Indian Journal of Ecology (2022) 49(3): 682-688
DOI: https://doi.org/10.55362/IJE/2022/3579

Manuscript Number: 3579
NAAS Rating: 5.79

Contribution of GIS in the Identification and Mapping of Natural Forest Habitats: Case Study of the Forests of El Kala, Wilaya of El Tarf, Algeria

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***Abstract*:** The El Kala region, with its different natural forest habitats, represents an important biological heritage at the national and international levels. Today, it is threatened by various dangers, such as overexploitation and fires. It is therefore urgent to preserve these sensitive and fragile habitats and imperative to better identify them to apply adequate preservation and management measures. Current forest inventory data do not allow the identification of these habitats. The quality of these data also limits the relevance of landscape analyses. The current approach is inspired by various European experiences, including the ecological approach of phytosociology for habitat determination. The phytoecological study and the use of a high-resolution satellite image sentinel-2B allowed us to elaborate on a land-use map. Statistical processing using factorial correspondence analysis helped us to identify the habitats. The mapping was facilitated by the use of an open-source geographic information system Qgis 3.4.9. Finally, were able to discriminate two forest habitats with *Quercus suber* L. and one habitat with *Quercus faginea* Lam. The exploitation of Sentinel-2B images is very useful for high-resolution monitoring of land use and the extent of fragmentation of natural forest habitats caused by anthropozoic action.

Keywords: GIS, Sentinel-2B image, El Kala forests, Forest management, Natural forest habitats

Mediterranean woodland formations are characterized by a high degree of fragility due to environmental conditions and human action. Throughout its history, Algerian woodlands have been subjected to various forms of aggression: anthropozoic and climatic, leading to a degradation of woodland areas into scrub and grassland. The El Kala region, which is one of the Mediterranean basin's hotspots (Véla and Benhouhou 2007) with high biodiversity, is currently experiencing these dangers. Indeed, the regressive dynamics of the ecosystems have intensified over the last decades and we are witnessing the fragmentation and reduction of forest habitats.

In Algeria, few studies have been conducted to define forest habitats. These studies have mainly focused on the mapping of forest stations (Terras 2011), the mapping of mammal biotope (Zahafi 2017), the mapping of rainforests in the region of El Kala (Kahli et al 2018), the diversity of habitats (Medjahdi and Letreuch belarouci 2017 and Zeraia 2018) and finally, the degradation, reduction and dynamics of habitats under the influence of anthropogenic pressures (Siba et al 2022). All these studies have concerned different aspects of habitats without providing a clear methodology for the identification and mapping of natural habitats. This approach is inspired by various European experiences, namely: the Corine Biotope typology (Bissardon et al 1997), which has now been succeeded by the EUNIS (European Nature Information System) typology by Louvel et al (2013), as well as the habitat notebooks which are the French version of the Natura 2000 nomenclature (Bensettiti et al 2002, Bensettiti et al 2005). The present work concerns the identification and mapping of forest habitats in the El Kala region. The mapping of habitats and species must necessarily be based on field observations and to do this our approach is inspired by the methodological guide for the mapping of natural habitats and plant species applied to terrestrial sites of the natura 2000 network (Clair et al

2006).The objective of our work is to implement, from data collected in the field and by exploiting a satellite image, a map of natural forest habitats that will be useful in the management and monitoring of these ecosystems (Nguyen et al 2021, Khalaf and Younis Al-alaf 2021).

MATERIAL AND METHODS

Study area: The study area is located in the extreme North-East of Algeria, our study area covers an area of more than 30 000 hectares, part of which is included in the El-Kala National Park which is fully included in the Wilaya of El-Tarf, and another part outside the park located in the communes of El-Tarf and Zitouna. It is located between 8°14'29.76" and 8°29'57.48" East longitude and 36°34'51.6" and 36°48'36" North latitude. It is bounded to the north by the East-West motorway, to the south by Jebel El Ghourrah, to the east by Tunisia, and to the west by Zitouna and Bouteldja (Fig. 1).

Data description: The mapping of habitats and species must necessarily be based on field observations and to do this present approach is inspired by the methodological guide for the mapping of natural habitats and plant species applied to terrestrial sites of the natura 2000 network (Clair et al 2006, Cajeri et al 2012) as well as the ecological approach of phytosociology for the determination of habitats (Bonhême 2021). The phytoecological study and the use of a satellite image will enable us to draw up a map of the land occupation. The processing of the floristic surveys by correspondence factorial analysis will facilitate the identification of the different habitats. The approach adopted for the identification and mapping of forest habitats in our study area is based on the processing of a 10m sentinel 2B image by the open-source software QGIS 3.4.9 and consists of three phases:- Processing of the satellite image, Mapping of the land use and Statistical processing of the data using factorial correspondence analysis (FCA) for habitat identification and mapping.

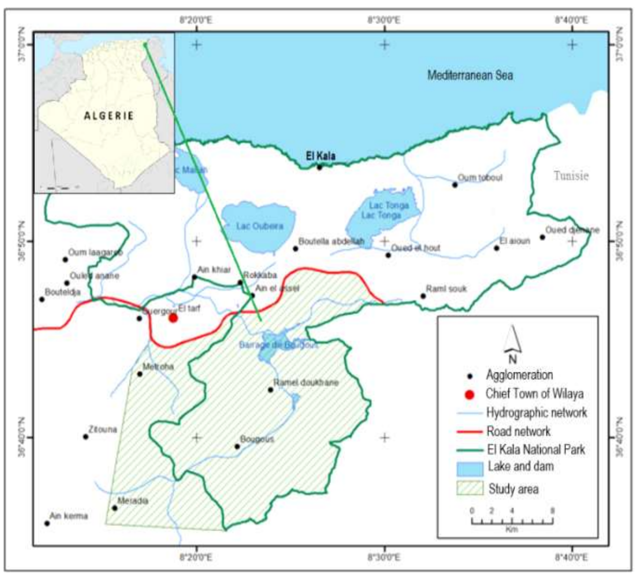

Fig. 1. Location of the study area

Satellite image processing: In this phase, proceeded to a color composition of the three visible RGB bands of the sentinel image 2B of 6 June 2020 (T32SM_ 20200602T100559, downloaded from the Copernicus platform at https://scihub.copernicus.eu) using QGIS 3.4.9 Madeira software. The three bands are merged into individual files by creating a layer stack. The layer stack allows the bands to be displayed in red, green, or blue depending on the use. Once the colored composition was obtained we highlighted our site of interest using the clipping option which reduces the file size and allows for faster processing of the image and used the boundary of our study area (Fig. 2 and 3) and then proceeded to a supervised classification (Fig. 4) of this area to have more precision (Qadir 2019).

Land use mapping: The field study began in April 2021 with a survey of the area, taking into account the results of the classification, which guided us in the choice of the location of

Fig. 2. Merge of the RGB bands

Fig. 3. Cutting of the study area

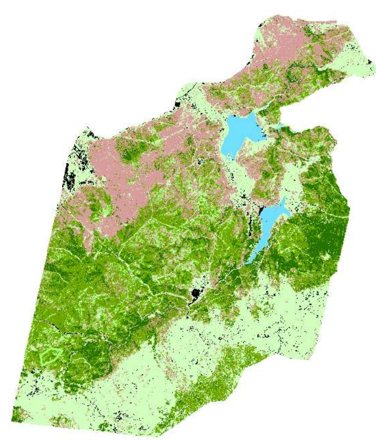

Fig. 4. Result of the supervised classification

the sampling plots, taking into account biotic and abiotic factors. Field sampling will allow the identification and characterization of all the facies identified by the supervised classification.

The choice of plot locations calls for various sampling methods specific to the types of problems posed, and considering the objective of the study, we adopted subjective sampling for the installation of the plots. Within each plot, carried out an inventory that took into account two aspects: biotic and abiotic. A complete floristic survey was carried out on each 400 m^2 plot with the scoring of the abundance-dominance of the species present (Bert 1992). The ecological data are assessed, or measured directly in the field. The pre-minute land use map obtained by supervised classification and floristic information allows us to establish the land use map. The latter is primarily a map of the present vegetation, understood mainly in terms of its structure and essential floristic composition, plus the other forms of land use (Long 1974).

Statistical processing of the surveys by correspondence factor analysis (CFA) and identification of forest habitats: The processing of the phytoecological surveys was carried out using factorial correspondence analysis (FCA). The latter was developed by Benzekri (1964) and Cordier (1965) and was the most suitable method in this field. Since then, this method has been used successfully by many authors (Lacoste and Roux 1971, Romane 1972, Bonin and Roux 1978, Montana and Greig-Smith 1990, Mercier et al 1992). Correspondence factorial analysis makes it possible to highlight the relationships between the various plant groups and ecological factors (climatic, edaphic, etc.). For a forester, especially a manager, this type of computer processing is a crucial phase that facilitates the identification of homogeneous and homo-ecological zones at the level of stations and stands and makes it possible to define forest habitats based on a combination of the most discriminating floristic groups, characterized by a type of soil and placed in a precise climatic context. The factorial correspondence analysis was applied to a presence/absence matrix of 23 surveys and 40 species using the XLSTAT software. The collected data are integrated with a geographical information database. The processing and analysis of the data will allow the identification of habitats.

RESULTS AND DISCUSSION

The application of GIS allowed to produce the land use map by superimposing the different digitized layers and created a database by bringing together all the layers and their attributes. Land use map database contains all the information about the map units survey number, the vegetation formation, the type of the formation, its floristic composition, its height, and density, as well as the altitude, the exposure, observations. The results obtained are represented in the form of cartographic support identifying the various components of the area studied. Five physiognomic types are highlighted: forests, matorrals, plantations, wadi vegetation (riparian vegetation) as well as grasslands and fallow lands. These vegetation formations occupy a surface area of 33,408.4 ha, i.e., 96.6% of the study area. The remainder is made up of 1,148.62 ha and is occupied by: firebreaks, bare soil, settlements, rocky outcrops, reservoirs and dams as well as road infrastructures (Fig. 5 and 6).

Forests: They occupy a large area of 12 826, 8 hectares (37, 1% of the total area) and highlighted several forest facies, pure forests, and mixed forests. Pure forests with *Quercus faginea* Willd. occupying an area of 1335, 4 hectares. Mixed forest with *Quercus faginea* Willd. and *Quercus suber* L. covering an area of 658, 5 hectares. Pure *Quercus suber* L. forests covering 10 832, 4 hectares.

Matorrals: These are the result of forest degradation and are characterized by trees not exceeding 6 meters in height. In present study area, they occupy a surface area of 9773 hectares, i.e., 28.28% of the total surface area. These essentially evergreen bushy formations that derive from the forest play a fundamental role in the current Mediterranean landscape (Quezel and Medail 2003).

Plantations: These occupy an area of 2 115, 3 hectares, i.e., 6, 12% of the total area. They are essentially made up of pure stands of *Eucalyptus* sp or mixed with *Acacia dealbata* Link.

Riparian vegetation (wadi vegetation): These are plant formations found on the banks of the wadis to the north and south of the study area and occupy a surface area of 174 hectares. They are mainly represented by: *Populus alba* L., *Populus nigra* L., *Laurus nobilis* L., *Nerium oleander* L., *Salix alba* L. and *Salix pedicellata* Desf.

Grasslands and fallow lands: These formations are mainly found in the southern part of the study area and occupy a

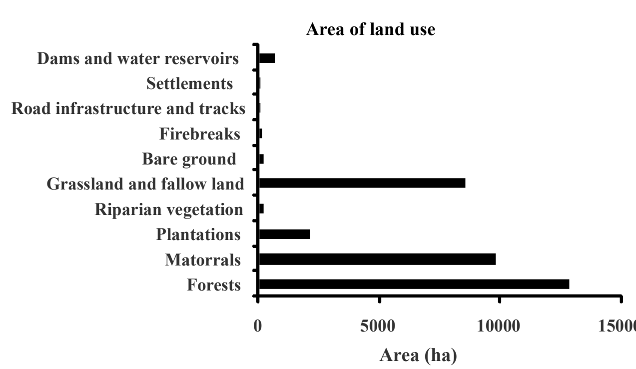

Fig. 5. Distribution of area by land-use type

significant area of 8,519 ha or 24.65% of the total area.

Bare soil: This covers an area of 197, 1 ha.

Road infrastructure and tracks: They occupy 56, 39 hectares. Settlements: These cover 83.53 hectares.

Firebreaks: These cover 162, 4 hectares. Dams and water reservoirs: The Mexa and Bougous dams cover an area of 649, 2 hectares.

Mapping of forest habitats: The natural forest habitats of the study area were identified by employing factorial correspondence analysis (FCA). The latter is a preferred tool for processing floristic data. It was elaborated based on information from the land use map and data from plant surveys carried out during our field campaigns.

Correspondence factor analysis: It distributed the species and records around the first two main axes that express the maximum information. The ½ factorial design absorbs the maximum inertia, 58.69% of the total variation. On the positive side of axis 1, the set I formed by ten surveys (3, 4, 5, 6, 7, 9, 10, 11, 13, and 14) which is opposed to the set II formed by ten surveys (1, 2, 8, 12, 15, 16, 18, 19, 22 and 23). As for axis 2, only three surveys (17, 20, and 21) are found in its positive part forming set III. The cloud of sets in the 1-2 plane (Fig. 7) with its typical parabolic shape seems to show a Guttman effect (Escofier and Pagès 2005).

Group I: It includes degraded forest facies, matorrals, and plantations characterized by the following species: *Quercus suber* L., *Calicotome spinosa* (L.) Link, *Erica arborea* L., *Phillyrea angustifolia* L., *Lavandula angustifolia* Mill, *Pistacia lentiscus* L., *Olea europaea* subsp. *Europaea* L., *Cistus monspeliensis* L., *Cistus salviifolius* L., *Chamaerops humilis* L., and *Ampelodesmos mauritanicus* (Poir) T.Durand and Schinz. The presence of *Calicotome spinosa* (L.) Link. is an indicator of the degradation of the cork oak forest, which can lead to the disappearance of the cork oak and its usual cork tree, and the installation of a flora belonging to other degraded facies such as *Ampelodesmos mauritanicus* (Poir) T. durand and Schinz (Dahmani 1984 , Zeraia 1981). *Pistacia lentiscus* L, on the other hand, is a species known for its thermo-xerophilic character and is indicative of the degradation of cork oak forest (Debazac 1959, Aime 1976 and Dahmani 1984). The presence of *Pistacia lentiscus* L. also indicates degradation caused by fires, hence the

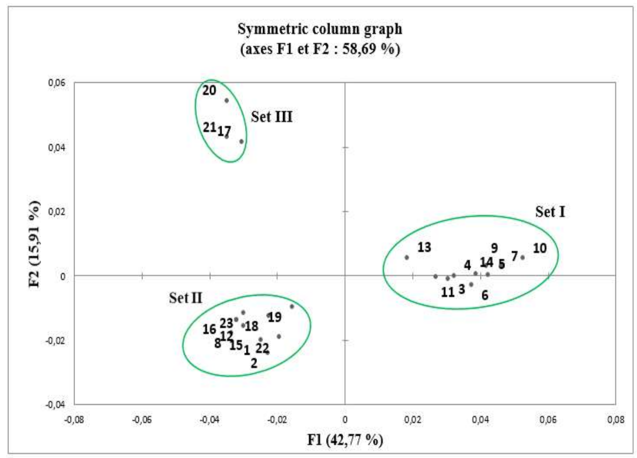

Fig. 7. Projection of the 23 floristic statements of the factorial analysis of correspondences on the factorial plan ½

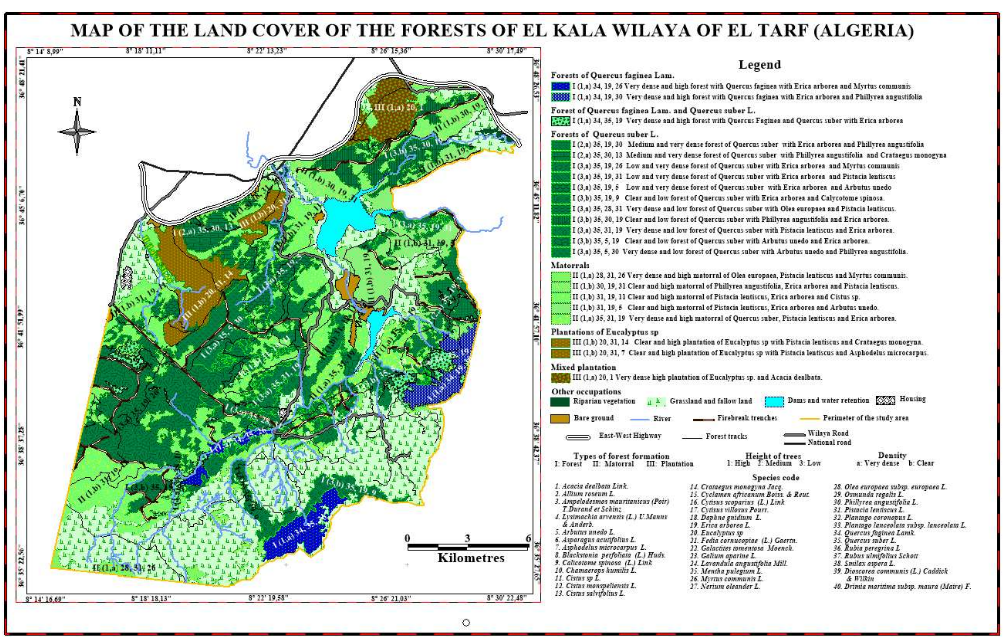

Fig. 6. Land use map of the study area (forests of El Kala)

degradation of the vegetation cover, which creates openings for tree and shrub strata and the installation of thermophilic species (Khelifi 1987) such as *Chamaerops humilis* L. and heliophilic species such as *Cistus salviifolius* L. The association of *Pistacia lentiscus* L. and *Ampelodesmos mauritanicus* (Poir) T.Durand and Schinz. bears witness to the degradation of the cork oak forest. This group, which includes degraded facies with cork oak, represents the habitat of *Quercus suber* L. in a thermophilic environment.

Group II: This groups together forest facies with *Quercus suber* L. with an undergrowth dominated by the following species: *Quercus suber* L., *Cytisus villosus* Pourr. *Rubus ulmifolius* Schott, *Crataegus monogyna* Jacq, *Daphne gnidium* L., *Myrtus communis* L., *Rubia peregrina* L., *Pistacia lentiscus* L., *Cytisus scoparius* (L.) Link, *Smilax aspera* L., *Daphne gnidium* L. and *Dioscorea communis* (L.) Caddick & Wilkin. The appearance of *Rubia peregrina* L., which is a hygrophilous species (Khelifi 1987), characterizes well-drained humus soils. *Crataegus monogyna* Jacq. and *Rubia peregrina* L. are humicolous species (Bekdouche 2010). This group, which includes the advanced cork oak forests, forms the habitat of *Quercus suber* L. in a humid environment.

Group III: It occupies the positive side of axis 2, and includes records of pure Quercus faginea Lamk. forests as well as mixed *Quercus faginea* Willd. and *Quercus suber* L. forests where the atmosphere is forested. The species characterizing this group are: *Quercus faginea* Willd., *Quercus suber* L., *Rubus ulmifolius* Schott, *Viburnum tinus* L., *Crataegus monogyna* Jacq, *Cytisus villosus* Pourr, *Asparagus acutifolius* L., *Rubia peregrina* L., *Dioscorea communis* (L.) Caddick and Wilkin, *Osmunda regalis* L., *Myrtus communis* L. *Arbutus unedo* L., *Cyclamen africanum* Boiss. and Reut, *Smilax aspera* L. and *Blackstonia perfoliata* (L.) Huds. The tree stratum prevents the passage of light to the lower strata, which favors the development of a lianascent flora such as *Smilax aspera* L. (Khelifi 1987). The presence of *Osmunda regalis* L., *Cyclamen africanum* Bois. and Reut. and *Dioscorea communis* (L.) Caddick and Wilkin. This indicates that the environments are shaded. Group III groups together the facies of the Zeen oak with its floral procession representing the habitats of *Quercus faginea* Willd in a cool environment.

Map of natural forest habitats: In present study were able to delineate three natural forest habitats in our study area, two with *Quercus suber* L and one with *Quercus faginea* Willd covering an area of 24 715,4 ha (Fig. 8).

Thermophilous habitat with *Quercus suber* L.: It is dominated by a degraded undergrowth of thermophilous character and covers an area of 14 766, 6 ha or 59.77% of the total forest area. This area shows the extent of degradation in our study area. This habitat, which is normally found only in the thermo-Mediterranean zone at an altitude of no more than 400 m, is found in the Meso-Mediterranean zone at an altitude of more than 800 m, colonizing the *Quercus faginea* Willd. habitat, thus forming fragments of thermophilous habitats with *Quercus suber* L. This dynamic transformation of the most humid and evolved habitats into thermophilic and degraded habitats is the consequence of anthropic actions,

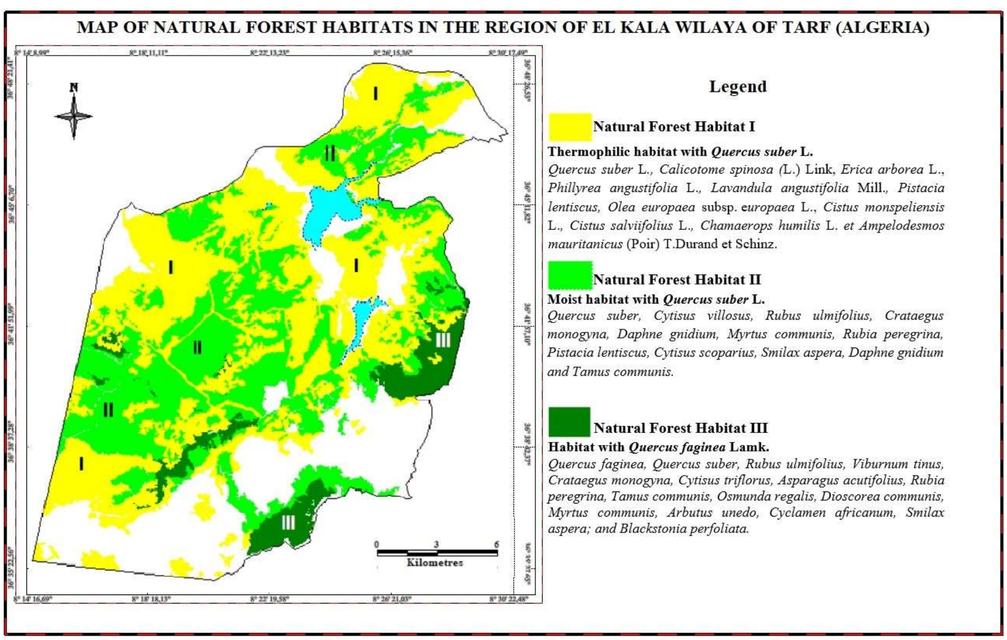

Fig. 8. Map of natural forest habitats

primarily fires, combined with climate change. The opening of the shrub layer after fire favors the installation of thermophilic species (Khelifi 1987) such as *Pistacia lentiscus* L., *Cistus monspeliensis* L., and *Cistus salviifolius* L. (Dahmani 1984).

Moist habitat with *Quercus suber* L.: This habitat includes the most advanced facies of *Quercus suber* L. and is found in almost the entire study area between 150 m and 950 m altitude, covering an area of 7 944,2 ha, i.e., 32.15% of the total forest area in our study area. It is characterized by a cover of more than 90% and an undergrowth with a humid atmosphere. However, its extent is limited by the thermophilic cork oak facies, which reduces its area to the detriment of the thermophilic habitat. The presence of certain species such as *Pistacia lentiscus* in its floristic procession shows the frequency of fires, which favors the fragmentation of this habitat. Habitat fragmentation leads to both quantitative and qualitative habitat loss for species that originally depended on the ecosystem (Faboorg et al 1993). And finally, habitat destruction leads to the loss of rare and endemic species at the expense of ubiquitous ones (Jeph and Khan 2019). At altitude, the presence of *Quercus suber* in this habitat and always associated with *Cytisus villosus* Pourr. which characterizes humid and shady environments, and its appearance indicates that these subterranean forests are gradually giving way to the zenaia (Zeraia 1981) in a logic of progressive dynamics.

Habitat with *Quercus faginea* Willd. : It is located between 300 m and 1200 m in both vegetation levels, but its surface area is very limited, covering only 1 993,9 ha. In the thermo-Mediterranean vegetation level, it is found along watercourses where the atmosphere is more or less humid in the southern part. The largest area of this habitat is located in the south-eastern part of the study area between 450 m and 1200 m altitude. In these conditions, the trees of Oak zeen reach average heights of 19 m, the global cover of the vegetation in these conditions is 100% and the undergrowth is essentially made up of species indicative of shady environments such as the species *Osmunda regalis* L. (Belouahem-Abed 2009). The presence of *Cyclamen africanum* Bois. and Reut. which is a mesophilic species indicative of humus soils indicating a humid and cool forest environment. These conditions allow the good development of *Quercus faginea* Willd. which is a deciduous tree, endemic to the Mediterranean, and prefers brown, leached, deep, permeable, and slightly acid soils.

CONCLUSION

The present approach allowed us to identify and map the natural forest habitats of our study area. The contribution of the high-resolution satellite image sentinel 2B seems to be relevant for the identification of the different sylvofacies and the estimation of the land cover areas. GIS seems to be the right tool for monitoring the natural dynamics of ecosystems and the biotic disturbances, natural or anthropogenic, that the ecosystem is undergoing. The results showed that this ecological approach of phytosociology for habitat determination seems to be a suitable methodology for the identification and mapping of habitats and can be generalized for the whole forest territory, for better management and monitoring of these ecosystems.

REFERENCES

Aime S 1976. *Contribution to the ecological study of the cork oak. Study of some limits*. Doctoral thesis, University of Nice, France.

Bekdouche F 2010. *Evolution after fire of the cork oak ecosystem of Kabylie (North Algerian)*. Ph.D. thesis, University of Tizi-Ouzou, Algeria.

Belouahem-Abed D 2012. *Ecological study of wetland forest stands in the regions of Skikda, Annaba and El Tarf (North-East Algeria).* Ph.D. thesis, University Badji Mokhtar Annaba, Algeria.

Bensettiti F, Gaudillat V and Haury J 2002. *Natura 2000 habitat booklet. Volume 3 - Wetland Habitats*. Published by Documentation Française. Knowledge and management of habitats and species of community interest, Éd. La Documentation française, Paris, p 457.

Bensettiti F, Boullet V, Chavaudret-Laborie C and Deniaud J 2005. *Natura habitat booklet 2000. Tome 4 (vol.1). Agropastoral habitat*s. Éd. La Documentation française, Paris, 2 volumes : p 445 and p 487.

Bert GD 1992. *Production of Pectin Fir and quality of its wood according to the types of sites in the French and Swiss* Jura. Rev. For. Fr. XLIV. **5**: 415-429.

Benzecri J 1964. *On the factorial analysis of proximities*. Pub. Statist. Univ. Paris. 165-180.

Bissardon M, Guibal L and Rameau JC 1997. Corine biotopes. Original version. French habitat types. ENGREF, Nancy, p 217.

Bonhême I 2021. *Determination of natural habitats by forest inventory - the objectives and concepts used*. Ed IGN, p 58.

Bonin G and Roux M 1978. Use of factorial correspondence analysis in the phytoecological study of some grasslands of the Lucanian-Calabrian Apennines. *Acta Oecologica.* Oecologia Plantarum **13**(2): 121-138.

Cajeri P, Curti C, Lafon V, Launay R and Sauriau PG 2012. *Mapping of intertidal habitats in the Natura 2000 sites of the Charente Peninsula: complementarity of field inventory, remote sensing and GIS approaches*. XIIèmes National Coastal Engineering Days, Civil Engineering. Cherbourg, 12-14 June 2012. 855-864.

Clair M, Gaudillat V and Herard K 2006. *Mapping of natural habitats and plant species applied to terrestrial sites of the Natura 2000 network*. Methodological guide. National Museum of Natural History, Federation of National Botanical Conservatories, p 66.

Cordier B 1965. *On the Factorial Analysis of Correspondences. Thesis*. Doctorat 3ème cycle. University of Rennes, France.

Dahmani M 1984*. Contribution to the study of the holm oak (Quercus rotunditfolia Lamk.) groups of the Tlemcen mountains (western Algeria). Phytoecological and phytosociological approach.* Thesis. Doctorat 3ème cycle. University of Science and Technology Houari Boumediene, Algeria.

Debazac EF 1959. *The forest vegetation of the Kro*umirie. Ann. Ec. Nat. des eaux et des Forêts. T XVI. Fasc. 2, p 131.

Escofier and Pagès 2005. *Simple and multiple factor analyses Objectives, methods and interpretation*. 4th edition Ed DUNOD, p 318.

Faaborg J, Brittingham M, Donovan M, and Blake J 1993. *Habitat fragmentation in the temperate zone: a perspective for managers.* Gen. Tech. Rep. RM-229. Fort Collins, Colorado: Rocky Mountain Forest and Range Experiment Station, US Dept, of Agriculture, Forest Service: 331-338.

Jeph A and Khan J.B 2019. Study on some threatened, rare and endangered plant's species in reserve forest area of Jhunjhunu District, Rajasthan. *Indian Journal of Ecology* **46**(4): 755-759.

Kahli A, Belhadj G, Gaget E, Merle C and Guelmami A 2018. Mapping rainforests in the El Kala region (Algeria) using earth observation tools. *Journal of Ecology, Earth and Life* **73**(4): 431-445.

Khalaf AB and Younis Al-alaf M 2021. Use of remote sensing and GIS techniques in monitoring of land use/ land cover changes: Case study of Kanaan area of Diyala Province, Central Iraq. *Indian Journal of Ecology* **48**(4): 990-994.

Khelifi H 1987. *Contribution to the phytoecological and phytosociological study of cork oak formations in North East Algeria*. Thesis. Doctorat 3ème cycle. University of Science and Technology Houari Boumediene, Algeria.

Lacoste A and Roux M 1971. The multidimensional analysis in phytosociology and ecology. Application to data from the subalpine level of the Alpes-Maritimes. I. Analysis of floristic data. *Acta Oecologica. Oecologia Plantarum* **6**: 353-369.

Long G 1974. *Phytoecological diagnosis and land use planning. T1 principes généraux et méthodes.* Paris VI, p 252.

Louvel J, Gaudillat V, and Poncet L 2013. EUNIS, *European Nature Information System. Correspondences between EUNIS and CORINE Biotopes v.1 classifications. Terrestrial and freshwater habitats.* MNHN-DIREV-SPN, MEDDE, Paris, p 50.

Médail F and Quézel P 2003. Possible ecological consequences of climate change on the flora and vegetation of the Mediterranean basin. *Bocconea* **16**(1): 397-422.

Medjahdi B and Letreuch Belarouci A 2017. Biodiversity of the forest habitats of the Trara Mountains (Western Algeria). *Geo-Eco-Trop* **41** (1): 29-38.

Mercier P, Chessel D and Dolédec S 1992. Complete correspondence analysis of an ecological profile data table: A central ordination method. *Acta Oecologica. Oecologia Plantarum* **13**: 25-44.

Montana C and Greig-Smith P 1990. Correspondence analysis of species by environmental variable matrices. *Journal of Vegetation Science* **1**: 453-460.

Nguyen DH, Ngo T.D, Nguyen QK, Dang HC, Kolesnikov SI and Ha DT 2021. Remote sensing planet images application in mapping the status of tropical forests: A case research in Kontum Province, Vietnam. *Indian Journal of Ecology* **48**(4): 970-976.

Qadir A, Abir IA, Nawaz S, Khan N, Adil MA, Olukunle RK, Akhtar N, Anees MTA, Hossain K and Ahmad A 2019. Crop acreage and crop yield estimation using remote sensing and GIS techniques, Bulandshahr District. *Indian Journal of Ecology* **46**(3): 470-474.

Romane F 1972. *An example of the use of factorial correspondence analysis in plant ecology. In: Grundfagen und Methoden in der Pflanzensoziologie*. Maarel, E. van der & Tüxen, R. (Eds.) Dr. W. Junk b.v, The Hague: 155-162.

Siba A, Aboura R, Kechairi R, Maatouk M and Sebbah B 2022. Diachronic study (2000-2019) of bioclimate and land use in Tlemcen region, Northwest Algeria, *International Journal of Environmental Studies*. DOI: 10.1080/00207233.2022.2058761.

Terras M 2011. *Typology, forest site mapping and forest stand modelling. Case of the forest massifs of the wilaya of Saida (Algeria*). Ph.D. thesis in agronomy and forestry sciences. Université Abou Bakr Belkaid. Tlemcen, Algeria.

Véla E and Benhouhou S 2007. Evaluation of a new plant biodiversity hotspot in the Mediterranean Basin (North Africa). *Comptes Rendus Biologies* **330**(8): 589-605.

Zahafi B 2017. *Contribution to the inventory of mammals and mapping of their biotope in the mountains of beni-chougrane mascara*. Ph.D. thesis in sciences. Biology. Université Mustapha Stambouli de Mascara, Algeria.

Zeraia A 1981. *Comparative interpretation of ecological, phenological and subero-ligneous production data in the cork oak forests of crystalline Provence (southern France) and Algeria*. Thesis. Doctorate University of Aix Marseille. France.

Zeraia A 2018. *Biodiversity of the forest and steppe vegetation of Algeria*. Ed : European University Publisher, p 118.

Received 06 February, 2022; Accepted 22 May, 2022