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Ecological Characterization of the Flora in Reserva Ecológica Arenillas, Ecuador

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Abstract: Ecuador, located in the Neotropics, has 66 protected natural areas, which represent about 13.77% of its overall territory. The Reserva Ecológica Arenillas reserve (REAr), located in southwestern Ecuador, protects an area of dry forest, coastal thorn forest, and mangroves. This dry forest is part of the Pacific equatorial core and is included the Tumbes–Chocó–Magdalena, one of the 34 biodiversity hot spots of the world. It is an extremely fragile ecosystem and therefore the need for conservation is of the utmost importance. Knowledge of the flora and their ecological characteristics is still limited, which was one of the main objectives of this work. In this study, 118 plots located in different locations of the REAr were selected in order to sample the trees, shrubs, and herbaceous plants within them. This information was supplemented with data from the literature and the GBIF; life forms were included according to Raunkiaer's classification and their growth habits. The flora of the REAr was represented by 381 species, belonging to 77 families. The two most numerous families were the Fabaceae (51 plant species) and Malvaceae (31 species). The dominant life form was the phanerophytes with 200 species (52.5%), followed by therophytes with 104 species (27.3%), and camephytes with 22 species (5.8%). Physiognomy was dominated by the herbaceous growth (44%). The biodiversity indices of two ecosystems were studied (The deciduous forest of the Jama-Zapotillo lowland and the low forest and deciduous shrubland of the Jama-Zapotillo lowland), obtaining higher values for the deciduous forest ecosystem of the Jama-Zapotillo lowland. With these indicators, a classification of each forest type was made by performing a hierarchical cluster analysis. The information provided in this paper is particularly important for focusing conservation efforts and preventing the loss of flora diversity in these forests, which are subject to great anthropogenic pressures.

Keywords: biodiversity; floristic composition; tropical dry forest; species diversity

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1. Introduction

Ecuador is one of the 17 mega-diverse countries of the world [1]. It has 17,748 confirmed species of native flora, and it is estimated that with the continuation of studies of Ecuadorian flora, the total number of vascular plants could reach 25,000 species [2]. A large proportion of these species (1600) are included in the IUCN Red List. Furthermore, more species are added to the Red List every year. In 2019, a total of 354 new species were included in the list.

Dry ecosystems are one of the most valuable types of ecosystems in Ecuador. Together with dry ecosystems of northern Peru they form the Tumbesian Region. This is one of the areas of South America with the greatest number of endemic species, while at the same time being one of the most threatened regions [3]. Among the different dry ecosystems in the Tumbesian region in Ecuador, the equatorial dry forest is among the most fragile [4].

This is a unique ecosystem of the world and is located in the south of the country, in the regions of Esmeraldas, Manabí, Santa Elena, Guayas, El Oro, and Loja.

One of the main remnants of the equatorial dry forest in the south of Ecuador is the Reserva Ecológica Arenillas reserve (henceforth REAr). Moreover, it is the only ecological reserve that conserves mangroves and tropical dry forests in the southwestern region of the country. In spite of its ecological relevance, the REAr presents conservation problems, such as the fragmentation of its ecosystems, the expansion of agriculture and cattle ranching inside the limits of the reserve, and several climate change-related impacts [5]. Another difficulty encountered by the REAr is the redefinition of its limits. It has been a military base and an exclusion zone since the 1970s because of its strategic location on the border with Peru [6]. Originally, the former military base had an area of 22,000 ha. When the Ecological Reserve was created in 2001, the protected area comprised only 17,082.7 ha of the original extent and in 2012, it was reduced to 13,170.03 ha. [7].

Since the creation of the natural reserve, the REAr has been studied very little from a floristic point of view. One of the first studies was that of Ceron et al. [8], in which 105 species belonging to 49 families were identified. These results were similar to those found by Estrella and Troya [9] (104 species grouped into 82 genera and 48 families) and Ochoa et al. [10] (79 species grouped into 69 genera and 41 families). Nevertheless, other studies that were based on higher sampling efforts have documented highly diverse flora [11], indicating that increasing the sampling effort may reveal much larger numbers. Based on these studies and other studies in different dry forest regions, it is also known that there are evident differences in the composition and biodiversity between the different zones of the REAr [12], but the factors that delimit this special differentiation in the dry forest have not yet been explored in great detail. Thus, it becomes difficult to study and obtain rigorous conclusions about the current lists of scientific data on the species that exist in this ecosystem.

Overall, the REAr, due to its history, diversity of habitats, geographic location, and sociological environment, is an interesting biodiversity scenario for the study of conservation, monitoring of plant species, and the improvement of our knowledge of the main functions of this ecosystem that is threatened by anthropic pressure. However, not much information exists about its floral composition, diversity, and the underlying drivers. Therefore, the objective of this work was to analyze the floristic composition, ecological characteristics, and diversity of the ecosystems within the REAr. By doing so, we updated the information on the flora of the REAr, increasing its value for conservation initiatives and contributing to a proper design of future management and conservation actions.

2. Material and Methods

2.1. Study Area

This study is conducted in the REAr, which is located to the south of the equator between the cantons of Huaquillas and Arenillas (Figure 1), within the latitudes from 3°27′30.94″ S to 3°39′37.49″ S and from 80° 9′18.65″ W to 80° 9′47.93″ W. This reserve has an area of 13,170 ha and an average elevation of 120 m above sea level (masl) [8]. The REAr is composed of a matrix of dry forests, desert scrubs, and mangroves. The climate of the study area is warm-dry, with an average temperature of 24 °C, and rainfall varies between 300 and 500 mm/year from the lower elevated northern area of the reserve to the higher elevated southern part.

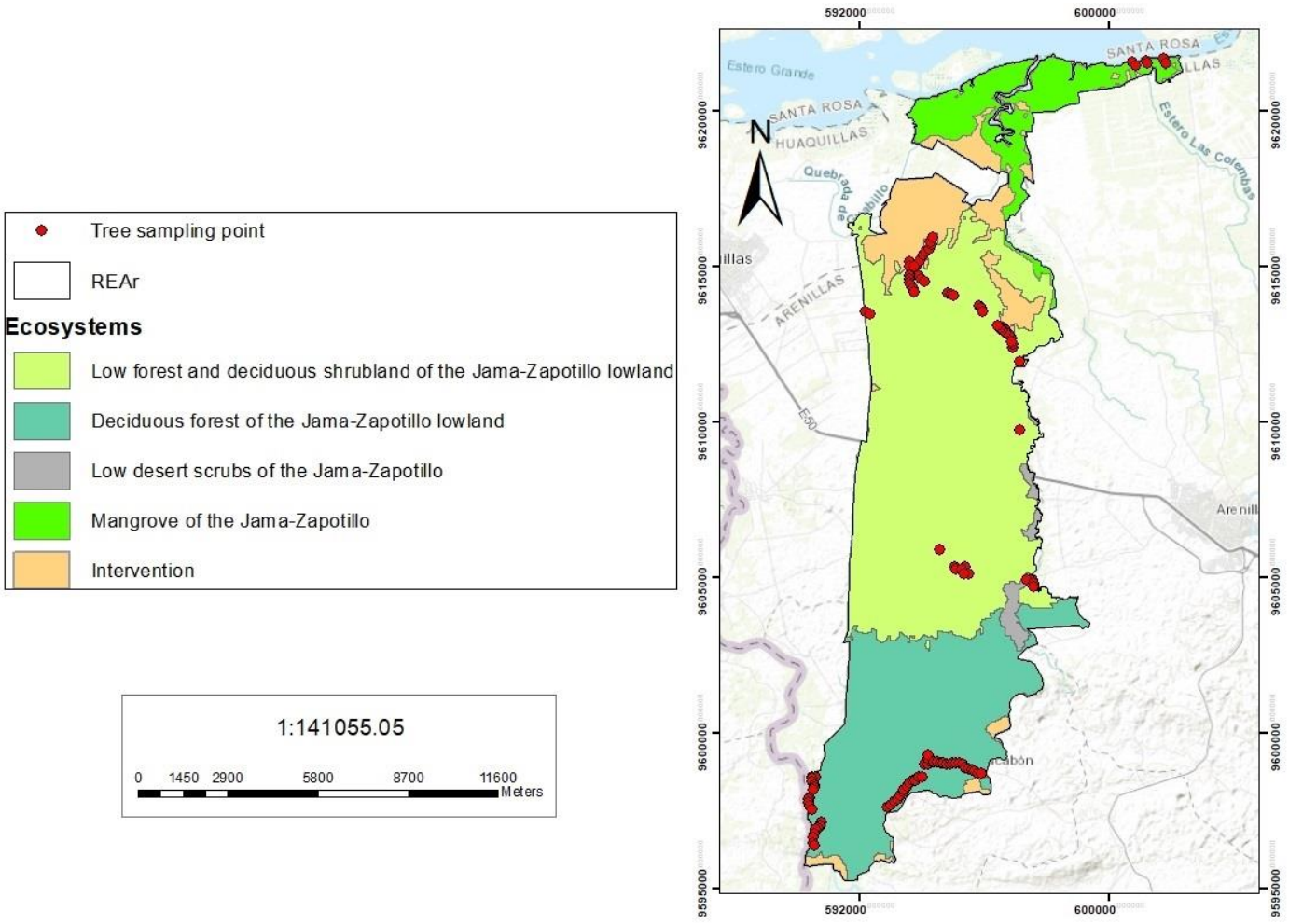

Figure 1. Map showing the location of the REAr, the ecosystems represented, and the selected sampling points.

2.2. Characterization of the Richness, Composition, and Diversity of Flora Species in the REAr

According to the ecosystem classification system of Ecuador [13], we can find four types of ecosystems in the study area: (1) The deciduous forest of the Jama-Zapotillo lowland, (2) the low forest and deciduous shrubland of the Jama-Zapotillo lowland, (3) the mangrove of the Jama-Zapotillo, and (4) the low desert scrubs of the Jama-Zapotillo. In this study, we sampled 118 plots of 20 × 20 m surface areas in two of the different dry forest types (the low deciduous forest of the Jama-Zapotillo and low forest and deciduous shrubland of the Jama-Zapotillo) and in the mangrove (the mangrove of the Jama-Zapotillo) (Figure 1). Sampling locations were selected following a random design, but locations with difficult or impossible access were discarded. In each 20 × 20 m plot, four 5 × 5 m subplots were selected to study shrubs, and four 1 × 1 m subplots to study herbs. Life form classes were identified according to Raunkiaer's classification [14]. Field sampling was carried out during the rainy season to achieve a better identification of the species, according to the flowering and fruiting times of most of the known species. The physiognomies of the plants (herbaceous, shrubs, and trees) were noted in the field during sampling. Each of the plots were georeferenced with a handheld GPS (GARMIN GPSMAP 65) with a 5 m horizontal accuracy. The list of flora of the REAr created by Molina Moreira in 2017 [11] was used as the basis for the study. This is the latest and most complete study conducted so far in the REAr, and included 291 species from 64 families. The specimens from this area that have already been deposited in the Reinaldo Espinoza Herbarium of the Universidad Nacional de Loja (LOJA), the Herbarium of the Universidad Técnica Particular de Loja (HUTPL), the Herbarium of the Universidad de

Guayaquil (GUAY), and the Herbarium of the Universidad de Almería (HUAL) [15], were also studied.

A database was created with information on the species found in scientific literature and those detected during field sampling. This database was complemented with the records of the Global Biodiversity Information Facility (GBIF) [16] and Tropicos [17], and we used the information about the ecosystem type to locate where sampling plots or literature records were acquired according to the ecosystem classification system of continental Ecuador.

The nomenclature of the scientific names was based on Plants of the World Online, Kew Science (https://powo.science.kew.org/; last access on 15 August 2022), and the families were classified according to the APG IV classification system.

2.3. Data Analysis

Based on the field sampling records, we studied the plant diversity of the deciduous forest of the Jama-Zapotillo lowland and the low forest and deciduous shrubland of the Jama-Zapotillo lowland ecosystems. To achieve this, we selected the results of 110 plots (the remaining eight plots belonged to the mangrove ecosystem) and calculated species richness, abundance, and diversity. Species richness was calculated as the number of species present per plot. Abundance was calculated as the numbers of each individual species per plot. Two different diversity indices were used, Shannon's index and Simpson's index, according to Equations (1) and (2), respectively:

$$H = -\sum_{i=1}^{S} p_i \; x \; log_2 \; p_i \quad (1)$$

$$D = 1 - \sum {p_i}^2 \quad (2)$$

where H = Shannon's index, D = Simpson's diversity index, pi = Abundance of specie i (N) relative to the total number of species (N), and S = species richness [18].

With these indicators obtained at the plot level in the two sampled ecosystems, a hierarchical cluster analysis was performed using Sorensen's distance measure [19,20]. The Ward method was then used to achieve the highest clustering structure coefficient. The analysis was performed using the Agnes function of the cluster 'factoextra' package in the R software, version 4.2.1. [21].

This analysis was performed at the plot level and for each of the two sampled ecosystems within the REAr (the deciduous forest of the Jama-Zapotillo lowland and low forest and deciduous shrubland of the Jama-Zapotillo lowland), separately. Differences in the different indices between the classes obtained after hierarchical classification were tested by one-way ANOVA and HSD post hoc analyses using the 'dplyr' package of the R software version 4.2.1 [21]. The p-value was set to be <0.05.

We used the Ward method because of its strong grouping structure for our variables (abundance, richness, and diversity) (Table 1).

Table 1. Agglomeration factors of the four clustering methods.

Deciduous Forest of the Jama-Zapotillo Lowland				
Clustering Methods	**Average**	**Single**	**Complete**	**Ward**
Agglomeration factor	0.9491697	0.8425549	0.9721348	0.9872076
Low forest and deciduous shrubland of the Jama-Zapotillo lowland				
Clustering methods	Average	Single	Complete	Ward
Agglomeration factor	0.8996283	0.7202592	0.9487867	0.9791087

3. Results

In the REAr, 381 plant species belonging to 77 families were identified. Physiognomy was dominated by the herbaceous growth form, containing 167 plant species (44%), fol-

lowed by 134 species of shrubs (35%) and 80 species of trees (21%). The three largest families were the Fabaceae with 51 plant species, followed by the Malvaceae with 31 species and the Euphorbiaceae with 26 species. The dominant life forms were phanerophytes with 200 species (52.5%), followed by therophytes with 104 species (27.3%), chamephytes with 22 species (5.8%), epiphytes with 21 species (5.5%), hemicryptophytes with 21 species (5.5%), geophytes with 7 species (1.8%) and hydrophytes with 6 species (1.6%) (Table 2).

Table 2. Summary of the list of vascular plants of the REAr, with their scientific name, family, growth habit, and life form, according to Raunkiaer's classification (G, geophytes; H, hemicryptophytes; Hy, hydrophytes; P, phanerophytes; T, therophytes; E, epiphytes).

Family	Taxon	Life Form	Growth Habit
Acanthaceae	*Dicliptera unguiculata* Nees	T	Herb
Acanthaceae	*Dicliptera peruviana* (Lam.) Juss.	T	Herb
Acanthaceae	*Dicliptera paposana* Phil.	T	Herb
Acanthaceae	*Dyschoriste repens* (Nees) Kuntze	T	Herb
Acanthaceae	*Justicia comata* (L.) L.	T	Herb
Acanthaceae	*Avicennia germinans* (L.) L.	T	Herb
Acanthaceae	*Ruellia floribunda* Hook.	T	Herb
Acanthaceae	*Ruellia blechum* L.	T	Herb
Acanthaceae	*Tetramerium nervosum* Nees	T	Herb
Acanthaceae	*Elytraria imbricata* (Valh) Pers.	T	Herb
Achatocarpaceae	*Achatocarpus pubescens* C.H.Wright	P	Shrub
Aistroemeriaciae	*Bomarea obovata* Herb.	P	Herb
Aizoaceae	*Trianthema portulacastrum* L.	T	Herb
Aizoaceae	*Sesuvium portulacastrum* (L.) L.	T	Herb
Alismataceae	*Echinodorus bracteatus* Micheli	T	Herb
Amaranthaceae	*Alternanthera echinocephala* (Hook.f.) Christoph	T	Herb
Amaranthaceae	*Alternanthera ficoidea* (L.) P.Beauv.	T	Herb
Amaranthaceae	*Alternanthera paronychioides* A.St.-Hil.	T	Herb
Amaranthaceae	*Alternanthera pubiflora* (Benth.) Kuntze	T	Herb
Amaranthaceae	*Alternanthera porrigens* (Jacq.) Kuntze	T	Herb
Amaranthaceae	*Alternanthera brasiliana* (L) Kuntze	T	Herb
Amaranthaceae	*Amaranthus polygonoides* Roxb	T	Herb
Amaranthaceae	*Iresine angustifolia* Euphrasén	T	Herb
Amaranthaceae	*Achyranthes aspera* L.	T	Herb
Amaranthaceae	*Iresine diffusa* Humb. & Bonpl. ex Willd	T	Herb
Amaranthaceae	*Chamissoa altissima* (Jacq.) Kunth.	T	Herb
Amaranthaceae	*Gomphrena holosericea* (Mart.) Moq.	T	Herb
Amaranthaceae	*Salicornia fruticosa* (L.) L.	T	Herb
Amaryllidaceae	*Leptochiton quitoensis* (Herb.) Sealy	G	Herb
Amaryllidaceae	*Eucrosia bicolor* Ker Gaw	G	Herb
Anacardiaceae	*Spondias mombin* L.	P	Shrub
Anacardiaceae	*Mangifera indica* L.	P	Tree
Anacardiaceae	*Loxopterygium huasango* Spruce ex Engl	P	Tree
Apiaceae	*Conium maculatum* L.	T	Herb
Apocynaceae	*Pseudomarsdenia cundurango* (Rchb. f.) Schltr.	T	Herb
Apocynaceae	*Prestonia mollis* Kunth.	T	Herb
Apocynaceae	*Asclepias* L.	T	Herb
Apocynaceae	*Asclepias* L.	T	Herb
Apocynaceae	*Asclepias curassavica* L.	T	Herb
Apocynaceae	*Rauvolfia littoralis* Rusby	T	Herb
Apocynaceae	*Rauvolfia tetraphylla* L.	T	Herb
Apocynaceae	*Cascabela thevetia* (L) Lippold	P	Herb
Apocynaceae	*Nerium oleander* L.	P	Herb
Araceae	*Anthurium barclayanum* Engl.	H	Herb
Araceae	*Anthurium soukupii* Croat	H	Herb

Table 2. *Cont.*

Family	Taxon	Life Form	Growth Habit
Arecaceae	*Saribus rotundifolius* (Lam) Blume	P	Herb
Arecaceae	*Adonidia merrillii* (Becc) Becc.	P	Herb
Arecaceae	*Pritchardia pacifica* Seem & H.Wendl	P	Herb
Asparagaceae	*Sansevieria trifasciata* Prain	P	Herb
Asparagaceae	*Yucca guatemalensis* Baker	G	Shrub
Asteraceae	*Acanthospermum microcarpum* BLRob.	T	Herb
Asteraceae	*Synedrella nodiflora* (L) Gaertn.	T	Herb
Asteraceae	*Emilia fosbergii* Nicolson	T	Herb
Asteraceae	*Eclipta prostrata* (L.) L	T	Herb
Asteraceae	*Viguiera dentata* (Cav.) Spreng.	T	Herb
Asteraceae	*Bidens pilosa* L.	T	Herb
Asteraceae	*Sphagneticola trilobata* (L) Pruski	P	Shrub
Asteraceae	*Tessaria integrifolia* Ruiz & Pav.	P	Shrub
Asteraceae	*Verbesina eggersii* Hieron.	P	Shrub
Asteraceae	*Verbesina lloensis* Hieron	T	Shrub
Asteraceae	*Barnadesia* Mutis ex L.f.	T	Shrub
Asteraceae	*Bidens bipinnata* L.	T	Shrub
Asteraceae	*Dasyphyllum* Kunth	T	Herb
Asteraceae	*Galinsoga* Ruiz & Pav.	T	Herb
Asteraceae	*Milleria quinqueflora* L.	T	Herb
Asteraceae	*Pseudogynoxys chenopodioides* (Kunth) Cabrera	P	Shrub
Asteraceae	*Tagetes erecta* L.	T	Herb
Basellaceae	*Anredera ramosa* (Moq.) Eliasson	E	Herb
Bignoniaceae	*Lundia* Puerari ex DC.	T	Shrub
Bignoniaceae	*Bignonia longiflora* Cav.	P	Shrub
Bignoniaceae	*Handroanthus billbergii* (Bureau & K. Schum.) S.O.Grose	P	Tree
Bignoniaceae	*Jacaranda mimosifolia* D.Don	P	Tree
Bignoniaceae	*Handroanthus chrysanthus* (Jacq.) S.O.Grose	P	Tree
Bignoniaceae	*Fridericia dichotoma* (Jacq.)	P	Tree
Bignoniaceae	*Mansoa hymenaea* (DC.) A.H:Gentry	P	Tree
Bignoniaceae	*Mansoa verrucifera* (Schlecht) A.H.Gentry	P	Tree
Bignoniaceae	*Tecoma castanifolia* (D. Don.) Melch	P	Shrub
Bixaceae	*Bixa orellana* L.	P	Shrub
Bixaceae	*Cochlospermum vitifolium* (Willd.) Spreng	P	Tree
Boraginaceae	*Cordia lutea* Lam.	P	Shrub
Boraginaceae	*Heliotropium angiospermum* Murray	T	Shrub
Boraginaceae	*Heliotropium curassavicum* L.	T	Shrub
Boraginaceae	*Heliotropium indicum* L.	T	Shrub
Boraginaceae	*Tournefortia microcalyx* (Ruiz & Pav.) I.M.Johnst.	C	Shrub
Boraginaceae	*Varronia cylindristachya* Ruiz & Pav.	P	Shrub
Boraginaceae	*Varronia macrocephala* Desv.	P	Shrub
Bromeliaceae	*Aechmea pyramidalis* Benth.	H	Herb
Bromeliaceae	*Bromelia pinguin* L.	E	Herb
Bromeliaceae	*Bromelia karatas* L.	E	Herb
Bromeliaceae	*Tillandsia multiflora* Benth.	E	Herb
Bromeliaceae	*Tillandsia usneoides* (L.) L.	E	Herb
Bromeliaceae	*Tillandsia streptocarpa* Baker	E	Herb
Bromeliaceae	*Tillandsia latifolia* Meyen	E	Herb
Bromeliaceae	*Tillandsia recurvata* (Gaudich.) Baker	E	Herb
Bromeliaceae	*Tillandsia triglochinoides* C.Presl	E	Herb
Bromeliaceae	*Tillandsia disticha* Kunth.	E	Herb
Bromeliaceae	*Tillandsia barclayana* Baker.	E	Herb
Bromeliaceae	*Tillandsia espinosae* L. B. Sm.	E	Herb
Bromeliaceae	*Tillandsia cyanea* L. B. Sm.	E	Herb
Bromeliaceae	*Tillandsia caerulea* Kunth	E	Herb
Burseraceae	*Bursera graveolens* (Kunth) Triana & Planch	P	Tree

Table 2. *Cont.*

Family	Taxon	Life Form	Growth Habit
Cactaceae	*Pilosocereus lanuginosus* (L.) Byles & G:D. Rowley	P	Shrub
Cactaceae	*Armatocereus cartwrightianus* Backeb.	P	Shrub
Cactaceae	*Armatocereus matucanensis* Backeb.	P	Shrub
Cactaceae	*Opuntia ficus-indica* (L.) Mill.	P	Shrub
Cactaceae	*Opuntia stricta* (Haw) Haw.	P	Shrub
Cactaceae	*Opuntia quitensis* F.A.C. Weber	P	Shrub
Cactaceae	*Melocactus peruvianus* Vaupel	P	Shrub
Cactaceae	*Selenicereus monacanthus* (Lem) D.R.Hunt	P	Shrub
Cactaceae	*Cereus hexagonus* (L.) Mill.	P	Shrub
Cactaceae	*Cephalocereus* Pfeiff.	P	Shrub
Cactaceae	*Cleistocactus* Pfeiff.	P	Shrub
Cannabaceae	*Celtis iguanaea* (Jacq) Sarg	P	Shrub
Cannabaceae	*Trema micrantha* (L.) Blume	P	Shrub
Capparaceae	*Beautempsia avicenniifolia* Gaudich. ex Alleiz.	P	Shrub
Capparaceae	*Capparicordis crotonoides* (Kunth) Iltis & Cornejo	P	Shrub
Capparaceae	*Colicodendron scabridum* (Kunth)	P	Tree
Capparaceae	*Cynophalla heterophylla* (Ruiz & Pav. ex DC.) Iltis & Cornejo	P	Tree
Capparaceae	*Cynophalla flexuosa* (L.) J.Presl	P	Tree
Caricaceae	*Carica papaya* L.	P	Shrub
Caricaceae	*Carica parviflora* (A. DC.) Solms	P	Shrub
Celastraceae	*Tricerma octogonum* (L'Hér.) Lundell	P	Shrub
Combretaceae	*Conocarpus erectus* L.	P	Tree
Combretaceae	*Terminalia catappa* L.	P	Tree
Combretaceae	*Laguncularia racemosa* (L.) C.F.Gaertn	Hy	Tree
Commelinaceae	*Commelina diffusa* Burm.f.	P	Herb
Commelinaceae	*Commelina* Plum. ex L.	P	Herb
Commelinaceae	*Calli cordifolia* (Sw.) Andiers. & Woodson	P	Herb
Convolvulaceae	*Camonea umbellata* (L.) A.R.Simões & Staples	P	Herb
Convolvulaceae	*Cuscuta acuta* Engelm.	P	Herb
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	P	Herb
Convolvulaceae	*Evolvulus convolvuloides* (Willd. ex Schult.) Stearn	T	Herb
Convolvulaceae	*Evolvulus nummularius* (L.) L.	T	Herb
Convolvulaceae	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	T	Herb
Convolvulaceae	*Ipomoea cholulensis* Kunth	P	Herb
Convolvulaceae	*Ipomoea hederifolia* L.	T	Herb
Convolvulaceae	*Ipomoea regnellii* Meisn.	P	Herb
Convolvulaceae	*Ipomoea quamoclit* L.	P	Herb
Convolvulaceae	*Ipomoea pes-caprae* (L.) R. Br.	P	Herb
Convolvulaceae	*Ipomoea nil* (L) Roth	P	Herb
Convolvulaceae	*Ipomoea carnea* Jacq.	P	Herb
Convolvulaceae	*Ipomoea triloba* Thunb	P	Herb
Convolvulaceae	*Jacquemontia corymbulosa* Benth	P	Herb
Convolvulaceae	*Jacquemontia unilateralis* (Roem. & Schult.) O'Donell	P	Herb
Convolvulaceae	*Distimake aegyptius* (L.) A.R.Simões & Staples	P	Herb
Cucurbitaceae	*Momordica charantia* L.	P	Herb
Cucurbitaceae	*Luffa operculata* (L.) Cogn.	P	Herb
Cucurbitaceae	*Cucurbita pepo* L.	T	Herb
Cucurbitaceae	*Cayaponia glandulosa* (Mart.) Cogn.	T	Herb
Cucurbitaceae	*Echinopepon racemosus* (Steud.) C. Jeffrey	P	Herb
Cyperaceae	*Cyperus squarrosus* L.	H	Herb
Cyperaceae	*Cyperus compressus* L.	H	Herb
Cyperaceae	*Cyperus ligularis* L.	H	Herb
Cyperaceae	*Cyperus microbolbos* C.B.Clarke	H	Herb
Cyperaceae	*Fimbristylis littoralis* Gaudich.	Hy	Herb
Erythroxylaceae	*Erythroxylum glaucum* O. E. Schulz	P	Herb
Erythroxylaceae	*Erythroxylum acuminatum* Ruiz & Pav.	P	Shrub
Euphorbiaceae	*Jatropha curcas* L.	P	Shrub
Euphorbiaceae	*Euphorbia serpens* Kunth.	T	Shrub

Table 2. *Cont.*

Family	Taxon	Life Form	Growth Habit
Euphorbiaceae	*Euphorbia hirta* L.	T	Shrub
Euphorbiaceae	*Euphorbia heterophylla* L.	T	Shrub
Euphorbiaceae	*Cnidoscolus aconitifolius* (Mill.) IM Johnst.	P	Shrub
Euphorbiaceae	*Croton hirtus* L'Hér.	P	Shrub
Euphorbiaceae	*Croton fraseri* Mull. Arg.	P	Shrub
Euphorbiaceae	*Croton rivinifolius* Kunth	P	Shrub
Euphorbiaceae	*Croton eggersii* Pax	P	Shrub
Euphorbiaceae	*Croton aequatoris* Croizat	P	Shrub
Euphorbiaceae	*Croton eggersii* Pax	P	Shrub
Euphorbiaceae	*Croton jamesonii* Müll. Arg.	P	Shrub
Euphorbiaceae	*Croton schiedeanus* Schltdl.	P	Shrub
Euphorbiaceae	*Codiaeum variegatum* (L.) Rumph. ex A.Juss	P	Shrub
Euphorbiaceae	*Acalypha villosa* Jacq.	P	Shrub
Euphorbiaceae	*Acalypha subcastrata* F.Aresch.	T	Shrub
Euphorbiaceae	*Acalypha diversifolia* Jacq.	P	Shrub
Euphorbiaceae	*Acalypha cuspidata* Jacq.	P	Shrub
Euphorbiaceae	*Acalypha setosa* A. Rich.	P	Shrub
Euphorbiaceae	*Acalypha cuspidata* Jacq.	P	Shrub
Euphorbiaceae	*Acalypha alopecuroides* L.	T	Shrub
Euphorbiaceae	*Dalechampia scandens* L.	T	Shrub
Euphorbiaceae	*Codiaeum variegatum* (L.) Rumph. ex A. Juss.	P	Shrub
Euphorbiaceae	*Manihot esculenta* Crantz	G	Tree
Fabaceae	*Senegalia polyphylla* (DC.) Britton & Rose	P	Tree
Fabaceae	*Vachellia macracantha* (Humb. & Bonpl. ex Willd.) Seigler & Ebinger	P	Tree
Fabaceae	*Aeschynomene tumbezensis* J.F. Macbr.	P	Tree
Fabaceae	*Aeschynomene scoparia* Kunth	P	Tree
Fabaceae	*Aeschynomene americana* L.	T	Tree
Fabaceae	*Albizia multiflora* (Kunth) Barneby y J.W.Grimes	P	Tree
Fabaceae	*Caesalpinia pulcherrima* (L.) Sw.	P	Tree
Fabaceae	*Chloroleucon mangense* (Jack.) Britton & Rose	P	Tree
Fabaceae	*Calliandra tumbeziana* J.F. Macbr.	T	Shrub
Fabaceae	*Canavalia ensiformis* (L.) DC.	T	Shrub
Fabaceae	*Canavalia rosea* (SW)	P	Shrub
Fabaceae	*Canavalia brasiliensis* Mart. ex Benth.	P	Shrub
Fabaceae	*Centrosema pubescens* Benth.	P	Shrub
Fabaceae	*Cercidium praecox* (Ruiz & Pav) Hawkins	P	Shrub
Fabaceae	*Chamaecrista nictitans* (L.) Moench	T	Shrub
Fabaceae	*Crotalaria incana* L.	P	Herb
Fabaceae	*Coursetia caribaea Ochroleuca* (Jacq.)	P	Shrub
Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	P	Tree
Fabaceae	*Desmanthus virgatus* (L.) Willd.	T	Herb
Fabaceae	*Desmodium scorpiurus* (Sw.) Desv. ex DC.	T	Shrub
Fabaceae	*Desmodium procumbens* (Mill.) C.L.Hitchc.	T	Shrub
Fabaceae	*Erythrina smithiana* Krukoff	P	Tree
Fabaceae	*Erythrina velutina* Willd.	P	Tree
Fabaceae	*Geoffroea spinosa* Jacq.	P	Tree
Fabaceae	*Indigofera subulata* Vahl ex Poir.	P	Tree
Fabaceae	*Leucaena trichodes* (Jacq.) Benth.	P	Tree
Fabaceae	*Libidibia glabrata* (Kunth) C.Cast. & G.P.Lewis	P	Tree
Fabaceae	*Machaerium* Pers.	P	Tree
Fabaceae	*Machaerium millei* Standl.	P	Tree
Fabaceae	*Mimosa albida* Humb. & Bonpl. ex Willd	P	Tree
Fabaceae	*Mimosa acantholoba* (Humb. & Bonpl. ex Willd.) Poir.	P	Tree
Fabaceae	*Mimosa pigra* L.	P	Tree
Fabaceae	*Neptunia plena* (L.) Benth.	T	Shrub
Fabaceae	*Parkinsonia aculeata* L.	P	Tree
Fabaceae	*Pithecellobium dulce* (Roxb.) Benth.	P	Tree
Fabaceae	*Piptadenia retusa* (Jacq.) P.G.Ribeiro, Seigler & Ebinger	P	Tree

Table 2. *Cont.*

Family	Taxon	Life Form	Growth Habit
Fabaceae	*Piscidia carthagenensis* Jacq.	P	Tree
Fabaceae	*Pithecellobium excelsum* (Kunth) Mart.	P	Tree
Fabaceae	*Prosopis juliflora* (Sw.) DC.	P	Tree
Fabaceae	*Prosopis pallida* (Willd.) (Humb. & Bonpl. ex Willd.) Kunth	P	Tree
Fabaceae	*Phaseolus vulgaris* L.	T	Herb
Fabaceae	*Pseudosamanea guachapele* (Kunth) Harms	P	Tree
Fabaceae	*Samanea saman* (Jacq.) Merr.	P	Tree
Fabaceae	*Senna mollissima* (Humb. & Bonpl. ex Willd.) H.S.Irwin & Barneby	P	Tree
Fabaceae	*Senna oxyphylla* (Kunth) H.S.Irwin & Barneby	P	Tree
Fabaceae	*Galactia striata* (Jacq.) Urb.	P	Herb
Fabaceae	*Vigna caracalla* (L.) Verdc.	T	Herb
Fabaceae	*Schizolobium parahyba* (Vell.) S.F. Blake	P	Tree
Fabaceae	*Stylosanthes scabra* Vogel	P	Herb
Fabaceae	*Stylosanthes guianensis* (Aubl.) Sw.	P	Herb
Fabaceae	*Inga edulis* Mart.	P	Tree
Lamiaceae	*Hyptis atrorubens* Poit.	T	Shrub
Lamiaceae	*Tectona grandis* L. f.	P	Tree
Loasaceae	*Gronovia scandens* L.	P	Herb
Loasaceae	*Mentzelia aspera* L.	T	Herb
Loranthacea	*Psittacanthus divaricatus* (Kunth) G.Don	P	Shrub
Lythraceae	*Adenaria floribunda* Kunth	P	Shrub
Malpighiaceae	*Bunchosia plowmanii* W.R. Anderson	P	Shrub
Malpighiaceae	*Malpighia glabra* L.	P	Shrub
Malpighiaceae	*Malpighia emarginata* DC.	P	Shrub
Malvaceae	*Abutilon pedunculare* Kunth	P	Shrub
Malvaceae	*Abutilon reflexum* (Lam.) Sweet	P	Shrub
Malvaceae	*Abutilon umbellatum* (L.) Sweet	P	Shrub
Malvaceae	*Abutilon dianthum* C. Presl	P	Shrub
Malvaceae	*Ayenia magna* L.	P	Shrub
Malvaceae	*Bastardia bivalvis* (Cav.) Kunth ex Griseb.	P	Shrub
Malvaceae	*Bastardia viscosa* (L.) Kunth	P	Shrub
Malvaceae	*Ceiba trichistandra* (A. Gray) Bakh.	P	Tree
Malvaceae	*Cienfuegosia tripartita* (Kunth) Gürke	T	Herb
Malvaceae	*Corchorus orinocensis* Kunth	T	Shrub
Malvaceae	*Eriotheca ruizii* (K. Schum.) A. Robyns	P	Tree
Malvaceae	*Guazuma ulmifolia* Lam.	P	Tree
Malvaceae	*Hibiscus escobariae* Fryxell	P	Shrub
Malvaceae	*Hibiscus phoeniceus* Jacq.	P	Shrub
Malvaceae	*Hibiscus rosa-sinensis* L.	P	Shrub
Malvaceae	*Hibiscus pernambucensis* Arruda	P	Shrub
Malvaceae	*Malachra fasciata* Jacq.	T	Shrub
Malvaceae	*Malvaviscus concinnus* Kunth	P	Shrub
Malvaceae	*Byttneria parviflora* Benth.	C	Shrub
Malvaceae	*Byttneria glabrescens* Benth.	C	Shrub
Malvaceae	*Gaya peruviana* Ulbr. f.	C	Shrub
Malvaceae	*Sida acuta* Burm.f.	C	Shrub
Malvaceae	*Sida ciliaris* L.	C	Herb
Malvaceae	*Sida repens* Dombey ex Cav.	C	Herb
Malvaceae	*Sida setosa* Mart. ex Colla	C	Herb
Malvaceae	*Theobroma cacao* L.	P	Shrub
Malvaceae	*Wissadula diffusa* R.E.Fr.	C	Shrub
Malvaceae	*Pavonia fruticosa* (Mill.) Fawc. &Rendle	C	Shrub
Malvaceae	*Triumfetta bogotensis* DC.	C	Shrub
Malvaceae	*Gossypium barbadense* L.	P	Shrub
Malvaceae	*Sidastrum paniculatum* (L.) Fryxell	T	Shrub
Marantaceae	*Thalia geniculata* L.	T	Shrub
Meliaceae	*Cedrela odorata* L.	P	Tree
Meliaceae	*Azadirachta indica* A. Juss.	P	Tree

Table 2. *Cont.*

Family	Taxon	Life Form	Growth Habit
Moraceae	*Ficus citrifolia* Mill.	P	Tree
Moraceae	*Ficus elastica* Roxb. ex Hornem.	P	Tree
Moraceae	*Artocarpus altilis* (Parkinson) Fosberg	P	Shrub
Moringaceae	*Moringa oleifera* Lam.	P	Tree
Muntingiaceae	*Muntingia calabura* L.	P	Herb
Musaceae	*Musa x paradisiaca* L.	T	Herb
Myrtaceae	*Eugenia biflora* (L.) DC.	P	Herb
Nyctaginaceae	*Boerhavia coccinea* Mill.	T	Herb
Nyctaginaceae	*Boerhavia erecta* L.	T	Shrub
Nyctaginaceae	*Pisonia floribunda* Hook. f.	P	Shrub
Nyctaginaceae	*Pisonia ambigua* Heimerl	P	Shrub
Nyctaginaceae	*Pisonia aculeata* L.	P	Shrub
Nyctaginaceae	*Bougainvillea peruviana* Bonpl	P	Shrub
Nyctaginaceae	*Bougainvillea spectabilis* Willd.	P	Shrub
Nyctaginaceae	*Cryptocarpus pyriformis* Kunth	P	Herb
Nyctaginaceae	*Mirabilis violacea* (L.) Heimerl	T	Herb
Nyctaginaceae	*Mirabilis nyctaginea* (Michx.) MacMill.	T	Herb
Nymphaeaceae	*Nymphaea ampla* (Salisb.) DC.	Hy	Herb
Nymphaeaceae	*Nymphaea pulchella* DC.	Hy	Tree
Oleaceae	*Priogymnanthus apertus* (B.Ståhl) P.S.Green	P	Shrub
Onagraceae	*Ludwigia linifolia* (Vahl) R.S.Rao	T	Shrub
Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H. Raven	T	Shrub
Opilaceae	*Agonandra excelsa* Griseb.	P	Herb
Orchidaceae	*Oncidium hyphaematicum* Rchb.f	E	Herb
Orchidaceae	*Epidendrum bracteolatum* C. Presl	E	Herb
Orchidaceae	*Notylia replicata* Rchb.f.	E	Herb
Orchidaceae	*Rodriguezia strobelii* Garay	E	Herb
Orchidaceae	*Zelenkoa onusta* (Lindl.) M.W.Chase & N.H.Williams	E	Herb
Orchidaceae	*Encyclia aspera* (Lindl.) Schltr	E	Herb
Orchidaceae	*Campylocentrum micranthum* (Lindl.) Rolfe	E	Herb
Oxalidaceae	*Oxalis dombeyi* A.St.-Hil.	G	Herb
Oxalidaceae	*Oxalis microcarpa* Benth.	G	Herb
Passifloraceae	*Passiflora biflora* Lam.	P	Herb
Passifloraceae	*Passiflora eggersii* Harms	P	Herb
Passifloraceae	*Passiflora suberosa* L.	P	Herb
Phyllanthaceae	*Phyllanthus niruri* L.	T	Shrub
Phytolaccaceae	*Achatocarpus pubescens* C.H.Wright	P	Tree
Piperaceae	*Peperomia pellucida* (L.) Kunth	T	Herb
Plumbaginaceae	*Plumbago scandens* L.	T	Herb
Poaceae	*Cynodon dactylon* (L) Per.	H	Herb
Poaceae	*Echinochloa colonum* (L.) Link	H	Herb
Poaceae	*Lasiacis divaricata* (L.) Hitchc	H	Herb
Poaceae	*Paspalum vaginatum* Sw.	H	Herb
Poaceae	*Sporobolus pyramidatus* (Lam.) Hitchc.	H	Herb
Poaceae	*Panicum trichoides* Sw.	H	Herb
Poaceae	*Panicum polygonatum* Schrad.	H	Herb
Poaceae	*Panicum maximum* (Jacq.)	H	Herb
Poaceae	*Olyra latifolia* L.	H	Herb
Poaceae	*Setaria palmifolia* (J. Koenig) Stapf	H	Herb
Poaceae	*Chloris virgata* Sw.	H	Herb
Polygalaceae	*Asemeia violacea* (Aubl.) J.F.B.Pastore & J.R.Abbott	T	Herb
Polygalaceae	*Polygala paniculata* L.	T	Herb
Polygonaceae	*Triplaris cumingiana* Fisch. & C.A. Mey.	P	Tree
Polygonaceae	*Coccoloba ruiziana* Lindau	P	Tree
Portulacaceae	*Portulaca oleracea* L.	H	Herb
Primulaceae	*Bonellia sprucei* (Mez) B.Ståhl & Källersjö	P	Tree
Pteridaceae	*Adiantum raddianum* C. Presl	G	Herb
Pteridaceae	*Acrostichum aureum* L.	H	Herb

Table 2. *Cont.*

Family	Taxon	Life Form	Growth Habit
Rhamnaceae	*Scutia spicata* (Humb. & Bonpl. ex Schult.) Weberb.	C	Tree
Rhamnaceae	*Gouania mollis* Reissek	C	Tree
Rhamnaceae	*Sarcomphalus thyrsiflorus* (Benth.) Hauenschild	P	Tree
Rhizophoraceae	*Rhizophora* × *harrisonii* Leechm.	Hy	Tree
Rhizophoraceae	*Rhizophora mangle* L.	Hy	Tree
Rubiaceae	*Simira ecuadorensis* (Standl.) Steyerm.	P	Tree
Rubiaceae	*Randia armata* (SW.) DC.	P	Shrub
Rubiaceae	*Sphinctanthus aurantiacus* (Standl.) Fagerl.	P	Shrub
Rubiaceae	*Ixora coccinea* L.	P	Shrub
Rubiaceae	*Sommera purdiei* Standl.	P	Shrub
Rubiaceae	*Duroia hirsuta* (Poepp.) K.Schum.	P	Tree
Rubiaceae	*Spermacoce remota* Lam.	P	Tree
Rubiaceae	*Morinda citrifolia* L.	P	Tree
Rutaceae	*Zanthoxylum martinicense* (Lam.) DC.	P	Tree
Rutaceae	*Zanthoxylum rigidum* Humb. & Bonpl. ex Willd.	P	Tree
Rutaceae	*Amyris balsamifera* L.	P	Shrub
Rutaceae	*Citrus* ×*sinensis* (L.) Osbeck	P	Tree
Rutaceae	*Citrus* × *limon* (L.) Osbeck	P	Tree
Rutaceae	*Zanthoxylum fagara* (L.) Sarg.	P	Tree
Sapindaceae	*Sapindus saponaria* L.	P	Tree
Sapindaceae	*Serjania mucronulata* Radlk.	P	Shrub
Sapindaceae	*Cardiospermum corindum* L.	P	Herb
Scrophulariaceae	*Capraria peruviana* Benth	C	Shrub
Solanaceae	*Solanum peruvianum* L.	T	Herb
Solanaceae	*Browallia americana* L.	T	Herb
Solanaceae	*Solanum filiforme* Ruiz & Pav.	T	Herb
Solanaceae	*Solanum nigrum* L.	T	Herb
Solanaceae	*Solanum pimpinellifolium* L.	T	Herb
Solanaceae	*Lycianthes ecuadorensis* Bitter	T	Herb
Solanaceae	*Lycianthes cyathocalyx* (Van Heurck & Müll. Arg.) Bitter	T	Herb
Solanaceae	*Witheringia solanacea* L'He'r	C	Herb
Solanaceae	*Lycium nodosum* Jacq.	P	Herb
Solanaceae	*Capsicum annuum* L.	C	Herb
Talinaceae	*Talinum paniculatum* (Jacq.) Gaertn.	H	Shrub
Talinaceae	*Talinum fruticosum* (L.) Juss.	T	Shrub
Tropaeolaceae	*Tropaeolum harlingii* Sparre	P	Shrub
Urticaceae	*Laportea aestuans* (L.) Chew	T	Shrub
Verbenaceae	*Citharexylum quitense* Spreng.	T	Tree
Verbenaceae	*Citharexylum gentryi* Moldenke	T	Tree
Verbenaceae	*Lantana sprucei* Hayek	C	Shrub
Verbenaceae	*Lantana fucata* Lindl.	C	Shrub
Verbenaceae	*Lantana camara* L.	C	Shrub
Verbenaceae	*Lantana trifolia* L.	C	Shrub
Verbenaceae	*Lantana verticillata verticillata* (L.) Nicolson	P	Herb
Verbenaceae	*Lantana velutina* M. Martens & Galeotti	C	Shrub
Verbenaceae	*Lantana horrida* Kunth	C	Shrub
Vitaceae	*Cissus erosa* Rich.	P	Herb
Zygophyllaceae	*Kallstroemia pubescens* (G.Don) Dandy	T	Herb

Forest Classification

Based on the hierarchical grouping performed on the similarities of species richness, abundance, Shannon index, and Simpson index (Supplement S1 in Supplementary Material), we identified three dry forest types in the deciduous forest of the Jama-Zapotillo lowlands ecosystem. Type I (black line) contains 12 sample plots, type II (red line) contains 26 sample plots and type III (green line) contains 19 sample plots (Figure 2).

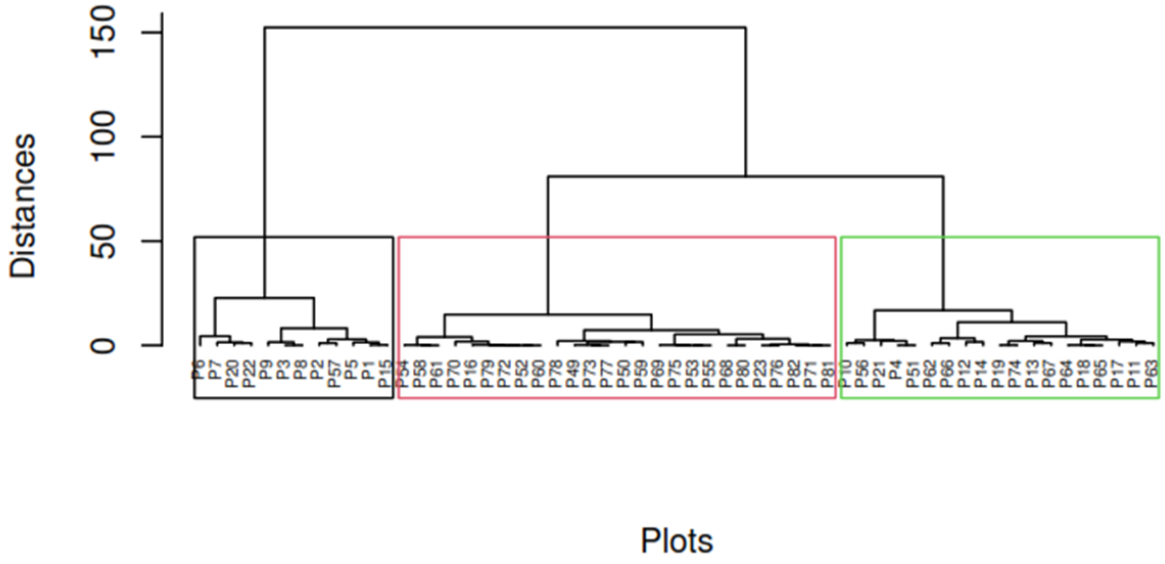

Figure 2. A dendrogram (Using the ward.D algorithm and Euclidean distance) of the grouping of the plots sampled in the deciduous forest of the Jama-Zapotillo lowland ecosystem. The grouping of the plots into the three forest types, according to the calculated diversity indices, is illustrated.

The mean values of the diversity indices showed significant differences between forest types I and III. Type I presented the highest species richness (6.16) and abundance (18.58). The type I forest was also the ecosystem with the highest values of the two different diversity indices, but no significant differences were found between this ecosystem and ecosystem type III. Forest type III had the lowest values of both diversity indices. The highest values of richness, abundance, and diversity that were found in forest type I (Figure 3) fits with the specific features that define a conserved forest, with some relevant species such as *Handroanthus chrysanthus*, *Eriotheca ruizii*, *Bursera graveolens*, and *Ceiba trischistandra*. The maximum height that was determined in this forest was 27 m, which was represented by the presence of the species *Ceiba trischistandra*.

Figure 3. Comparison of the mean values of each diversity index in the three forest types determined in the deciduous forest of the Jama-Zapotillo lowland ecosystem.

As similarly observed in the deciduous forest of the Jama-Zapotillo lowland, the hierarchical grouping of the low forest and deciduous shrubland of the Jama-Zapotillo lowland discriminated three forest types based on the similarity of the indicators: species richness, abundance, Shannon index, and Simpson index. Type I (black line) contains 27 plots, type II (red line) contains 5 plots and type III (green line) 21 plots. (Figure 4).

Figure 4. A dendrogram (Using the ward.D algorithm and Euclidean distance) of the grouping of the plots sampled in the low forest and deciduous shrubland of the Jama-Zapotillo lowland ecosystem of the REAr. The grouping of the plots into three forest types, according to the calculated diversity indices, is illustrated.

Significant differences in species richness (p-value = 1.27×10^{-6}), abundance (p-value < 2×10^{-16}), and Shannon index (p-value = 0.00712) were identified among the three forest types identified for this ecosystem. Forest type III had the highest species richness (7.00), abundance (20.20), alpha diversity with Simpson's index (0.72), and Shannon index (1.63), which represent characteristics that define a well preserved forest (Figure 5). In type III, the following species stood out: *Cochlospermum vitifolium*, *Handroanthus chrysanthus*, *Caesalpinia glabrata*, and *Geoffroea spinosa*. The maximum height that was determined in this forest was 13 m.

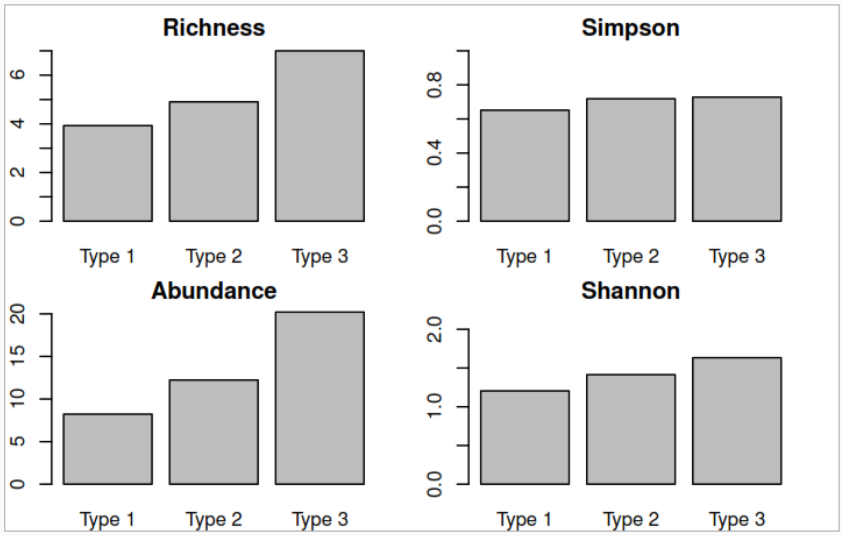

Figure 5. Comparison of the mean values in the three forest types of the low forest and deciduous shrubland of the Jama-Zapotillo lowland ecosystem.

4. Discussion

The detailed floristic analysis of our study reveals that, despite only focusing our sampling on two of the four ecosystems, [13], the richness and diversity of the species in this ecological reserve is greater than what was described in the last catalog of vascular flora detailing the complete sets of ecosystems included within the REAr [11]. The physiognomy of the species found in the study area was dominated by the herbaceous growth form with 167 species (44%). This is particularly interesting, as the tree species component in the tropical dry forests of the equatorial Pacific region is known, but knowledge of the shrubs and herbs is very limited. Nevertheless, seasonal dry forests have a very wide range of climatic tolerance [22], the predominance of herbaceous species over tree species may be due to the climatic conditions [23–25]. In the present study, all flora species were inventoried during the rainy season, corresponding with the onset of herbaceous flora.

Our findings are similar to those obtained in studies analyzing the floristic features of the dry forests of the central coastal Andes mountains that cover the Tumbesian region (58 forest families) [24] and other studies on Ecuador's dry forests that report data on woody plant species [26,27]. Among all of the families, the Fabaceae was the most abundant, followed by the Malvaceae and Euphorbiaceae, and the dominant species in the reserve was the *Handroanthus chrysanthus*. These results are in accordance with previous studies reporting the Fabaceae as the best represented group in neotropical dry forests [28] and with specific studies in this region. For example, Molina [11] documented that the Fabaceae and Euphorbiaceae were the two predominant families in the REAr, and Luna et al. [12] cited the Fabaceae and Malvaceae as the most representative families. In 2006, Cerón et al. [8] reported that the Malvaceae and Poaceae were the most numerous families, with8 species each, while the Fabaceae had 7 species.

Species assemblages in tropical dry forests appear to be primarily controlled by altitude and water availability [28], and the life forms reflect the bioclimate of the area. Raunkiaer [14] designed three main phytoclimates based on the landform spectrum, including phanerophyte for the tropics, therophyte for xeric environments, and hemicryptophyte for the cool temperate region. The present study identified seven different classes of life forms in the study area. As is the case in most dry forest remnants, our study reveals that the dominant life forms in the REAr were phanerophytes (52.5%) and terophytes (86%).

Many botanists have collected and studied the flora of Ecuador since the early 18th century [29–32]; the findings of our study highlight the importance of conserving the forests of the REAr and the species composition of the region. The analysis of species dominance and diversity within the REAr shows that 35% of the tree species identified are exclusive to the large floristic group of the Central Andes of the neotropical dry forest coast [24]. In the seasonal dry forests of Ecuador and Peru, 313 woody species can be found [33]. The presence of the Andes is one of the main causes of the isolation of the trans-Andean Pacific coastal region, which is characterized by the high levels of floristic endemism in the seasonal dry forests of Ecuador [33,34].

Many species are shared between dry forest formations and between the provinces of Ecuador [26]. In this study, we have observed that the species richness and diversity of REAr ecosystems depend on the dominant ecosystem type. Herbaceous species abundance and Shannon type diversity were higher in the deciduous forest of the Jama-Zapotillo lowland. The dominant families by number of species, density, abundance, and dominance of individuals are: the Fabaceae, Mimosaceae, Moraceae, and Bombacaceae [35,36]. The species composition analysis of this dry forest was dominated by species such as *Handroanthus chrysanthus* and revealed a general pattern of variation in community diversity and species composition. Several authors [26,34,37] have reported similar composition patterns of this species in the dry forests of the same region. The dendrograms divide the ecosystems studied into three types that differ in richness, abundance, and diversity. This seems to be related to the anthropic pressures exerted, with the least rich and diverse areas being the most degraded near the border, roads, or agricultural environments.

The information provided in this study is especially relevant due to the fragility of the tropical dry forest, which is the main ecosystem within the REAr and is the ecosystem

where our specific data collection has been performed. Indeed, the tropical dry forest is one of the most threatened biomes in the world [26,38] and has experienced one of the most extensive rates of habitat loss during the last few decades [38]. Be that as it may, it is a much less-studied ecosystem than other tropical ecosystems, such as rainforests [6]. The small extension and high fragmentation of the Ecuadorian dry forests makes them more sensitive than those which are located in other countries [39]; this situation is especially relevant in the REAr. Despite being classified as a natural reserve, the highest protection level in Ecuador, it is a vulnerable area due to the constant pressure of extracting resources and expanding the agricultural and ranching areas within the REAr limits. In addition, clandestine crossings by outsiders and the deforestation of trees to create new access routes occur in this border area. These activities exert a strong negative impact on the vegetation. Further studies are needed on the biodiversity of the REAr and the relationships within the ecosystems and external pressures. Furthermore, transdisciplinary initiatives that take into account the ecological and human dimensions are a priority for safeguarding the integrity of the REAr [40,41] along with similar regions. Strategies can be implemented in this manner to reduce the negative impacts on these regions and provide alternative livelihoods for local communities. This would allow for the sustainable use and conservation of the REAr's invaluable biodiversity for future generations, as well as its associated ecosystem services [42–44].

5. Conclusions

The present study reveals that the REAr has a greater floristic diversity than has previously been described. These new data are beneficial for the protection and conservation of this region.

The predominant life forms are phanerophytes and terophytes, which are conditioned by the presence of dry tropical climate in deciduous forests.

Within the dry forest zone, there is a great variety of forest types with different levels of richness, possibly because of differences in the level anthropogenic pressure between zones (i.e., greater impacts and more degraded areas with less richness are on the edges of the reserve, the areas closest to access roads or agricultural zones).

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app12178656/s1, Supplement S1: Ecosystem type and biodiversity and richness values of all field plots.

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