BIHAREAN BIOLOGIST 19 (1): 01 – 13
Article No.: e251101

http://biozoojournals.ro/bihbiol/index.html

Mapping and distribution of the Atlas pistachio (*Pistacia atlantica* Desf.) in the provinces of Naâma and El Bayadh (South-West Algeria)

Naimi BENDOUINA*, Lakhdar GUERINE,
and Kouider HADJADJ

Laboratory of Sustainable Management of Natural Resources in
Arid and Semi-Arid Areas, University Center Naâma, Algeria.
* Corresponding author: N. Bendouina, E-mail: naimi.bendouina@cuniv-naama.dz

Received: 27 October 2024 / Accepted: 13 February 2025 / Available online: June 2025 / Printed: June 2025

Abstract. The Atlas pistachio tree (*Pistacia atlantica* Desf.) plays a crucial role in ecology, biogeography, and economy. Its state of degradation requires immediate and effective intervention. It is subject to intense human pressure, severely limiting its growth and development, and it is essential to develop an appropriate management plan to conserve and promote this species. This begins with a thorough understanding of the tree and its needs. The present work delineates and maps the Atlas pistachio tree stands in the El-Bayadh and Naâma regions of southwestern Algeria using the UTM GEO MAP application developed by Y2 Tech, which offers several functions, including offline GPS capabilities. Combined with the GIS, we could count a population of 18,901 trees, arranged as groves in the dayas and as isolated trees scattered along wadi beds and cliffs, with a predominance in the Saharan sector (42.44%). The municipalities of El-Bayadh and Naâma have different densities, ranging from 0.08 to 7.8 trees per km², with exceptionally high densities in cities such as Brézina and Ain Benkhellil. The pistachio tree coexists with a rich diversity of flora, including jujube (*Ziziphus lotus* (L.) Lam) and other local species. However, it is threatened by overgrazing, siltation, and illegal logging.

Keywords: Atlas pistachio, El-Bayadh, Naâma, GIS, cartography.

Introduction

Pistacia atlantica Desf. of the Anacardiaceae family is a woody, spontaneous species that can reach heights exceeding 20 m (Asma 2019, Belhadj et al. 2008, Guerine & Hadjadj 2019, Hadjadj et al. 2022, Zohary 1952). This species is common in both the Mediterranean and Iranian-Turanian regions and is described as endemic to North Africa, where it forms tree steppes in arid and semi-arid bioclimates (Belhadj 1999, Belhadj 2002, Belhadj et al. 2008, Chermat & Bounar 2020, Monjauze 1980, Ozenda 1983, Quézel & Médail 2003). This tree can regenerate and grow in very arid environments where few other species can survive. Its robustness makes it attractive for reforestation and forestry initiatives in semi-arid and arid areas (Belhadj et al. 2008). This species is tolerant of different soil types, including alkaline soils, and can survive with low rainfall, sometimes less than 150 mm (Benhassaini & Belkhodja 2004).

This species continuously degrades under the pressure of multiple anthropogenic and climatic impacts (Belhadj 1999, Belhadj 2002, Dahmani 2011, Fetati 2017, Hadjadj et al. 2024, Hadjadj et al. 2022). This vast area, spanning thousands of hectares, is thus subject to worsening degradation, desertification, siltation, and erosion (Bneder 2017, Guerine et al. 2022) and requires immediate and effective action (Benhassaini & Belkhodja 2004, Brahim et al. 2019).

Therefore, this study, which aims to identify the Atlas pistachio stands in the El-Bayadh and Naâma regions of southwestern Algeria, is

essential. This species, considered part of the region's forest heritage, plays a crucial role in maintaining the region's ecological balance and biodiversity. It is a species that deserves our utmost respect and protection, as it will inevitably become extinct if scientists and managers do not effectively protect it.

In the absence of a precise delimitation of the distribution area of Atlas pistachio trees in El-Bayadh and Naâma (south-western Algeria), we propose exploring the use of very high spatial resolution remote sensing data, such as [specific type of data], to map this tree cover. The mapping will be based on measurements and observations, followed by validation and control missions in the field. GPS (Global Positioning System) and GIS (Geographic Information Systems) are two geomatics tools that can be used together to map natural ecosystems effectively (Aouragh et al. 2013, Barour & Taouarfia 2022, Beaulieu et al. 2012, Khalil et al. 2015, Piedallu & Gégout 2002).

This research is not just about mapping the distribution of the Atlas pistachio tree in the El-Bayadh and Naâma regions of southwestern Algeria. It's about leveraging advanced technology and scientific methods to understand and protect this species. By using the UTM GEO MAP application developed by Y2 Tech, we can accurately determine the current state of the Atlas pistachio tree distribution and define a reference state in the form of a GIS database. This will enable us to develop a method of spatiotemporal analysis of the Atlas pistachio tree stands, offering hope for its conservation.

Materials and methods

Study area

The study area, located in the south-western region of Algeria and comprising the provinces of El-Bayadh and Naâma, extends over three (03) natural regions: the high steppe plains area, the Saharan Atlas area, and the pre-Saharan rangelands area (Guerine et al. 2020, Quézel & Santa 1962, Quézel et al. 1962). Both provinces are pastoral (Aïdoud et al. 2006, Benhabyles 2012).

Different activities characterize these main areas. The northern area, characterized by high steppe plains, is inaccurately referred to as a "high plateau" due to the prevalence of pastoral activities. The Ksour mountains and the foothills of the Saharan Atlas are characterized by oasis agriculture with localized horticulture. In the south, areas are set aside for agricultural investment, particularly in floodplains and for livestock transhumance during the winter. Overall, the best land is in the oases and dayas, and cultivation of marginal land exposes the soil to accelerated erosion, exacerbating environmental degradation (Mederbal et al. 2009).

The region has a semi-arid to Saharan bioclimate, with cool-to-cold fluctuations. Average annual rainfall varies from 250 mm/year to less than 100 mm/year in the south, with extreme inter-annual variability in rainfall resulting in episodes of drought and rainfall. The climatic drought observed in the region is severe and persistent, with dry years exceeding the wet years for all weather stations between 1981 and 2022 (based on climate data from https://power.larc.nasa.gov). Compared to the climate data of Seltzer: 1913-1938, a decrease in the average annual rainfall was observed: -6.8 mm (-4%) in Ain Sefra, -13.48 mm (-10%) in El-Abiodh Sid Cheikh, -17.99 mm (-6%) in El-Bayadh, -59.89 mm (-20%) in Mécheria. These figures support the conclusions of some authors on climate change in western Algeria, which is characterized by a rainfall deficit (Hirche et al. 2007, Smahi et al. 2022). In addition to climatic hazards, the study area (Figure 1) has soils that are highly susceptible to desertification, as well as socio-economic constraints such as overgrazing, making it a highly sensitive zone to desertification. Desertification processes in this region lead to reduced land productivity, soil degradation, loss of biodiversity, depletion of water resources, and increased vulnerability of

the local population.

In addition, the study area is characterized by high demographic pressure, intensive exploitation of natural resources, low diversification of economic activities, and high dependence of local populations on natural resources (Guerine et al. 2020, 2022, Hadjadj et al. 2022, 2023).

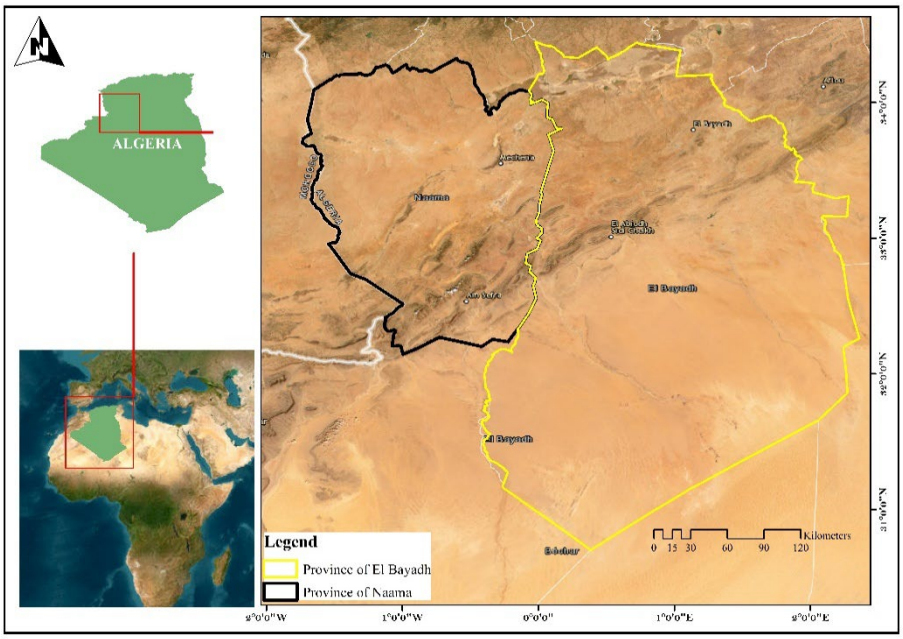

Figure 1. Location map of the study area.

Data and materials

First, we utilized Google Earth Pro (Google 2022), a platform that provides high-resolution imagery to support the location and georeferencing of Atlas pistachio trees. We also utilized ArcGIS 10.8 (ESRI 2019), a Geographical Information System (GIS) software package that enables us to digitize and produce various maps, including location maps and maps of the pistachio tree distribution area in the Atlas. A smartphone with the Android application UTM Geo Map 4.1.6 (UTM Geo Map 2023) was also used for reading coordinates. The UTM Geo Map application, developed by Y2 Tech, offers a range of features, including offline GPS functionality, coordinate maps, overlays, coordinate conversion, distance measurement, and area measurement. The free version includes maps with markers and buffering tools, while the paid version provides access to elevation profile data. The application is particularly suitable for smartphones with magnetic sensors, enabling GPS to operate offline, like a conventional handheld GPS (Prasetyo & Suwindiatrini 2020).

Methods

The georeferencing of Atlas pistachio trees in the provinces of El-Bayadh and Naâma was carried out using very high-resolution images from the Google Earth Pro platform as a medium for locating these trees in the form of points, using the WGS84 longitude-latitude projection. This projection is particularly recommended for regional or national projects, as it is universal. It allows the whole area to be treated consistently, avoiding the shifts associated with the zones (31 and 30) of the UTM projection (Figure 2).

Data were collected from high-resolution Google Earth satellite imagery and field surveys using a smartphone equipped with the Android application UTM Geo Map 4.1.6, which recorded the data in KML (Keyhole Markup Language)

format. Data validation was the subject of a long field prospection period spanning three years, from May 2021 to June 2023. Each tree checked in the field was hammered and given a registration number in the database (Figure 3). The data recorded in KML format was processed in ArcGIS (10.8) to delineate the species' range. The study area was divided into three distinct regions according to the phytogeographical division of northern Algeria (Quézel et al. 1962), which presents physical and phytosociological indicators that can be used to differentiate these areas. To map the distribution area of the Atlas pistachio tree in our study area, we used the "Buffer Zone" tool in ArcGIS at a 2.5 km radius, representing the average distance between pistachio trees, and merged the points according to commune and biogeographical area.

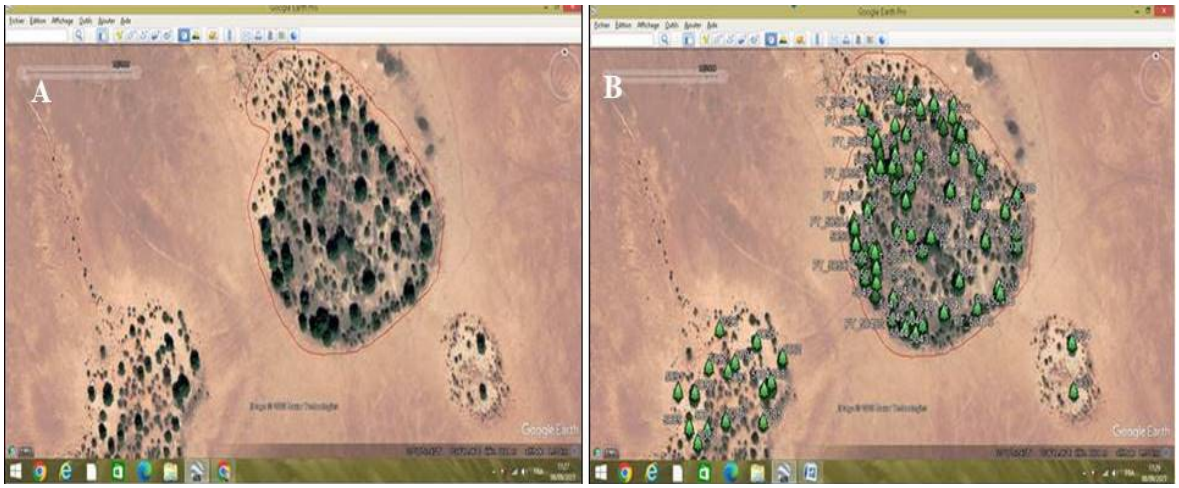

Figure 2. Geolocation of trees on Google Earth (2024) (A), visualization, and marking with points and coding (B).

Figure 3. Geolocation validation and tree coding.

Results

Figure 4 shows the distribution of Atlas pistachio geolocations across the provinces of El-Bayadh and Naâma in the western highlands of Algeria.

Distribution of the Atlas pistachio by biogeographical area and by municipality

The distribution of the pistachio tree, as defined by the biogeographical division of Quézel et al. (1962), shows that the area of this species' presence encompasses three regions: the high steppe plains, the Saharan Atlas, and the Saharan area (Table 1).

Regarding administrative division, the distribution area of the Atlas pistachio tree in the provinces of El-Bayadh and Naâma includes 27 municipalities and 18,901 Atlas pistachio trees.

Regarding the number of trees, the Atlas pistachio is unevenly distributed among the municipalities of the two provinces and the three biogeographical areas. Brézina dominates with 4,735 trees (25.05%), followed by Ain Benkhellil with 3,658 trees (19.35%) (Figure 5).

In terms of distribution by biogeographical area, as shown in Figure 6, the Atlas pistachio dominates the Saharan region, accounting for 42.44% of the total number of georeferenced trees. The high steppe plains area contains 31.63% of the trees, and the Saharan Atlas area accounts for 25.93%.

Distribution of Atlas pistachio in the high plateaus steppe area

In the high steppe plains biogeographical area, *Pistacia atlantica* Desf. Occurs in the province of Naâma (Figure 7), in the form of groves in the dayas and wadi beds with variable densities in the municipalities of Ain Benkhellil, Kasdir, Mekmen Benamar, El Biodh, and Naâma. The density in the distribution area defined for this area varies from 0.84 to 7.8 trees/km² over an area of 1361.41 km² at altitudes between 1098 and 1120 m. on a silty-sandy-clay substrate.

The flora of the Atlas pistachio tree includes *Ziziphus lotus, Atriplex halimus, Atractylis serratuloides, Lygeum spartium, Noaea mucronata,* and *Peganum harmala*. Natural regeneration of some young plants has been observed inside jujube trees *(Ziziphus lotus*), which provide good protection for young shoots against wind and livestock (Belhadj 1999). In this area, the Atlas pistachio faces problems of overgrazing and siltation (Figure 8).

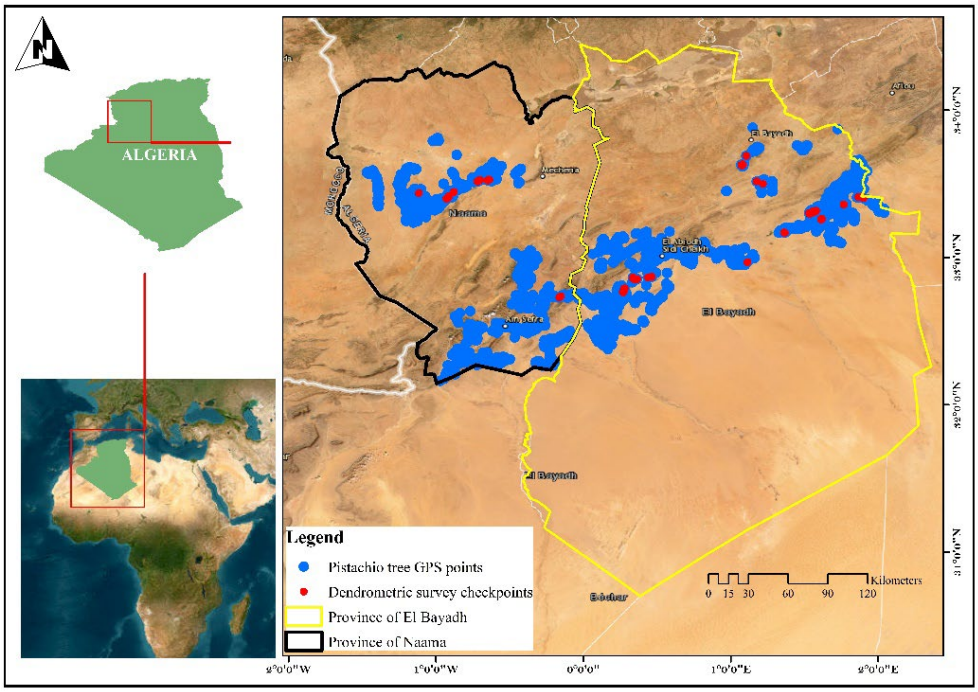

Figure 4. Geolocation map of Atlas pistachio trees across El-Bayadh and Naâma provinces.

Table 1. Distribution of Atlas pistachio by biogeographical area and municipality.

Provinces	Biogeographical area	Municipality	Number of trees
El Bayadh	Saharan Atlas	Ain El Orak	3
		Arbaouat	788
		Boussemghoun	201
		Brezina	11
		Chellala	16
		El Abiodh Sidi Cheikh	128
		El Bayadh	5
		El Bnoud	2
		El Mehara	237
		Ghassoul	100
		Krakda	4
		Sidi Ameur	117
		Sidi Slimane	1
		Sidi Tifour	1 494
		Stitten	13
		Boualem	91
	Total Saharan Atlas		3 211
	Saharan area	Brezina	4 724
		El Abiodh Sidi Cheikh	1 451
		El Bnoud	510
		Sidi Ameur	836
		Sidi Tifour	412
	Total Saharan area		7 933
Total El Bayadh			11 144
Naama	Saharan Atlas	Ain Sefra	10
		Asla	475
		Djenien Bourezg	179
		Moghrar	324
		Naama	35
		Sfissifa	17
		Tiout	650
	Total Sahara Atlas		1 690
	High steppe plains	Ain Ben Khelil	3 658
		El Biod	60
		Kasdir	1 961
		Mekmen Ben Amar	290
		Naama	10
	Total high steppe plains		5 979
	Saharan area	Moghrar	88
	Total Saharan area		88
Total Naama			7 757
Total			18 901

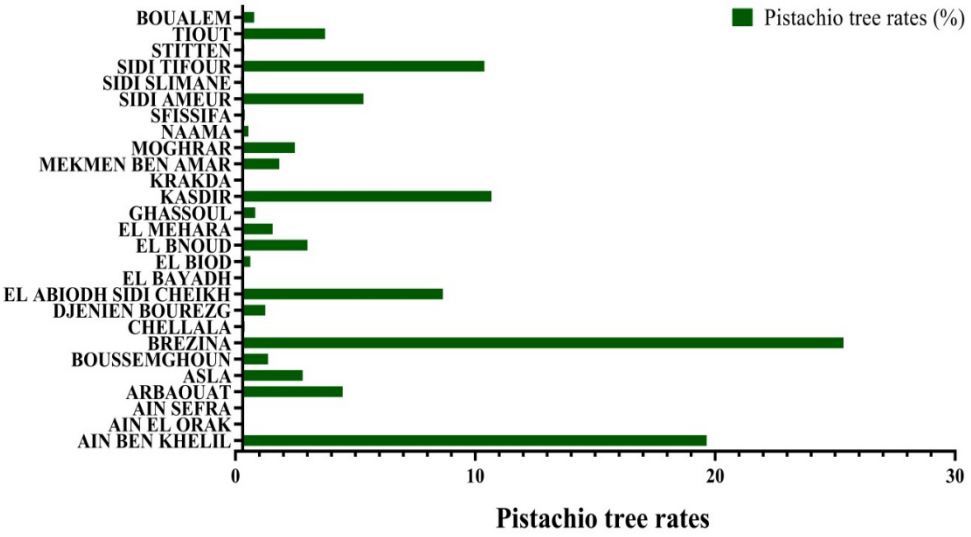

Figure 5. Atlas pistachio tree distribution by municipality of El-Bayadh and Naâma provinces.

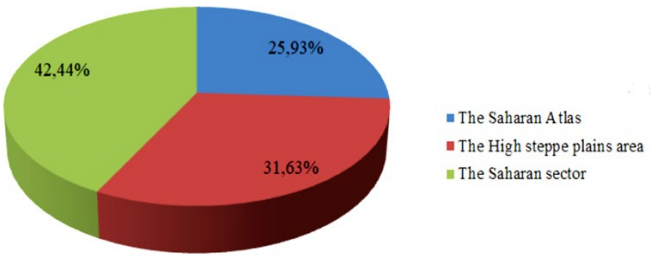

Figure 6. Atlas pistachio tree distribution by biogeographical area.

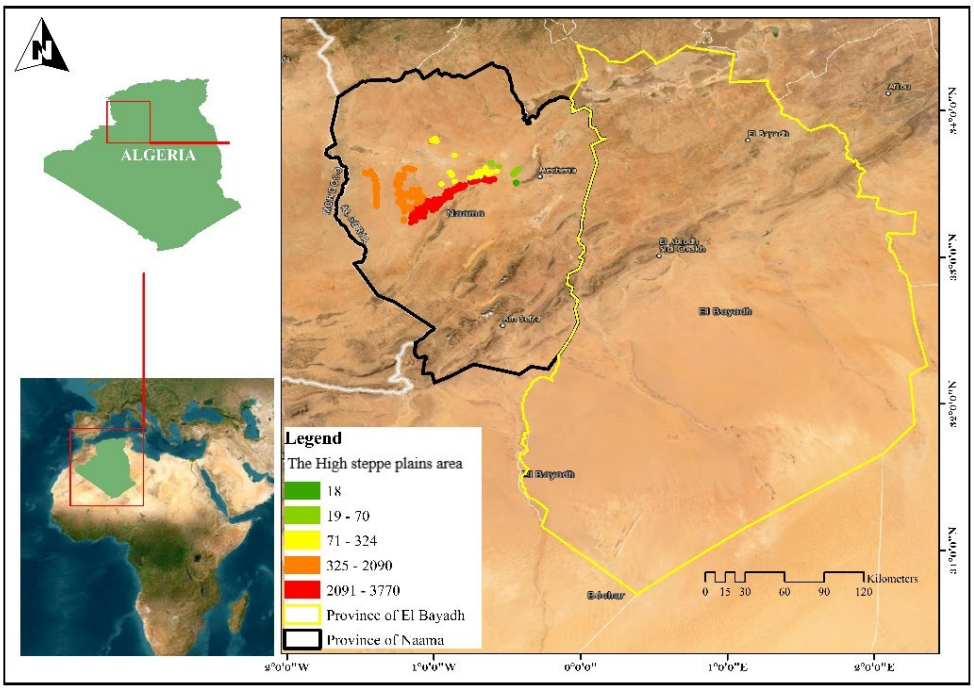

Figure 7. Distribution of Atlas pistachio in the high steppe plains area of Naâma province.

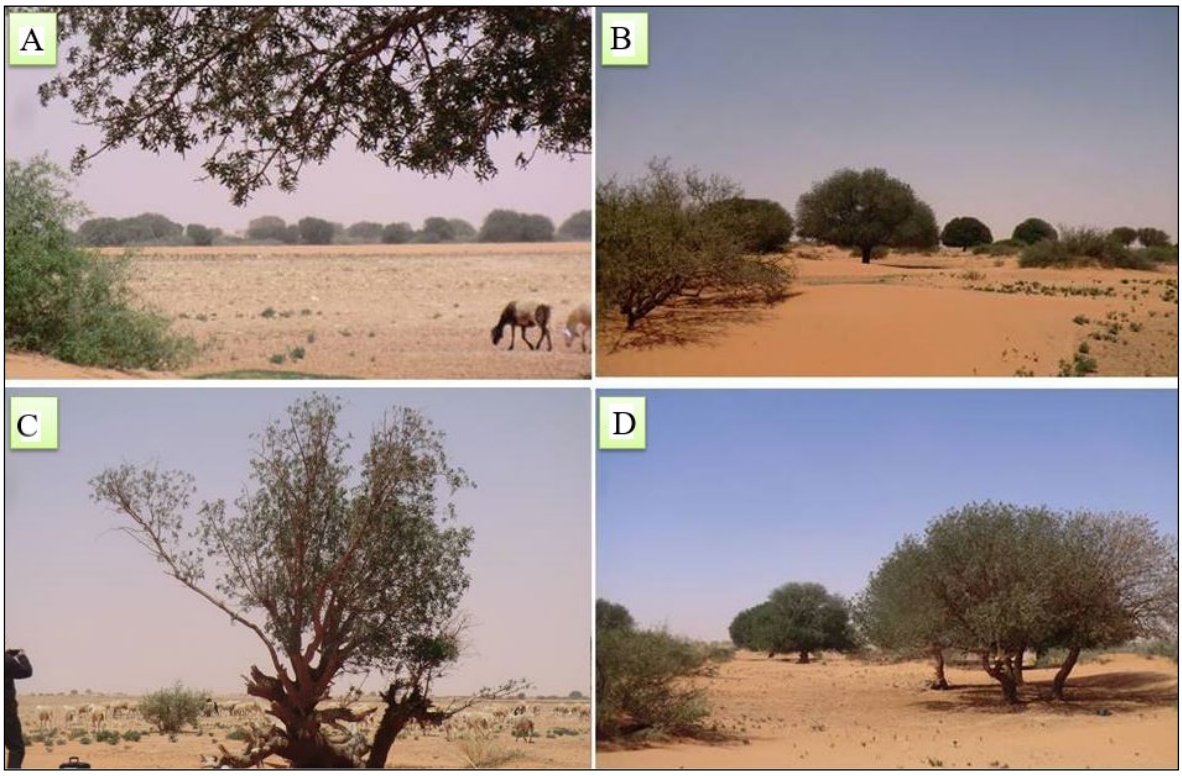

Figure 8. Photos of Atlas pistachio trees taken in the Ain Benkhellil region; A and C photos of anthropic pressure from logging and grazing; Band D photos of siltation of groves.

Distribution of Atlas pistachio in the Saharan Atlas area

Figure 9 shows the distribution of the Atlas pistachio tree in the Saharan Atlas area.

In the biogeographical area of the Saharan Atlas, the atlas pistachio tree is found in the form of scattered and isolated trees on wadi beds, valley sides, and cliffs, on sandy-loamy substrates and lithosols characteristic of cliff areas, with varying densities in the communes of the Saharan Atlas from the south-east to the north-west: Djenien Bourzeg, Moghrar, Ain sefra, Tiout, Asla, Boussemghoune, Chellala, Arbaouet, El-Abiodh Sid cheikh, Ain Orak, El-Bayadh, Krakra, Ghassoul, Brézina, Sidi Amar, Boualem, Sidi Taiffour and Sidi Slimane at altitudes ranging from 816 m to 1840 m.

The population density in this area varies from 0.08 to 5.44 people per square kilometer over a total area of 4,003.95 square kilometers, with the highest density recorded in the Sidi Taiffour mountains at 1616. The pistachio trees in the atlas are arranged linearly along the watercourses and the hydrographic network.

The flora of the pistachio trees in the atlas includes *Crataegus oxyacantha* L., *Juniperus phoenicea* L., *Pinus halepensis* Mill., *Quercus coccifera* L., *Quercus ilex …*, *Retama raetam …*, *Olea europaea, Ziziphus lotus, Thymelea microphylla, Asphodelus microcarpus, Atractylis halimus, Atractylis serratuloides, Carthamus pinnatus* Desf. *Catananche caerulea, Cirsium echinatum, Cirsium undulatum, Cistus bourgaeanus* Coss, *Lamium amplexicaule, Lomelosia stellata, Lygeum spartium, Macrochloa tenacissima* (L.) *Kunth, Marrubium vulgare* L., *Paronychia capitata, Salvia verbenaca* L., *Sedum sediforme, Stipa parviflora, Stipa tenacissima, Thapsia garganica* L., *Thymus algeriensis, Thymus ciliatus*.

The natural regeneration of a few young plants was observed inside jujube trees (*Ziziphus lotus*) or in cliff cracks (Figure 10).

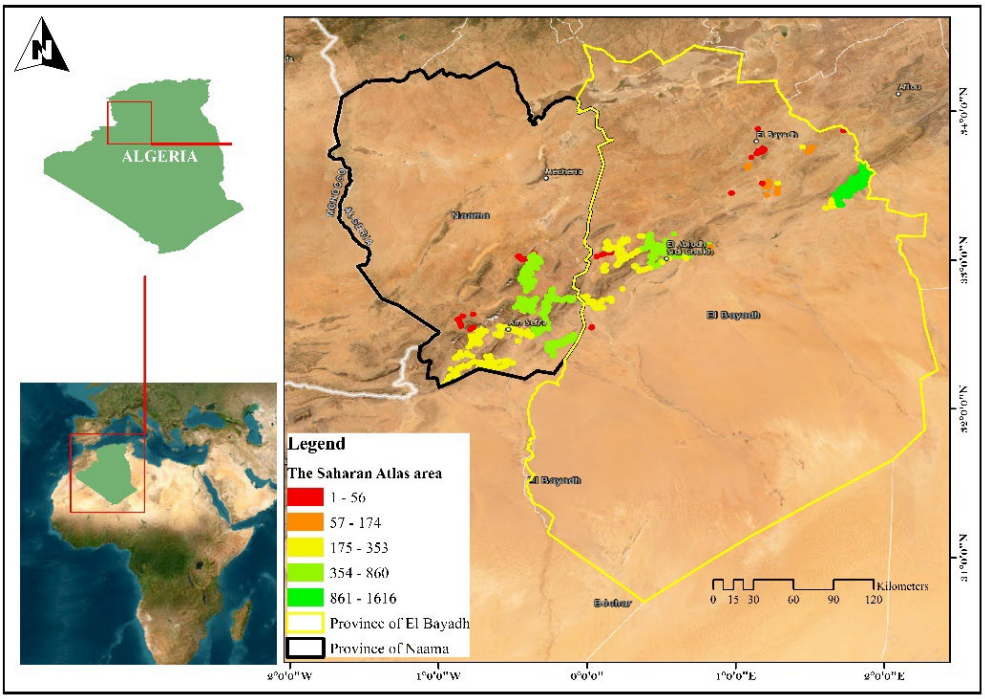

Figure 9. Distribution of Atlas pistachio in the Saharan Atlas area.

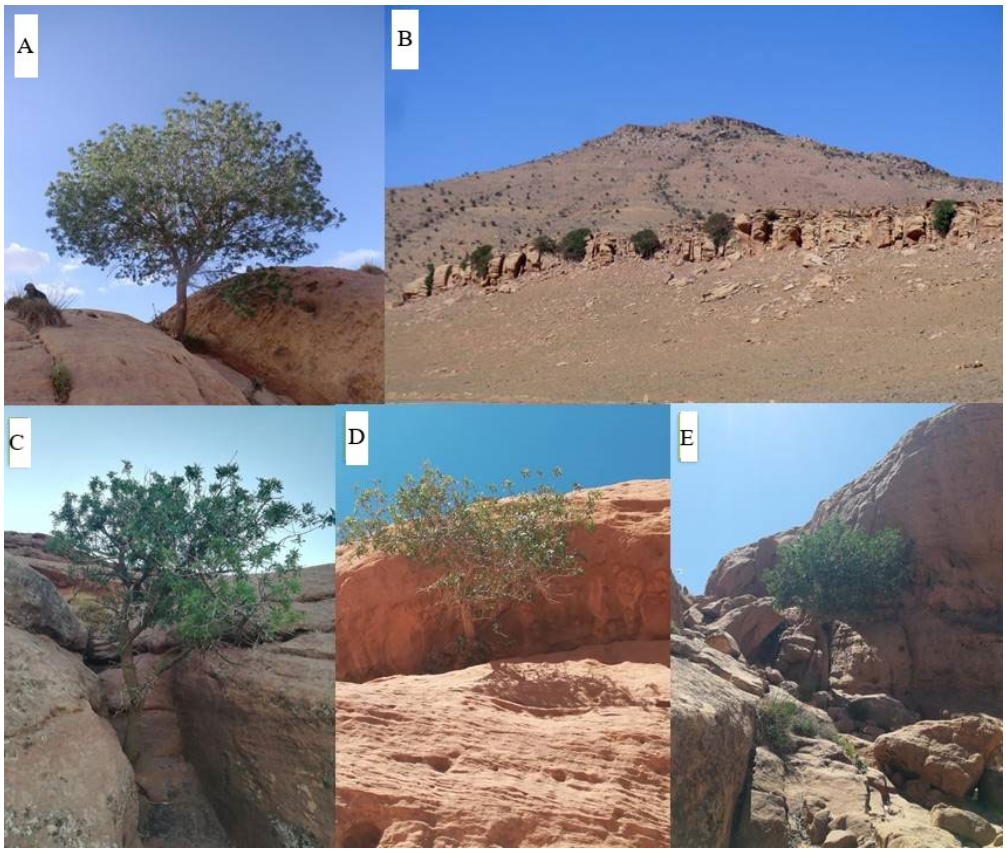

Figure 10. Photos of Atlas pistachio trees taken in the Saharan Atlas (A and D), the Ain Le Ksour mountains in the municipality of Ghassoul (B), the cliffs of Djebel Boudergua in El-Bayadh (C and E) and the cliffs of Khalouet Sid cheikh in the city of Arbaouet.

Distribution of Atlas pistachio in the Saharan area

Figure 11 shows the distribution of the Atlas pistachio tree in the Saharan area. The Atlas pistachio '*Pistacia atlantica* Desf.' is present in the form of groves in the dayas and as isolated trees in the wadi beds with varying densities in the communes of Sidi Taiffour, Sidi Amar, Brézina, El-Abiodh Sid Cheikh, Bnoud, and Moghrar. The density in the distribution area defined for this area varies from 0.95 to 6.45 feet per km² over an area of 2502.07 km² at altitudes between 770 and 1149 m on a silty-sandy-clay substrate.

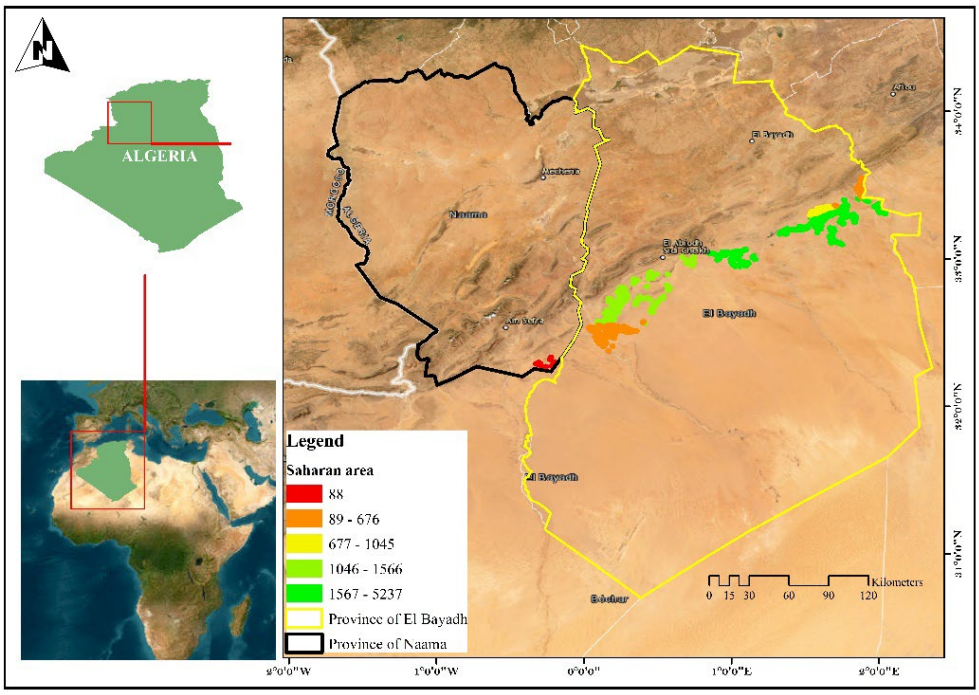

Figure 11. Map of the distribution area of the Atlas pistachio in the Saharan area (El Bayadh and Naâma provinces).

The flora of the Atlas pistachio tree in the Saharan area consists of *Arthrophytum scoparium, Noaea mucronata, Calycotome spinosa, Retama raetam, Ziziphus lotus, Stipa tenacissima, Olea europea, Thymelea microphylla,* and *Peganum harmala.* The natural regeneration of some young plants has been observed within the jujube trees (*Z. lotus*). Just as in the high steppe plains area, the Atlas pistachio faces the problem of overgrazing and illegal felling (Figure 12).

The Green Dam and the distribution of the Atlas pistachio tree

The distribution of Atlas pistachio in the provinces of El-Bayadh and Naâma is superimposed on the Green Dam, in the Saharan Atlas zones, in the Saharan domain (southern Atlas foothills), and the steppe highlands. In these regions, pistachio groves form distribution areas parallel to the Green Dam (Figure 13). The distribution of the Atlas pistachio in the two provinces of El-Bayadh and Naâma suggests that targeted conservation strategies should be implemented. Including the Atlas pistachio range in the Green Dam extension and rehabilitation program will help conserve biodiversity, ensure the sustainability of local ecosystems, protect the soil, and conserve water.

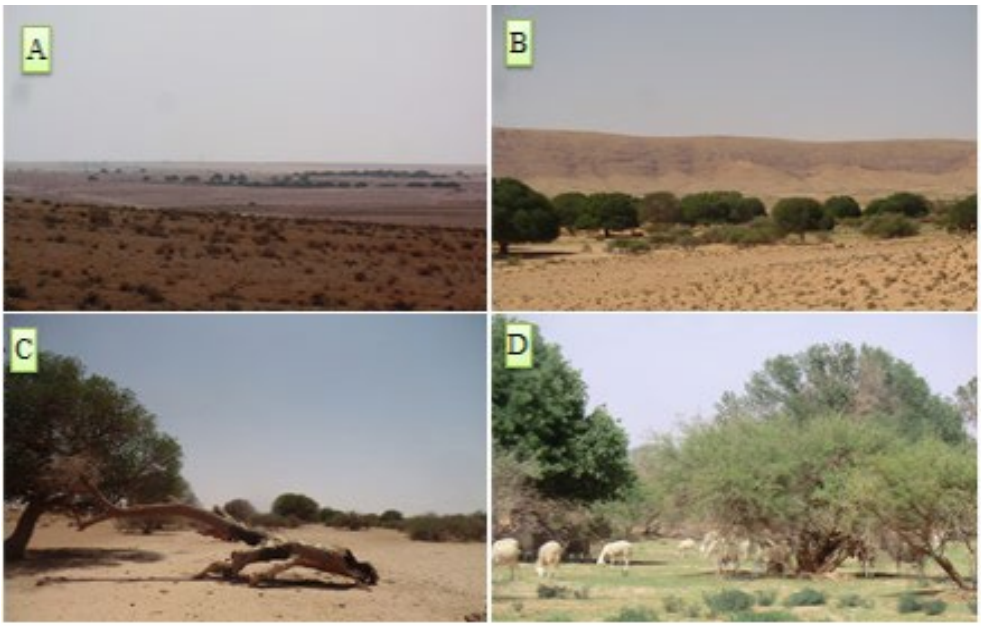

Figure 12. Photos taken in the southern region of El-Bayadh province (A) General view of the scattered groves in the Messayed region (B) Photos of a few trees in the Brézina region (C) Illegal felling of Atlas pistachio trees (D) Overgrazing in Atlas pistachio groves.

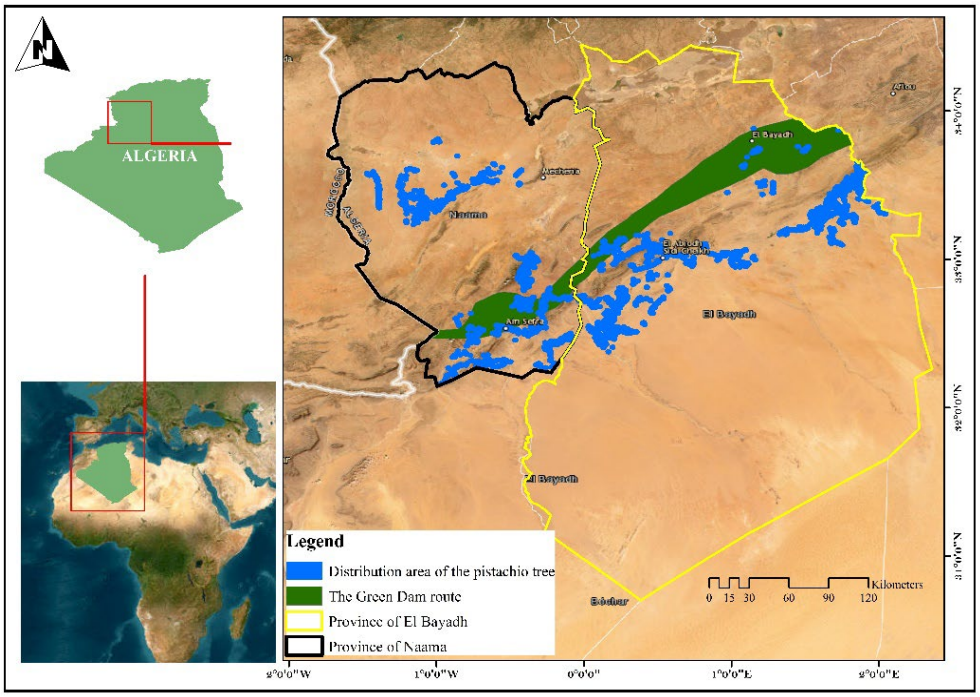

Figure 13. Distribution of Atlas pistachio plantations according to the Green Dam route in El-Bayadh and Naâma provinces.

Discussion

The results obtained in the El-Bayadh and Naâma provinces align with studies on the Atlas pistachio tree in Algeria (Belhadj 1999, 2002, Chermat & Bounar 2020). Cases of regeneration of the Atlas pistachio tree were observed in the three areas of the study site, within the tufts of

jujube that protect the young seedlings on the inaccessible mountain cliffs, which retain rainwater and thus favour seed germination. The same observations have been made previously (Fetati 2017, Guelmani 2023, Hadjadj et al. 2022. 2024, Ifticene-Habani & Abdoun 2018, Khaldi & Khouja 1996, Khalil et al. 2015, Kouria & Bouamer 2020).

The record of the floristic composition of pistachio stands in the atlas is consistent with the work of (Hadjadj et al. 2022, Monjauze 1968), who describe the presence of pistachio, generally on cliffs and steppes, with *Arthrophytum scoparium, Anabasis aretioides* and *Launea arborescens*. On the south-eastern slopes, it is associated with *Stipa tenacissima* and, at higher altitudes, with *Juniperus phoenicea* and *Quercus ilex*.

Because of its hardiness and ability to produce rich humus, the Atlas pistachio could be used as a pioneer species for reforestation, helping to restore rugged terrains and severely degraded environments while also contributing to the fight against desertification (Greco 1966) and (Monjauze 1980) pointed out that in Algeria, if the regeneration of the Atlas pistachio tree in certain forest areas is protected in the long term, this could probably lead to the formation of forest stands very similar to those composed of mature cork oak and holm oak (Bouabdelli et al. 2018) Its ability to adapt to arid conditions and colonise degraded areas makes it valuable for soil restoration and protecting fragile ecosystems.

References

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

Aouragh, M., Lacaze, B., El Mahdad, E.H., El Aboudi, A., El Mousadik, A., Fouad, M., Defaa, C. (2013): Identification des changements récents de l'occupation du sol de la commune de Temsia en Souss à partir d'images de télédétection à haute résolution spatiale. Deuxième congrès international de l'arganier, INRA-Maroc et ANDZOA, Dec 2013, Agadir, Maroc. pp.99-103.

Asma, E.Z.-B. (2019). Taxonomic and botanical retrospective review of *Pistacia atlantica* Desf.(Anacardiaceae). Arabian Journal of Medicinal and Aromatic Plants 5: 47-77.

Barour, A.A., Taouarfia, M. (2022): Cartography and spatial distribution of the genus *Pistacia* in Souk Ahras, Northeast Algeria. Biodiversitas Journal of Biological Diversity 23: 286-290.

Beaulieu, J., Murray, S., Villeneuve, C. (2012): Cartographie détaillée des milieux humides du territoire du Centre-du-Québec-rapport synthèse. Canards Illimités – bureau du Québec et le ministère du Développement durable, de l'Environnement et des Parcs, Direction du patrimoine écologique et des parcs, Québec.

Belhadj, S. (1999): Pistachio situation in Algeria. FAO - IHEAM Nucis. Newsletter. 8: 30.

Belhadj, S. (2002): Geographical distribution of *Pistacia atlantica* Desf. in Algeria. III International Symposium on Pistachios and Almonds 591: 499-503.

Belhadj, S., Derridj, A., Auda, Y., Gers, C., Gauquelin, T. (2008): Analyse de la variabilité morphologique chez huit populations spontanées de *Pistacia atlantica* en Algérie. Botany 86: 520-532.

Benhabyles, L. (2012): Contribution à l'étude phytoécologique comparative des parcours pâturés et mis en défens dans la région de Gâaloul. Thèse de doctorat, Faculté des Sciences Biologiques, Université des sciences et de la technologie Houari Boumedième.

Benhassaini, H., Belkhodja, M. (2004): Le pistachier de l'Atlas en Algérie entre la survie et disparition. La feuille et l'aiguille 54: 1-2.

Bneder (2017): Diagnostic écologique des peuplements du pistachier de l'Atlas et proposition d'un plan d'action pour leur réhabilitation et leur extension . Phase 1: Etude descriptive et analytique 309 pp.

Bouabdelli, Z., Belhadj, S., Smail-Saadoun, N., Mevy, J.P., Notonnier, R., Tonetto, A., Ortas, I., Gauquelin, T. (2018): Influence de l'aridité sur la variation de la colonisation mycorhizienne arbusculaire chez cinq populations naturelles algériennes du pistachier de l'atlas (*Pistacia atlantica* Desf.). Revue d'Ecologie, Terre et Vie 73: 330-344.

Brahim, M.M., Khéloufi, B., Nouri, T., Latifa, M. (2019): Restoration of the steppe ecosystem through agroforestry: A study of the germination and emergence of *Pistacia Atlantica* Desf in the El Bayadh region, Algeria. Livestock Research for Rural Development 31 (9): 196.

Chermat, L., Bounar, R. (2020): Demarcation and protection of *Pistacia atlantica* Desf. in setifian steppe (north-east of Algeria). Journal of EcoAgriTourism 16(2): 45-50.

Dahmani, W. (2011): Etude de la variabilité morphologique du pistachier de l'Atlas (*Pistacia atlantica* Desf.) dans les zones steppiques de la région de Tiaret, Université d'Oran1-Ahmed Ben Bella.

ESRI (2019): ArcGIS Desktop 10.8 [Logiciel].version: 10.7.0.10450.

Fetati, A. (2017): Le pistachier de l'Atlas, cette ressource encore mal connue: Dynamique végétale du taxon *Pistacia atlantica* Desf. ssp. atlantica dans la région nord

occidentale oranaise, Algérie, Éditions universitaires européennes.

Greco, J. (1966): L'érosion, la défense et la restauration des sols, le reboisement en Algérie," Ministère de l'agriculture et de la réforme agraire.

Google (2022): Google Earth Pro. https://www.google.com/earth/download/gep/agree.html, accessed on 12.12.2024.

Guelmani, N. (2023): Contribution a l'étude ethnobotanique, phytoécologique et phytodynamique de *Pistacia atlantica*. Desf, dans les dayas de la région de Laghouat, Universite Mouloud Mammeri De Tizi Ouzou.

Guerine, L., Hadjadj, K. (2019): Ecodendrometric characterization of Atlas pistachio (*Pistacia atlantica* Desf) stands in the Ain Ben Khelil region (South-western Algeria). Indian Forester 145(11): 1053-1061.

Guerine, L., Belgourari, M., Guerinik, H. (2020): Cartography and diachronic study of the Naama Sabkha (South-western Algeria) remotely sensed vegetation index and soil properties. Journal of Rangeland Science 10: 172-187.

Guerine, L., Hadjadj, K., Mouissa, H., Benamara, N., Bendouina, N. (2022): Study of plant diversity in the rangelands of *Stipa tenacissima* L.: case of Sfissifa and El Biodh region (South West Algeria). Current Trends in Natural Sciences 11: 176-193.

Hadjadj, K., Guerine, L., Bendouina, N. (2022): Consideration of dendrometric and ecological characteristics as indicators of rehabilitation of Atlas pistachio stands (*Pistacia atlantica* Desf.): Case of the south-western region of Naama (Western Algeria). Current Trends in Natural Sciences 11: 202-211.

Hadjadj, K., Guerine, L., Belhadj, S., Soufan, W., Rihan, H.Z. (2024): Ecological dynamics and diagnosis of dieback of *Pistacia atlantica* Desf.-Anacardiaceae in the messaâd region (Djelfa, Algeria) using the ARCHI method. Pakistan Journal of Botany 56: 621-629.

Hadjadj, K., Guerine, L., Bendouina, N., Kebbir, N., Sahraoui, N. (2023): Les produits forestiers non ligneux d'origine végétale issus du parc national de Djebel Aissa. First International Seminar on Sustainable Management of Natural Resources in Arid and Semi-Arid Areas. Naâma - Algeria: 24th & 25th October 2023.

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

Ifticene-Habani, N., Abdoun, F. (2018): Croissance radiale et réponse au climat du pistachier de l'Atlas (*Pistacia atlantica* Desf.) dans le Parc national de Theniet El Had (Algérie). Bois & Forêts des Tropiques 335: 3-13.

Khaldi, A., Khouja, M. (1996): Atlas pistachio (*Pistacia atlantica* Desf.) in North Africa: taxonomy, geographical distribution, utilization and conservation. pp. 57-62. In: Padulosi, S., Caruso, T., Barone, S. (eds.), Workshop "Taxonomy, distribution, conservation and uses of *Pistacia* genetic resources", Palermo, Italy, 1995. The International Plant Genetic Resource Institute, Rome, Italy.

Khalil, F., Yahia, R., Mouhabenlafdel, D., Azzouz, B., Hamid, M., Mohame, L., Abdelbasset, B. (2015): Delimitation des peuplements du pistachier de l'atlas (*Pistacia atlantica* Desf.) dans la region orientale du Maroc par le GPS combine au SIG. Algerian Journal of Arid Environment 5: 32-39.

Kouria, B., Bouamer, Z. (2020): Contribution à l'étude de la répartition floristique du pistachier de l'Atlas (*Pistacia atlantica* Desf.) dans la région d'Oued Settafa wilaya de Ghardaïa. Master Thesis - Université de Ghardaïa.

Mederbal, K., Jose, R., Boukhari, Y. (2009): Ecosystème steppiques (cas de Brezina–El Bayadh) caractérisation et proposition d'une fiche de travail sur terrain. Séminaire international (la présentation et la mise en valeur de l'écosystème steppique-Msila-Algeria.

Monjauze, A. (1968): Répartition et écologie de *Pistacia atlantica* Desf. en Algérie. Bulletin de la Société d'histoire naturelle d'Afrique du Nord 56-2.

Monjauze, A. (1980): Connaissance du bétoum *Pistacia atlantica* Desf. Revue forestière française 32: 356-363.

Ozenda, P. (1983): Flore du Sahara. Deuxième edition du CNRS. Paris.

Piedallu, C., Gégout, J.-C. (2002): Etude de la précision du système GPS en milieu forestier. Revue forestière française 54(5): 429-442.

Prasetyo, H.Y.D., Suwindiatrini, K.A. (2020): Pemanfaatan aplikasi smartphone android dalam Pengambilan Data Cagar Budaya. Jurnal Tumotowa 3: 86-95.

Quézel, P., Médail, F. (2003): Ecologie et biogéographie des forêts du bassin méditerranéen, Elsevier Paris.

Quézel, P., Santa, S. (1962): Nouvelle flore de l'Algérie et des régions désertiques méridionales. Editions du CNRS, Paris.

Quézel, P., Santa, S., Schotter, O., Emberger, L. (1962): Nouvelle flore de l'Algérie et des régions désertiques méridionales. Editions du CNRS, Paris.

Smahi, Z., Triki, N., Kious, C. (2022): Evolution de la désertification du Chott Chergui. Les ouvrages du CRASC: 49-62.

UTM Geo Map (2023): UTM Geo Map [Application mobile]. Google Play. https://play.google.com/store/apps/details?id=info.yogantara.utmgeomap&hl=fr

Zohary, M. (1952): A monographical study of the genus *Pistacia*. Palestine Journal of Botany (Jerusalem Series) 5: 187-228.

**** https://power.larc.nasa.gov, accessed at: 2023.12.17