EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology, 2025, 26(4), 150–160
https://doi.org/10.12912/27197050/200801
ISSN 2719–7050, License CC-BY 4.0

Received: 2025.01.17
Accepted: 2025.02.19
Published: 2025.03.01

Contribution to the evaluation of the ordinary biodiversity and environmental status of the Chettaba forest (Algeria) by the potential biodiversity index

Malika Rached-Kanouni[1,2*], Maya Benoumeldjadj[2,3], Alia Zerrouki[1], Bousba Ratiba[4], Boutheyna Touafchia[1]

[1] Larbi Ben M'hidi University, Department of Natural and Life Sciences, Exact Sciences and Natural and Life Sciences Faculty, Oum El Bouaghi, Algeria
[2] AUTES research Laboratory, University of Constantine 3, Salah Boubnider, Constantine city, Algeria
[3] Larbi Ben Mhidi University Oum El Bouaghi, Department of Architecture, Earth Sciences and Architecture Faculty, Algeria
[4] Department of Biology and Plant Ecology, Faculty of Natural Sciences and Life, Frères, Mentouri University, Constantine 25000, Algeria
* Corresponding author's e-mail: kmalikbio@yahoo.fr

ABSTRACT

The degradation of forest habitats and the resulting loss of biodiversity is a major global problem. To integrate biodiversity in the current management of forests, managers need tools based on established scientific knowledge and adapted to their needs and constraints. The objective of the present work is to study the characteristics of the biodiversity of the Chettaba forest (East of Algeria) in order to develop a management plan. In this perspective, a description of the dendrometric properties and the capacity of reception of the forest was carried out. This description was carried out through the implementation of a multifunctional inventory composed of a dendrometric inventory and a potential biodiversity inventory (PBI), a rapid habitat assessment method widely used in France. The results obtained show an average PBI in the Chettaba forest. With total scores ranging from 15 to 31 with percentages from 30 to 62% of the maximum potential. The PBI values related to the factors related to the stand and its forest management are considered average ranging from 31% to 63%, while the PBI values of the factors related to the context vary between 27% and 60% for all plots of the forest. The average tree density is 457 individuals/ha, with an average diameter of 16.31 cm and an average height of 4.35 m for an average basal area of 11.77 m^2/ha. Overall, this work provides an overview of the distribution of plots with different levels of potential biodiversity. The current decline in biodiversity shed light on the critical need to develop tools and methods to improve the effectiveness of biodiversity conservation and monitoring in managed and protected areas.

Keywords: Chettaba forest, biodiversity, dendrometric parameters, potential biodiversity index.

INTRODUCTION

Global biodiversity loss has reached unsustainable rates over the past century, so much so that the scientific community now assumes a sixth mass extinction (Pievani, 2015). Biodiversity conservation has become an important parameter of sustainable forest management, since the Helsinki conference in 1993, as a follow-up to the Earth Summit in Rio De Janeiro in 1992 that enshrined the concept of biodiversity. Forests are complex ecosystems whose biological diversity provides multiple ecosystem services that comprise much of Earth's terrestrial biodiversity (Borie & Hulme 2015; Kok *et al*., 2017). They provide habitats for many taxonomic groups including: birds, vertebrates, invertebrates and microorganisms, which are affected in different ways by current and past forest management practices (Lassauce *et al*., 2011; M'arialigeti *et al.,* 2016; Douda et al., 2017; Oettel, 2021). Conservation and restoration of forest ecosystems is one of the main critical tasks for protecting global ecosystems (Chazdon *et al*., 2017; Mancosu *et al.*, 2018).

The variety and complexity of the biological domains concerned constitute a practical difficulty for the manager in assessing biodiversity. It is also necessary to integrate dynamic aspects because it is not enough to take into account only current diversity, but also to consider the possibilities of emergence of future diversity (Larrieu, 2008). Methods for assessing biodiversity and sustainable forest management have developed strongly over the last two decades at various stand scales of the national forest estate (Rossi & al., 2013). Approaches classically used to assess forest biodiversity are based mainly on the three main levels of organization: taxonomic, genetic and ecosystem (Gosselin & Laroussinie, 2004). In addition, other factors are involved in describing biodiversity and distinguishing between these types. According to the following levels: remarkable biodiversity, which consists of the protection of threatened, or endangered species and habitats; ordinary biodiversity, which encompasses all scales from local to national and even international, and functional biodiversity, which takes into consideration the functioning and sustainability of ecosystems (Gosselin et al., 2009). However, biodiversity assessment is difficult to complete in its entirety due to the complex and tedious complementary analysis (Gonin *et al*., 2012). For this reason, and in order to better understand this diversity and to guide forest managers towards sustainable forest management, a new index has been developed to analyze ordinary biodiversity in forests in a simple and efficient way. This is the potential biodiversity index (PBI) (Larrieu & Gonin 2008).

The potential biodiversity index (PBI) is an index created in France in 2008 as part of a national program conducted at the Centre National "Propriété Forestière" (Larrieu and Gonin 2008; Emberger *et al.,* 2020). The objective of this index is to provide forest managers with a simple and direct tool to assess the potential biodiversity of a forest stand (Larrieu *et al*., 2013; Baiges *et al,* 2019; Larrieu *et al.,* 2019; Gonin *et al*., 2022). Since 2008, the PBI has been highly developed and widely used in forest management (Gonin *et al*., 2022). This decision-support tool can be used to diagnose the improvable elements of a stand and thus guide management to improve its carrying capacity. The potential biodiversity index is a composite indicator uses several measurements made in different units (Levrel, 2007). In this sense, it consists in assessing a set of ten factors among those usually recognized as the most favorable to the internal diversity of forest stands (Müller *et al*., 2007; Emberger *et al,* 2021).

The PBI is an indirect indicator that evaluates the capacity of the stand to host species and not their actual presence. It is therefore based on the characteristics of the trees, the stand and the biotope, but not on taxonomic inventories. Even in the case of the "Native Species" factor, the diversity assessed is not that of the species but that of the species related to them (Gonin *et al*, 2017). To be able to apply the PBI inventory in good conditions, it is necessary to know its area of validity. The PBI can be used in forests of the Atlantic and continental domains, from the plains to the subalpine level, as well as in the Mediterranean region (Larrieu and Gonin, 2016).

Our study focuses on the Chettaba state forest, located southwest of Constantine (Algeria). It covers an area of 2398 ha (Lemouissi *et al.*, 2014). Its potential biodiversity is characterized by a mixed stand of holm oak (*Quercus ilex* L.) and Aleppo pine (*Pinus halepensis* Mill.). A stand unfortunately threatened by several factors, the main one being the anthropic action. In this context, we are interested in assessing the ordinary taxonomic biodiversity of these formations, while applying the PBI, tested for the first time on the Constantinian forest, in order to collect the information necessary for the determination of the best practices and approaches to protection and / or sustainable management.

MATERIAL AND METHODS

Study area

The forest of Chettaba is located southwest of Constantine (Algeria). The study area is located on the topographic map of Constantine (scale 1/200 000 sheet No. 17) and located between the coordinates 36°19'4" north latitude and 6°28'36" east longitude (Fig. 1). It covers an area of 2398 ha, a perfectly limited area divided into six districts. The extreme altitudes of the forest are about 1104 m (maximum altitude) and 652 m (minimum altitude) and its bioclimate is semi-arid to sub-humid. The average annual precipitation is estimated to be between 670 and 800 mm

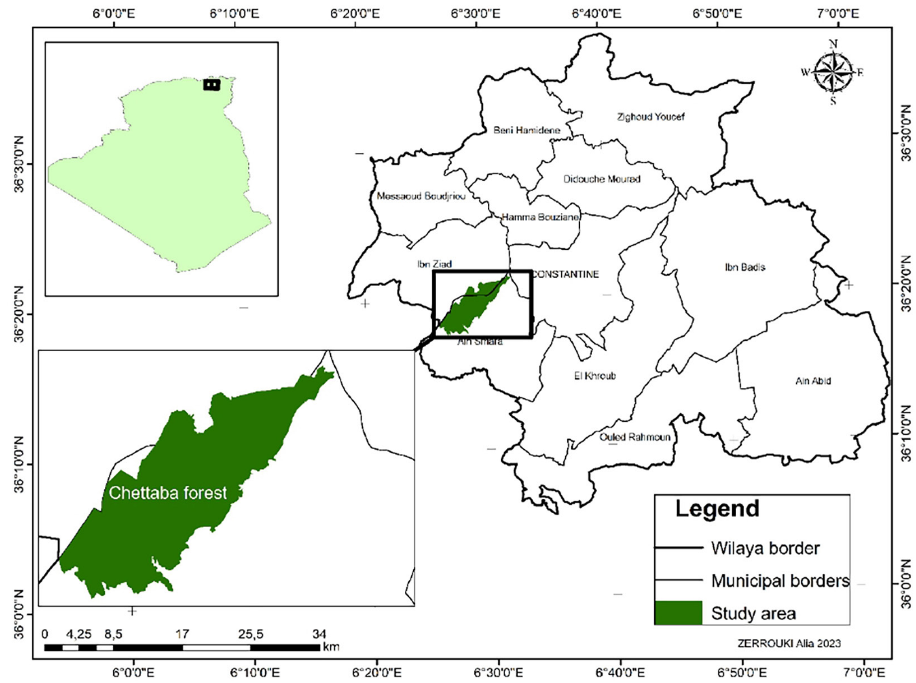

Figure 1. Location of the study area

and the average annual temperature is 18 °C, with the average of the hottest month above 35 °C and the average of the coldest month varying between 1.25 and 3.05 °C.

Six randomly plots selected of holm oak (*Quercus ilex* L.) of an equivalent area of 900m^2 were selected; within each plot all individuals were inventoried. Since the study is focused on the plots, it is preferable to make a complete inventory. It consists of an exhaustive count of stems and by diameter classes (Rached-Kanouni *et al.,* 2019). The dendrometric measurements and the PBI evaluation are carried out in June-July.

The dendrometric parameters selected for the study are density, diameter, mean height and basal area.

Stand density (N) is the average number of standing trees per hectare.

$$N = n / s \quad (1)$$

where: *n* – being the total number of trees per plot, *s* – area of the plot (*s* = 0.09 ha).

The basal area of the stand is the sum of the basal areas of all the trees. It results from the following formula:

$$G = \frac{\pi}{4s} \sum_{i=1}^{n} d_i^2 \quad (2)$$

where: *G* – basal area expressed (m^2/ha), d_i – diameter (m) of tree i in the plot, *s* – area of the plot (Ngom *et al,* 2013).

Biodiversity index potential

The potential taxonomic biodiversity of a forest stand actually present was estimated by the PBI. It is based on the identification of ten specific factors. Seven are factors directly related to forest management, the other three to the context, both historical and stationary (Larrieu & Gonin 2008; Larrieu et al., 2012; Emberger et al., 2016). Each of these ten factors is assigned a score of 0, 2 or 5 according to predefined thresholds. All factors, with the exception of temporal continuity, were recorded in the field and subsequently evaluated according to the PBI protocol. By comparing field observations with threshold values. The PBI factors considered are from A to J and are either management-related (factors A–G) or context-related (H–J) (Larrieu and Gonin, 2008). Management-related factors include the number of native tree species (A), vertical structure in terms of canopy layers (B), standing dead wood (C) and fallen wood (D), large live trees (E), live trees carrying microhabitats (F), and the percentage of open areas (G). Contextual factors relate to temporal continuity of the forest area (H) as well as aquatic (I) and rocky (J) habitats. All factors, except temporal continuity, were recorded in the field and subsequently assessed using the PBI protocol. By comparing field observations with threshold values, a scoring system assigns a score of 0, 2 or 5 per factor (Emberger *et al.*, 2016).

Interpreting the potential biodiversity index

The potential biodiversity index is composed of two scores that are subtotals of the values obtained for factors A to G, which are dependent on forest management, and for factors H to J, which are related to context (Table 1). The PBI is expressed by keeping the two components of the overall score separate and scoring each as a percentage of the theoretical maximum score.

RESULTS

Table 2 presents the dendrometric characteristics of the trees in the different plots of the Chettaba forest. The average density of trees is 457 individuals/ha for a basal area of 16.31 m^2/ha. The comparison of the means of the dendrometric parameters by analysis of variance (Fisher's test) indicates that there is a significant difference for height (p = 0.029) and highly significant difference of diameter and basal area between these parameters (p < 0.001).

Plots 1 and 2 are the densest with 1056 and 500 individuals/ha respectively. The average diameter is between 9.76±4.16 cm and 22.08±11.26 cm, these stands are in the state of thicket to forest. Our results reveal that small diameter trees are observed in all plots. Basal area is closely related to diameter, with land-use units containing many small-diameter individuals and having low basal areas. The highest basal area value is recorded on plot 4 (16.11 m^2/ha) and the lowest is observed on P3 (9.14 m^2/ha).

Specific biodiversity

At the level of the forest of Chettaba, the *Quercus ilex* is the species that has the largest number of trees noted (85% of all trees observed). In second place, we find the *Juniperus oxycedrus* (4.5%), the *Pinus halepensis* (4%) and *Phillyrea angustifolia* (2.8%). We counted 247 individuals in the altitudinal interval between 804 and 1093 m. These individuals are grouped in 8 woody species, divided into 7 families (Fagaceae, Pinaceae, Oleaceae, Cuperssaceae, Rosaceae, Fabaceae and Anacardiaceae) (Fig. 2).

Stand structure based on diameter and height

The diameter values of the sample trees are shown in Figure 3. The majority of the trees belong to class 2 (7.5–17.5 cm) with a rate of 42.67%. In second position are classes 3 (17.5–27.5 cm), 1 (<7.5 cm) and 4 (27.5–47.5 cm) with a respective percentage varying between 16.67%, 16% and 6%. These 4 categories represent young trees. In

Table 1. Interpretation of PBI index

PBI: Criteria A to G			PBI: Criteria H to J		
Absolute value	Relative value (%)	Biodiversity related to management	Absolute value	Relative value (%)	Contributions of the context
0 – 5	0 – 15	Low	0	< 10	Low
6 – 12	16 – 35	Fairly low	2 – 9	10 – 60	Average
13 – 22	36 – 65	Average			
23 – 31	66 – 90	Quite strong	10 – 15	> 60	Strong
32 – 35	91 – 100	Strong			

Table 2. Main dendrometric data

Plots	N (stems/ha)	D (cm)	H (m)	G (m^2/ha)
P1	1056	9,76±4,16^{c}	3,97±1,36^{bc}	0,10± 0,07^{c}
P2	500	15,41±9,84^{b}	4,43±2,25^{ab}	0,29±0,48^{b}
P3	222	19,28±12,66^{ab}	4,86±2,27^{a}	0,46±0,56^{ab}
P4	344	17,18±14,94^{ab}	3,64±1,14^{c}	0,52±1,04^{a}
P5	278	22,08±11,26^{a}	4,69±1,86^{ab}	0,53± 0,45^{a}
P6	344	17,11±8,45^{ab}	4,50±2,31^{ab}	0,31± 0,25^{ab}
p		<0,0001	0,029	<0,0001

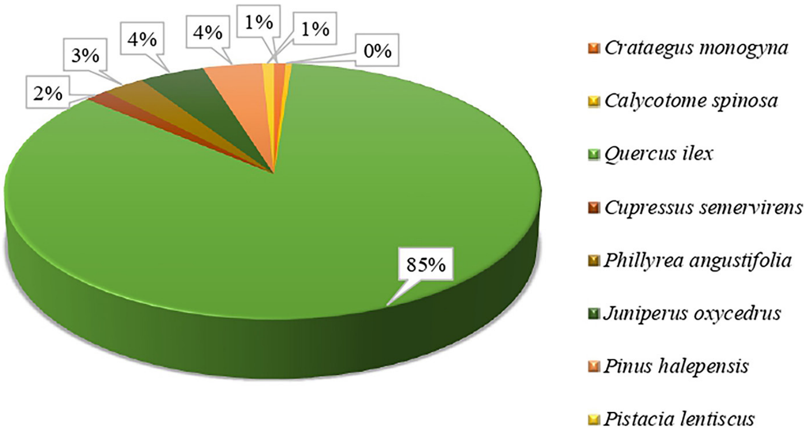

Figure 2. Distribution of species in the study area

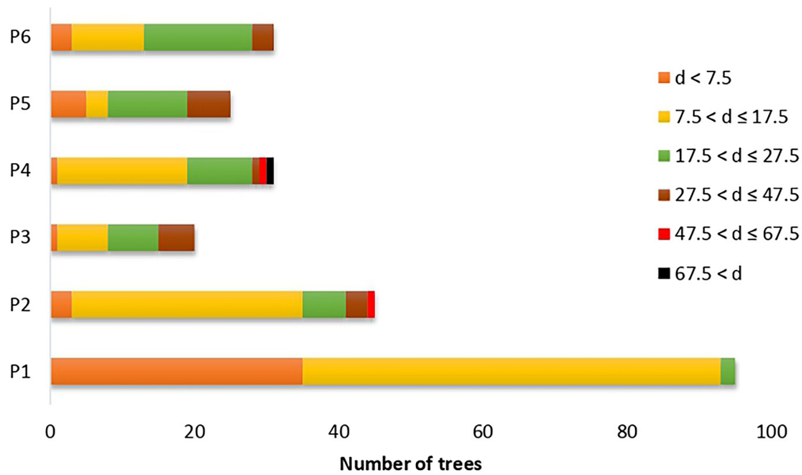

Figure 3. Dishibution of trees by diameter classes

addition, many individuals are only at a young life stage. On the other hand, large diameter stems are low in plots 4 and 2 and non-existent in the other plots. Trees height measurements are presented in Figure 4. Class 2 (2–4 m) is the most dominant with 35%, followed by class 3 (4–6 m) with 30.67% of the observed trees. The fourth class (6–8m) is less important than the previous ones with a percentage of 9.33%; while the other classes are less frequent. There is an almost total absence of trees over 12 m.

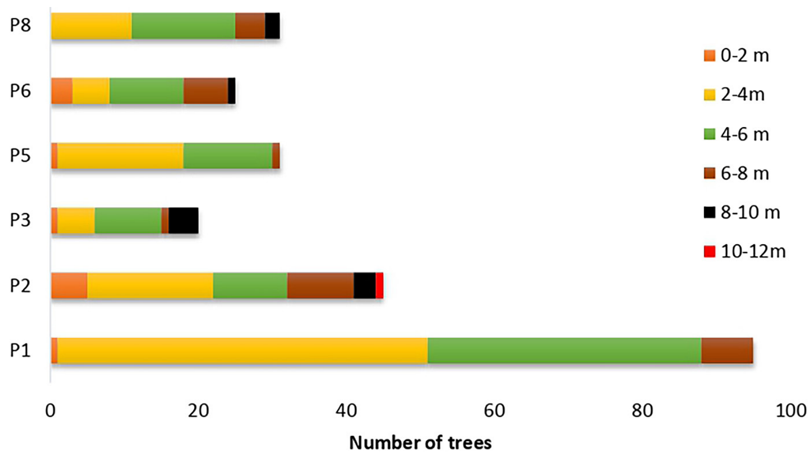

Figure 4. Dishibution of trees by height classes

The PBI evolution

Our IBP results indicate that the total plot scores range from 15 to 31, with a percentage of 30 to 62% of the maximum potential. According to the IBP scale, they are classified as fairly low to fairly strong (Table 3). PBI values for stand and forest management factors (A–G) are considered average, ranging from 31% to 63%, while PBI values for context-related factors range from 27% to 60% for all plots (Table 4).

For each of the PBI factors, the score for factor A, related to the number of tree species, it is not correlated with the species richness of any of the species groups. Therefore, it is not suitable, on its own, for assessing potential biodiversity. The number of tree species varies from 1 to 5 per plot; *Quercus ilex* still dominates; *Calycotome spinosa* is present on only one plot. Plots 1, 3, 5 and 6 are rated 2. These plots are characterized by three genera (pine, evergreen oak and filaria), while a score of 0 is given to plots 2 and 4 where the number of native genera does not exceed 2. For factor B, the vertical structure of the vegetation generally shows a vertical stratification with only three strata, the number 2 means that there are 3 strata within the 6 plots (herbaceous stratum, semi-woody stratum, woody stratum occupied by low height foliage (< 5m) and intermediate (5–15 m). This distribution also shows the absence of tall foliage (>15 m). Factor scores for C and D show very few dead wood elements, especially those of large diameter. Very large trees (diameter at breast height > 60 cm) are present on half the plots. However, tree-habitats are important and provide a diversity of tree-related microhabitat types, the frequency of dendromicrohabitats is lower due to the low density of large wood.

Hard-bottom toe cavities, evolving toe-trunk soil cavities, water-filled cavities, and fresh sap flows are among the most common types. Microhabitats existing on the majority of sample trees are lichen, hence the score of 5. Open environments (edge and gap types) are maximal for the stand as a whole with a score of 5. With respect to contextual factors, and with respect to the age of the forest, it seems clear to us that our stand is part of a forest that is probably old (boundary unclear) or has been partially cleared. The area is characterized by the presence of a small temporary stream. A diversity of rocky environments is also notable. Among the most remarkable types, we note the accumulation of stones and stabilized boulders, of natural origin (stable scree) or anthropic (pile of stone, low wall or ruin). The results obtained are represented in table form with a "radar" representation that allows the contribution of each of the factors to the overall score to be quickly visualized, thus making it possible to define the areas for improvement (Fig. 5).

Table 3. IBP note

Plots	Absolute value	Relative value %	Class
P1	15	30	quite low
P2	31	62	quite strong
P3	23	46	average
P4	24	48	average
P5	15	30	quite low
P6	28	56	average

Table 4. Potential biodiversity related to management and context

Plots	PBI: Criteria A to G			PBI: Criteria H to J		
	Absolute value	Relative value (%)	Class	Absolute value	Relative value (%)	Class
P1	11	31	quite low	4	27	low
P2	22	63	quite strong	9	60	average
P3	16	46	average	7	47	average
P4	17	48	average	7	47	average
P5	11	31	quite low	4	27	low
P6	19	55	average	9	60	average

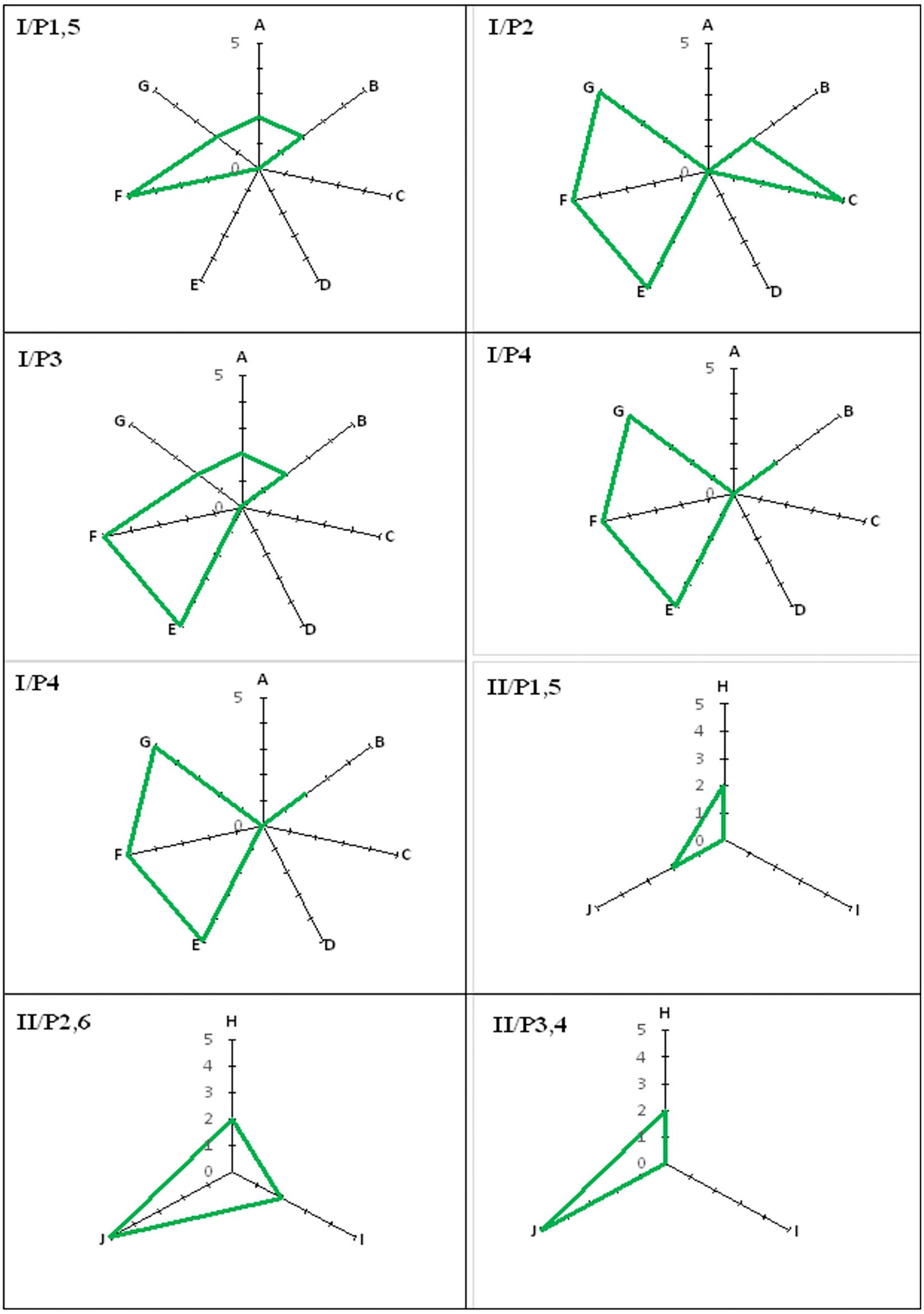

Figure 5. PBI results (in %). I: related to the seven factors describing the current stand; II: related to the three factors describing the context. A: Tree richness, B: Ve1tical strncture, C: Standing dead wood, D: dead wood on the ground, E: Ve1y large trees, F: Habitat-trees, G: Openness, H: Temporal continuity of thewoody state, I: aquatic rnacrohabitats, J: Rocky rnacrohabitats

DISCUSSION

The results show that the potential forest biodiversity is average in the forest massif of Chettaba. Rached-Kanouni *et al.* (2020) showed that this biodiversity is low in the forest massif of Sidi R'Ghies in Oum El Bouaghi, while these forests occupy the same bioclimatic stage. The total density observed is 2744 individuals/ha in the studied massif. However, it is higher in plot 1 with 1056 individuals/ha for an average diameter and height of 9.76 cm and 3.97 m respectively.

These results are in perfect agreement with those of Rached et al. in 2020 for the Sidi R'Ghies forest in Algeria. The observed density is high and the other parameters are low which reflects an aggregate distribution of the vegetation, with the presence of very sparse areas or areas where individuals are in groves (Ngom, 2013). These stands have high density and low basal area values this is explained by competition between trees (Sarmoum, 2018; Zerrouki *et al.,* 2022). Average, or low values of PBI criteria often depend on climate, soil, and anthropogenic actions. PBI is a method for diagnosing potential forest biodiversity, based on rapid surveys, as confirmed by this application on the study plots. The actual results of the study reveal that the scores of the factor "A" are average on all the plots. The diversity of native forest species is thus globally average. However, this result can be explained by the fact that in most surveys the maximum number of species is 3 (*Quercus ilex, Pinus halepensis, Phillyrea angustifolia*). The consideration of species diversity is based on the number of genres present; each genus being counted regardless of its cover. On the larger scale of a forest massif, this information remains interesting. The associated biodiversity varies according to the species but it increases globally with the number of indigenous species (Gosselin *et al.,* 2006).

The influence of the number of strata on biodiversity is at the origin of the factor B which tends to obtain a score of 2 on all the plots, due to the inevitable absence of the high tree layer (more than 20 m). This distribution also shows the low density of adult individuals. The latter is indicative of a highly disturbed environment. Each of the four vegetation strata considered (herbaceous and semi-woody stratum, shrub stratum < 7 m, stratum 7–20 m and stratum > 20 m) play an important role on forest biodiversity. The presence of a certain number of species, notably birds, depends on the presence of one or more of these strata in a specific way. Consideration of structural features could have great potential for better monitoring and management of biodiversity conservation (Yao *et al.,* 2019; Angiolini *et al.,* 2021).

Overall, the values for factors C and D are low. The amount of dead wood present is interesting information. These deadwoods are an important component for potential biodiversity as they provide habitat for many saproxylic insects (Koch *et al.*, 2018) and lichens (Hofmeister *et al.,* 2016). This difference in scale of observation causes stumps and dead wood to be considered absent. However, low stumps and dead wood with circumference less than 120 cm exist in large quantities. Factor E is at the bottom of the scale of the two previous factors, given the absence of large live trees, so there is little chance of satisfactory values being achieved in the short term for factors C and D, at generally low scores. Only three plots achieve a score of 5, and these are concentrated exclusively in plots 2, 3 and 4. Old and large trees are important forest structures for many taxa (kebrle *et al.,* 2021). They are an important habitat feature, biodiversity of forest ecosystems; they are also valuable for storing carbon (Mildrexler *et al.,* 2020). F-factor values are high in the study area where lichens exist on the majority of trees in the sample, for which the score is 5. Microhabitats are relevant indicators of biodiversity. They harbor a wide range of biodiversity on living or dead standing trees (Larrieu *et al.,* 2018). They are, moreover, a particular substrate or living site for species or communities during part of their life cycle (Larrieu *et al.,* 2018; 2022). The G factor has medium to high scores, well distributed over all plots. High scores are concentrated on half of the plots. Vegetation in open areas is more diverse than in stands. Most foresters tend to rank every opening in the canopy, whereas the PBI considers only the parts of open areas that produce flowers (Gosselin *et al.,* 2020). The H factor has average values across all plots, due to the likely ancient history of the forest. Regarding the context factors, and in terms of forest age, it seems clear to us that our stand is part of an old forest that has been partially cleared. The area is characterized by the presence of a small temporary watercourse. A diversity of rocky environments is also remarkable. The associated habitats of aquatic environments (factor I) and rocky environments (factor J) favor the presence of specific taxa. The ecological diversity of these habitats is important and explains the development of specific vegetation including numerous species (Larrieu & Gonin, 2008).

CONCLUSIONS

In view of the challenges facing forest management today (global warming, increased demand for wood energy), taking biodiversity into account in forests is a major necessity. The use of indicators allowing the evaluation and monitoring of ordinary biodiversity is an undeniable asset to guide the management of stands. The existence of an index evaluating the potential biodiversity at the scale of the forest massif would make it possible to orient management recommendations within the framework of a global management, thus making it possible to better take into account aspects of ordinary biodiversity that are easy to evaluate on a large scale. The PBI can only provide a rough estimate of the biodiversity potentially present in a forest. However, it is easy to apply and can indicate the capacity of a forest to support forest taxa based on stand structure, composition and habitat attributes. This indicator evaluates the potential biodiversity of a stand, which corresponds to its carrying capacity, in relation to its current characteristics, and without prejudging the real biodiversity. The results of the PBI have thus highlighted diversity in terms of microhabitats and rocky environments. These characteristics have attributed great importance to the potential diversity of this stand and the formations they harbor. In addition, they reveal a different and particular situation regarding the *Q. ilex* of the Chettaba forest. The potential biodiversity, linked to the management and the context, is average for the PBI index. The biodiversity carrying capacity is average, even low, and needs to be improved. To maintain biodiversity at its current level for favorable factors (to let a fraction of the stand complete its sylvigenetic cycle), it is advisable to preserve the secondary species and to stratify the stand.

Acknowledgements

The authors would like to thank the Forest Conservation of Constantine for their support and permission to access the sites and would like to thank the following people for their help with the implementation of this paper: Abd El Hafid Boudraa, Badri Boukous, Mokhtar Adjadj, Walid Medjoub, Ain Semara Forest District.

REFERENCES

1. Angiolini, C., Foggi, B., Sarmati, S., Gabellini, A., Gennai, M., Castagnini, P., Mugnai, M., Borie, M., & Hulme, M. (2015). Framing global biodiversity: IPBES between mother earth and ecosystem services. Environmental Science & Policy, 54, 487–496. https://doi.org/10.1016/j.envsci.2015.05.009
2. Baiges, T., Cervera, T., Gonin, P., Larrieu, L., & Palero, N. (2019). Posada a punt de l'Índex de Biodiversitat Potencial (IBP): un termòmetre per a mesurar la capacitat d'allotjar biodiversitat dels boscos (gestionats) de Catalunya. Revista Silvicultura, 80, 26-36. https://cpf.gencat.cat/web/.content/or_organismes/or04_centre_propietat_forestal/03_linies_actuacio/transferencia_de_coneixement/IBP_CAT/Binaris/IBP_Silvicultura_2019.pdf
3. Borie, M., & Hulme M. (2015). Framing global biodiversity: IPBES between mother earth and ecosystem services. Environmental Science & Policy, 54, 487–496. https://doi.org/10.1016/j.envsci.2015.05.009.
4. Chazdon, R. L., Brancalion, P.H., Lamb, D., Laestadius, L., Calmon, M. & Kumar, C. (2017). A policy-driven knowledge agenda for global forest and landscape restoration. Conservation Letters, 10(1), 125–132. https://doi.org/10.1111/conl.12220.
5. Douda, J., Boublík, K., Doudová, J. & Kyncl, M. (2017). Traditional forest management practices stop forest succession and bring back rare plant species. Journal of Applied Ecology, 54(3): 761-771. https://doi.org/10.1111/1365-2664.12801.
6. Emberger, C., Larrieu, L. & Gonin, P. (2016). Dix facteurs clés pour la diversité des espèces en forêt. Comprendre l'Indice de Biodiversité Potentielle (IBP). Paris: Institut pour le développement forestier, déc. 2016, 58.
7. Emberger, C., Larrieu, L., & Gonin, P. (2021). Dix caractéristiques clés pour l'accueil d'une diversité d'espèces en forêt. Forêt-Nature,101, 10–11
8. Emberger, C., Larrieu, L., Gonin, P., Baiges, T., Cervera, T., & Palero, N. (2020). Els nostres boscos són plens de vida. Descobrim l'Índex de Biodiversitat Potencial (IBP). CPF, CNPF, INRAE Dynafor, 4.
9. Gonin, P., Larrieu, L. & Deconchat, M. (2017). L'Indice de biodiversité potentielle (IBP) : comment l'étendre à l'ensemble des forêts méditerranéennes? Forêt méditerranéenne. 38(3), 335–342. https://hal.archives-ouvertes.fr/hal-03556536
10. Gonin, P., Larrieu, L. & Martel, S. (2012). L'indice de biodiversité potentielle (IBP) en région méditerranéenne. Forêt méditerranéenne. 33(2), 133–142. https://hal.archives-ouvertes.fr/hal-03573282.
11. Gosselin, F. & Larrieu, L. (2020). Developing and using statistical tools to estimate observer effect for ordered class data: The case of the IBP (Index of Biodiversity Potential). Ecological Indicators, 110: 105884. https://doi.org/10.1016/j.ecolind.2019.105884
12. Gosselin, M., & Laroussinie, O. (2004). Biodiversité et Gestion forestière : connaître pour préserver. Synthèse bibliographique. Co-édition GIP

Ecofor-Cemagref, Antony. pp. 320.

13. Gosselin, M., Valadon, A., Bergès, L., Dumas, Y., Gosselin, F., Baltzinger, C. & Archaux, F. (2006). Prise en compte de la biodiversité dans la gestion forestière : état des connaissances et recommandations, Paris, Office national des forêts, pp. 161.
14. Hofmeister, J., Hošek, J., Malíček, J., Palice, Z., Syrovátková, L, Steinová, J. & Černajová, I. (2016). Large beech (Fagus sylvatica) trees as 'lifeboats' for lichen diversity in central European forests. Biodiversity and Conservation, 25(6), 1073–1090. https://doi.org/ 10.1007/s10531-016-1106-x.
15. Kebrle, D., Zasadil, P., Hošek, J., Barták, V. & Šťastný, K. (2021). Large trees as a key factor for bird diversity in spruce-dominated production forests: Implications for conservation management. Forest Ecology and Management, 496, 119460. https://doi.org /10.1016/j.foreco.2021.119460.
16. Kok, M.T., Kok, K., Peterson, G.D., Hill, R., Agard, J. & Carpenter S R. (2017). Biodiversity and ecosystem services require IPBES to take novel approach to scenarios. Sustainability Science, 12(1): 177–181. https://doi.org/10.1007/s11625-016-0354-8.
17. Larrieu, L., Courbaud, B., Drénou, C., Goulard, M., Bütler, R., Kozák, D., Kraus, D. & Krumm, F. (2022). Key factors determining the presence of Tree-related Microhabitats: A synthesis of potential factors at site, stand and tree scales, with perspectives for further research. Forest Ecology and Management, 515, 120235. https://doi.org/10.1016/j.foreco.2022.120235
18. Larrieu, L., Gonin, P., & Deconchat, M. (2013). Le domaine d ' application de l'indice de biodiversité potentielle (ibp). Rev. For. Française (August 2015). https://doi.org/10.4267/ 2042/50657
19. Larrieu, L., & Gonin, P. (2008). L'indice de Biodiversité Potentielle (IBP): une méthode simple et rapide pour évaluer la biodiversité potentielle des peuplements forestiers. Revue forestière française, 60(6), 727–748. https://dx.doi.org/10.4267/2042/28373.
20. Larrieu, L., & Gonin, P. (2010). L'indice de biodiversité potentielle ou IBP : un outil pratique au service de la biodiversité ordinaire des forêts. Forêt entreprise, 190, 52–57. https://prodinra.inra.fr/record/40015.
21. Larrieu, L., Gosselin, F., Archaux, F., Chevalier, R., Corriol, G., Dauffy-Richard, E., Deconchat, M., Gosselin, M., Ladet, S., Savoie, J.M., Tillon, L., & Bouget, C. (2019). Assessing the potential of routine stand variables from multi-taxon data as habitat surrogates in European temperate forests. Ecological Indicators, 104, 116–126. https://doi.org/10.1016 /j.ecolind.2019.04.085
22. Larrieu, L., Paillet, Y., Winter, S., Bütler, R., Kraus, D., Krumm, F., Lachat, T., Michel, A.K., Regnery, B., & Vandekerkhove, K. (2018). Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. Ecological Indicators, 84, 194–207. https://doi.org/10.1016/j.ecolind.2017.08.051.
23. Lassauce, A., Paillet, Y., Jactel, H., & Bouget, C. (2011). Deadwood as a surrogate for forest biodiversity: meta-analysis of correlations between deadwood volume and species richness of saproxylic organisms. Ecological Indicators, 11(5), 1027–1039. https://doi.org/ 10.1016/j.ecolind.2011.02.004.
24. Lemouissi, S., Rached-Kanouni, M., Hadef, A., Amine-Khoja, M., & Alatou, D. (2014). Adaptation of Holm oak (Quercus ilex L.) to seasonal climate variations. International Journal of Management Sciences and Business research, 3(5): 30–35. http://www.oiirj.org/
25. Mancosu, E., Marín, A.I., Malak, D.A., Trombetti, M. & Bastrup-Birk, A. (2018). Setting priorities for the management of primary forest areas: the importance of a harmonized inventory for supporting regional conservation and restoration efforts. In 5th Forum Carpaticum.
26. Márialigeti, S., Tinya, F., Bidló, A., & Ódor, P. (2016). Environmental drivers of the composition and diversity of the herb layer in mixed temperate forests in Hungary. Plant Ecology, 217(5), 549–563. https://doi.org/10.1007/s11258-016-0599-4.
27. Mildrexler, D.J., Berner, L.T., Law, B.E., Birdsey, R.A., & Moomaw, W.R. (2020). Large trees dominate carbon storage in forests east of the cascade crest in the United States Pacific Northwest. Frontiers in Forests and Global Change, 3, 594274. https://doi.org/ 10.3389/ffgc.2020.594274.
28. Ngom, D., Fall, T., Sarr, O., Diatta, S., & Akpo, L.E. (2013). Caractéristiques écologiques du peuplement ligneux de la réserve de biosphère du Ferlo (Nord Sénégal). Journal of Applied Biosciences, 66, 5008–5023. https://doi.org/10.4314/jab.v65i0.89644.
29. Oettel, J., & Lapin, K. (2021). Linking forest management and biodiversity indicators to strengthen sustainable forest management in Europe. Ecological Indicators, 122, 107275. https://doi.org/10.1016/j.ecolind.2020.107275.
30. Pagano, U. (2021). Ecological transition and new dwelling paradigms. Science & Philosophy, 9(2), 97–114. http://dx.doi.org/10.23756/sp.v9i2.692.
31. Pievani, T. (2015). La sesta estinzione di massa. Ambiente Rischio Comunicazione, 10, 8-16).
32. Rached-Kanouni, M., Kadi, Z., Khammar, H., Bousba, R., Amrane, R., Chellal, B., & Ababsa, L. (2020). Sanitary situation of Aleppo pine and holm oak on the Sidi R'Ghies forest, Algeria. Biodiversitas Journal of Biological Diversity, 21(9), 3954–3960. https://doi.org/ 10.13057/biodiv/d210905.
33. Rossi, M., & Vallauri, D. (2013). Evaluer la naturalité. Guide pratique, version 1.2. World Wildlife

Fund, Marseille.

34. Widerberg, M.K., Ranius, T., Drobyshev, I., & Lindbladh, M. (2018). Oaks retained in production spruce forests help maintain saproxylic beetle diversity in southern Scandinavian landscapes. Forest Ecology and Management, 417, 257–264. https://doi.org/10.1016/ j.foreco.2018.02.048.
35. Yao, J., Zhang, C., de C´aceres, M., Legendre, P., & Zhao, X. (2019). Variation in compositional and structural components of community assemblage and its determinants. J. Veg. Sci, 30, 257–268. https://doi.org/10.1111/jvs.12708.
36. Zeller, L., Baumann, C., Gonin, P., Heidrich, L., Keye, C., Konrad, F., Larrieu, L., Meyer, P., Sennhenn-Reulen, H., Müller, J., Schall, P., & Ammer, C. (2022). Index of biodiversity potential (IBP) versus direct species monitoring in temperate forests. Ecological Indicators, 136, 108692. https://doi.org/10.1016/j.ecolind.2022.108692
37. Zerrouki, A., Rached-Kanouni, M., Redjaimia, L., Kara, K., Touafchia, B., & Ababsa, L. (2022). Evaluation de l'état sanitaire de chêne vert de la forêt de Chettaba (Constantine). Revue des BioRessources, 12(1): 23–35.