

Article

Characterization and Valuation of the Ecosystem Services of the Coastal Cantabrian Holm Oak Forest in Spain: The Example of the Urdaibai Biosphere Reserve (Bizkaia, Basque Country)

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Abstract

Holm oak groves of *Quercus ilex* subsp. *ilex* are one of the most characteristic environmental elements of the Cantabrian strip of the Iberian Peninsula. The Cantabrian holm oak forest does not have a clear origin. There is a possibility that it has a relict character, and it could also respond more to human activity over the last 10,000 years. Nowadays, it is a rare, scarce, and finicultural forest in this demarcation, but it provides many ecosystem services. To carry out a comparative analysis and assessment of its potential as Green Infrastructure and of its coastal facies (Urdaibai, Bizkaia), 10 random and stratified inventories were carried out. These plots were monitored regularly for more than 2 years and in seasonal visits to avoid phenological bias. The resulting synthetic syninventories were then assessed according to the LANBIOEVA (Landscape Biogeographical Evaluation) Methodology, which has been applied for more than 35 years in different ecosystems and landscapes at a global scale. Scores for various parameters related to ecosystem services are of high conservation interest, and the cultural services are medium to high. Concerning conservation priority, the low records of the three threat parameters result in mean values that are in the first quartile for this parameter, which attests to a good level of conservation. The conclusion is clear: the Biosphere Reserve status has had a positive influence on the proper management and conservation of the Cantabrian holm oak forest and its associated ecosystem services. However, certain threats that still weigh on this ecosystem need to be addressed.

Keywords: *Quercus ilex* subsp. *ilex*; green infrastructure; ecosystem services; LANBIOEVA; Urdaibai Biosphere Reserve



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1. Introduction

There are many models and methodologies that attempt to evaluate or assess any type of formation or ecosystem. One of the first approaches to vegetation valuation was the use of indices such as the Shannon–Wiener index, which measures species diversity, and which is still widely used due to its ability to reflect richness and evenness in a plant community [1]. In addition, the measurement of vegetation cover, as proposed by Mueller-Dombois and Ellenberg (1974) [2], has been instrumental in assessing the density and spatial distribution of species in different habitats.

On the other hand, techniques such as vertical vegetation structure analysis [3] and habitat modelling, used to simulate the relationship between species and their environment, allow for a more dynamic and predictive assessment of ecosystems [4].

Technological advances have now made it possible to integrate traditional methods with new tools, such as satellite imagery and drones, which have expanded the possibilities for more accurate and large-scale assessments [5]. These advances have driven research into how to assess vegetation in a more efficient and accessible way, ensuring that quality data is available for decision-making in environmental and land management.

Such is the case of the InVEST initiative, developed by Stanford University, which enables decision-makers to quantitatively assess the trade-offs associated with different land and ecosystem service management alternatives and to identify areas where investment in natural capital can simultaneously enhance human development and conservation. This toolkit includes various ecosystem service models, as well as a series of auxiliary tools that support the localization and processing of input data and the understanding and visualization of results [6]. The LANBIOEVA methodology identifies the most pressing threats to vegetation in a given area, allowing, subsequently, and through the InVEST methodology, for the exploration of management models that best reconcile human development with the conservation of these resources. In this regard, we would like to highlight works such as those by Rositano & Ferraro (2017) and Simulasia (2021) [7,8]. On the other hand, vegetation landscapes have often been valued solely from a naturalistic, ecological, or environmental perspective. However, they contain and treasure a series of heritage elements, often even immaterial, such as mythological elements, ancestral beliefs, customs, etc., that must be considered at least at the same level as the previous ones [9]. In fact, it is strategic to value a series of criteria that relate to two fundamental groups within ecosystem services (hereinafter ES), the cultural ones, but also the provisioning ones.

The loss of vegetation formations, whether due to deforestation, urbanization, or climate change, has significant negative consequences for the health of the planet and human communities. Active conservation is essential to ensure the long-term sustainability of ecosystems and people's quality of life. Conservation priority may vary according to the region and the challenges it faces. In any case, in an uncertain paradigm such as global change and, within it, climate change, green infrastructure (hereinafter GI) becomes a strategic element at territorial, economic, ecological, social, cultural, etc., levels [10].

In the face of this threat, it is essential to adopt new paradigms that support much more balanced territorial, economic, social, and environmental policies, as well as to develop protocols for the comprehensive assessment of biotic heritage and the GI for its proper conservation [11]. In response to this last need, one of the basic objectives of applied biogeography is to implement methodological tools and provide the necessary results that offer society not only knowledge but also instruments to support land-use planning and management policies. It is important to carry out detailed assessments and consider the long-term impacts of conservation decisions to ensure a holistic and sustainable approach [12–14]. This requires not only theorizing about the role of green infrastructure (GI) and its associated ES, but also thoroughly characterizing them and approaching their evaluation or quantification through methods such as the one proposed in the present study. This approach aligns closely with other methodologies, such as ARIES (Artificial Intelligence for Environment and Sustainability), which was developed as a platform for ES assessment and is committed to providing a methodological framework for the evaluation and quantification of ES for both academics and policymakers [7,15]. It is also consistent with the k.LAB methodology, which offers scientific models and data to simulate and integrate environmental and socio-economic systems [16]. Like LANBIOEVA, the latter is based on biological parameters, such as biodiversity, ecosystem maturity, ecological

development, the presence of protected, endemic, or relict taxa, among others, as well as aspects rooted in cultural heritage. This requires not only theorizing about the role of the GI and its associated ES but also characterizing them in detail and approaching their assessment or quantification through methods such as the one used in this paper.

The choice of methodology will depend on the ultimate purpose or the specific objectives of each study or research project, in such a way that it enables the provision of scientific models and data that simulate and integrate environmental and socio-economic systems for investigation or analysis. The number of evaluation formulas is so wide and diverse that it is desirable to arrive at methodological proposals that are as consensual as possible, acceptable to the majority of experts, and that offer decision-makers and managers tools based on a cross-cutting vision that combines aspects related to natural and cultural values, including, among the latter, those related to the perception of biotic environments by the population that inhabits, enjoys, and manages them [17]. It is along these lines that, more than three decades ago, a valuation methodology with geographical roots took its first steps, which was initially applied to plant groupings in the Basque Country [18–20] but which has now been applied to more than 250 different communities on a global scale and with a vision centered on ES numbers and their quantification. The LANBIOEVA biogeographic valuation methodology emerges, therefore, as a comprehensive and advanced tool to assess and understand the importance of the GI and its ES in specific geographic environments, but with the intention of having a global character by means of a thorough study of as many plant landscapes as possible from all over the world.

This methodology specifically addresses the valuation of plant formations, landscapes, and ecosystems, providing a comprehensive framework for the analysis and quantification of ES. This approach goes beyond mere species identification, incorporating ecological, ethnographic, territorial, and perceptual elements to obtain a complete picture of plant ecosystems and their territorial distribution. It fuses scientific rigor with innovative approaches, providing a solid framework for analyzing species distribution according to key biogeographical variables. The authors propose a holistic inventory and assessment method, which not only considers the presence or absence of certain species but also integrates cultural factors to obtain a more complete and accurate assessment, thus providing a valuable tool for decision-making related to conservation and management of the GI and the territory.

In fact, it has already been used to quantify and assess the ecosystem services of rural land in Mutriku (Gipuzkoa) [21], establishing itself as one of the pioneering methodologies in the Basque Autonomous Community and serving as a model for its implementation within the General Urban Development Plans of that region. Similarly, it was employed in the development of the Ecosystem Services Landscape Action Plan for Astigarraga (Lozano et al., 2021) [22], which is now also being incorporated into the municipality's General Urban Development Plan.

Moreover, LANBIOEVA has strong cartographic capabilities, allowing for the spatial mapping of each criterion and, consequently, of each ecosystem service [15]. In this regard, it follows a structure similar to that presented in works such as Brown & Fagerholm (2015) [23], which offer a comprehensive compilation of GIS-based methodologies dedicated to mapping green infrastructure and its associated ecosystem services. Adapting spatial mapping methodologies to determine the scope and quantification of ecosystem services in a given territory is not a straightforward task [24]. However, studies such as those by Egoh et al. (2012) or Tardieu (2017) [25,26] provide concrete models that can serve as valuable references for incorporation into methodologies such as the one discussed here.

The main objective of this work is to characterize, inventory, and assess the ES offered by the IV, through the LANBIOEVA methodology, of one of the most extensive and charismatic examples of the Cantabrian holm oak forest: the one located in the RBU.

In turn, there are different operational objectives:

- To carry out a representative number of inventories that can help us to characterize with certainty the vegetation associated with these Cantabrian holm oak groves;
- To obtain a series of parameters such as the number of taxa by large physiognomic groups and, in general, to make the relevant comparisons with the figures obtained in other holm oak groves;
- To recover the cover of each taxon by stratum and, in general, to evaluate certain structural criteria of the forest;
- Determine the partial and general values of different criteria related to the forest;
- Determine the partial and general values of different criteria related to the floristic community itself (sustainability), its role at a territorial, mesological, and structural level (regulation), and others derived from cultural and heritage indices (provisioning and cultural);
- To highlight the threats and anthropic impacts that act or may act on this formation;
- As a final objective, to offer the manager of the territory and of the RBU itself a series of partial or general values and indices so that they can be considered when conserving, ordering, and adequately and sustainably managing the GI and the ES associated with it.

2. Study Area

The Urdaibai Biosphere Reserve (hereinafter RBU for the translation from Spanish *Reserva de la Biosfera de Urdaibai*) is in the estuary of the same name (Busturialdea District) where the river Oka flows into the Cantabrian Sea, within the central coastal sector of the province of Bizkaia (Basque Country) (Figure 1). It has a surface area of slightly more than 220 km² [27] and, due to its great biological, cultural, and heritage richness, it was declared a Biosphere Reserve in 1984 by the UNESCO MaB committee. From the very beginning, the autonomous government of the Basque Country took this nomination and the sustainable management of this area very seriously, and enacted a law for its protection, development, and management (Law 5/1989, of 6 July, on the protection and development of the Urdaibai Biosphere Reserve) [28].

The Cantabrian holm oak forest is one of the most characteristic and representative biogeographical and environmental elements, not only of the RBU itself, but of the Cantabrian strip of the Iberian Peninsula, in general, and of the Basque Country, in particular. To a large extent, this UNESCO designation was granted to this area due to the large size and good state of conservation of these forests in this region. However, it has not yet been properly addressed in its conception of GI and valuing the ES it provides.

This plant formation is predominantly adapted to the thermocoline floor that is prevalent along the coastal stretch between the municipality of Zarautz in Gipuzkoa, to the east, and the Asturian basin of the Nalón and Narcea rivers, to the west [29]. However, there are important patches in the interior of the Cantabrian strip of Spain, outside this thermocoline floor, and more closely related to the colline. However, their vegetation cortex differs [30]. However, the distribution of this plant grouping responds not only to climatic reasons, but also—and in some cases preferably—to edaphological and anthropic reasons. Indeed, it is most perfectly suited to steeply sloping karstic terrain, on poor, often skeletal soils (rhododendric leptosols), with a low water retention capacity [31]. Thus, although rainfall is abundant (always above 1000 mm per year), the conditions of a certain edaphic xericity favor the presence of holm oaks in an area where the potential vegetation would

correspond, with good edaphic conditions (deep, fresh, and well-structured soils), to an oak woodland-mixed *Quercus robur* forest [32]. Indeed, several studies have shown that rendzic soils are highly susceptible to erosion when vegetation cover is lost [33,34], particularly in steep-slope areas with high levels of precipitation, such as this region, where annual rainfall approaches 1500 mm. In this context, the presence of dense arboreal and sub-arboreal cover, as is the case here, effectively prevents erosive processes. Consequently, the preservation of the regolith and the mineralization and structuring of the soil horizon represent one of the most important ecosystem services provided by the Cantabrian holm oak forest, while also contributing to improved water circulation [35]. In this sense, palaeoenvironmental studies have shown evidence of erosion processes and resisting situations linked to periods of human history when the arboreal vegetation was extensively and deeply cleared (mainly during the Neolithic and Romanization periods) [36]. This research suggests that the holm oak forest did not form important tree masses during the Paleolithic and that its expansion could be attributed to these dynamics of massive deforestation, with the consequent erosive processes and soil impoverishment that highlighted important extensions of lapiaz [37].

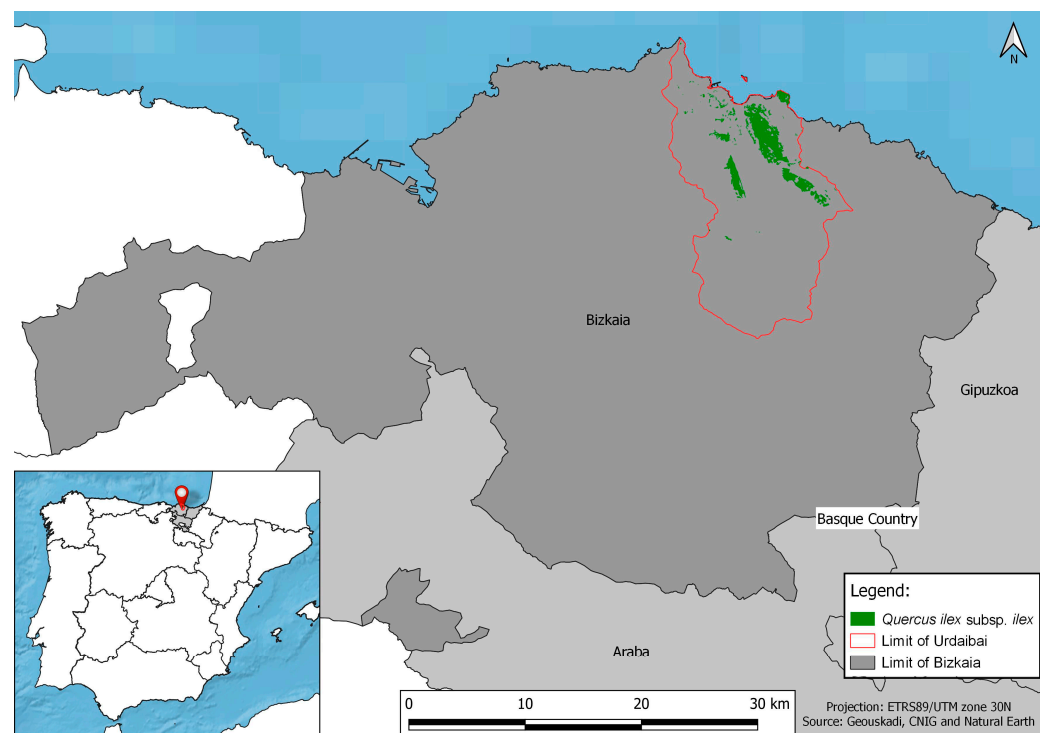


Figure 1. Location of the two study areas.

Other authors, on the other hand, argue that the Cantabrian holm oak woodland is a relict of a formation which, during the last periods of the Tertiary, extended throughout the Mediterranean strip, including a large part of these territories which, although bathed by the Cantabrian Sea, enjoyed conditions similar to what the Macaronesian region would represent today and, in particular, the laurel forest [38,39]. This last hypothesis is mainly motivated by the fact that there are evergreen and, to a certain extent, even laurel species, which are still present in the laurel forests of the Macaronesian region. Thus, taxa such as *Quercus ilex* subsp. *ilex*, *Laurus nobilis*, *Arbutus unedo*, *Phyllirea latifolia*, *Olea europaea* var. *sylvestris*, *Pistacea lentiscus*, etc., can be found with greater or lesser profusion and dominance.

In view of the aforementioned palynological and anthropological studies, this formation develops and generates a sufficiently deep and well-structured edaphic layer. Then,

it will lead to its gradual replacement by another, more adapted to better bio-edaphic conditions, such as, for instance, oak grove or mixed calcareous forest of *Quercus robur* [24], because of the geomorphological properties of the doline bottoms and karst landings, which are mainly occupied by holm oak forests, if not dominance of the aforementioned Cantabrian mixed forest.

The fact that Urdaibai is one of the best enclaves in relation to the great extension of the Cantabrian holm oak forest patches and, at the same time, that it has been protected for the last 40 years and, therefore, has a great quality and maturity of the forest masses, prompted us to start a profuse fieldwork to, through the LANBIOEVA biogeographical assessment method, inventory, characterize, and evaluate what type of ES it provides and measure to what extent these are more or less important in a semi-qualitative way, incorporating, as has been customary over the last 35 years and in more than 300 formations on a global scale, the aspects, criteria, and values of a natural, environmental, and/or ecological (support and regulation) nature, also taking into account the cultural and heritage aspects related to past and present uses and customs, sustainability, and also the perception and wishes of the local and visiting population, as well as the ethnobotanical and didactic value of these stands (provisioning and cultural services).

Finally, all these partial valuations, grouped into interests, are then confronted with the threats and impacts that this formation may be enduring or suffering at present or in the future. In a paradigm of climate and global change, it is strategic to measure parameters and issues related to ES (mesological, ethnobotanical, and heritage values) and ecological connectivity and do so by taking the pulse of the population closest to the ecosystem and territory under study [40].

3. Materials and Methods

3.1. Biogeographical Inventory

The inventory model has been tested, contrasted, and applied on successive occasions to collect all the geographical, environmental, heritage, and biogeographical data necessary for the subsequent assessment [41]. Both the delineation of the plots and their number are supported by empirical evidence gathered over the past 35 years, as well as by other studies and authors [38,39,42]. By consistently using the same number of plots, statistical treatment becomes comparable, allowing for the establishment of percentiles and quartiles across all inventoried and assessed ecosystems. This approach also enables a relative evaluation of each criterion and its associated ecosystem services through comparison. Once the Cantabrian holm oak forest patches to be studied were delimited (Figure 1), the location of the plots (10) was established using a stratified and random method established within the Arcview 8.2 Geographic Information System (GIS).

For each of the inventories or 20×20 m plots, data on the location and identification of the site (UTM coordinates, place names, etc.), general geographic and environmental aspects and features, photographs of the plot, etc., were obtained. Data was then collected on all the taxa of the vascular flora by determining exactly which taxa were found in the field and in the herborized samples. Other parameters are also assessed, such as the general cover of bryophytes, fungi, and lichens (always broken down into two large groups: those that occupy rocks and soils and those that appear in epiphytic or parasitic form on trunks, branches, and stumps). Two other parameters are also assessed, in general terms, namely the global cover of leaf litter and the percentage of bare soil and rocks in the plot.

The taxa of the vascular flora are organized into three main physiognomic groups: trees and shrubs: large phanerophytes and camelephytes above one meter in height; shrubs and climbers: small camelephytes; and scandent and herbaceous plants: hemicryptophytes, geophytes, and therophytes.

A classical valuation method (the sigmatist method of the Braun–Blanquet school) was used to determine the coverages, with a scale of 6 classes (r = less than 1%, 1 between 1.1% and 10%, 2 between 10.1% and 25%, 3 between 25.1% and 50%, 4 between 50.1% and 75%, and 5 between 75.1% and 100%) for each of the strata (more than 5 m, between 1 and 5 m, between 0.5 and 1 m, and below 0.5 m) and the overall vegetation grouping; between 1 and 5 m; between 0.5 and 1 m and below 0.5 m and the overall plant grouping. For the sake of precision, the qualitative coverage data have been converted into percentages using the meaning of each of these ranges (for example, for class r , the mean value is 0.5%; for 1, its mean value would be 5%; and so on) and so on for each species and in each inventory. The values are then summed and divided by the number of inventories where the taxon appeared, so that the overall percentage cover of the species is obtained. This data does not appear in Table 1 but will be quoted for some representative species. Although the coverage data are not exact, they represent the best possible approximation for studying vegetation structure and have implications for various ecosystem services. These include cultural services (primarily ethnobotanical and perceptual value), provisioning services (such as medicinal and edible plants), regulating services (by preventing erosion or contributing to soil formation), and even supporting services, such as photosynthetic processes.

Table 1. Biogeographic evaluation indices and criteria according to LANBIOEVA methodology.

Conservation interest (INCON)	Natural interest (INNAT)		Diversity (DIV)	Number of species (1–10 points depending on the number)
			Naturality (NAT)	Training with exotic or native taxa (1 to 10 points depending on number and coverage of taxa)
	Phytocenotic interest (INFIT) Supporting or supporting SE		Maturity (MAD) $\times$ 2	Degree of maturity in plant succession. Multiplied by 2 as the most important of these criteria (2 to 20 points).
			Regenerability (REG)	Ease or difficulty to regenerate after catastrophe (1 to 10 points depending on ability)
			Rarity (RAR) $\times$ 2	Number of rare taxa and rarity of the formation. Multiplied by 2 is the most important of these criteria (2 to 20 points depending on the degree of rarity).
			Endemicity (END)	Number of endemic taxa and degree of endemicity of the formation (1 to 10 points according to the degree of endemicity).
	Territorial interest (INTER)		Relictism (REL)	Number of relict taxa and degree of relictism of the formation (1 to 10 points according to degree of relictism)
			Finicole (FIN)	Number of endemic taxa and finicole of formation (1 to 10 points according to finicole of formation)
			F. geomorphology (GEO) $\times$ 2	Avoidance of erosive processes. Multiplied by 2 as the most important of these criteria (2 to 20 points).
	Mesological interest (INMES) SE of regulation and supply		F. climatic (CLI)	Generation of microclimatic conditions (1 to 10 points)
			F. hydrological (HID)	Ensuring good water circulation (1 to 10 points)
			F. edaphic (EDA)	Ensuring good soil structure (1 to 10 points)
			F. faunistic (FAU)	Providing shelter, trophic resources, etc. for the faunal community (1 to 10 points depending on faunal load)
	Structural interest (INEST) All types of ES		Richness by strata (RIQUEST) $\times$ 0.5	Number of species per stratum. Multiplied by 0.5 if less important (0.5 to 10 points according to richness).
			Strata coverage (COBEST) $\times$ 0.5	Cover per stratum. Multiplied by 0.5 if less important (0.5 to 10 points according to cover).

Table 1. Cont.

			Richness of microenvironments (RIQHAB)	Number of microenvironments that cannot be disaggregated (0 to 20 points for these microenvironments).	
			Connectivity/spot size (CONESP)	Size and connectivity of the patch (0 to 30 points according to its extent and connection)	
Cultural Interest (INCUL)			Ethnobotanical value (ETNO) $\times$ 2	Sustainable and traditional use of flora. Multiplied by 2 as the most important of these criteria (2 to 20 points according to sustainable use).	
			Heritage interest (INPAT) Cultural ES and provisioning	Perceptual value (PER)	Local people’s perceptions of the value of training (1 to 10 points according to their rating).
				Didactic value (DID)	Educationalists’ assessment of the value of training for teaching (1 to 10 points according to their rating)
			Structural cultural interest (INCULEST) $\times$ 2 Cultural ES	Structural physiognomic value (FISEST)	Dasotipologies of the governance of the shafts (1 to 10 points)
				Structural cultural value (CULEST)	Different ethnographic, historical, archaeological elements, etc. (1 to 10 points)
			X		
PRICON	AM	Threat Factor (AM)	Population pressure ratio (DEM)	Human population density in the territory (1 to 10 points according to density).	
			Access/transit coefficient (ACT)	Matrix combining 6 categories of accessibility and walkability (1 to 10 points according to this relationship).	
			Alternative hazard ratio (ALT)	Possibility of the existence of other natural or anthropic hazards (1 to 10 points according to possibility).	

3.2. Biogeographical Assessment: LANBIOEVA Methodology

The LANBIOEVA valuation methodology is based on two fundamental and well-differentiated valuation concepts: conservation interest and conservation priority. The former is the sum of the scores obtained for natural interest and cultural interest. Natural interest is made up of four groups of criteria: phytocoenotic, territorial, mesological, and structural. Phytocoenotic interest encompasses intrinsic characteristics of the vegetation and landscape that fall within what are known as supporting services and regulating services, such as pollination, pest and disease control, photosynthetic processes, and the maintenance of biodiversity, such as diversity (number of species within the plot), naturalness (number and cover of introduced, xenophytic or alien species), maturity (degree of forest development or number of years of development and conservation), and spontaneous regenerability or resilience (capacity of the formation to recover more or less quickly and easily from a human or environmental catastrophe). The territorial also measures sustaining or supporting values, but these tend to be overlooked. However, for biogeography, they play an essential role, as they are directly linked to the territory. These are services related to the maintenance of biodiversity through the conservation of special taxa, photosynthetic processes, certain cultural services, such as the appreciation of specific species, aesthetic, spiritual, and symbolic values, and even recreational and leisure activities, such as ecotourism and scientific pursuits. The attributes of rarity (measured under two different parameters: the degree of rarity or scarcity of the formation itself and its constituent taxa), endemism (degree of endemism of both the formation and its constituent taxa), and relictism (the same as the previous two but, in this case, to what extent both the formation and its taxa are inherited from previous eras with bioclimatic characteristics that do not correspond to the current zonal ones) are considered, as well as finicultural character (to what extent the formation and/or the constituent taxa are at

the edge of their range). The mesological one assesses, to a large extent, what is referred to as regulatory ES: the geomorphological functions (capacity of the formation to avoid erosional processes and to self-manage in a sustainable way), climatic (ability to maintain optimal microclimatic conditions—milder temperatures, higher humidity, thermal comfort, etc.), hydrological (capacity to mitigate or buffer torrential rains and ensure good and progressive water circulation, provide the provision of water in good condition for subsequent consumption or use by humans), edaphic (capacity to conserve soils and process organic matter for its mineralization and absorption by plants), and faunal (capacity to sustain, provide shelter, trophic resources, ensure pollination, prevent pests, etc. for fauna). The structural one assesses taxon richness per stratum, overall cover per stratum, microhabitat richness and connectivity, and the extent of the vegetation patch. All these criteria affect all ES types in a tangential but transversal way. These aspects result in a structural analysis. The greater the diversity per stratum and even the general cover per stratum, the better the environmental and ecological quality of the stratum. However, to avoid repetition, a weighting index of 0.5 is applied to the first two indices (taxon richness per stratum and general cover per stratum).

This is another basic feature of the LANBIOEVA methodology, since not all criteria are of equal importance, weighting indices are also used. In the previous case, to avoid a reiteration of values or criteria, these were divided by 2, but, in general, for each group of criteria, one of them is weighted by 2, i.e., it doubles its potential value. These questions were not decided at random but correspond to an in-depth analysis of the scientific literature and empirical research over the years. Thus, within the phytocenotic interest, the most relevant is that of maturity, since the more mature the formations are, the more capable they are of providing all types of ES, so that the result obtained for each plot is multiplied by 2. In the case of territorial criteria, it would be rare, which is normally assessed based on the IUCN lists or the lists of threatened ecosystems and species of state and regional governments that evaluate the scarcity or danger of disappearance of taxa. For mesological interest, the most important criterion would be geomorphological, since biostatic or rexistatic conditions largely condition the other criteria.

Cultural interest considers two groups of values: heritage, which evaluates three sub-criteria (ethnobotanical, perceptual, and didactic value), and structural-cultural, which considers the structural physiognomic value and the structural cultural value (Table 1). In terms of heritage, the ethnobotanical value is the most important and is therefore also multiplied, in this case, by 2. The ethnocultural criterion values issues, such as the ancestral uses of the formations and their constituent elements (food, raw materials, medicines) but also those related to uses such as sports, leisure, spiritual, recreational, physical, mental health, etc.). These three values or criteria were determined based on a survey of 230 individuals from the surrounding area, varying in age, gender, and educational level. The design and implementation of the survey followed the model proposed by Torres et al. (2019) [43], thereby minimizing potential biases. The structural culture includes two equally relevant criteria, and, therefore, it is the sum of these that is multiplied by 2. The latter is primarily related to ES, such as public enjoyment and recreation, physical and mental health, and even aesthetic, spiritual, and identity values, since the ethnographic elements and practices considered may form an inherent part of the sense of belonging and attachment to a particular territory and/or landscape.

Each of the criteria listed ranges from 1 to 10 points, depending on the characteristics shown by the plot for each of these criteria. For example, within the first group, the phytocenotic criteria, the diversity criterion is based on the following assumptions and values:

1 point. without a monospecific inventory;

2 points.	2–4 taxa;
3 points.	5–9 taxa;
4 points.	10–14 taxa;
5 points.	15–19 taxa;
6 points.	20–24 taxa;
7 points.	25–29 taxa;
8 points.	30–34 taxa;
9 points.	35–39 taxa;
10 points.	40 or more taxa.

Once again, we must remember that these scores and intervals do not respond to the whim of the members of this research team, but rather to an exhaustive bibliographic analysis and to the empirical data recorded in the 35 years of development of the methodology. It is very unusual to find, for example, more than 40 taxa within a plot of 20 m × 20 m, although in certain landscapes or ecosystems, especially in tropical areas, they have been inventoried.

As can be seen, each criterion has a scale ranging from 1 to 10, so that this standardization contributes to a better understanding of the methodology and a better interpretation of the results by both the researcher and the decision-maker or manager.

The conservation priority is obtained by multiplying the conservation interest by the threat factor weighing on the vegetation unit concerned. This is calibrated according to three parameters: population pressure, accessibility–transitability, and alternative threats. The demographic pressure coefficient rewards or penalizes situations of high or low population density, with greater or lesser danger of alteration of the vegetation. The accessibility–transitability coefficient values the greater or lesser ease of reaching the enclave, and the “friction” that it shows to human transit. It is assessed by means of a double-entry matrix that combines the different degrees of accessibility and trafficability. The lower the accessibility and trafficability, the lower the risk of damage to the unit under study. That of alternative threats calibrates other types of risks and hazards to which the integrity of the plant grouping concerned may be subjected: natural or provoked catastrophes (floods, fires), palpable damage by acid rain, toxic or polluting discharges, eutrophication, pests or other causes of excessive mortality, invasion or displacement of the original vegetation by aggressive xenophytic plants, short-term disappearance of vegetation by massive logging, development for infrastructures, constructions, power lines, reservoirs, dredging, extractive activities, etc. (Table 1).

4. Results

Taxonomic data and their respective overall coverages are given below for each of the 10 working plots (see Table 2).

As can be seen in Table 2, this formation, within the 10 plots, has 25 trees, 13 shrubs and climbers, and 32 herbaceous plants, making a total of 70 species.

The most represented species in trees and shrubs are *Quercus ilex* subsp. *ilex* (all plots), *Arbutus unedo* (all plots), *Laurus nobilis* (nine plots), *Phyllirea latifolia* and *Crataegus monogyna* (eight plots), *Cornus sanguinea* (seven plots), *Quercus robur* (six plots), and *Rhamnus alaternus* (five plots). Concerning shrubs and climbers, *Rubus ulmifolius* subsp. *fruticosum*, *Smilax aspera*, *Hedera helix*, *Rosa sempervirens*, *Tamus communis*, and *Ruscus aculeatus* appear on all 10 plots, *Rubia peregrina* on 9, and *Hipericum androsaemum* on 6. The presence of these vines and bushes in almost all the inventories is certainly remarkable. Herbs, on the other hand, have the following data: *Asplenium adiatum-nigrum* and *Viola riviniana* (seven plots), *Brachypodium pinnatum* subsp. *rupestris* and *Lamium galeobdolon* (six plots), *Saxifraga hirsuta*

subsp. *hirsuta* (five plots), and, in four, *Fragaria vesca*, *Asplenium trichomanes*, *Helictotrichum cantabricum*, *Polypodium cambricum* subsp. *cambricum* and *Polystichum setiferum*.

As for bryophytes, lichens, fungi, leaf litter, and bare soil, most of the plots show the presence of all these aspects except for plots 3, 4, 5, and 8, which did not show any fungi.

In terms of cover, the most dominant species is *Quercus ilex* subsp. *ilex*, which, on average, is in the range between 50% and 75%. The rest of the species show more modest cover, although, in decreasing order, the following should be highlighted: *Clematis vitalba* (average cover above 35%), *Laurus nobilis* and *Smilax aspera* (average cover over 30%), *Hedera helix* and *Phyllirea latifolia* (average cover 30%), *Hypericum androsaemum* (25%), *Quercus robur* (22%), *Fraxinus excelsior* and *Hypericum androsaemum* (19%), and *Castanea sativa* (15%). The rest is below 15%. All herbaceous trees show low coverages, always below 12%. The highest coverages for bryophytes, lichens, fungi, and other parameters are recorded for leaf litter on soil (42%) and mosses on rocks and soil (33%), followed by mosses on branches, trunks and stumps (31%), bare soil and rock (21%), lichens on branches and trunks (19%), and lichens on soil and rocks together with fungi show the lowest coverages with 7% each. All these data demonstrate a high species diversity compared to other studies, such as those by Jerez (2003), Porras et al. (2003), Sainz and Sánchez de Dios (2011), and Lozano et al. (2022) [41,44–46]. Regarding the ecosystem valuation, Table 3 below shows the partial results for each of the criteria in each plot, as well as the overall average in the last column.

Table 2. Species and general cover by physiognomic groups and plots.

	1	2	3	4	5	6	7	8	9	10
<i>Quercus ilex</i> subsp. <i>ilex</i>	4	4	4	4	4	3	4	4	5	4
<i>Quercus x gracilis</i>	r	r	r							
<i>Arbutus unedo</i>	2	2	r	1	1	1	1	1	2	3
<i>Sorbus torminalis</i>	r	r	r			r	r			
<i>Pinus radiata</i>	r									
<i>Quercus robur</i>	r	1	3			2	2	1		
<i>Laurus nobilis</i>	1	1	3	r		3	2	2	2	5
<i>Phillyrea latifolia</i>	3	3	r	2	1			3	1	2
<i>Rhamnus alaternus</i>	1	r	1		2				1	
<i>Erica arborea</i>	r	1								
<i>Cornus sanguinea</i>	r	r	r	r		1	r	1		
<i>Prunus spinosa</i>	1	1	1							
<i>Crataegus monogyna</i>	r	r	1	2	1	1	r		r	
<i>Ligustrum vulgare</i>		1	r						r	
<i>Fraxinus excelsior</i>			2			1		2		
<i>Acer campestre</i>			1	1			2			
<i>Olea europaea</i> var. <i>sylvestris</i>					r					
<i>Ostrya alba</i>					r					
<i>Ilex aquifolium</i>					r	1				
<i>Castanea sativa</i>						2	1			

Table 2. Cont.

	1	2	3	4	5	6	7	8	9	10
						r	1			
							r			
									2	
										r
										r
BUSHES AND CLIMBERS	<i>Rubus ulmifolius</i> subsp. <i>fruticosum</i>	2	2	1	1	1	1	2	1	1
	<i>Smilax aspera</i>	4	4	1	1	3	3	2	3	1
	<i>Hedera helix</i>	3	3	3	2	1	2	3	1	2
	<i>Rubia peregrina</i>	1	1	1	1		r	1	1	2
	<i>Rosa senpervirens</i>	r	1	1	r	1	r	r	2	r
	<i>Tamus communis</i>	1	r	r	1	r	1	1	1	1
	<i>Ruscus aculeatus</i>	1	1	4	1	1	2	1	3	1
	<i>Hypericum androsaemum</i>	r	r	r	r		r	2		
	<i>Clematis vitalba</i>			r	2		r	3		
	<i>Lonicera peryclimenum</i>				r					
	<i>Genista hispanica</i> subsp. <i>occidentalis</i>					1				
	<i>Daphne laureola</i> subsp. <i>laureola</i>						r			
	<i>Trachycarpus fortunei</i>									1
	<i>Asplenium adiantum-nigrum</i>	1	r	1	1			r	2	1
HERBS	<i>Saxifraga hirsuta</i> subsp. <i>hirsuta</i>	1	r	r	2		1			2
	<i>Fragaria vesca</i>	1	r	r	r					
	<i>Brachypodium pinnatum</i> subsp. <i>rupestris</i>	1	2	2	2	r		1		
	<i>Asplenium trichomanes</i>	r	r	r	r					
	<i>Helictotrichum cantabricum</i>	r	r	r		r				
	<i>Hepatica nobilis</i>	r			r		1			
	<i>Viola riviniana</i>		r	r	r	r		r	r	r
	<i>Euphorbia flavicomia</i> subsp. <i>ocidentalis</i>		r	1	r					
	<i>Stachys officinalis</i> subsp. <i>officinalis</i>		r	r	r					
	<i>Asplenium ceterach</i> subsp. <i>ceterach</i>		r							
	<i>Vicia sepium</i>		r	1	r					
	<i>Polypodium cambricum</i> subsp. <i>cambricum</i>		r				r		1	r
	<i>Lamium galeobdolon</i>		r	r	r		r	1		r
	<i>Geranium robertianum</i>		r	r	2					
	<i>Asplenium scolopendrium</i>			1						
	<i>Polystichum setiferum</i>			r			1	1	r	
	<i>Ranunculus acris</i> subsp. <i>despectus</i>			1	1					
	<i>Osmunda regalis</i>			r						
	<i>Mercurialis perennis</i>			r			r			
	<i>Teucrium scorodonia</i>				r					
	<i>Potentilla sterilis</i>				r					
	<i>Oxalis acetosella</i>				1					
	<i>Geum urbanum</i>						r			

Table 2. Cont.

	1	2	3	4	5	6	7	8	9	10
<i>Arisarum vulgare</i>						r				
<i>Pteridium aquilinum</i>							1			
<i>Carex sylvatica</i> subsp. <i>sylvatica</i>							r			
<i>Euphorbia amygdaloides</i> subsp. <i>amygdaloides</i>							r			
<i>Carex pendula</i>								r		
<i>Brachypodium sylvaticum</i>									1	1
<i>Carex remota</i>									r	r
<i>Iris foetidissima</i>									1	1
Moss on trunks and branches	3	3	4	4	r	3	2	1	2	1
Moss on soil and rocks	3	3	3	4	1	4	3	3	1	2
Lichens on branches and trunk	2	2	1	2	1	2	2	1	1	2
Lichens on soil and rocks	1	1	1	1	1	1	1	r	r	1
Fungi	r	r				r	1		r	r
Leaf litter	4	4	4	3	4	3	2	4	4	4
Bare soil and rocks	2	2	1	1	2	2	3	2	1	1

About the degree of endemism, the Cantabrian holm oak forest cannot be regarded as endemic, given the wide distribution of holm oak forests throughout the Mediterranean basin. However, one taxon can be considered endemic, namely *Helictotrichon catabricum*, which is distributed throughout the Pyrenees and the Cantabrian Mountains [48]. Consequently, solely the plots in which this taxon has been inventoried will receive a score of one point: one, two, three, and five. The remaining plots demonstrate an absence of data for this parameter, with an average value of 0.4.

Regarding the degree of relict, neither the formation nor any of the inventoried and located species can be considered as such, so all plots will register zero points for this criterion.

As for the degree of fineness of the formation or its constituent taxa, the fact is that the Cantabrian holm oak forests show a northern distribution, at the northern limit of the Iberian Peninsula, so the formation should be considered as finicky at the order scale [28]. It is evident that, given that these patches constitute the northernmost occurrence of *Quercus ilex* subsp. *ilex* holm oak groves, a total of four points are awarded to the formation. Furthermore, the following finifolious taxa are recognized: *Quercus ilex* subsp. *ilex*, *Olea europaea* var. *sylvestris*, *Ostrya alba*, *Phyllirea latifolia*, *Pistacea lentiscus*, and *Arisarum vulgare*. In these populations, the most northerly specimens are evident [49]. The highest-ranking plots were those designated 5 (eight points), 9 (seven points), and 1, 3, 4, 6, 8, and 10 (six points). The lowest scores were recorded for plots 2 and 7, with five points being awarded. The mean score attained was 6.1 points.

However, for this group of criteria, the best rated plots were three with 17 points, five with 15.5, one with 15, four with 14.5, and two and nine with 15.5. At the lower end of the scale are 8 with 9 points, 7 with 10, and 10 with 11. The average is 13.25 points.

Regarding the mesological criteria, the geomorphological function of these formations is of the greatest importance, and consequently, this is multiplied by two. Plots 1, 2, 3, 4, 6, and 7 have been identified as those demonstrating optimal biostasis conditions, as evidenced by their highest score of 20 points. The lowest scores are observed in plots 5, 8, 9, and 10, which have a total of 16 points. The mean score attained was 18.4 points.

The climatic function that measures the capacity of the formation to generate special microclimatic conditions shows the highest scores for plots 1, 2, 3, 4, 6, and 7, with the maximum score being 10 points. The lowest scores were recorded for plot 58, which received seven points, followed by plot 5 with eight points, and plots 9 and 10 with nine points each. The average score was 9.3 points.

Table 3. Assessment of each of the criteria for each plot and synthetic assessments.

ASSESSMENTG		CRITERIA	1	2	3	4	5	6	7	8	9	10	SINT	
INCON	INFIT	DIVERSITY	6	9	10	8	5	7	7	5	6	5	6.8	
		NATURALITY	9	10	10	10	10	10	10	10	10	9	9.8	
		MATURITY (X2)	20	20	20	20	17	20	18	18	14	14	18.1	
		REGENERABILITY	8	8	7.5	7.5	8	8	8	8	7	7	7.7	
		SUM INFIT	43	47	47.5	45.5	40	45	43	41	37	35	42.4	
	INTER	RARITY (X2)	8	7.5	10	8.5	6.5	7.5	5	3	6.5	5	6.75	
		ENDEMICITY	1	1	1	0	1	0	0	0	0	0	0.4	
		RELICT	0	0	0	0	0	0	0	0	0	0	0	
		RANGE-EDGE VEGETATION	6	5	6	6	8	6	5	6	7	6	6.1	
		SUM INTER	15	13.5	17	14.5	15.5	13.5	10	9	13.5	11	13.25	
	INNAT	F. GEOMORPHOLOGICAL (X2)	20	20	20	20	16	20	20	16	16	16	18.4	
		INMES	F. CLIMATIC	10	10	10	10	8	10	10	7	9	9	9.3
	F. HIDROLOGICAL		10	10	10	10	8	10	10	8	8	8	9.2	
	F. EDAPHIC		8	8	8	8	8	8	8	8	8	8	8	
	F. FAUNISTIC		10	10	10	9	8	10	9	8	8	8	9	
	SUM INMES		58	58	58	57	48	58	57	47	49	49	53.9	
	INEST	RICHNESS. BY STRATOS (X0.5)	8	8.5	9	7.5	7	8.5	8	7	7	6.5	7.7	
		COB. BY STRATOS (X0.5)	7	7.5	7.5	6	5.5	6.5	7.5	6	5.5	8.5	6.75	
		RICHNESS OF THE MICROHABITAT	6	6	6	4	3	6	7	3	4	5	5	
		SPACE CONNECTIVITY	24	24	24	24	18	20	20	20	1	1	17.6	
		SUM INEST	45	46	46.5	41.5	33.5	41	42.5	36	17.5	21	37.05	
	SUM INNAT		161	164.5	169	158.5	137	157.5	152.5	133	117	116	146.6	
	INCUL	INPAT	ETHNOBOTANICAL VALUE (X2)	20	20	20	20	14	20	18	14	20	20	18.6
			PERCEPTUAL VALUE	7	7	9	7	5	9	8	7	10	10	7.9
			DIDACTIC VALUE	10	10	10	10	7	10	9	5	8	10	8.9
			SUM INPAT	37	37	39	37	26	39	35	26	38	40	35.4
		INCUL -EST	STRUCTURAL PHYSIOGNOMIC VALUE	2	2	2	2	2	2	2	2	1	2	1.9
			STRUCTURAL CULTURAL VALUE	5	5	5	6	5	5	5	5	2	3	4.6
			SUM INCULEST (X2)	14	14	14	16	14	14	14	14	6	10	13
			SUM INCUL	51	51	53	53	40	53	49	40	44	50	48.4
	SUM INCON		212	215.5	222	211.5	177	210.5	201.5	173	161	166	195	
THREAT FACTOR	DEMOGRAPHIC PRESSURE	1	1	1	1	1	3	3	2	7	7	2.7		
	ACCESSIBILITY- TRANSITABILITY	3	4	6	4	2	2	2	4	9	9	4.5		
	ALTERNATIVE THREATS	1	1	3	3	5	3	3	5	3	3	3		
	GLOBAL THREAT FACTOR	5	6	10	8	8	8	8	11	19	19	10.2		
PRICON		1060	1293	2220	1692	1416	1684	1612	1903	3059	3154	1909.3		

The hydrological function measures the interception of rainfall and good water circulation from the leaves to the soil. In this case, the best-rated plots would be one, two, three,

four, six, and seven, with the maximum score of 10 points. The rest of the plots would score eight points. The average is 9.2.

The edaphic function, which is defined as the capacity to conserve the soil and to generate a greater and better structure, is situated at eight points for all the plots. This corresponds precisely to a well-developed and structured vegetation, but with a certain xericity, in this case precisely of an edaphic nature.

The analysis of habitat functionality, which evaluates the capacity of an environment to act as a refuge, breeding, resting, wintering, and trophic resource provider, among other regulating and provisioning services, reveals that the highest scores are concentrated in plots 1, 2, 3, and 6, with a score of 10 points. Plots 4 and 7 are a joint second, with a score of nine points, while the remaining plots received eight points. The mean score attained was nine points.

The sum of these five criteria would result in the mesological value, which shows the best records for plots 1, 2, 3, and 6 with 58 points, followed by 4 and 7 with 57, 9 and 10 with 49, and finally, 5 with 48.

With regard to the criteria of structural roots, the first one, which is the richness by strata, shows the following plots and scores: 3 with 9 points, 2 and 6 with 8.5, 1 and 7 with 8, 4 with 7.5, 5, 8 and 9 with 7 and, in last place, 10 with 6.5. The average score is 7.7 points.

The coverage by strata shows plot 10 with 8.5 points, plots 2, 3, and 7 with 7.5, plot 1 with 7, plots 4 and 8 with 6, and plot 9 with 5.5. The average is 6.75 points.

The microhabitat richness shows the following hierarchy: seven points for plot 7, six points for plots 1, 2, 3, and 6, five points for plot 10, four points for plots 4 and 9, and the lowest scores for plots 5 and 8 (three points). The average is five points.

The connectivity-spot size criterion shows that plots 1, 2, 3, and 4 have 24 points, plots 6, 7, and 8 have 20 points, plot 5 has 18 points, and the last two (9 and 10) have only 1 point, as they have just over 0.4 ha and no connectivity. The average, although misleading due to the large differences between plots, is 17.6 points.

However, the sum of this group of criteria results in the following order: the best rated plot is plot 3 with 46.5 points, followed by plot 2 with 46 points and plot 1 with 45 points. This is followed by plot 7 with 42.5 points, plot 4 with 41.5 points, plot 6 with 41 points, and plot 8 with 36 points. The average is 37.05 points.

The four groups of criteria added together give rise to one of the major indices, the one that reflects the natural value. In this case, the hierarchy would be as follows: the best valued plot is plot 3 with 169 points, followed by plot 2 with 164.5, plot 1 with 161, plot 4 with 158.5, plot 6 with 157.5, and plot 7 with 152.5. At the bottom are 10 with 116, 9 with 117, 8 with 133, and 5 with 137.

With regard to cultural values, these are divided into two summatives: heritage interest and cultural-structural interest. The former, in turn, is the sum of three criteria. The most important, and for this reason, is multiplied by 2, is ethnobotanical. In this case, most of the plots receive the maximum score (20 points): 1, 2, 3, 4, 6, 9, and 10, with 18 for seven and 14 for five and eight. The average is 18.6 points.

In terms of the local population's assessment of these plots, assessed by means of 200 surveys, the highest scores are given to plots 9 and 10, followed by 3 and 6 with nine points, 1, 2, 4, and 8 with seven points, and, in last position, 5 with five points. The average is 7.9 points.

The didactic value, on the other hand, was assessed through five interviews with education professionals (primary, secondary, and university). In this case, the most highly rated items are 1, 2, 3, 4, 6, and 10, with the highest score, followed by 7 with nine points, 9 with eight, 5 with seven, and 8 with five. The average score is 8.9 points.

The sum of these three criteria shows the following distribution: plot 10 with 40 points (the maximum that can be achieved), plots 3 and 6 with 39, plot 9 with 38, plots 1, 2, and 4 with 37, plot 7 with 35, and plots 5 and 8 with only 26 points. The average is 35.4 points.

From a cultural–structural perspective, the primary criterion under consideration is that of physiognomic–structural. In this instance, most of the plots exhibited two distinct types of trunk morphology (two points), namely tall wood with a natural development of the trunks and intervened wood through pollarding. Pollarding entails the falling of the primary trunk at a height of 2.5 m, with the objective of yielding adequate firewood for charcoal production. Except for plot 9, which is devoid of pollarded trunks (one point), all other plots exhibit the two aforementioned typologies. The mean would be 1.9 points.

On the other hand, the cultural–structural value includes all types of ethnographic, historical, artistic, past, or traditional elements. In this case, the highest scores are given to plot 4 with six points, 1, 2, 3, 5, 6, 7, and 8 with five points, 10 with three points, and 9 with two points. The average is 4.6 points.

Adding these two criteria together and multiplying the result by two gives the following scores: 16 points for plot 4, 14 points for plots 1, 2, 3, 5, 6, 7, and 8, 10 points for plot 10, and 6 points for plot 9. The average is 13 points.

Following the aggregation of all the cultural values, the resultant overall cultural value is as follows: plots 3, 4, and 6 received 53 points, plots 1 and 2 received 51 points, plot 10 received 50 points, plot 7 received 49 points, plot 9 received 44 points, and plots 5 and 8 received 40 points. The mean score attained was 48.4 points. This can be regarded, akin to the natural value, as an additional synthetic index to be considered by the manager, in this instance encompassing all the cultural aspects and values, i.e., all the ES that a forest of this type can provide.

If we add natural and cultural values together, we will obtain another finalist value, such as conservation interest. This is as important as the conservation priority. In fact, the latter is often ignored, and the former is taken into account. In any case, the hierarchy is as follows: plot 3 would score 222 points, plot 2: 215.5, plot 1: 212, plot 4: 211.5, plot 6: 210.5, plot 7: 201.5, plot 5: 177, plot 8: 173, plot 10: 166, and plot 9: 161. The average for this parameter is 195 points. Regarding the conservation of this vegetative landscape, it should be noted that, among the different formations analyzed using the LANBIOEVA methodology, all plots fall within the third quartile, very close to the 75th percentile (Table 4), demonstrating the value of this ecosystem and its provision of ES.

About the group of parameters or criteria that determine the level of threat, the first refers to demographic pressure. The value in question is contingent upon the number of inhabitants per km², with variations observed across individual municipalities. The initial five plots are situated in municipalities exhibiting exceedingly low densities and are thus assigned a point, with plot 8 receiving two points, and plots 6 and 7 receiving three points. The most threatened plots are designated as 9 and 10, each allocated seven points.

In terms of accessibility–transitability, the plots with the highest degree of threat are 9 and 10 with nine points, followed by 3 with six, 2, 4, and 8 with four, 1 with three, and 5, 6, and 7 with two.

Finally, for this set of parameters, the ratings for the alternative threats are collected. In this instance, plots 5 and 8 are the most threatening, with a score of five points each. The next most vulnerable plots are 3, 4, 6, 7, 9, and 10, which have a score of three points each. Finally, plots 1 and 2 have a score of one point each. The mean average is three points.

The sum of all the threats gives the following values, from highest to lowest: 19 points for 9 and 10, 11 for 8, 10 for 3, 8 for 4, 5, 6, and 7, 6 for 2, and 5 for 1. The average is 10.2 points. In light of the threats, it can be concluded that all the plots—and therefore the Cantabrian holm oak forest of Urdaibai—exhibit a high level of conservation, reflected by the generally

low threat level placing them in the second quartile, though close to the 25th percentile (Table 4), demonstrating that its protection has been and remains effective. However, plots located at lower elevations and closer to urban centers or major infrastructure corridors require increased monitoring and protection. Urban and economic developments are overlooking the value of this ecosystem and causing damage to specific areas.

Table 4. Quartiles and scores recorded for each of the criteria groups on a global scale.

Criteria/Interest Groups	CURRENT QUARTILES			
	P 25	P 50	P 75	P 100
INFIT	32.8125	41.41725	48.1076875	50
INTER	3.878125	10.9585	27.8705	28.89
INMES	41.3875	50.0335	59.461125	60
INEST	16.890625	22.6975	88.570625	92.88
INNAT	98.14375	125.6125	182.50625	186
INPAT	21.56875	28.75	39.375	40
INCULEST	4.721875	7.4125	16.5875	17.16
INCUL	26.734375	34.735	52.889375	54
INCON	125.215625	158.3375	224.053125	228.08
AM	9.75	14.45625	25.3296875	26
PRICON	1335.9375	1977.75	4151.4375	4288

To conclude the evaluation, another of the finalist values, the conservation priority, is the product of the conservation interest and the overall threat factor. In this case, the hierarchy is as follows: plot 10 with 3154 points, followed by plot 9 with 3059, plot 3 with 2220, plot 8 with 1903, plot 4 with 1692, plot 6 with 1684, plot 7 with 1612, plot 5 with 1416, plot 2 with 1293, and, finally, plot 1 with 1060. The average is 1909.3 points.

5. Discussion

The number of taxa for this formation is relatively modest in comparison with other similar works that have characterized other localities of the same formation. For example, in a study by Lozano-Fernández (2021) [50] with the same methodology and number of plots, in the town of Ataun (Gipuzkoa, Basque Country), the number of trees and shrubs was the same as that of the RBU and the number of bushes and climbers recorded one species less for Urdaibai, but the real difference was found for herbaceous species. In Urdaibai, there are 32, while in Ataun, there are 57. Logically, there is a clear difference in that those in Urdaibai are protected and have a higher level of development than those in Ataun. This suggests that, in the former, the tree and shrub stratum is relatively dense, thereby limiting the light reaching the lower strata. In contrast, Ataun exhibits a less intricate, developed, and even grassy physiognomy.

In the same way, but with holm oak groves in the interior of the Iberian Peninsula, 4 trees and shrubs, 8 bushes and climbers, and 67 herbaceous plants were recorded in the holm oak grove of Cubillas using the same methodology. In total, there were 79 species [51]. In this case, there are former pastures or woodlands cleared for livestock farming that have lost this use, but which largely maintain the structure of a few trees, and which, by allowing more light to pass through, show a certain high number of herbaceous species. These are cultural forests that were managed until a few years ago, as is the case in the Dehesas of Carrascal *adehesado* in Ciudad Real, with very similar figures to the previous

ones [52,53]. At this point, the need to combine mixed management models between strict conservation and active conservation by humans and their sustainable activities should be taken into account. Excessive homogenization of the territory through strict conservation measures has been demonstrated to result in a loss of taxonomic diversity [54]. In contrast, traditionally managed ecosystems with sustainable policies have been shown to generate landscape heterogeneity, which in turn leads to greater diversity [55]. This significant ecosystem service is frequently underappreciated [35].

However, the most striking and differential aspect in terms of the floristic composition between the examples mentioned above and the coastal holm oak grove of Urdaibai is the existence of numerous thermophilic species, such as *Olea europea*, *Arbutus unedo*, *Osyris alba*, *Laurus nobilis*, etc., which do not appear in the inland ones, not even in the one in Ataun.

Another relevant issue is the remarkable litter cover. The fact that the soil is relatively sparse and unstructured results in the accumulation of an extensive mulch that is difficult to mineralize, so that the organic horizon is always wide and contains abundant organic matter in the form of leaf litter. Lichen and moss cover is also high, indicating a good quality of the environment and guaranteed humidity. Curiously, while soil water is scarce due to infiltration, the dense and to some extent shady undergrowth, which is configured as a relatively impenetrable forest due to the number of trees, shrubs, bushes, and scandens, means that the relative humidity is high and sunlight is low, as it is intercepted by the tree canopy. This results in a great profusion of both bryophytes and lichens, and to a lesser extent, fungi.

In relation to ecosystem valuation, the following Table 4 illustrates the quartiles that have been collected to date in the more than 250 formations that have been inventoried and valued on a global scale [15].

With regard to the criteria of phytocenotic roots (support services), the average of the Urdaibai plots is slightly above the 50th percentile, which would place it at the beginning of the third quartile. Although there are certain differences between plots, the formation shows high levels of diversity, but, above all, of maturity. These are relatively mature holm oak woods. Curiously, this does not usually coincide with high levels of diversity since, as mentioned above, the dense canopy of trees and shrubs does not allow much light to pass through to the lower strata, where herbaceous plants are not excessively abundant and, for the most part, correspond to shady species, which are highly adapted to low levels of radiation. A positive aspect is the low number of foreign taxa, which, moreover, do not show large coverage and only appear in three inventories. This is a good indicator of the good health of the forest.

When compared with the Cantabrian holm oak forest of Ataun, this site demonstrates a notably higher level of biodiversity. By contrast, Urdaibai exhibits somewhat more modest biodiversity metrics. There are no significant discrepancies in the remaining criteria. It is possible that some wood extraction works, but above all grazing, in the case of Ataun, generate more open holm oak groves and, therefore, a greater diversity of herbaceous plants and a greater provision, in this case of provisioning services, which, in turn, results in sustainability, among others.

Territorial interest shows large differences between plots, by up to nine points. This is mainly determined by very rare, rare, and scarce taxa. Overall, there are up to 3 very rare, 4 rare, and 26 scarce taxa [50].

These are not low figures. Although Ataun has 50 taxa in these categories, the fact is that the endemism is similar, and the finnoecious species are also similar. In both cases, moreover, there are no relict taxa, and the formation is not relict either. The average for this group of criteria is 13.25 points, once again at the beginning of the third quartile, occupying a medium-high position due fundamentally to the finniculous nature of the

formation and the rarity of certain species that are components of these forests. All these criteria have, therefore, a medium–high value in relation to the ES of support, but, at the same time, they can also result in culturally rooted services, since they are associated with aesthetic, recreational, and ecotourism values, etc. Not only should they be considered as environmental or ecological services, but the potential to attract tourist resources related to the enjoyment of the environment or the observation and photography of emblematic species of flora and fauna is also very relevant in the area [56].

About the mesological criteria, these forests have a great mesological role to play in avoiding erosive processes and situations of resistance, especially considering that they are located on very scarce and lean soils and in situations of high slopes and high rainfall. Furthermore, its dense nature shows good figures for factors such as climate and hydrology, as well as playing an outstanding role in terms of fauna. In comparison with the holm oak groves of Ataun, the figures are higher since those of Urdaibai, due to their protected status, are in a situation of greater maturity and, therefore, play a more important role in accordance with the biotopic and biocenotic factors of the environment. The average for the sum of these criteria is 53.9 points, with the maximum potential being 60. In this case, this training appears in the third quartile and shows scores associated with regulation criteria that are certainly notable, which, in turn, is related to other criteria of a provisioning, sustaining, and even cultural nature.

As far as structural values are concerned, there are no major differences either. The holm oak forest is rich in strata, but not so much in the diversity of species per stratum. This is more pronounced in Urdaibai, where the dense tree canopy impoverishes the undergrowth. There are also a good number of microenvironments in relation to rock and hypogean habitats, the abundance and diversity of lichens, bryophytes, and fungi, or old trunks. The scores derived from the connectivity and extent of the Cantabrian holm oak forest patches are not negligible either and are very similar.

However, in this case, there are two tiny plots, smaller than one hectare, which gave rise to scores of only one point, and which weighed down the overall average. In any case, the average sum of these criteria is 37.05 points, which places this formation, once again, at the beginning of the third quartile. Most of the forests on the European continent are very small in extent and lack connectivity, so that the most important criterion for the potential of this group tends to weigh down this type of forest. Urdaibai is no stranger to this dynamic, with a very intensive and long-standing occupation of the land, which means that there is great pressure on wooded areas from agricultural land, facilities, infrastructures, economic activities, and housing. A social consensus is needed to avoid excessive proliferation of anthropogenic activities that fossilize the soil and reduce these good patches of GI [57].

Adding these four groups of criteria together, the result is a natural interest of 146.6 points for the Urdaibai holm oak forest and 152.9 for the Ataun holm oak forest. These are relatively high scores if we compare them with the 250 formations studied on a global scale to date [12]. In fact, this training is again placed in the third quartile, which means high values, and which refers to the ESs of sustaining, provisioning, and regulating.

With regard to cultural interest, heritage interest is elevated due to the substantial perceptual interest obtained through population surveys. In terms of ethnobotanical value, although many of the ancestral uses have been lost or are in decline, the holm oak forest is still used in a sustainable way, with extensive livestock farming. It offers highly appreciated fruits and mushrooms, plays a tractor role for all kinds of outdoor activities (sports, hiking, nature enjoyment, animal and plant watching, ecotourism, rural and ethnographic tourism, etc.), and, therefore, registers high-to-very high scores.

The educational value is also notable in terms of explaining issues such as the regeneration of the holm oak grove itself, the customs and traditions associated with it, and even

the botanical history of its origin, evolution, and development through human activities. Education is an ES that is often overlooked but has a great impact when it comes to instilling the values of respect and rational use of resources in future generations [58]. All in all, the number of points is slightly higher in Urdaibai than in Ataun (48.4 to 32.9). In this case, the situation of the Urdaibai holm oak forest is within the third quartile, but in the upper part of the range.

If we add the natural and cultural scores together, we obtain the conservation interest, which is slightly higher in Ataun than in Urdaibai (197.2 to 195 points). In any case, the holm oak forest of Urdaibai is in the third quartile, in a high position due to maintaining relatively high natural and cultural registers. As indicated, this final value can already be considered by the manager with a view to the correct planning and management of this type of forest. This value also includes criteria of different roots that have a bearing on all types of ESs (provisioning, regulating, sustaining, and cultural). It can also be taken as an accurate diagnosis of the quality of the ecosystem and, therefore, of the IV, with a view to procuring the entire list of ESs.

Concerning conservation priority, which multiplies conservation interest by the degree of threat faced by the plant groupings, the three parameters that make up this last value have, fortunately, modest scores. The population density is higher in Urdaibai than in Ataun, as is the accessibility and trafficability, while the alternative threats are similar because, while Urdaibai is a protected area, Ataun is a relatively inaccessible area with steep slopes. However, the appearance of some uncontrolled hiking, the clandestine dumping of rubbish, and the introduction of xenophytic plants in the vicinity may be the most alarming risks. As a result of these low levels of threat, relatively low conservation priority scores appear (1909.3 for Urdaibai compared to 1648.9 for Ataun). In general, it is difficult to obtain scores above 2000 points. Urdaibai is placed in the second quartile, a fairly high position considering the regional context and the scores obtained in the studied formations within the European continent. It is worth noting that the level of threat is relatively low (10.2 points on average), which places this formation at the beginning of the second quartile, practically on the border with the first quartile. In this sense, the implementation of more forceful or effective measures for the correct conservation of this GI would not be a priority. However, it is important to acknowledge that, although the pressures are not excessively high, the conservation interest is significant. Consequently, vigilance regarding the maintenance of these conservation measures should be maintained, while also seeking to minimize the obvious impacts that exist within the RBU [58].

In this regard, and based on the data provided by the previous reference, the level of protection of the forest stands within the RBU has been high, although there are some weaknesses, such as land-use changes from natural or potential forests to pine or eucalyptus plantations driven by clear economic interests. However, such changes have occurred in only a few plots. Impacts on the Cantabrian holm oak forest are also evident in the urban development plans of municipalities such as Forua, Murueta, and Ereño. In these cases, the impacts on the provision of ecosystem services are greater due to the proximity of populations to these forested areas.

Nevertheless, a comparison between this region and the neighbouring Uribe–Costa area shows that, while the recovery and conservation of these forest assets have been more successful within the RBU, this has not negatively affected the standard of living or various socioeconomic values of the population in the protected area. It is therefore demonstrated that nature conservation contributes to greater well-being and a higher socioeconomic level among the affected population.

The LANBIOEVA methodology is a robust instrument for ecosystem inventory and assessment, which, in this instance, has been employed on an ecosystem that is emblem-

atic of the Cantabrian coast, namely the holm oak grove of *Quercus ilex* subsp. *ilex* in a specific location: The Urdaibai Biosphere Reserve. Consequently, the objective set has been achieved, and the catalogue of formations inventoried and assessed on a global scale has been completed. This tool, therefore, serves to qualitatively analyze and assess the ecosystem services of a given landscape, vegetation formation, or ecosystem, thus providing planners and land managers with a comprehensive diagnostic instrument that not only evaluates vegetation cover in an integrated manner but is also useful for valuing and assessing the ESs they provide.

The coastal holm oak grove (Urdaibai) attains comparable scores regarding conservation interest as other analogous formations, such as Ataun. Urdaibai has been found to demonstrate superior records in terms of cultural values, although it is notable that the natural values are also consistently significant, with relative positions consistently achieved in the third quartile. In any case, these are elevated values that result in the procurement and conservation of ESs for maintenance, provisioning, regulation, and cultural purposes. It is the latter that is of particular significance, with a vector of economic traction based on relatively sustainable activities, such as ecotourism, ethnographic and cultural tourism, observation of flora and fauna species, etc.

As far as the conservation priority is concerned, the scores for the three threat parameters are relatively low. Curiously, the Urdaibai holm oak grove, despite being in a protected area, registers a higher score than the Ataun grove, which does not have any, and it is therefore advisable to apply some form of mitigation to certain impacts. Particular attention should be given to the forest stands closest to inhabited areas, as these are where land-use changes have occurred in plots that once contained significant patches of Cantabrian holm oak forest. Efforts should also be made to prevent the conversion of natural land to plantations with exotic species such as pines (*Pinus* sp.), eucalyptus (*Eucalyptus* sp.), black locust (*Robinia pseudoacacia*), among others. Similarly, there should be a tendency to replace these areas, currently used for the rapid and intensive production of pulpwood, with reforestations using native species found within the Cantabrian holm oak forest, as well as in other formations like the pedunculate oak woodland (*Quercus robur*). In such instances, the administration responsible for management must consider the high conservation interest, while acknowledging the medium priority due to the minimal threat level. The conclusion drawn is unambiguous: the protection afforded by the Biosphere Reserve status has been effective in preserving a well-preserved formation, with minimal threats that, nevertheless, must be given due consideration and mitigated.

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