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Botany Teaching–Learning Proposal Using the Phytosociological Method for University Students' Study of the Diversity and Conservation of Forest Ecosystems for University Students

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Abstract: We propose a method consisting of four steps for phytosociological research and education on flora and vegetation diversity. We demonstrate the application of this method using as an example a territory of special interest due to its high index of endemism (*Dominican Republic Island*), which is a biodiversity hotspot and hosts several protected areas, such as the Jaragua-Bahoruco-Enriquillo Biosphere Reserve. Nonetheless, this model, based on teaching the phytosociological method, can be extrapolated to any location worldwide. As an example, we analyzed the dry and humid forests. Through the four research phases, this study revealed a greater number of endemic species in the dry forest compared to the humid forest, with more endemics found in districts A12 and A16. The sequenced teaching of the research phases allows for the training of university students, future managers, and educators. The model enables learning sampling techniques, developing analysis and interpretation skills, and assessing the need for conservation of habitats rich in endemic species. The teaching outcomes of this study provide optimal training for the management and dissemination of ecological values, which allow broader society to learn to respect the environment.

Keywords: research education; vegetation; habitats; endemism; natural areas; ecological islands

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1. Introduction

Studies on the endemic vegetation and flora of poorly known or unexplored areas remain highly important today [1], which is the case for the island territory of the Dominican Republic, for which the proposed teaching method is applicable.

The continuous monitoring of phytocenoses and the conservation of plant species contribute to the management and preservation of their habitats [2–4]. To achieve this, it is necessary to train managers and educators in bioclimatic, biogeographic, and vegetation knowledge, which is used in the construction of species distribution models [5].

This approach will facilitate the recovery of degraded forests in developing countries, where deforestation is a primary cause of habitat loss. In Central American tropical areas, deforestation is exacerbated by hurricanes, which result in the replacement of forests by secondary shrublands.

However, the deforestation of the humid forests of Cuba and the Dominican Republic leads to the emergence of a phytocenosis of pteridophytes, represented in the study area by *Gleichenia bifia* (Willd.) Spreng. and *Dicranopteris flexuosa* (Schrad.) Underw. These dense formations hinder the regeneration of well-developed forests.

Only small areas of well-preserved forests remain in the mountainous regions, which are the areas with the highest diversity and endemism [6–8]. These forests are crucial

for maintaining the island's biodiversity [9–11], as well as for preserving the relationship between forest stands and the water cycle, which is of utmost importance to society [12,13].

Given the high botanical and ecological value of the Dominican Republic, with its rich floristic diversity and numerous endemic species, it is essential to foster social awareness to achieve habitat conservation. This awareness arises when the floristic and habitat richness of the territories is understood, and this understanding is enhanced through the educational system. Many university students go on to become educators, capable of transmitting this knowledge to society, which is the primary reason for selecting these territories and proposing a model for research dissemination.

This method aims to promote sustainable development for the conservation of species and habitats by involving the educational system in conservation efforts [14,15].

This vision of conservation, which society acquires through the educational system, can be achieved through the use of natural spaces that act as laboratories. This educational model is based on in situ learning through the sampling of plant communities using the phytosociological method, as well as conducting floristic analysis and assessing the conservation status of habitats by analyzing characteristic and companion species.

There are more than 20 protected areas in the Dominican Republic (Biosphere Reserves, National Parks, Scientific Reserves, and Nature Reserves) that can serve as highly valuable educational resources, as stated by Ballantyne et al. and Ballantyne and Packer [15–17]. In this context, the Saragua-Bahoruco-Enriquillo Biosphere Reserve and Monte Cristi National Park (Cibao Valley) can function as laboratories for research on dry forests and their vegetation dynamics. The Ébano Verde Scientific Reserve, Los Haitises National Park, and Sierra de Neiba Park are well-suited for the study of rainforest ecosystems and their vegetation dynamics.

Several studies on green spaces and infrastructures [18,19] analyze how their influence contributes to sustainable development through enhanced environmental education. The investigation of forest diversity in the Dominican Republic enhances students' learning environments, requiring knowledge and awareness of plants and green spaces to improve their academic performance [20]. For this, not only is flexibility in the teaching model necessary, but it is also essential to integrate botanical content into the curricula [21].

The use of green spaces for teaching is of particular interest, according to some researchers [22–25], as it improves both the academic and health outcomes of the population by fostering greater cognitive development.

Research and learning are two interrelated concepts; it is essential to learn how to research, developing curiosity and the ability to observe the natural environment. For this, there must be flexibility in the teaching model, as suggested by Waite et al. [26], where theoretical and practical teaching are combined. In the case of studying forest diversity in the Dominican Republic, the flexibility of the teaching model allows students to immerse themselves in their natural environment. The natural environment serves as a laboratory for observation and experimentation, enabling students to learn about vegetation in a practical manner.

The main objective of this study was to apply a research-based teaching method, using as an example the research conducted by various authors, along with our own contributions, on the island of the Dominican Republic (Caribbean).

The island of the Dominican Republic was chosen to propose the application of the research–teaching method due to its unique characteristics, as it has a high index of endemic species, which stimulates students' knowledge and interest in research.

Authors such as Tilbury [27] emphasize the need for environmental education and analyze its integration into educational curricula, with a particular focus on teaching for the conservation of plants and ecosystems. Society plays a key role in the preservation and conservation of natural habitats and the endemic species they harbor [28–33].

Authors such as Mayoral García-Berlanga [34] and Rodríguez [35] argue that botany can play a crucial role in the development of scientific skills within society, especially among university students. To achieve this, it is essential to implement pedagogical

approaches that make science education more accessible, highlighting the value of botany as an educational tool. This discipline not only provides a wealth of information but is also easily applicable in learning environments. Furthermore, it is important to move away from purely expository teaching methods to increase contact with nature, facilitating a better understanding and appreciation of the plant world [36–41].

The objectives of this research had two fundamental aspects:

1. The first objective was to understand the diversity of forests and their conservation status: This objective focused on identifying and documenting the variety of forest types present in areas of special interest on the island of the Dominican Republic, evaluating their floristic diversity and the degree of conservation of each one.
2. The second objective was to propose a model to transmit research through immersion in a natural environment, aimed at university students: Based on the study of the forests of the Dominican Republic, we aimed to establish a research model that could be followed by undergraduate, master's, and doctoral students, as well as scholars of the natural world.

The initial hypothesis of this study was that the forests of the island of the Dominican Republic, due to their unique bioclimate and substrate diversity, exhibit a high rate of endemism and a distinctive vegetation structure that can be used as a model for teaching research methodologies to university students (future educators).

It was expected that through the application of this research, students would gain a better understanding of the diversity, conservation, and dynamics of forest ecosystems in areas of biogeographic interest, through an educational model that promotes learning by immersion in the natural environment. This approach would also revalue the environment as a didactic tool, generating meaningful experiences in nature that would influence the development of environmental sensitivity in adulthood.

2. Materials and Methods

2.1. Study Area

We proceeded to establish and delimit the study area, selected based on its edaphic and climatic diversity, which condition to a certain extent the type of vegetation [42,43].

Although there are few phytosociological studies on Caribbean vegetation, some relevant plant ecology research on the flora and vegetation in the Dominican Republic has proven highly valuable for subsequent studies [44–58].

The study area corresponds to the different biogeographic units of the Dominican Republic. The sampling of the various types of forests was conducted by applying the phytosociological method established by Braun-Blanquet [59]. This was followed by the statistical and phytosociological analytical phase to describe the plant communities. Using the published floras [50], we differentiated the endemic species from the non-endemic ones.

The location of the Antilles (Caribbean) in a subtropical environment, with a distinct distribution of rainfall influenced by the trade winds, is a key factor determining the type of vegetation present. The climate is bixeric, characterized by two rainy periods and two dry periods. Bioclimatically, the Dominican Republic has an ombrothermal index ranging from semi-arid to humid, with values of Io = 1.3–7.9, which defines the existence of two types of forests: humid forest and dry forest [42].

The highest precipitation values are found in the Central, Septentrional, Oriental, Sierra Bahoruco, and Samaná Peninsula mountain ranges, generally above 1000 m, with values exceeding 2000 mm. The lowest precipitation values are observed in the areas of Azua and the Cibao Valley, where rainfall ranges between 400 and 800 mm.

Bioclimatic diagrams were created using climatic data on temperatures and precipitation, following the criteria established by Professor Rivas-Martínez in his work Bioclimatic Classification of the Earth, as referenced in Cano et al. [42].

In certain situations, such as in the eastern plains with a sub-humid ombrotype, the territory behaves as if it were dry due to the limestone and serpentine coral substrates. This results in the development of phytocenoses that depend on the substrate, while in

the mountainous areas, where rainfall is very high, humid forests emerge. All of this contributes to the existence of unique habitats characterized by high biodiversity and endemism (Figure 1).

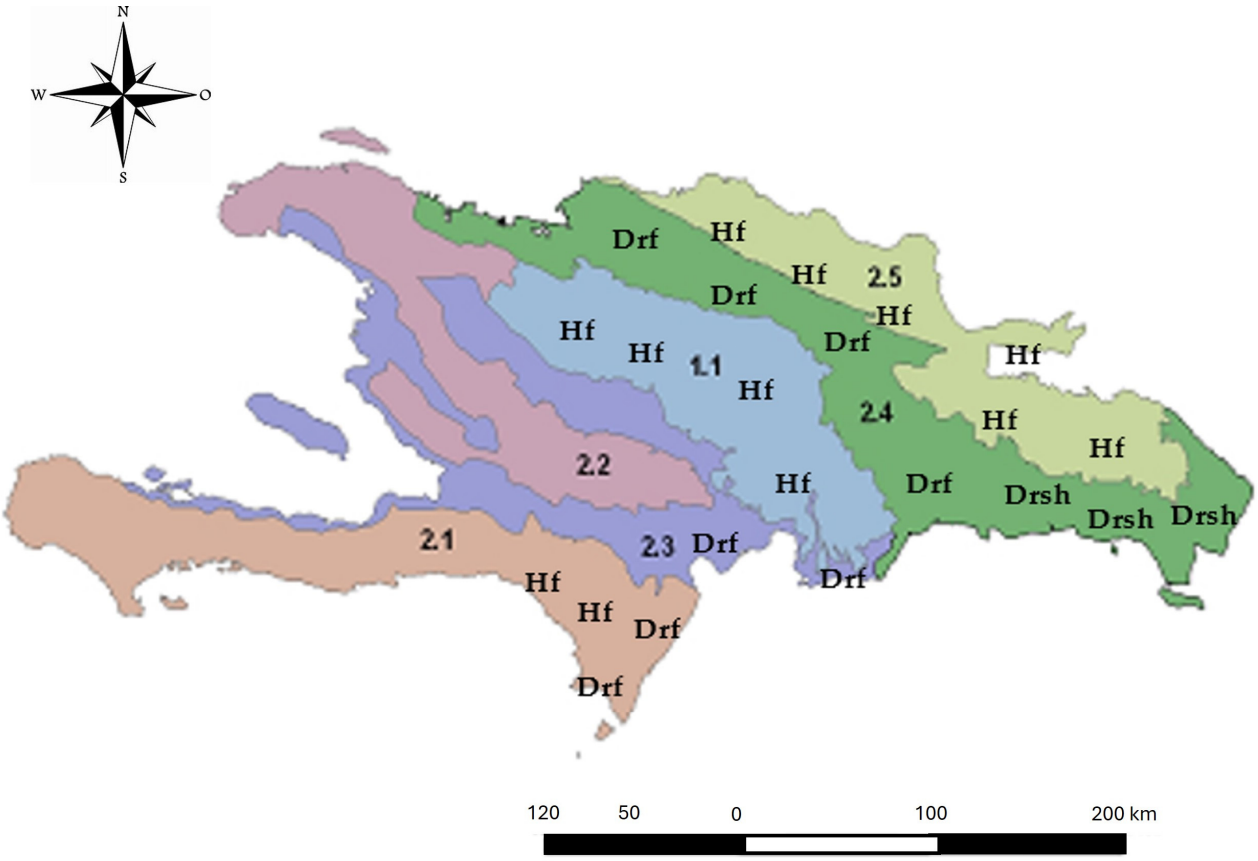


Figure 1. Biogeographic distribution of humid forests (Hf) in the Cordillera Central (1.1), Haitises, Samaná Peninsula, and Cordillera Septentrional (2.5). Sub-humid forests (Drsh) in the eastern lowlands (2.4). Dry forests (Drf) in Pedernales, Azua, and the Cibao Valley.

2.2. Methodology for Teaching Research

In general, two main methodologies for studying vegetation are widely accepted: the ecological approach favored by the Anglo-Saxon school and the phytosociological approach of Central Europe. While both methods share similarities and distinctions, we chose the phytosociological methodology, which is widely applied in EU countries.

This method includes defining the study area, conducting a bibliographic search, selecting sampling plots, performing phytosociological and bioclimatic analyses, carrying out statistical treatment, and developing vegetation catalogs to evaluate conservation and phytocoenotic diversity.

To apply that method, we focused this study on a specific territory (Dominican Republic) with forest vegetation as the theme.

This territory was chosen due to the uniqueness of the Dominican Republic, which hosts a high percentage of endemic species. This motivates students to understand the need for ecosystem conservation, training them for environmental management. This method can be applied not only in the study area but also in other parts of the world.

There are four steps to follow in the investigation:

1. Characterization of the study area.
2. Literature review and update.
3. Phytosociological approach and treatment.
4. Data analysis (tables, characteristic species).

The following steps are developed below:

1. Locating the research area.
2. Searching for bibliographic references related to the study area and other territories that help frame the research problem. These references should cover the geological, edaphic, climatic, bioclimatic, and biogeographical characteristics of the study area. Sections one and two are essential for starting the research.
   The initial bibliographic analysis revealed more than a hundred floristic and vegetation articles published in the journal *Moscosoa*. However, there were only our contributions on phytosociological studies. The selection of the study territory was based on its botanical and ecological values for conservation. In this subtropical territory, the selected sampling plots ranged between 1000 and 2000 m^2, with plots that were ecologically and floristically homogeneous. Once a plot was selected, the species were listed, and the abundance and dominance indices of each species were recorded. This sampling technique is commonly used in territories with different climates.
3. Subsequently, selecting the types of sampling plots and the phytosociological methodology to be followed, which must be determined according to the Central European school [59,60]. In this case, we opted for the phytosociological methodology, which requires the transmission of basic geobotanical concepts [61,62].
   Following the phytosociological methodology, two types of forests in the Dominican Republic were studied, and the species they contained were recorded using abundance–dominance indices (+,1,2,3,4,5) [59]. The dry forest (R1–R48) and the cloud forest (C49–C65) were analyzed, and the flora of the Dominican Republic was used for species identification [50].
4. Transforming phytosociological indices into those of Van der Maarel [63] for statistical treatment. To differentiate the two forest groups, statistical treatments, dendrograms, TWISPAN, and, for the bioclimatic influence on species distribution, linear regression analysis and CCA were employed, using Analysis Package III and XLSTAT software 2023.3.1.
5. For the biogeographic and bioclimatic study, we relied on previous works [42,43], following the framework established by Rivas-Martínez [5,64,65]. The bioclimatic diagrams were obtained based on the research of Professor Rivas-Martínez in his work Bioclimatic Classification of the Earth [66].
6. After completing the statistical treatment and distinguishing between the two major forest types (wet and dry), we proceeded to the phytosociological phase, classifying each forest type into a specific association and placing it within a hierarchical system of ranks.
7. Based on this framework, a comparative analysis was conducted between the diversity of characteristic and companion species within the association. By examining the relationship between characteristic and companion species and the index of endemism, the conservation status could be evaluated.
8. Subsequently, a vegetation catena was constructed, in which the geosigmetum (Ridge-Lake-Valley) was investigated, highlighting a new method for landscape understanding, where different sigmetum or vegetation series are in contact. The geosigmetum should be understood as a contiguous spatial sequence of vegetation series. It is, therefore, the sum of a set of vegetation series in contact, forming an integrated landscape unit, equivalent to a vegetation catena.

The elaboration of phytosociological and synthetic tables is of great interest for clarifying the conservation status of dry and humid forests. In the preparation of the synthetic tables, indexes I to V are used, with I representing the lowest presence in the number of phytosociological inventories and V representing the highest presence. The percentage equivalence is as follows: IV–V = 80–100%, III–IV = 50–80%, II–III = 30–50%, and I–II < 30%.

3. Results

The research methodology established responded to objective one, allowing us to obtain results related to floristic richness and conservation status. It proceeded with the selection of the study area, search for bibliographic references, study of physical, bioclimatic, and biogeographical factors, and then phytosociological sampling, statistical treatment, phytosociological analysis, and diversity analysis.

The model has been applied in European countries, but it has not yet been applied in most Asian, American, and Australian countries, though this model is transposable to these countries.

3.1. Bioclimatic and Biogeographic Analysis

The highest pluviometric values are found in the mountains, which act as barriers to the trade winds, while the lowest values are recorded in the southwest of the island, where the ombrotype becomes semi-arid (Figures 2 and 3).

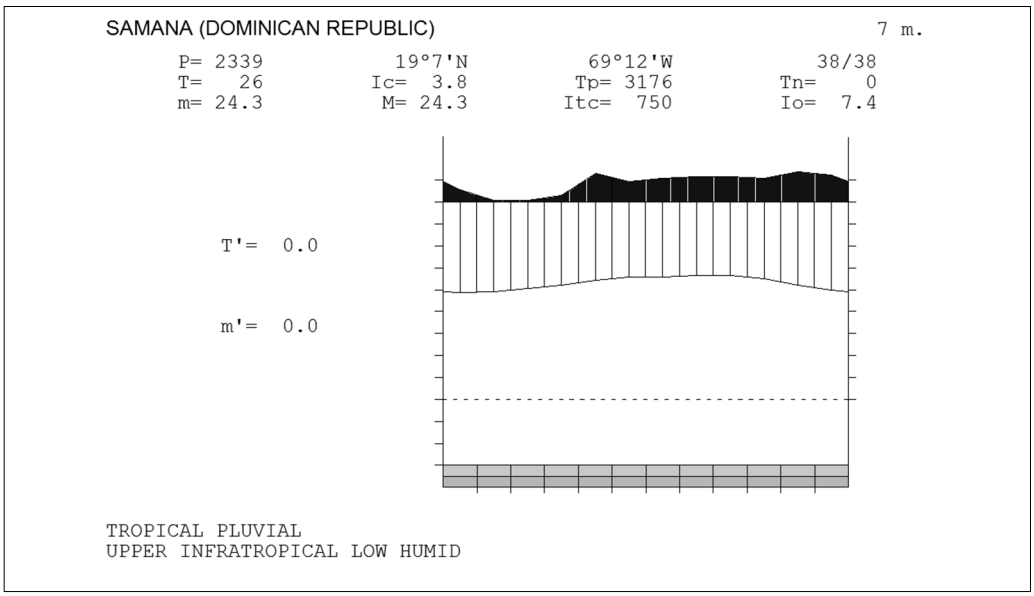


Figure 2. Bioclimatic diagram of the Samaná Peninsula, Dominican Republic. P = annual precipitation, T = mean annual temperature, M = mean temperature of the maximums of the coldest month, m = mean temperature of the minimums of the coldest month, T′= mean monthly temperature of the absolute maximums, m′ = mean monthly temperature of the absolute minimums, Tp = annual positive temperature, Tn = negative annual temperature, Ic = continentality index, Io = ombrothermal index, Itc = compensated thermicity index.

However, the Samaná Peninsula has low continentality (Ic = 3.8), high oceanity (Io = 7.4), and high thermicity (It/Itc = 750), which gives the territory an upper infratropical thermotype, and its ombrotype is classified as lower humid, with sub-humid to humid forests.

These Io values increase in the Cordillera Central, Sierras de Bahoruco, Neiba, and Cordillera Oriental, where sub-humid to humid forests dominate, including genera such as *Swietenia*, *Magnolia*, *Prestoea*, and *Cyathea* [67]. Conversely, at the opposite end of the island (Pedernales), the diagram indicates the same upper infratropical thermotype but a lower dry ombrotype, approaching semi-arid conditions, which allows for the presence of dry forest.

This dry forest is also found in the eastern plain with a sub-humid ombrotype, which is attributed to water loss through the porous substrate of coral origin. This phenomenon can be explained by incorporating the ombroedaphoxeric index into the bioclimatic study: Ioex = Pp − e/Tp × WR, where Pp = mean annual precipitation, Tp = positive temperature,

e = residual evapotranspiration, and WR = water retention capacity of the soil [9,68–70]. Regarding biogeography, we relied on the sector map developed by Cano et al. [43] (Figure 4).

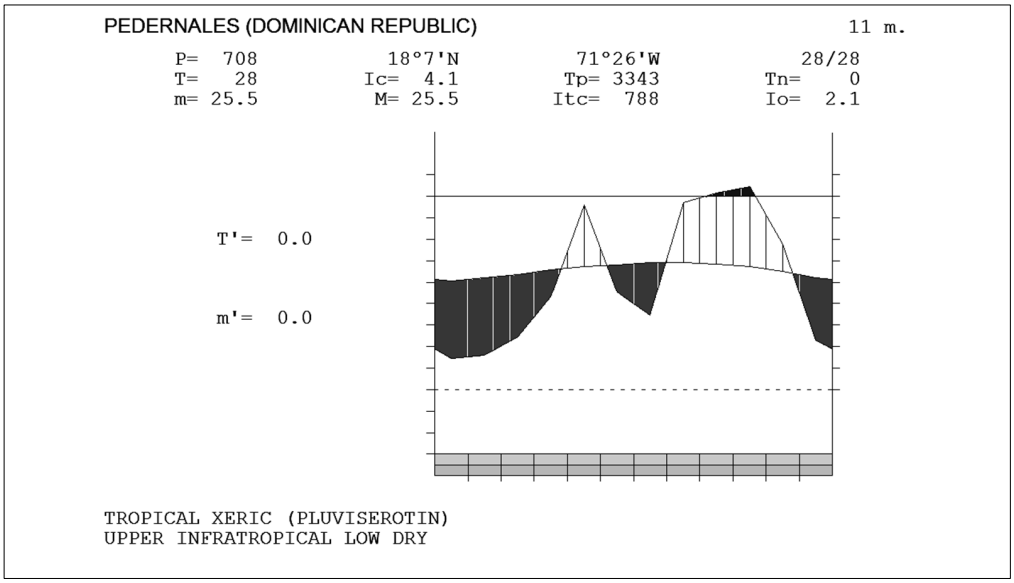


Figure 3. Bioclimatic diagram of Pedernales, Dominican Republic. P = annual precipitation, T = mean annual temperature, M = mean temperature of the maximums of the coldest month, m = mean temperature of the minimums of the coldest month, T′ = mean monthly temperature of the absolute maximums, m′ = mean monthly temperature of the absolute minimums, Tp = positive annual temperature, Tn = negative annual temperature, Ic = continentality index, Io = ombrothermal index, Itc = compensated thermicity index.

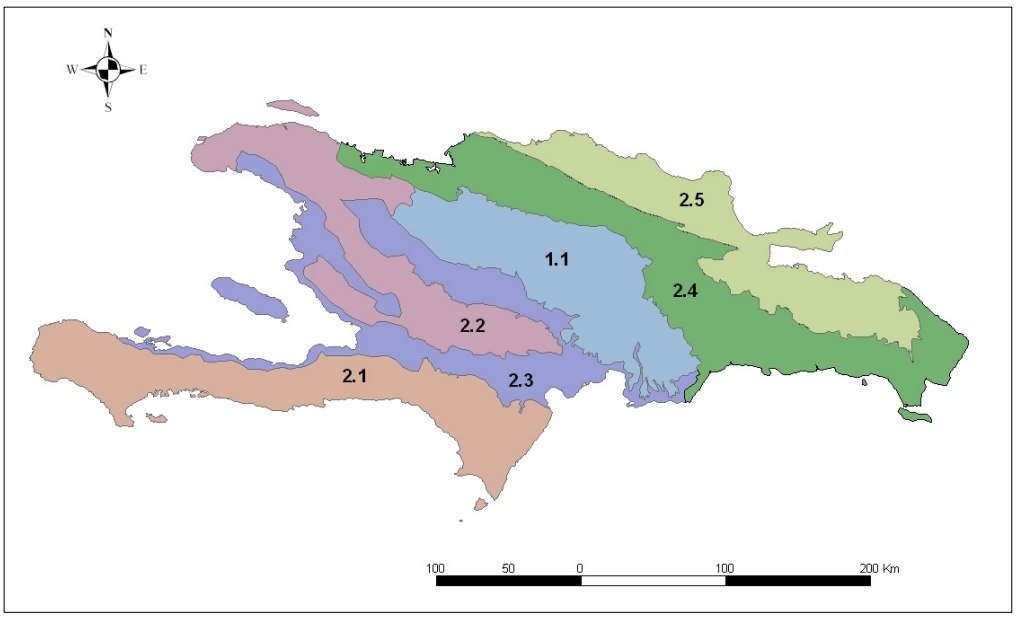


Figure 4. Map of the biogeographic sectors of La islã Española. 1.1 Centers. 2.1 Bahoruco-Hotense. 2.2 Neiba-Matheux-Northwest. 2.3 Azua- San Juán-Hoya Enriquillo-Puerto-Príncipe-Artiobonite-Gonaivës. 2.4 Caribe-Cibense. 2.5 North [43].

3.2. Analysis of Plant Communities

The cluster and Twinspan analyses distinguished two main forest groups in the Dominican Republic: humid forest (A) and dry forest (B). This classification serves as a primary criterion for differentiating these two broad groups. In the Twinspan analysis

(Figure 5), two groups of inventories were observed: A) The humid forest, dominated by *Didymopanax tremulus* Krug & Urb., *Hyeronima domingensis* Urb., *Magnolia hamorii* Howard, *Magnolia pallescens* Urb. & Ekm., *Prestoea montana* (Grah.) Nichol., *Alchornea latifolia* Sw., *Cyathea arborea* (L.) J.E. Smith, and *Cyathea furfuracea* Baker.

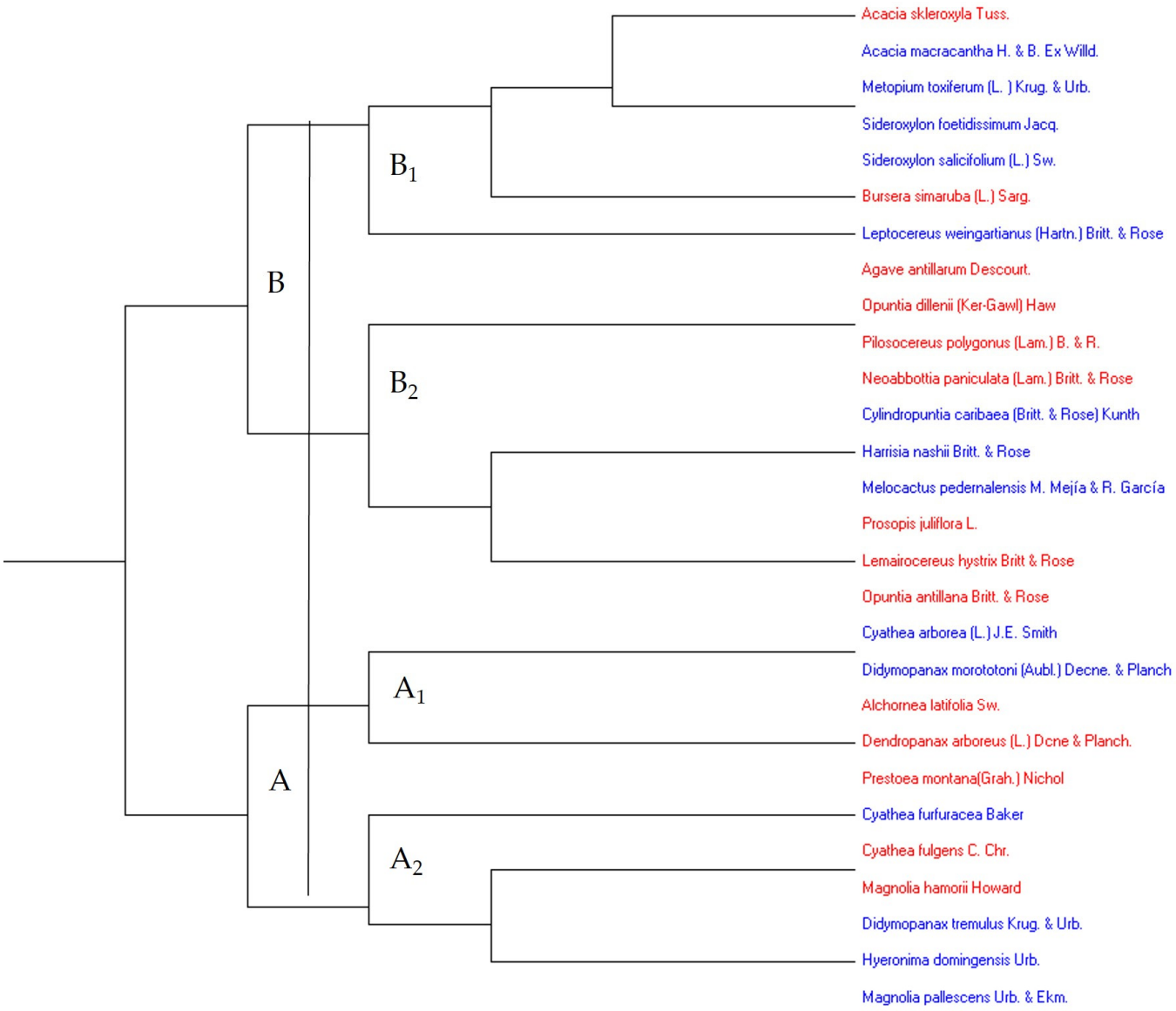


Figure 5. Twinspan dendrogram in which the red and blue colors express the relative distances between species populations. (A) Humid forest with subgroups A1 and A2. (B) Dry forest with two subgroups B1 and B2.

Subgroups A1 and A2 are included in group A. A1 represents the humid forests of the Eastern Cordillera and Haitises, which are altered forests with a low rate of endemism, as their Shannon_E diversity index (diversity of endemics) is zero according to the study by Cano-Ortiz et al. [67]. Subgroup A2 includes the humid forests of the Cordillera Central and Sierra de Bahoruco, with both populations at equivalent relative distances. The forests of *Magnolia hamori* Howard are specific to Sierra Bahoruco, while those of *Magnolia pallescens* Urb. & Ekm. are specific to the Central Cordillera.

(B) The dry forest, dominated by *Bursera simaruba* (L.) Sarg., *Metopium toxiferum* (L.) Krug & Urb., *Pilosocereus polygonus* (Lam.) B. & R., *Sideroxylon foetidissimum* Jacq., *Sideroxylon salicifolium* (L.) Sw., *Prosopis juliflora* L., *Lemairocereus hystrix* Britt & Rose, and *Acacia macracantha* H. & B. Ex Willd.

This group includes subgroup B1, which represents the forests of the eastern plains developed on coral limestone, with a sub-humid ombrotype. However, due to the low water retention capacity, the territory behaves as if dry (biogeographic unit 2.4). Subgroup B2 includes the semi-arid populations of Azua, Enriquillo, and Pedernales (biogeographic units 2.1 and 2.3).

To subgroup B1 (TWISPAN) belong the associations *Ass. Zamio debilis-Metopietum toxiferi* and *Ass. Chrysophyllo oliviformi-Sideroxyletum salicifolii*, phytocenoses that develop in sub-humid environments and on coral-origin substrates, where high water loss occurs, allowing the entry of xerophytic species.

To subgroup B2 (TWISPAN) belong the associations: *As. Coccotrino gracili-Burseretum simarubae*, *As. Harrisio nashii-Prosopidetum juliflorae*, *As. Crotono poitaei-Erythrosyletum rotundifolii*, *As. Lonchocarpo pycnophylli-Cylindropuntietum caribaeae*, and *As. Neoabbottio paniculatae-Guaiacetum officinali* [69].

Group A, which includes the type (C) inventories, represents the cloud forest with the associations *Hyeronimo montanae-Magnolietum pallescentis*, *Cyatheo furfuracei-Prestoetum montanae*, *Hyeronimo dominguensis-Magnolietum hamorii*, and *Ormosio krugii-Prestoetum montanae*.

In the dendrogram shown in Figure 6, three distinct groups of plant communities are identified at the cut-off level: Group B, which contains two subgroups, G1 and G2, including the type (R) inventories associated with dry forest communities.

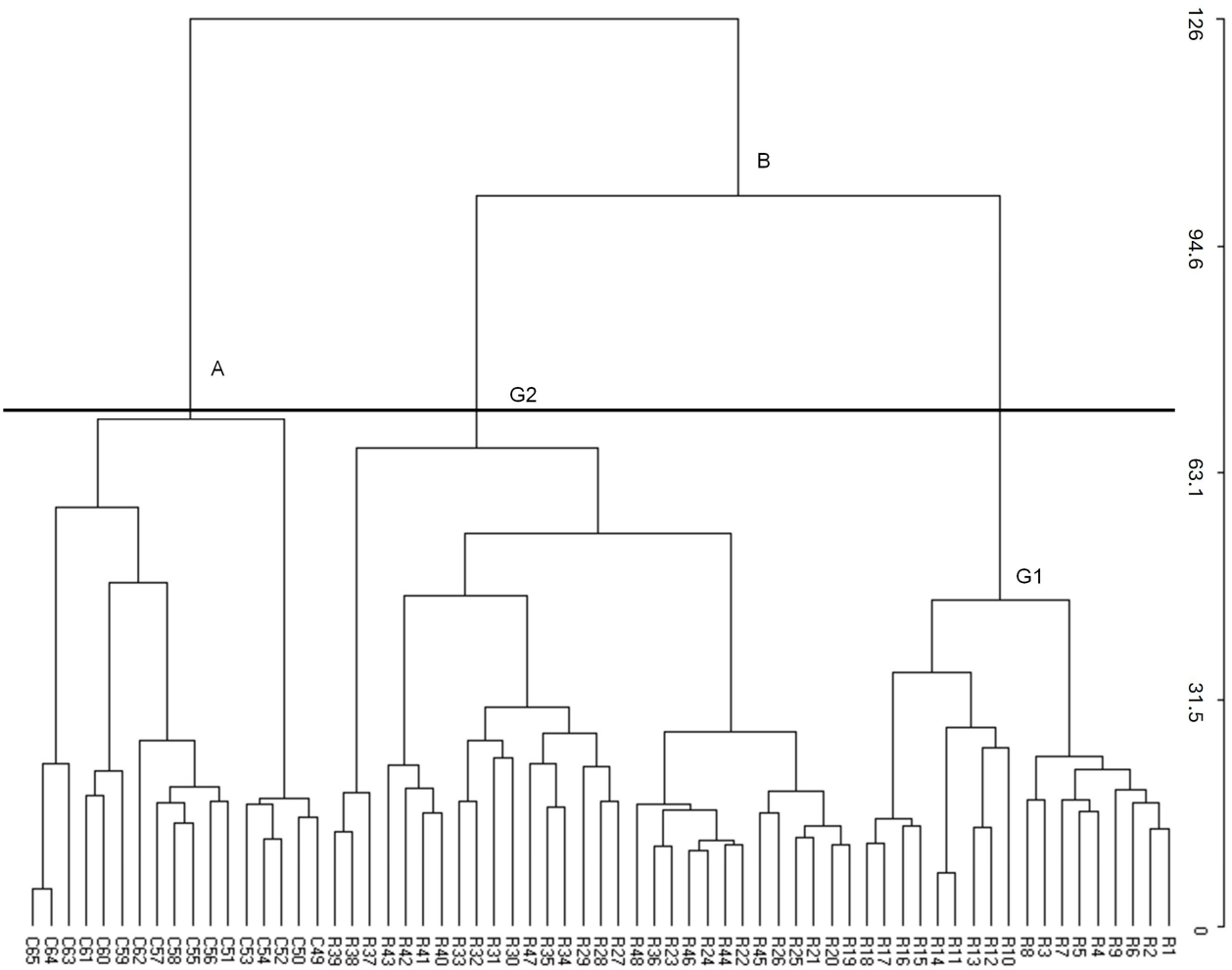


Figure 6. Diversity of forest types. Dry forest (R1–R48) (B) and cloud forest (C49–C65) (A). Dendrogram in which group A includes the inventories of the humid forest, dominated by species of *Cyathea, Prestoea, Didymopanax, Alchornea, Hyeronima,* and *Magnolia*. Group B includes two large subgroups, G1 and G2, which include the dry forest populations of Azua, Enriquillo, Pedernales, Cibao Valley, and Eastern Plains (biogeographic units 2.1, 2.3, and 2.4, respectively).

The results of the regression analysis are Maha: y = 0.08585x − 1.5, R^2 = −0.951; Sisa: y = 0.5799x − 0.4, R^2 = 0.9994; Meto: y = 0.4065x − 0.5, R^2 = 0.9979; Sifo: y = 0.0633x − 0.5, R^2 = 0.9708, highlighting the clear correlation between the abundance values for these species and the values for Io and ETP (Figure 7).

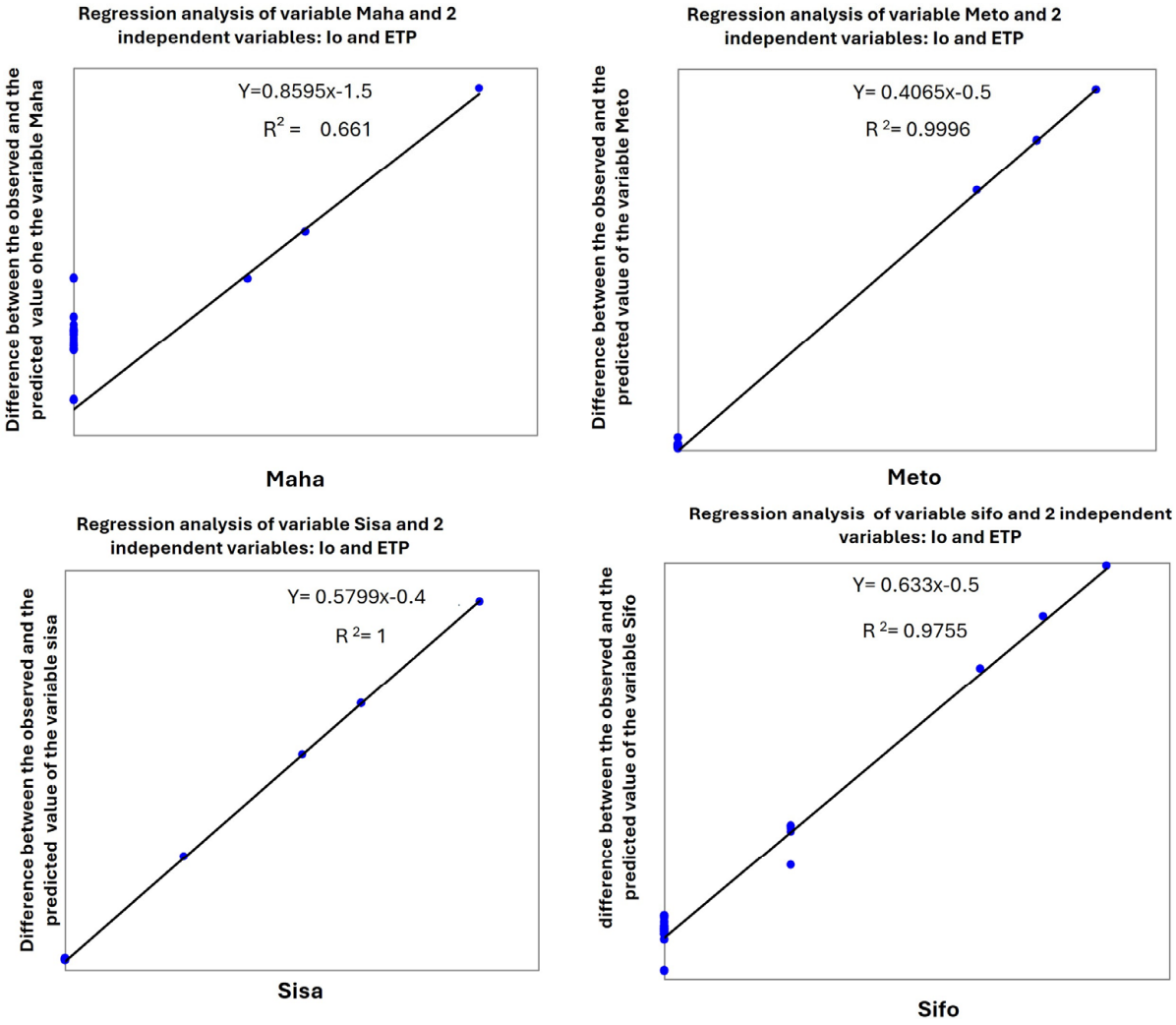


Figure 7. Regression analysis: Maha, Sifo, Sisa, Meto, and Io, ETP Maha = *Magnolia hamorii* Howard, Meto = *Metopium toxiferum* (L.) Krug. & Urb., Sisa = *Sideroxylon salicifolium* (L.) Sw., Sifo = *Sideroxylon foetidissimum* Jacq., Io = ombrothermic index, ETP = potential evapotranspiration.

The CCA analysis (Figure 8) shows two groups of inventories: R1-R39 (dendrogram), representing the dry forest and dominated by *Bursera simaruba* (L.) Sarg., Meto = *Metopium toxiferum* (L.) Krug. & Urb., *Pilosocereus polygonus* (Lam.) B. & R., Sifo = *Sideroxylon foetidissimum* Jacq., Sisa = *Sideroxylon salicifolium* (L.) Sw., *Prosopis juliflora* L., *Lemairocereus hystrix* Britt & Rose, and *Acacia macracantha* H. & B. Ex Willd.; and the group C40-C65, dominated by *Didymopanax tremulus* Krug. & Urb., *Hyeronima domingensis* Urb., Maha = *Magnolia hamorii* Howard, *Magnolia pallescens* Urb. & Ekm., *Prestoea montana* (Grah.) Nichol., *Alchornea latifolia* Sw., *Cyathea arborea* (L.) J.E. Smith, and *Cyathea furfuracea* Baker.

All the habitats described on the island of the Dominican Republic have a high index of endemic species, which highlights their special conservation importance, particularly those located on special substrates such as serpentinites [47] (Table 1). From a landscape perspective, the vegetation on serpentinites constitutes a catena (Geosigmetum) of conservation interest due to its high percentage of endemic floristic elements associated with serpentinites (Figure 9).

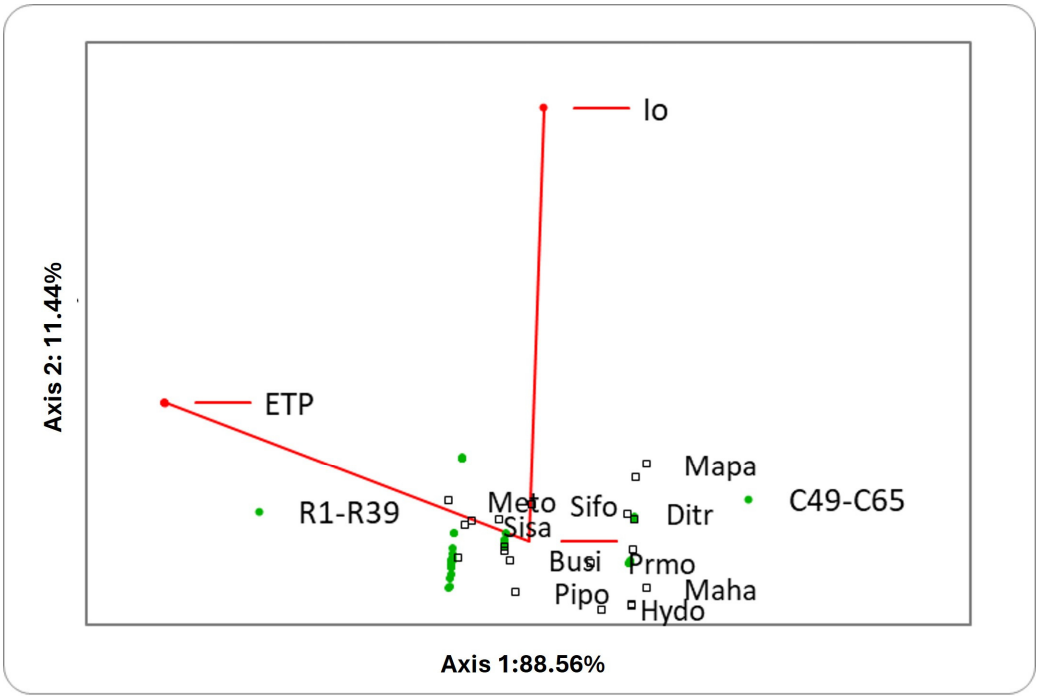


Figure 8. Canonical correspondence analysis (CCA). R1–R39 and C49–C65 of the dendrogram.

Table 1. Syntaxis of the different associations (endemic = E).

	1	2	3	4	5	6	7	ST
Acacia skleroxyla Tuss.	II				I	I	I	E
Agave antillarum Descourt.			V	I	II	V	III	E
Serjania sinuata (Poir.) Schum.	I			I	I	V	I	E
Guapira brevipetiolata (Heimerl) Alain	I			I	I		V	E
Pictetia sulcata (P. Beauv) Beyra & Lavin	I				I		IV	E
Leptocereus weingartianus (Hartn.) Britt. & Rose	I	I	IV		I			E
Cissus oblongo-lanceolata Krug & Urb.	I	II			I			E
Coeloneurum ferrugineum (Spreng.) Urb.	II					V		E
Galactia dictyophylla Urb.	I					V		E
Malpighia setosa Sprengel	I				I			E
Eugenia samanensis Alain		I			I			E
Comocladia cuneata Britton	I	III						E
Pereskia quisqueyana Alain	I	I						E
Hyperbaena brevipes Urb.	I	I						E
Lonchocarpus neurophyllus Urb.	II							E
Goetzea ekmanii O.E. Schulz	II							E
Poitaea dubia (Poiret) Lavin	I							E
Pseudophoenix sargentei Wendl *subsp. saoanae* (O.F.Cook.) Real	I							E
Diospyros domingensis (Urb.) Alain	I							E
Exostema acuminatum Urb.	I							E
Comocladia domingensis Britton	I							E
Consolea picardae (Urb.) Areces	I							E
Isidorea pungens (Lam.) B. L. Rob.	I							E
Melicococcus jimenezii (Alain) Acev. Rodr.	I							E
Cordia fitchii Urb.		I						E
Guettarda dictyophylla Urb.		I						E
Tabebuia obovata Urb.		I						E
Croton astrophorus Urb.			I	II	II			E
Coccotrinax gracilis Burret			V					E
Ipomoea viridiflora Urb.			IV					E
Pictetia sulcata (P. Beauv) Beyra & Lavin var. ternata (DC.) Urb.			I					E

Table 1. *Cont.*

	1	2	3	4	5	6	7	ST
Harrisia nashii Britt. & Rose				V	IV	V	I	E
Pavonia coccinea Cav.				I	I			E
Cordia salvifolia Juss. ex Poir.				I		III		E
Scolosanthus triacanthus (Spreng.) DC.				I	II		III	E
Melocactus lemairei (Monv.) Miq.				I	II		III	E
Gochnatia microcephala var *buchii* (Urb.) Alain					II		I	E
Croton poitaei Urb.				I	III			E
Caesalpinia buchii Urb.				I	II			E
Crossopetalum decussatum (Baill.) Lourteig				I	II			E
Karwinskia coloneura Urb.				I				E
Justicia abeggii Urb. & Ekm.				I				E
Lantana leonardorum Moldenke					II			E
Eupatorium sinuatum Lam. var *viscigerum* Urb. & Ekm.					II			E
Guettarda tortuensis Urb. & Ekm.					II			E
Solanum polyacanthum Lam.					I			E
Coccothrinax argentea (Lodd.) Sarg.					I			E
Lantana ciferriana Mold.					I			E
Catesbaea glabra Urb.					I			E
Cassine lanceolata (Urb. & Ekm.) *Alain*					I			E
Coccoloba leoganensis Jacq.					I			E
Coccoloba buchii Urb.					I			E
Lantana buchii Urb.					I			E
Galactia synandra Urb.					I			E
Isidorea pedicellaris Urb. & Ekm.					I			E
Poitaea multiflora (Sw.) Urb.					I			E
Solanum aquartia Dunal var *luxurians* (O.E. Schulz) Alain					I			E
Lantana pauciflora Urb.					I			E
Pseudocarpidium domingense (Urb. & Ekm.) Mold.					I			E
Croton gonaivensis Urb. & Ekm.					I			E
Lonchocarpus pycnophyllus Urb.						V		E
Cameraria linearifolia Urb.						V		E
Bonania domingensis Urb.						III		E
Bursera spinescens Urb. & Ekm.						III		E
Reynosia cuneifolia Urb. & Ekm.						III		E
Thouinidium inaequilaterum Alain						III		E
Caesalpinia domingensis Urb.						III		E
Ipomoea desrousseauxii Steud.						III		E
Annona bicolor Urb.						III		E
Coccoloba incrassata Urb.						I		E
Guettarda stenophylla Urb.						I		E
Eugenia pomifera (Aubl.) Urb.						I		E
Malpighia micropetala Urb.						I		E
Calliandra pedicellata Benth.						I		E
Chamaesyce adenoptera (Bertol.) Small						I		E
Melocactus pedernalensis M. Mejía & R. *García*						I		E
Thouinia domingensis Urb. & Radlk.						III	I	E
Neoabbottia paniculata (Lam.) Britt. & Rose							V	E
Plumeria subsessilis DC A..							I	E
Solanum microphyllum (Lam.) Dunal							IV	E
Mimosa diplotricha C. Wright							III	E
Eugenia lindalhlii Urb. & Ekm.							I	E
Coccotrinax spissa Bailey							V	E

1.-As. *Zamio debilis-Metopietum toxiferi* Cano & Veloz 2012. 2.-As. *Chrysophyllo oliviformi-Sideroxyletum salicifolii* Cano & Veloz 2012. 3.-*Coccotrino gracili-Burseretum simarubae* Cano, Cano-Ortiz & Veloz 2015. 4.-*Harrisio nashii-Prosopidetum juliflorae* Cano Ortiz & Veloz in Cano Ortiz et al., 2015. 5.-*Crotono poitaei-Erythrosyletum* rotundifolii Cano Ortiz & Veloz in Cano Ortiz et al., 2015. 6.-*Lonchocarpo pycnophylli-Cylindropundietum caribaeae*. Cano Ortiz & Veloz in Cano Ortiz et al., 2015. 7.-*Neoabbottio paniculatae-Guaiacetum officinali*. Cano Ortiz & Veloz in Cano Ortiz et al., 2015. ST = status. E = endemic.

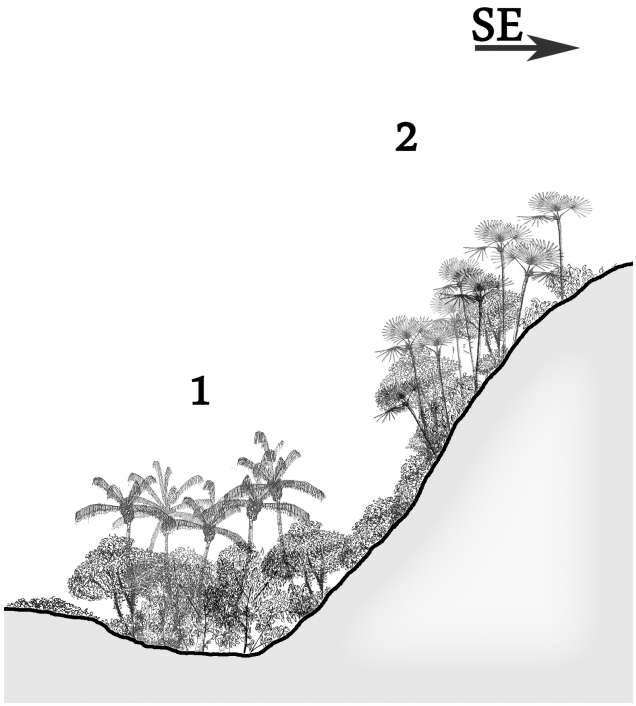


Figure 9. Dry sub-humid forest on serpentinites in the Sierra de Yamasa. 1 and 2: Palm forest (*Coccothrinax argentea*) present in the *Crotono poitaei-Erythrosyletum rotundifolii* association, with abundant intricate thickets rich in serpentine species.

The humid forest (A) is well represented in the biogeographic district units A1, A5, A6, A12, and A16 (Figure 10), with Cordillera Central (A16) harboring the greatest number of endemic species and where the humid forest (broadleaf) is better conserved. The following rainforest associations belong to this group: *Cyatheo furfuracei-Prestoetum montanae*, *Ormosio krugii-Prestoetum montanae*, *Hyeronimo montanae-Magnolietum pallescentis*, and *Hyeronimo dominguensis-Magnolietum hamorii*, each differentiated by the presence of endemic species exclusive to each syntaxon (Table 2) [67].



Figure 10. 1. Broadleaf forest. 2. As. *Cyatheo furfuracei-Prestoetum motanae*. 3. Phytocenosis of *Didymopanax morotononi*. 4 and 5. *Pinus occidentalis* pine forest with *Danthonia dominguensis* in the open areas.

Table 2. Summary table of the different associations (endemic = E).

	As1	As2	As3	As4	ST
Rondeletia ochracea Urb.	V	II	IV		E
Arthrostylidium multispicatum Pilger	V	V	II		E
Didymopanax tremulus Krug. & Urb.	IV	I	IV		E
Mikania venosa A. Liogier	II	III	V		E
Lobelia rotundifolia Juss.	III	I	I		E
Macrocarpaea domingensis Urb.	IV		II		E
Polygala fuertesii (Urb.) Blake	III		II		E
Marcgravia rubra A. Liogier	IV		I		E
Odontadenia polyneura (urb.) Wood.	II	I			E
Pleurothallis domingensis Cogn.	I	II			E
Cestrum coelophlebium O. E. Schulz	I	II			E
Gonocalyx tetrapterus A. Liogier	V				E
Hyeronima montana A. Liogier	V				E
Magnolia pallescens Urb. & Ekm.	V				E
Persea oblongifolia Kopp.	V				E
Styrax ochraceus Urb.	V				E
Tabebuia vinosa A. Gentry	V				E
Cinnamomum alainii (C.K. Allen) A. Liogier	IV				E
Pinguicula casabitoana J. Jiménez	III				E
Chaetocarpus domingensis Proctor	II				E
Lyonia alainii W. Judd.	I				E
Myrsine nubicola A. Liogier	I				E
Sagraea fuertesii (Cogn.in Urb.) Alain		II	I		E
Senecio lucens (Poir) Urb.		III			E
Tabebuia bullata A. Gentry		IV			E
Blechnum tuerckheimii A. Brause		III			E
Cestrum inclusum Urb.		I			E
Ipomoea furcyensis Urb.		I			E
Lobelia robusta Graham		I			E
Malpighia macracantha Ekm. & Nied.		I			E
Pilea geminata Urb.		I			E
Columnea domingensis (Urb.) Wiehler			V		E
Lasianthus bahorucanus Zanoni			V		E
Magnolia hamorii Howard			V		E
Mecranium ovatum Cog.			V		E
Vriesea tuercheimii (Mez.) L.B. Smith			V		E
Calyptrantes selleanus Urb. & Ekm.			IV		E
Hedyosmum domingense Urb.			IV		E
Hyeronima domingensis Urb.			IV		E
Hypolepis hispaniolica Mason			II		E
Meriania involucrata (Desv.) Naud.			II		E
Ocotea acarina C. K. allen			II		E
Cestrum daphnoides Griseb.			I		E
Cordia dependens Urb. & Ekm.			I		E
Ilex tuerckheimii Loes.			I		E
Leandra limoides (Urb.) W. Judd & Skean			I		E
Bactris plumeriana Mart.				III	E

As1.—*Hyeronimo montanae-Magnolietum pallescentis* Cano et al., 2020. As2.—*Cyatheo furfuracei-Prestoetum motanae* Cano, Cano Ortiz & Veloz in Cano Ortiz et al., 2020. As3.—*Hyeronimo dominguensis-Magnolietum hamorii* Cano, Cano Ortiz & Veloz in Cano Ortiz et al., 2020. As4.—*Ormosio krugii-Prestoetum montanae* Cano, Cano Ortiz & Veloz in Cano Ortiz et al., 2020. ST = status. E = endemic.

These associations in the vegetation catenas are located in areas with higher precipitation, forming distinct landscape units depending on the existing substrates (Figures 10–12).

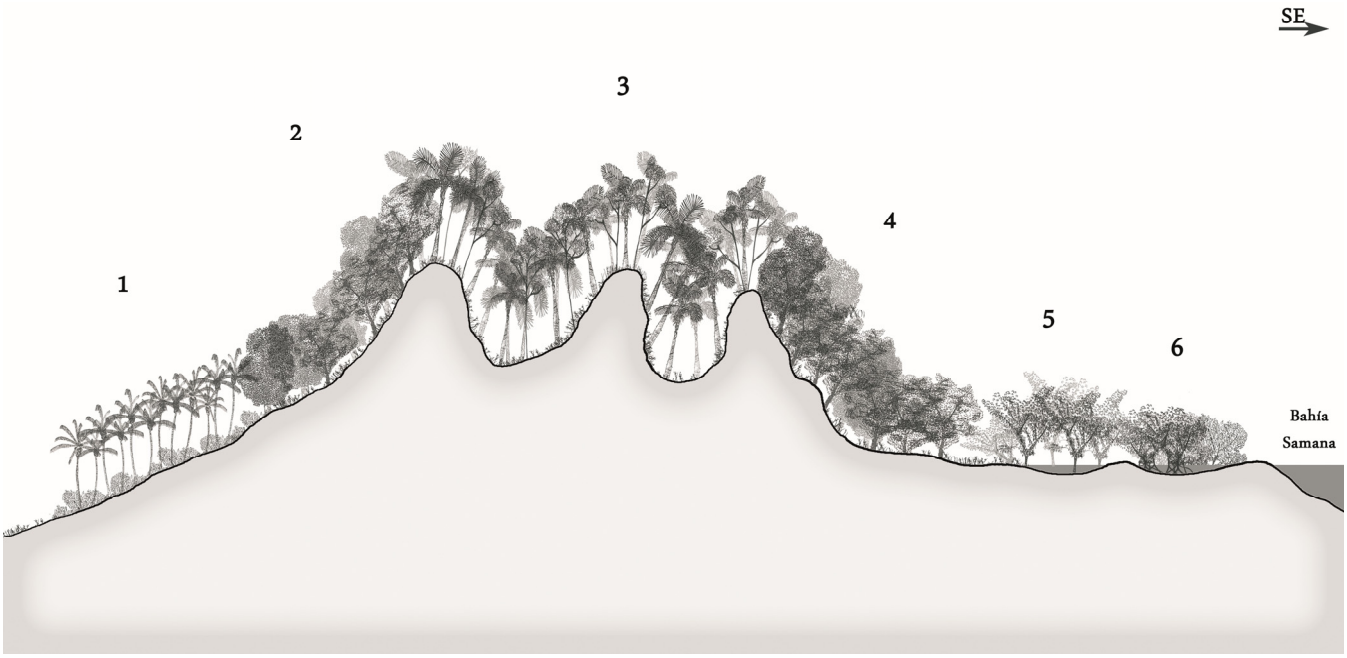


Figure 11. Humid–hyperhumid vegetation of the Haitises (Mogotes). 1. Cultivated coconut trees. 2 and 5. Forests of *Swietenia mahagoni.* 3. As. *Ormosio krugii-Prestoetum montanae*. 4. and 5. *Didymopanax morotononi* forest. 6. Mangrove.

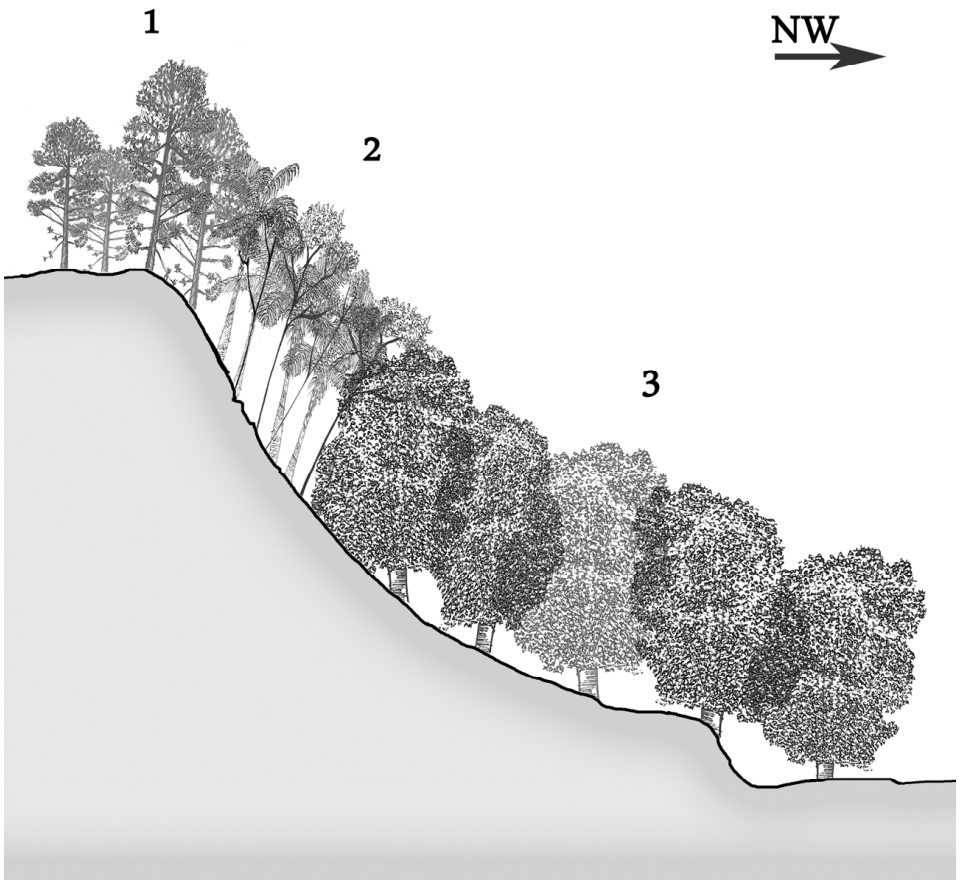


Figure 12. Vegetation of rainy environments (Sierra de Neiba). 1. *Pinus occidentalis* pine forest. 2. Forest of *Prestoea* montana. 3. Broadleaf forest of *Swietenia mahagoni.*

Some species, such as *Pinus caribaea*, form mixed forests with other tropical tree species and give name to the vegetation class *Byrsonimo-Pinetea caribaea* Samek & Borhidi in Borhidi et al. 1979 [71,72]. This tropical species, outside its native distribution area (Central America), can become invasive in some Asian countries [73]. For the catenal contact between different forest types, we follow Rivas-Martínez [74].

The biogeographical study conducted was primarily based on the distribution of 1582 endemic species across 19 areas (A1–A19) with a regional range (Figure 13), with the highest number of endemics located in the Bahoruco-La Selle (A12) and Cordillera Central (A16) areas [10].

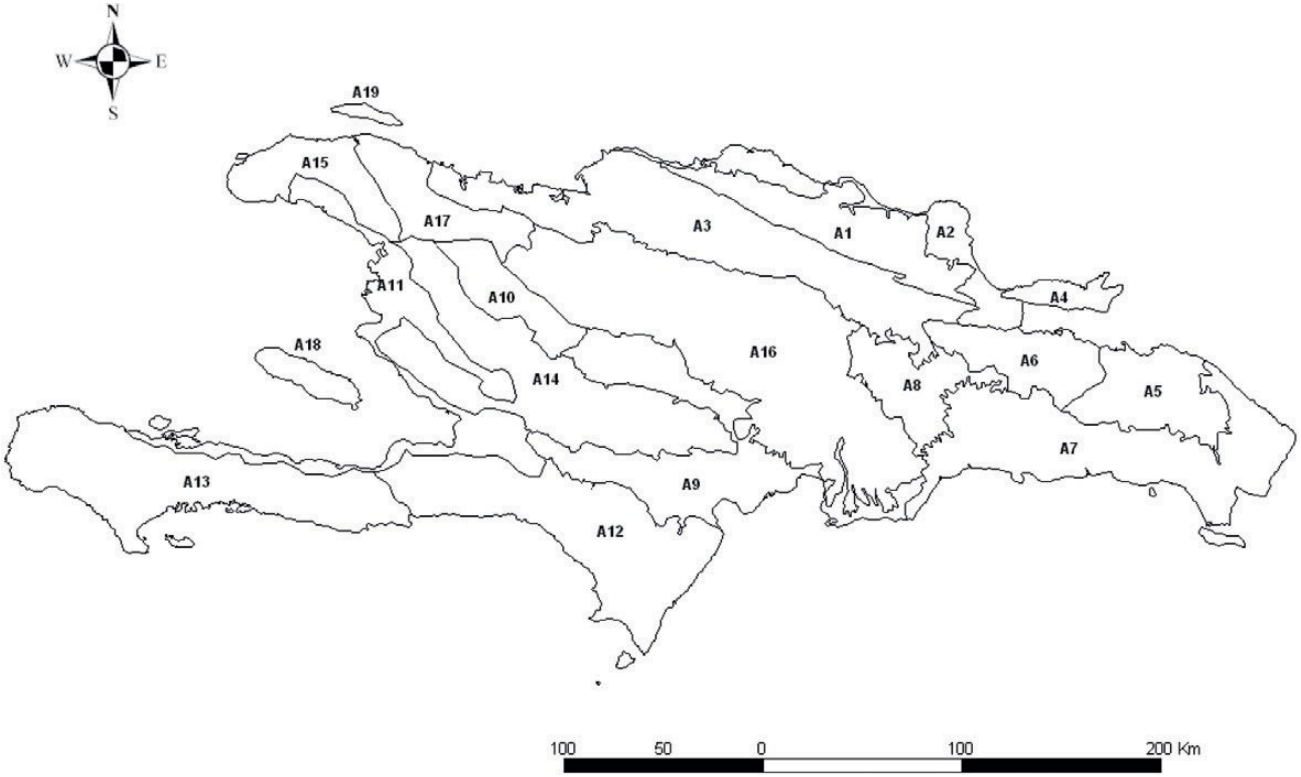


Figure 13. Map of the biogeographic zones (districts) of Hispaniola. A1. Northern Cordillera. A2. Coastal-Atlantic District. A3. Cibao Valley. A4. Samanense. A5. Oriental. A6. Haitian. A7. Oriental-Caribbean. A8. Yamasense. A9. Azua-Sán Juan-Lake Herniquillo. A10. Central Plain (Haiti). A11. Port-au-Prince-Ariobonita-Gonaivës. A12. Bahoruco-La Selle. A13. Hottense. A14. Neiba-Matheux. A15. Northwest Haiti. A16. Central-East. A17. Center-West (Massif du Nord). A18. Gonave Island. A19. Tortuga Island.

The study of the 19 areas of Hispaniola showed a total diversity of 2094 endemic species, of which 1162 are specific to each of the 19 biogeographic districts. As shown in Figure 14, the areas with the highest diversity of specific endemisms are A12 and A16, while those with the lowest index of endemisms are A5, A8, and A10 [11].

In relation to the second objective of this proposal, to establish a model of educational intervention through immersion in a natural environment, numerous authors highlight the effectiveness of this methodology, based on the direct interaction of the individual with the environment. Authors such as Samper and Ramírez [75] indicate that experiential learning allows the student to participate directly in the construction of their learning, working from the same context with new content.

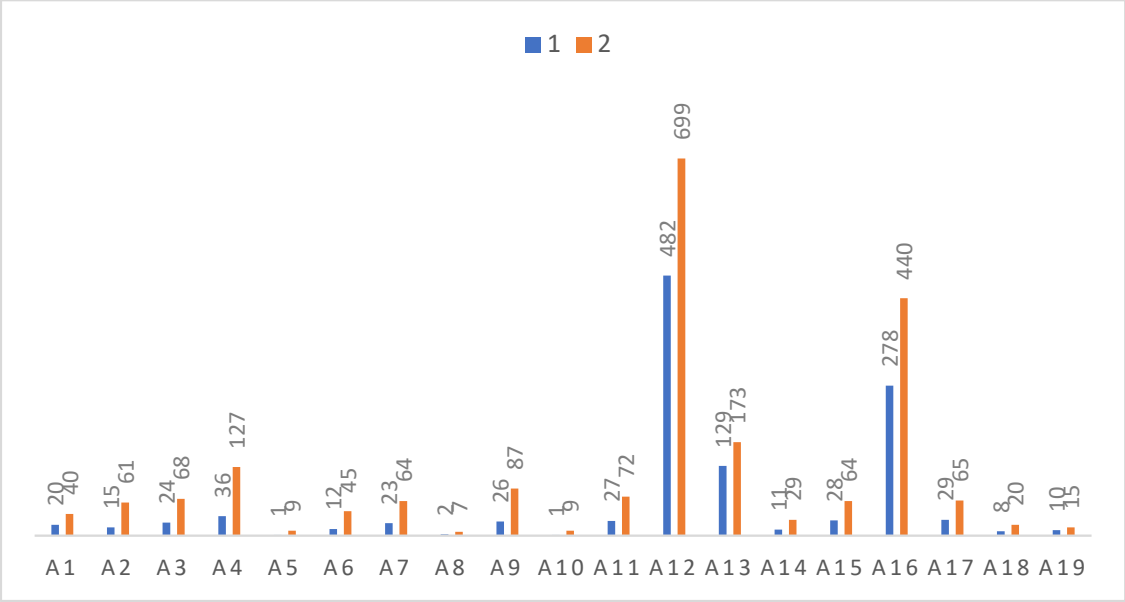


Figure 14. Analysis of the diversity of endemisms unique to a biogeographic district (1) and the total number of endemisms in that district (2). Districts A1–A19.

Based on the findings of these previous authors, the natural environment was revalued as an educational medium, and through this work, we came to propose the four steps of our purely active proposal:

1. Status of the Research Area. Biogeographic and Bioclimatic Study:
   - o Description of the study area.
   - o Initial contextualization to understand the relevance of the topic.
   - o Based on previous research and the work of Rivas-Martínez.
   - o Obtaining bioclimatic diagrams to classify the area.
2. Bibliographic Reference Search:
   - o Compilation of geological, edaphological, climatic, bioclimatic, and biogeographical information.
   - o These references frame the problem and provide a solid basis for the research.
3. Plot Selection and Phytosociological Methodology. Transformation of Phytosociological Indices. Statistical Treatment and Forest Separation:
   - o Decision on sampling plots.
   - o Use of phytosociological methodology according to the Central European school.
   - o Species identification using abundance–dominance indices.
   - o Transformation of the indices to Van der Maarel's indices for statistical treatment.
   - o Twinspan application to differentiate dry and wet forests.
   - o Analysis of invasive and catenal species among forest types.
4. Phytosociological analysis. Comparative Analysis of Species Diversity:
   - o Classification of forests into specific associations (Appendix A)
   - o Inclusion in a hierarchical system of ranks (Appendix A)
   - o Evaluation of the diversity of characteristic and companion species.
   - o Estimation of conservation status based on relationship and abundance of endemism.
   - o Integrated landscape analysis

The following phases in the analysis were studied: the area, the flora [50], the differentiation between characteristic and companion species [62], and the inclusion of the previously described associations and their catenary contacts [74].

4. Discussion

The four research steps outlined in the methodology guide the university researcher in learning how to establish a rationale for the work sequence, acquiring essential concepts such as the concept of association and characteristic or companion species [62], ultimately leading to the elaboration of phytosociological tables and an analysis of the flora, with a special emphasis on the endemic species present in the association [8,9].

From the presence in the phytosociological inventories, synthetic tables are elaborated, focusing on the endemisms present, to discern the endemic character of the plant association and to establish the degree of conservation. In this case, districts A5, A8, and A10 are those with the lowest number of endemisms, particularly in district A5 (Eastern Cordillera), where the association *Ormosio krugii-Prestoetum montanae* (As4) is located, with only *Bactris plumeriana* Mart. found as endemic, due to significant anthropic action.

In the comparative study of the diversity of the four associations As1–As4 by Cano-Ortiz et al. [67], using the Shannon index, the total diversity of the association is analyzed, including the totality of species present in the association, Shannon_T, versus the diversity of characteristic and companion species, Shannon_Ca and Shannon_Co. The difference between these last two values reflects the conservation status of the association and, consequently, the habitats.

Whenever Shannon_Ca > Shannon_Co, we accept that the association is stabilized, while there is a risk of disappearance if Shannon_Ca $\leq$ Shannon_Co.

Considering that alpha diversity (α) represents local diversity, and since several plant associations can coexist in the same locality, with beta diversity (β) representing the replacement of local species by species from other communities, the oscillation in the number of individuals [76,77] means that it is not always clear whether the plant association is well conserved.

As the plant association consists of a set of faithful characteristic species and other introgressive species from neighboring communities, it is logical to apply the diversity indices to all species present in the association, to the characteristic species, and to the companions to determine whether the association is stable or not.

In the case of humid forests, associations As1–As3 are well conserved. However, As4, located in the Eastern Cordillera is endangered due to anthropic action, which has caused the disappearance of endemic species.

According to Mejía & Jiménez [57], the endemicity was 32%, and the subsequent number of endemic taxa was 2050 out of a total of 6000 species, representing 34.16%. These species are included in 1284 genera, making the island of Hispaniola one of the world's main biodiversity hotspots due to its high percentage of endemicity. This highlights the need to promote the island's high conservation value at both social and educational levels [14,15].

Based on previous research conducted by the authors and a series of articles published in the journal *Moscosoa* on the flora and vegetation of the Dominican Republic [42–58], we proceeded to establish the method for teaching research. We considered that learning about vegetation, and especially forest diversity, enhances the cognitive development of individuals [78], promotes interdisciplinary learning, develops students' observation skills, and fosters problem-solving abilities [79,80]. To develop learning about the two types of forests and their conservation status, teaching for sustainable development is desirable, emphasizing a critical and nature-centered approach [81–83].

This vegetation teaching proposal enables students to conduct a comparative analysis of ecological and phytosociological methodologies. While both methods share the ultimate goal of enhancing vegetation knowledge, they display both similarities and differences, as highlighted in various studies [84–88]. Methodologically, these approaches align in certain aspects, such as the analysis of environmental factors and the determination of minimum area requirements. However, they diverge in the selection of sampling plots: ecological methods often employ random transects, whereas in the phytosociological approach, sampling plots must be ecologically and physiognomically homogeneous. Additionally, there are differences in the indices used to determine species abundance. Both methodologies

are clearly effective for vegetation study, though we chose the phytosociological method of the Central European school, a widely adopted approach in EU countries.

However, this is not always possible, either due to institutional barriers [89] or a lack of knowledge among those managing the education of green spaces, which leads them to undervalue these areas as formative laboratories. For these reasons, we propose the following model, consisting of a series of steps within the exploration process, which can have a significant impact on the research of young people beginning their journey in this field.

The proposed methodology promotes the direct immersion of students in the natural environment to foster experiential learning [90,91]. Through this methodological proposal, inquiry and direct observation are established, allowing students to freely explore the environment, observing and documenting their findings. Subsequently, practical and experiential activities will be carried out [92,93], including activities such as sample collection and phytosociological analysis.

In this teaching method, it is important to note that theoretical instruction typically outweighs practical teaching in most universities and research centers, a tradition that has persisted over time. To address this, we propose a practical, field-based approach outside the classroom, known as the 'flipped classroom' [94,95], alongside project-based learning. This approach includes field practices where students learn to collect ecological and floristic data and develop sampling techniques, complemented by a bibliographic study to obtain essential climatic data needed for calculating bioclimatic indices and creating bioclimatic diagrams.

Through a discussion process, critical thinking and the exchange of ideas about the environment and its conservation will be encouraged, which can be assessed through a structured interview [96].

The proposed didactic model not only facilitates the understanding of the diversity and conservation of the forests of the Dominican Republic, in line with what Ardoin et al. propose on education and conservation [15], but also serves as an effective pedagogical tool for training future researchers, strengthening the learning and integration of students in the natural environment [17,20,21,34]. This methodological approach enables students to acquire practical and theoretical skills through direct application in a natural environment. By following the phases of the model, students learn to carry out the following:

1. Identify and select relevant study areas.
2. Develop skills in the search and analysis of bibliographic and field information.
3. Apply phytosociological sampling and analysis techniques: enabling students to understand the structure and composition of phytocenoses and to identify plant associations.
4. Perform statistical treatments and biogeographical analysis: facilitating data interpretation and predictive modeling.
5. Evaluate the conservation and dynamics of ecosystems: through the study of vegetation catenas and the identification of factors affecting biodiversity.

Student learning with the proposed method, in which education, sustainability, and development are interrelated according to Kopnina [81] and Garvey [83], should be enhanced, especially in developing countries with high botanical–ecological values.

It is observed that learning via this methodological research proposal is highly satisfactory for university students. In this context, the student learns and is motivated by knowledge, gaining the ability to identify vegetation associations and catenas, internalizing the ridge–slope–valley concept, and ultimately making an integrative interpretation of the landscape [97]. This learning enables effective environmental management in any territory, as the proposed methodology has universal applicability.

With this sequential research method, students acquire sufficient knowledge to act in real life as environmental managers. In addition, there is an increase in self-esteem, and they improve their environmental, social, and leadership skills, which is highly beneficial for transmitting these values to society [98–100]. Studies by various authors clearly demon-

strate the significant influence of environmental education on academic performance and the acquisition of positive attitudes toward the environment [100–104]. This impact is observed universally across different environments and countries, reinforcing the rationale for this educational proposal aimed at university students.

5. Conclusions

Once the four steps proposed for the investigation of the territory have been completed, which any university student can follow using this model, the following conclusions can be drawn.

The insular phenomenon of the island of Hispaniola results in a high rate of endemism both in the mountains and in the valleys. This particularity also makes the habitats themselves endemic, requiring special protection measures to preserve the unique biodiversity of the region.

It is essential to promote a thorough knowledge of the habitats, including a detailed initial description of their flora and plant associations. This knowledge is crucial for the implementation of effective and well-informed conservation strategies.

The biodiversity of the endemic habitats of the Dominican Republic's forests and their dynamic stages are represented in 35 plant associations, 14 alliances, 9 orders, and 9 phytosociological classes, according to the proposed taxonomic scheme. This detailed classification highlights the complexity and ecological richness of the island's forest ecosystems.

The conservation status of humid and dry forests shows significant differences depending on the level of anthropic action in each area. It is essential to apply specific conservation measures tailored to each forest type to ensure their long-term preservation.

Based on existing information on Caribbean vegetation, the conservation of all phytocenoses with a high percentage of endemic species is proposed. This action is crucial not only to maintain biodiversity but also to preserve the essential ecological functions of these forest ecosystems.

The research method proposed in this study not only advances scientific knowledge but also serves as an effective didactic tool for training future researchers. Students acquire essential practical and theoretical skills through the direct application of the method in a real study environment.

Finally, the application of this method in higher education fosters the development of critical research skills in students, preparing them to contribute effectively to biodiversity conservation and management in their future careers. This approach to teaching ensures that the next generation of researchers will be well-prepared to address the environmental challenges of the future.

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Appendix A

We collect in this appendix the syntaxa published so far on the island of Hispaniola (9 phytosociological classes, 9 orders, 14 alliances and 35 associations).

CHRYSOBALANO-ANNONETEA GLABRAE Borhidi & Muñiz in Borhidi, Muñiz & Del-Risco 1979

Tabebuio-Bucidetalia (Lvov 1967) Borhidi & Del-Risco in Borhidi, Muñiz & Del-Risco 1979

Marcgravio rubrae-Pterocarpion officinalis Cano, Velóz, Cano-Ortiz et Esteban Ruiz 2009
1-*Roystoneo hispaniolanae-Pterocarpetum officinalis* Cano, Velóz, Cano-Ortiz et Esteban Ruiz 2009
BYRSONIMO-PINETEA CARIBAE Samek and Borhid in Borhidi et al. 1979
Pinetalia occidentalis-maestrensis Knapp 1964 in Borhidi et al. 1979
Ilici tuerckheimi-Pinion occidentalis Cano, Velóz et Cano-Ortiz 2011
1-*Dendropemon phycnophylli-Pinetum occidentalis* Cano, Velóz et Cano-Ortiz 2011
2-*Cocotrino scopari-Pinetum occidentalis* Cano, Velóz et Cano-Ortiz 2011
RHIZOPHORO-AVICENNIETEA GERMINANTIS Knapp (1964) em. Borhidi & Del-Risco in Borhidi et al. 1979
Rhizophoretalia Cuatrecasas 1958
Al. Dalbergio-Rhizophorion manglis (Borhidi 1991) Cano, Cano-Ortiz, Velóz, Alatorre et Otero 2012
1-*Machario lunati-Rhizophoretum manglis* Cano, Cano-Ortiz & Velóz ex Cano, Cano-Ortiz, Velóz, Alatorre et Otero 2012
Avicennietalia germinantis Cuatrecasas 1958
Conocarpo-Laguncurion racemosae Cuatrecasas 1958
2-*Batidi-Avicennietum germinantis* Borhidi & Del-Risco & Borhidi 1991
(syn. As. *Laguncurio racemosae-Avicennietum germinantis* Reyes & Acosta 2003; As. *Avicennietum germinantis* Reyes & Acosta 2003)
3-*Rhabdadenio biflorae-Laguncularietum racemosae* Cano, Cano-Ortiz & Velóz ex Cano, Cano-Ortiz, Velóz, Alatorre et Otero 2012
4-Conocarpo erectae-Coccolobetum uviferae Reyes in Reyes & Acosta 2003
(syn. *Conocarpetum erectae* Reyes in Reyes & Acosta 2003)
5-*Sthalio monospermae-Laguncularietum racemosae* Cano, Cano-Ortiz & Velóz ex Cano, Cano-Ortiz, Velóz, Alatorre et Otero 2012
6-*Lonchocarpo pycnifolii-Conocarpetum erecti* Cano, Cano-Ortiz & Velóz ex Cano, Cano-Ortiz, Velóz, Alatorre et Otero 2012
TABEBUIO-BURSERETEA Knapp (1964) Borhidi 1991
Tabebuio-Burseretalia Knapp (1964) Borhidi 1991
Leptogono buchii-Tabebuion berterii Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
1-*Coccotrino argentei-Tabebuietum berterii* Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
2-*Zombio antillari-Leptogonetum buchii* Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
Calliandro haematommae-Phyllanthion nummularioidis Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
3-*Garcinio glaucescentis-Phyllanthetum numularioidis* Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
4-*Tabebuio ophiolithicae-Randietum aculeati* Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
PHYLLANTHO-NEOBRACETEA VALENZUELANAE Borhidi & Muñiz in Borhidi et al. 1979
Ariadno-Phyllanthetalia Borhidi & Muniz in Borhidi et al. 1979
Tetramicro canaliculatae-Leptochloopsion virgatae Cano, Velóz et Cano-Ortiz 2010
1-*Leptogono buchii-Leptochloopsietum virgatae* Cano, Velóz et Cano-Ortiz 2010
Rondeletio christii-Pinion occidentalis Cano, Cano-Ortiz, del Río, Velóz et Esteban Ruíz 2014
2-*Leptogono buchii-Pinetum occidentalis* Cano, Veloz & Cano Ortiz 2011
COCCOTHRINACETO-PLUMERIETEA Knapp in Boirhi 1991
Lantano-Cordietalia Borhidi in Borhidi et al. 1979
Crotono poitaei- Leptochloopsion virgatae Cano, Velóz et Cano-Ortiz 2010
1-*Crotono astrophori-Leptochloopsietum virgatae* Cano, Velóz et Cano-Ortiz 2010
2-*Melocacto pedernalensis-Leoptochloopsietum virgatae* Cano, Velóz et Cano-Ortiz 2010
3-*Solano microphylli-Leptochloopsietum virgatae* Cano, Velóz et Cano-Ortiz 2010
Pseudocarpidio-Guettardion Borhidi & Muñiz in Borhidi 1986

1-*Guettardo ellipticae-Guapiretum discoloris* García Fuentes et al. 2015
Eugenio-Metopietalia toxiferi Knapp (1942) Borhidi 1991
Eugenio-Capparidion Borhidi in Borhidi et al. 1959
4-*Chrysophyllo oliviformi-Sideroxyletum salicifolii* Cano & Velóz 2012
5-*Zamio debilis-Metopietum toxiferi* Cano & Velóz 2012
6-*Coccotrino gracili-Burseretum simarubae* Cano, Cano-Ortiz et Velóz 2015
CERCIDI-CEREETEA Borhidi 1996
Ritterocereetalia hystricis Borhidi 1996
Harrio nashii–Acacion skleroxylae Cano, Cano-Ortiz & Velóz ex Cano-Ortiz, Musarella, Spampinato, Velóz 2015
1-*Harrisio nashii–Prosopidetum juliflorae* Cano, Cano-Ortiz & Velóz ex Cano-Ortiz, Musarella, Spampinato, Velóz 2015
2-*Crotono poitaei–Erythroxyletum rotundifolii* Cano, Cano-Ortiz & Velóz ex Cano-Ortiz, Musarella, Spampinato, Velóz 2015
3-*Lonchocarpo pycnophylli–Cylindropuntietum caribaeae* Cano, Cano-Ortiz &Velóz ex Cano-Ortiz, Musarella, Spampinato, Velóz 2015
4-*Neoabbottio paniculatae–Guaiacetum officinalis* Cano, Cano-Ortiz & Velóz ex Cano-Ortiz, Musarella, Spampinato, Velóz
5-*Simaroubetum berteroani* García Fuentes et al. 2015
6-*Phllostylo rhamnoidis-Prosopidetum juliflorae* García Fuentes et al. 2015
7-*Consoleo moniliformis-Camerarietum linearifoliae* García Fuentes et al. 2015
8-*Lemairoceo hystricis-Prosopidetum juliflorae* García Fuentes et al. 2015
9-*Lycio americani-Prosopidetum juliflorae* García Fuentes et al. 2015
WEINMANNIO-CYRILLETEA Knapp 1964
Weinmannio-Cyrilletalia Knapp 1964
Rondeletio ochraceae-Clusion roseae Cano, Cano-Ortiz & Veloz 2020
1-*Cyatheo furfuracei-Prestoetum motanae* Cano, Cano-Ortiz & Veloz 2020
2-*Ormosio krugii-Prestoetum montanae* Cano, Cano-Ortiz & Veloz 2020
OCOTEO-MAGNOLIETEA Borhidi and Muñiz in Borhdi et al. 1979
Ocoteo-Magnolietalia Muñiz in Borhdi et al. 1979
Rondeletio ochraceae-Didymopanion tremuli Cano, Cano-Ortiz & Veloz 2020
1-*Hyeronimo montanae-Magnolietum pallescentis* Cano, Cano-Ortiz & Veloz 2020
2-*Hyeronimo dominguensis-Magnolietum hamorii* Cano, Cano-Ortiz & Veloz 2020

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