 861.

Maire R., Battandier J.M., Lapie G., De Peyerimhoff P. and Trabut L.C. (1925): *Atlas d'Algérie et de Tunisie: Carte Phytogeographique*

1:1.500.000. [*Atlas of Algeria and Tunisia: Phytogeographic Map 1: 1.500.000*].

Manos P.S. and Stanford A.M. 2001. The historical biogeography of *Fagaceae*: tracking the tertiary history of temperate and subtropical forests of the northern hemisphere. *Int. J. Plant. Sci*., 162 (S6): S77 – S93.

Mecellem D. and Chakali G. 2016. *Biological and ecological characteristics of Gypsy Moth, Lymantria dispar L. (Lep. Lymantriidae) in the gradation phase's in Blidéen Atlas forest* (Algeria).

Médail F. and Quézel P. 1997. Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. *Annals of the Missouri Botanical Garden* 84**:** 112–127.

Messaoudene M. 1996 – Chêne zéen et chêne afares. [Algerian and Afares cork trees]. *La forêt algérienne* (N°1 fév.-mars), INRF, Bainem, Alger, pp. 18-25.

Mir, C., Toumi, L., Jarne, P., Sarda, Violette Di Giusto F. and Lumaret, R. 2006. Endemic North African *Quercus afares* Pomel originates from hybridisation between two genetically very distant oak species (*Q. suber L. and Q. canariensis Willd*.): Evidence from nuclea and cytoplasmic markers. *Heredity.* 96. 175-84.

Myers N., Mittermeier R., Mittermeier G.C., Fonseca G. and Kent J. 2000. Biodiversity hotspot for conservation priorities. *Nature:* 403. 853-8.

Natividade J.V. 1956. *Subériculture*. Ecole Nationale des Eaux et Forêts [*Cork-oak growing*. National School of Water and Forests]. Nancy, 302 p.

Ozenda, P. 1975. Sur les étages de végétation dans les montagnes du bassin méditerranéen. [Vegetation Levels of the Mediterranean Basin Mountains]. *Doc. Cartogr. Ecolog*. 16: 1-32.

Prabhu R., Barrios E., Bayala J., Diby L., Donovan J., Gyau A., Graudal L., Jamnadass R., Kahia J. and Kehlenbeck K. 2015. Agroforestry: realizing the promise of an agroecological approach.

In: FAO, editor. Agroecology for food security and nutrition. Rome (Italy): *Proceedings of the FAO International Symposium*; p. 201–224.

Pausas, J.G. 1997. Resprouting of *Quercus suber* in NE Spain after fire. *Journal of Vegetation Science* 8:703–706.

Pausas J.S., Pereira M. and Aronson J. 2009. The Tree, J.G. In: Aronson et al. (eds.), *Cork Oak Woodlands on the Edge*. Island Press.

Quézel P**.** 1976. Les forêts du pourtour méditerranéen. [The forests around the Mediterranean region]. In: Forêts et maquis méditerranéens: écologie, conservation et aménagements. *Note technique MAB,* 2: 9-33. Paris, UNESCO.

Saccardy L. 1938. Le Chêne-Liège et le Liège en Algérie. [Cork oak in Algeria: the bark and the Tree]. In: *Revue de botanique appliquée et d'agriculture coloniale* [*Journal of Applied Botanics and Colonial Agriculture*], 18e année, bulletin n°204-205, Août-septembre 1938 pp. 574-593.

Sauvage C.H. 1961. *Recherches géobotaniques sur les subéraies marocaines.* [*Geobotanical research on Moroccan cork oak*]. Série botanique nº. 21. I.S.C. Rabat.

Seltzer P. 1946. *Les climats de l'Algérie*. [*Climates in Algeria*]. *Trav. lnst. Mét. Phys. Glo*. Algérie, Hors-série, 219 p. 1 carte. Travaux Institut de metéorologie et de physique du globe. Université d'Alger

Silva J.S. and Catry F. 2006. Forest fires in cork oak (*Quercus suber* L.) stands in Portugal. *Int. J. Environ. Studie*s, 63: 235 – 257.

Thomas F.M., Blank R. and Hartmann G. 2002. Abiotic and biotic factors and their interactions as causes of oak decline in Central Europe. *Forest Pathology* 32. 277-307.

Valencia A.S. 2004. Diversidad del género *Quercus* (Fagaceae) en México. [Diversity of the genus *Quercus* (Fagaceae) in Mexico]. *Boletín de la Sociedad Botánica de México Bol. Soc. Bot. Méx.* 75:33-53.

Varela M.C. 2000. Evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies-*Handbook of the Concerted Action*. FAIR 1CT95-0202.

Villemant C. 2006. *Bilan de la situation de Lymantria dispar dans l'ouest de bassin méditerranéen.* [*The gypsy moth*, Lymantria dispar *in the western Mediterranean basin:* pest *risk assessment*]. Actes du Congrès International Entomologie et Nématologie. Institut National Agronomique, El Harrach, Alger, 101- 114.

Vogiatzakis I.N. and Careddu M.B. 2003. Mapping the distribution and extent of *Quercus suber* habitats in Sardinia: a literature review and a proposed methodology *Geographical Paper No. 171*. University of Reading.

Xuejing L. 2010. *Assessment of Climate Change Impacts on Cork Oak in Western Mediterranean Regions: A Comparative analysis of Extreme Indices.* Master Degree thesis in Physical Geography. Lund University Sweden.