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Diversidad de agro ecosistema forestal en asentamiento del Parque Nacional Alejandro de Humboldt
Diversity of forest agroecosystem in settlement the Alejandro de Humboldt National Park

María Belkis Gallardo-López; Ovidia Mustelier-Del Rio; José Sánchez-Fonseca

Centro de Desarrollo de la Montaña. Limonar de Monte Ruz, El Salvador, Guantánamo, Cuba
Correo(s) electrónico(s)
maria@cdm.gtmo.inf.cu
ovidia@cdm.gtmo.inf.cu
josesanchezfonseca915@gmail.com
ORCID:https://orcid.org/0000-0001-9270-0159
https://orcid.org/0000-0002-7922-2313
https:// orcid.org/0000-0001-9775-1262

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Resumen

El trabajo se desarrolló con el objetivo de caracterizar la biodiversidad de los agro ecosistemas forestales en la localidad de Quibijánperteneciente al Parque Nacional Alejandro de Humbolt, se determinó la estructura, composición florística, así como laecología y manejo. Se establecieron 40 parcelas de muestreo de 20 x 20 m^2, se identificaron 2401individuos representados en 544especies, pertenecientes a 42 géneros,25 familias, fue analizado estadísticamente en cuanto a su riqueza, composición, estructura, diversidad y abundancia, comprobándose alta diversidad alfa y beta. Se determinaron las especies con mayor índice de valor de importancia ecológica comoCalophyllum. antillanum Bisse yLonchocarpus domingensis DC.Las familias con mayor representatividad en cuanto a las especies y géneros sonClusiaceae,Rutaceae *y* Lauraceae.

Palabras clave: Ecología;Riqueza;Composición;Estructura;Diversidad.

Summary

The work was developed with the objective of characterizing the biodiversity of the forest agroecosystems in the town of Quivijan belonging to the Alejandro de Humboldt National Park, the structure, floristic composition, as well as the ecology and management were determined. 40 sampling plots of 20 x 20 m2 were established, 2401 individuals represented in 544 species belonging to 42 genera, 25 families were identified, it was statistically analyzed in terms of its richn ess, composition, structure, diversity and abundance, verifying high alpha diversity and beta. The species with the highest ecological importance value index such as Calophyllum were determined. antillanum Bisse and Lonchocarpus domingensis DC,the most representative families in terms of species and genera are: Clusiaceae, Rutaceae and Lauraceae.

Keywords: Ecology;Richness;Composition;Structure;Diversity.

Introduction

Ecosystem conservation in protected areas includes the protection of the composition, structure and functioning of the elements that constitute biodiversity. Their protection is a complex problem that requires a deep understanding of the environment-society relationship in specific geographic spaces.

In mountain agro-ecosystems, a major problem is the management and conservation of natural resources, especially biological diversity, as a result of a group of causes, among which are the degradation of phyto- and zoogenetic resources; the lack of biodiversity monitoring and management systems to manage the risk derived from extreme climatic events; and the lack of identification of biodiversity elements that serve productive and conservation purposes.

Agroecological practices that have been developed in indigenous communities or rural sectors have shown to locals and outsiders their benefits in production, conservation, resource optimization, use of environmental resources, adaptation to critical situations such as climate change, among many others, but one of the main drawbacks is that these practices have not been properly evaluated.

Environmental deterioration in the world is largely due to the destruction of forests, which is increasing by a figure equivalent to 11.13 million hectares every year.

Many of these practices remain cloistered in certain sectors or communities, benefiting certain settlers, causing the rest of the population, mainly small and medium farmers, to opt for unsustainable solutions, which demand a lot of energy and resources and in many cases threaten the health of producers and their families, as well as the natural environment.

The agro-forest ecosystems in settlements within the Alejandro de Humboldt National Park after Hurricane Mathew deserves special attention because of the great diversity they present, an environmental space to be studied in its natural components such as soil, fauna, vegetation, hydrology and landscape. Characterizing the diversity of the forest is not an exception in this situation based on these studies; decisions can be made to apply conservation and mitigation measures.

The reserve in Alejandro de Humbolt National Park is a zone known for its high endemism, which represents a high level of importance because, based on different studies of richness and biodiversity carried out in this protected area, there is a positive relationship between the richness and size of the reserve, which is why it is essential to take into consideration its study.

The most significant feature of this massif is its physical and geographic complexity, which has conditioned a variety of natural landscapes with biological diversity and high floristic and faunal endemism.

It stands out for having the greatest richness and endemism of the country, for containing the largest remnant of mountainous ecosystem and the best preserved tropical rainforest in Cuba and the insular Caribbean. Its relief is unique worldwide, being a representative example of the development of karst forms and systems on non-carbonate lithologies.

The state and conservation of biological diversity guarantee irreplaceable services and benefits in relation to the supply, regulation and development of natural resources, as well as culture, recreation, religion and others, as basic elements to achieve human wellbeing.

Cuba is the country with the greatest biological diversity in the Antilles, both in total species richness and in the degree of endemism, and Guantánamo constitutes a biogeographic province within the Nipe - Zagua - Baracoa (N-S-B) massif.

The transformation of these ecosystems and landscapes within the Alejandro de Humboldt National Park corresponds to the recognition of major anthropization processes either by human hands or atmospheric phenomena.

The Evergreen Forest, on a metamorphic complex, deserved special attention after Hurricane Mathew because of its biodiversity, a forest formation characterized by exuberant vegetation with high temperatures and rainfall, an environmental space to be analyzed in its natural components such as soil, fauna, vegetation, hydrology and landscape.

The importance of the conservation of agro-ecosystems for the evaluation and maintenance of the systems necessary for the life of the biosphere, as well as the considerable reduction of the same as a consequence of certain human activities that cause the destruction of the natural habitat of numerous species, have motivated the identification of these aspects as one of the priority environmental problems for humanity.

For such effects, the scientific problem is determined: How will be the ecology and the management in the structure of the Evergreen forest in the Alejando de Humbolt National Park, Baracoa?

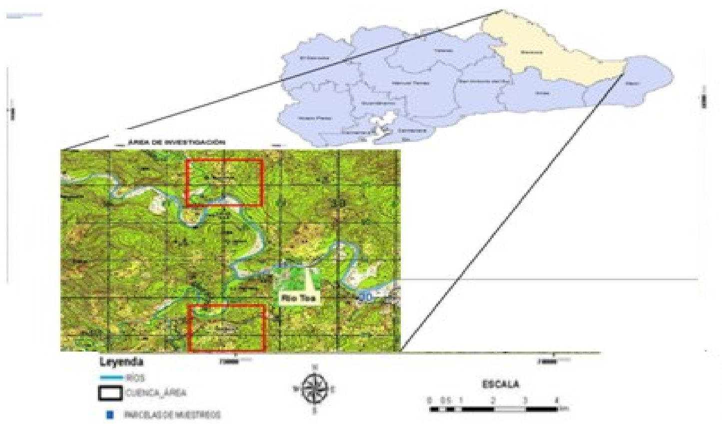
Therefore, the objectives are directed to characterize the ecology, management in the structure and floristic diversity of the Evergreen forest in the Alejando de Humbolt National Park, as well as to determine the structure, floristic composition, the ecology and management in the structure of the forest.

Development

The study area is located in the patrimony of the Baracoa Agroforestry Enterprise, in a forest with water and soil protection category, according to Law 85 of 1998, (Forestry Law) approved by the National Assembly of the People's Power of the Republic of Cuba.

As shown in (Figure 1), the watershed is located in the Nipe-Zagua-Baracoa mountain massif, north of the province of Guantánamo and northwest of the Alejandro de Humboldt National Park. The research was conducted in forest agro-ecosystems, in settlements within the Alejandro de Humboldt National Park, belonging to the Quibiján-Naranjal del Toa sector, Baracoa municipality, Guantánamo province, between November 2018 and May 2019.

Figure 1. Research area



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Climate Characterization

The climate, according to Zúñiga and Crespo, (2015), the climate of a certain place can be defined as a statistical description of the atmospheric state during a certain period of time. The climate of the area presents unique characteristics, being able to be called humid equatorial with values of more than 2722 millimeters of average rainfall, being considered the rainiest municipality in Cuba, in turn, presents the area with the highest rainfall. The average temperature is 25.8 °C, average relative humidity of 86.5%. That is why the number of rainy days in the year is very high, with an average of 180 to 240 days a year.

Soil types

According to the new version of the genetic classification of soils in Cuba, offered by Hernandez et.al. (2015) they are: Ferrallitic Red Leached or Ferrallitic Yellowish Leached. Methodology employed.

Forty rectangular plots of 20x 25m (500 m2), randomly distributed, were sampled for the study of the tree mass. In each plot, the floristic species present in the herbaceous (up to 0.99 m), shrub (1 to 4.99 m), and tree (greater than 5 m) strata were counted, which were defined according to the methodology proposed by Álvarez and Varona (2006). Species present in the shrub and tree strata were measured for height (m) using the Sunnto Hypsometer and diameter (m) with a tape measure greater than or equal to 5 m, according to the sampling criteria used by Sanchez. (2015).

The books of Urquiola et al., 2010) were used for species identification.

To determine if the sampling effort was sufficient to adequately represent the forest under study, the area-species curve was analyzed using PC-ORD software, Version 4.17 (Galvão et al., 2002).

Beta diversity (β)

For the analysis of area diversity, the relative abundance graph for the 10 most abundant species, a graph known as range-abundance or "Whitaker curve" According to Sánchez (2015), was performed.

Alpha diversity (α)

The alpha diversity, of floristic species was determined using the methodology of Aguirre (2012), where the richness index, proportional abundance of species, species dominance and the index of ecological importance value were determined.

Richness index

Richness refers to the number of species belonging to a certain group (plants, animals, bacteria, fungi, mammals, trees, among others) existing in a certain area according to (Margalef, 1968). It is expressed according to the formula:

$$Dmg = \frac{S-1}{\ln N}$$

Proportional abundance of species

The Shannon-Wiener index is one of the most widely used indexes to determine the diversity of plant species in a given habitat. To use this index, sampling must be random and all species of a plant community must be present in the sample according to Shannon (1948). This index is calculated using the following formula:

$$H^{/} = -\sum pi * \ln pi \quad Pi = \frac{Ni}{N}$$

Horizontal structure

To describe the horizontal structure, the following were determined: relative abundance, relative

frequency and relative dominance, (González el al., 2016), according to the following formulas:
The # of individuals of one specie:

AR = -- x 100
Total number of individuals of all species

Of plots on which a species occurs

FR = -- x 100
Total of occurrence in all plots

Basal area of a species
DR= --- x 100
Basal area of all species

The importance value index is a parameter that measures the value of species, typically based on three main parameters: relative dominance (either in the form of cover or basal area), relative abundance and relative frequency.

According to Keels et al. (1997), this index was evaluated by determining the values of abundance, dominance and relative frequency of each species:

IVIE = AR + DR + FR

Vertical structure

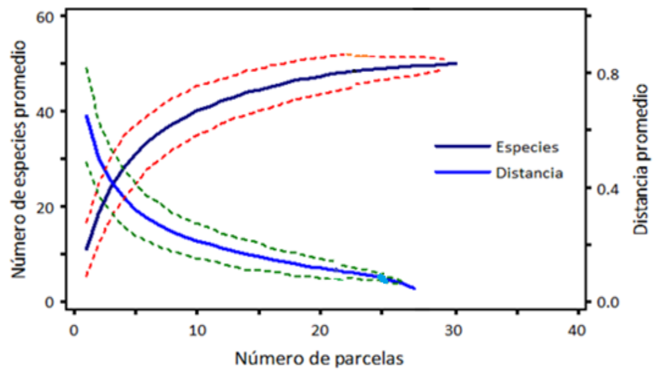
The characterization of the vertical structure is described taking into consideration the tree species found in the different substrates of the forest, according to the criteria of Sanchez (2015).

Results and discussion

Structure and composition of the agro-forest ecosystem

According to the area-species curve (Figure 2), the sampling was sufficient with 27 plots to represent the floristic composition of the agro-ecosystem. It can be observed that from these plots the vertical asymptote is achieved, where most of the taxa were identified in these units, keeping constant the occurrence of these species; also the distance curve is smoothed before reaching the zero value, conditions that must be met to estimate the sampling effort.

Figure 2 Area-species curve for forest agro-ecosystem.



Source: Own elaboration

This characteristic of the constant distribution of species in the area could be due to the agro-ecosystem condition caused by man himself, where conditions are created for the promotion of shading species that influence the development of crops of commercial and economic interest such as coffee and Theobroma cacao, L., among others.

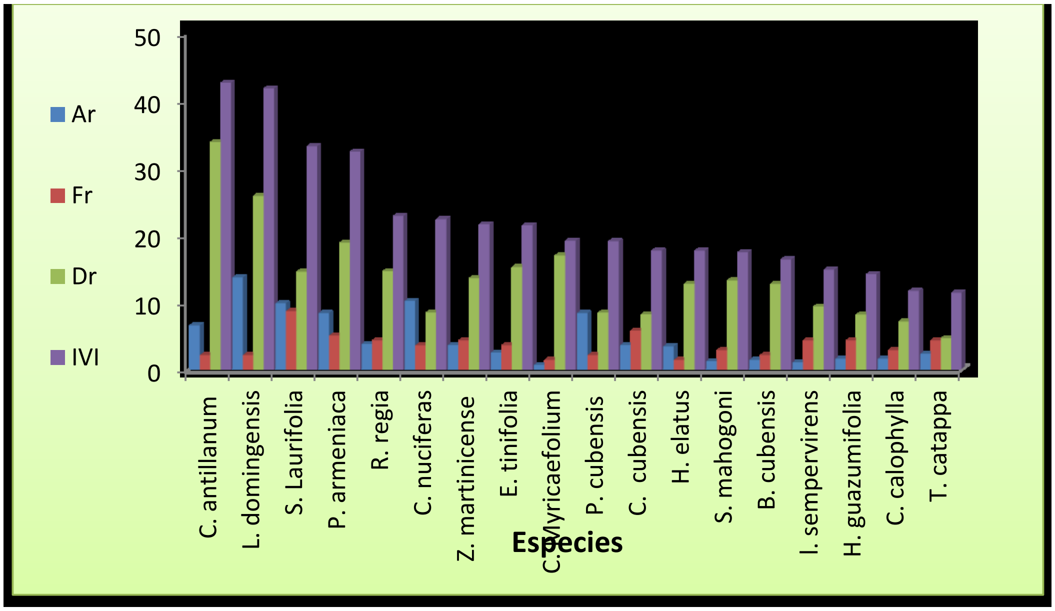
Beta diversity β

Horizontal structure

The study of the structure allowed evaluating for the agro ecosystem, the behavior of trees and species from the ecological parameters associated to the structural levels of the vegetation such as relative abundance, relative frequency and relative dominance of each species.

Taking into account the Ecological Importance Value Index (IVIE), at the species level, the agroecosystem was characterized in a general heterogeneous sense, since the ecological weight of the species with diameter greater or equal to 5 cm, resulted with different values, reflecting that the species that present greater dominance are the less abundant and frequent (Figure 3), this occurs whenever the greater ecological weight favors the rare species as a whole, as is the case of Calophyllum antillanum Bisse and Lonchocarpus domingensis, DC, among others.

Figure 3 Index of ecological importance value for 18 species in the evergreen forest.



Source: Own elaboration

These species represented as the most dominant, but less abundant and frequent, although they have a higher value of ecological importance, also have a low participation according to phytosociological parameters, which make them vulnerable to natural disturbances because they are subject to exploitation and extraction of wood for different commercial purposes.

These species less represented in the community, according to Moreno et al. (2011), may be more sensitive to environmental disturbances; it is, to identify a change in diversity, either in the number of species, in the distribution of species abundance or in dominance, warning of impoverishing processes.

Alpha diversity, Species richness

In the agro ecosystem sampled, 2401 individuals and 544 tree species and 25 families were recorded; Terminalia catappa LyJambosa vulgaris, DC, species reported and categorized, as invasive, were found to be very well established. In research conducted by Sánchez (2015), in pluvusilva forests on a metamorphic complex in the Toa Basin, he reported Terminalia catappa L and Jambosa vulgaris, DC as the most abundant invasive species.

These species, according to Sánchez (2015), develop quickly and can transform the structure and floristic composition, they tend to cover the entire forest, becoming the first species of the tree stratum until they transform the structural levels and floristic composition, as they can also colonize the entire vegetation, occupying the first places in abundance, dominance and frequency, with great values of ecological importance.

Of the total number of species recorded, 84 were native, which represent ecological and environmental importance in all types of land use categories, which comprised the study. Sanchez (2015), in research conducted in this same area reported 52 species, 24 families and 1507 individuals.

Within this agro-ecosystem, natural forest (Figure 4), was the land use category with few non-native species, the coffee system presented the highest number of species in a single site, representing 33.9% of the total diversity, even when only native species were considered.

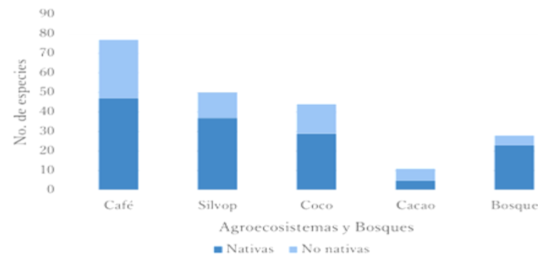


Figure 4 Number of species in the agro-ecosystem

Own elaboration`s source

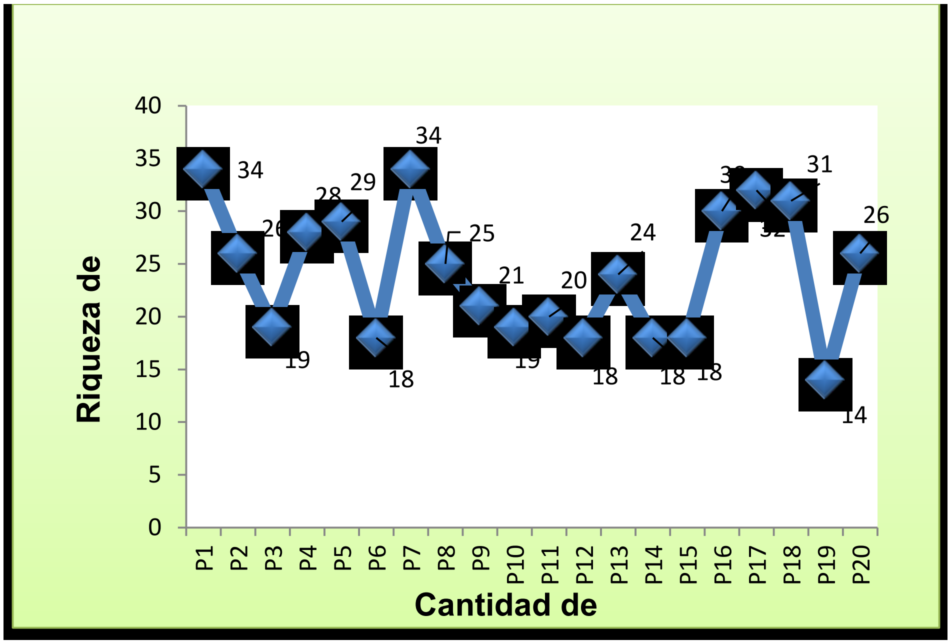
The highest diversity was found in the natural forest, but it only represented 33% of the native species. This indicates that it is not alpha diversity alone that determines the richness of shrub and tree species in the agroecosystem, but rather, it may be beta diversity that plays an important role.

In total, 22 endemic species were recorded, and at the system level, the highest representation of these taxa was found in the coconut and forest systems with nine and eight species, respectively.

Figure 2 shows the species richness values by plots, representing plots one, seven, 17 and 18 as the most representative in terms of species richness in these agro-productive settlements.

These plots identified with higher species richness, their representativeness could be related to an enrichment that was carried out in the area through forest management.

Figure 2 Forest species richness by plots



Source: Own elaboration

In most of the plots established in these agro-productive settlements, native species of recognized economic value such as: Taliparitis elatus Sw, Carapa guiarensis Aubl, Calophyllum utile Bisse and Cedrela mexicana M.j. Roem, among others, for the reconstruction or enrichment of rainforests.

Terminalia catappa and Jambosa vulgarisson are exotic species and are naturalized and well distributed throughout the area where they form part of the main forest strata.

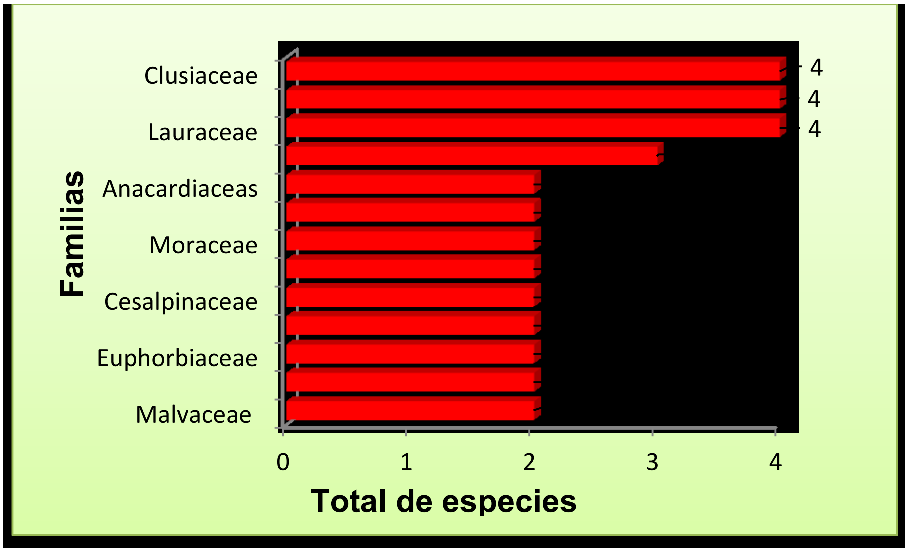
Sánchez (2015) reports them as invasive and with good natural regeneration.

Baró (2014) reported Terminalia catappac as an invasive species, while biological invasions are already recognized as one of the major problems facing humanity, particularly serious on islands. These species, often plant species, are causing enormous damage to biodiversity and to the valuable natural and agricultural ecological systems on which humans depend.

Families with the highest species richness of tree species

The Figure 6, shows the best represented families with respect to species richness, which determine the existing diversity for the agro ecosystem. The families Clusiaceae, RutaceaandLauraceaare the best represented with respect to species richness with 40% respectively, followed by Sapindaceae (30%), in contrast, the least represented families were: Anacardaceae, Malvaceae, Moraceae, Urticaceae, Cesalpinaceae, Myrtaceae, Euphorbiaseae, Arecaceae, and Malvaceaecon 20% among them.

Figure 6 Families with the highest species richness of arboreal plants.



Own elaboration`s source

The high diversity of the Clusiaceae, Rutaceae and Lauraceae families in the forest agroecosystem could be associated with the possibility of seed dispersal by biotic and abiotic agents, including atmospheric phenomena, which would increase the complexity of the interactions that make possible the recruitment of the different species in the forest ecosystem, in addition to the enrichment of forests and other activities within the agro-productive systems.

These families, better represented in relation to the number of species, are the most frequent in these ecosystems.

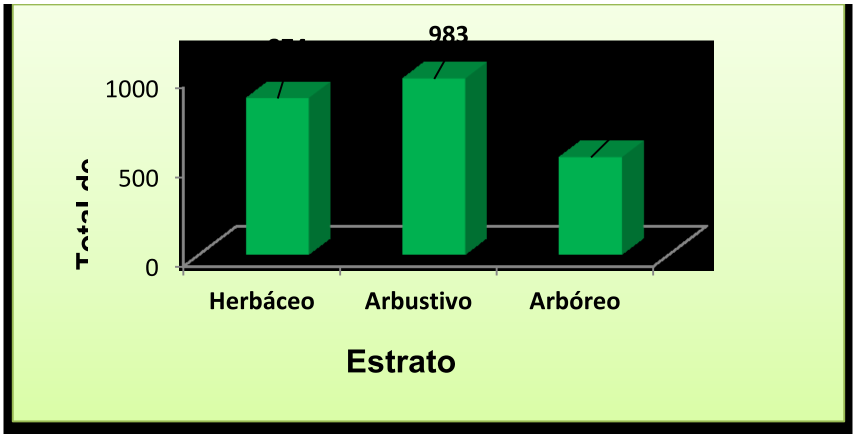
The most abundant families in relation to species richness for the agro-forest ecosystem in settlements within the park, group the majority of the inventoried individuals, because there are families well represented by four species with a number of individuals, for example: Clusiaceaea with four species and 500 individuals, Rutaceaecon four species and 346 individuals, Lauraceaecon four species and 247 individuals.

In this research there are some species by families with greater representativeness in the forest under study due to the high percentage of ecological importance value index such as Clusaceae: Calophyllum antillanum Bisse, Fabaceae: Lonchocarpus domingensis DC, Clusiaceae: Calophyllum utile Bisse, and Euphorbiaceae: Sapium Laurifolium Griseb.

Quantity of individuals by strata

Figure 7 shows the number of individuals by strata, representing the shrub stratum with the highest number of individuals, followed by the herbaceous and arboreal stratum.

Figure 7 Number of individuals by strata



Own elaboration `s source

When compared with the results reported by Sanchez (2015), it is identified that in this case there is similarity with this author, since he reports that the herbaceous stratum presented 804 individuals, the shrub 438, followed by the tree with 178; although there is a difference in the results of herbaceous and shrubs.

These similarities and differences could be a consequence of the abrupt changes that the forest suffered due to the passage of Hurricane Mathew, where an increase in natural regeneration is evidenced and therefore, the higher percentage of individuals over time in the shrub stratum as expected.

These results demonstrate the lack of balance in the number of individuals per stratum that should exist; according to Sanchez (2015), in its climatic state, the tree stratum should have few individuals.

The results show that the Quibiján and Naranjo Del Toa forests present differences in their strata according to the locality where they are located, as previously mentioned, they are located in part of the banks of the Quibiján and Toa rivers. In these areas, according to González et al. (2016), the divergence between the actions developed for the management of forest species constitutes one of the main causes of the existing difference between the strata, as well as the low percentage of the similarity index between the historical woody species of the studied landscape.

Relative abundance curves

Figure 8 shows the relative abundance curve obtained for the 21 most abundant species in the agroecosystem.

According to the characteristics of the curve of abundance and relative dominance for the agro ecosystem, it is confirmed the behavior of the shape of the curve obtained, it is observed that the species that are dominating the forest agro ecosystem are: Hibiscus elatus, Terminalia catappa L, Ocotea leucoxylon (Sw.), Luehea speciosa WiUd and Jambosa vulgaris DC occupying the first places in the ecological distribution of the forest, evidencing the proliferation of exotic and invasive species for these systems and especially for the agro ecosystem.

Figure8. Relative abundance curves for the 21 species identified.

Own elaboration `s source

Talipartis elatus occupies the first position, an important species of economic value, since its dominance in abundance and dominance provides stability in the evolution of the forest. This species has a germination power of 40% and its natural regeneration is excellent, which is an aspect that can be very important to take into account in future conservation strategies for the forest.

Terminalia catappa L, Ocotea leucoxylon (Sw.) Luehea speciosa WiUd and Jambosa vulgaris DC occupy the first places in the ecological distribution in the agro-ecosystem, it should be noted that the dominance of these taxa represents for this ecosystem a threat to the diversity, balance and functioning of this vegetation, even when the objective is production, but in the future these systems will suffer from good conservation.

In addition, in the information obtained from the curve to analyze the abundance and diversity of the species that are dominating this forest, it is confirmed that these taxa that occupy the second, third, fourth and fifth place are species of low economic value and can colonize the entire area and transform it if not managed.

According to Sánchez (2015), these forests have suffered from anthropic action that has been going on for years, causing loss in the structural levels and biodiversity of the ecosystem.

In the study region, many farms had a diversity of agroecosystems, which made it possible to evaluate different agroecosystems in the same area. There were also areas where the agro-ecosystem consisted of a mixture of main crops, e.g. coffee-silvopastoral, cocoa-coconut, among others, and in these cases the agro-ecosystem was classified according to the dominant crop (forest).

Conclusions

The degree of conservation of the vegetation cover was found to be moderately conserved for both systems, due to the irregularity of the original strata in the current vegetation. The agroforestry systems in the Quibiján - Naranjo Del Toa massif are characterized by having a complex structure in their tree cover, typical of crops with a low level of technification, reflecting the multiple uses of resources by farmers, which are integrated to cultural, social, economic and environmental processes, and as a whole favor the consolidation of sustainable productive systems. The implementation of technologies in the different sites belonging to the Integral Foresty Enterprise Baracoa, determine the improvement of the structure and floristic composition of the Evergreen forest in the Quibiján-Naranjal del Toa sector.

Referencia bibliográfica

Aguirre, Z. (2012). Composición florística y estructura del bosque estacionalmente seco en el sur occidente del Ecuador, provincia de Loja, municipio de Macara y Zapotillo. Universidad Nacional de Loja, Herbario Loja. *Arnaldao 16(2)*: 87-99, 2009

Baró, I. (2014). *Serie de folletos informativos sobre plantas invasoras*. Instituto de Ecología y Sistemática (AMA-CITMA). Vol. 30: Terminalia catappa.

Galvão, F., Roderjan, C., Kuniyoshi, Y. e Ziller, S. (2002). Composição Florística e Fitossociologia de caxetais do litoral do Estado de Paraná-Brasil. Floresta.*Curitiba. 32(1)*:17-39.

González, L. R., Palmarola, A., González, L., Bécquer, E. R., Testé, E. y Barrios, D. (ed.) (2016). Lista roja de la flora de Cuba.*Bissea, 10* (Núm. Espec. 1).

Hernández, A., Pérez, J.M., Bosch, D. y Castro, N. (2015).*Clasificación de los suelos de Cuba*. INCA, ISBN 978-959-7023-77-7, (p. 47).

Keels, S., Gentry, A.& Spinzi, L. (1997). Usig vegetation analysis to facilitate the selection of conservation site in eastern Paraguay. *Revista Washington: SI/MAB (Biodiversity measuring and monitoring certification training,) volume 2*

Ley No.85. (Ley Forestal) (1998). Asamblea Nacional del Poder Popular de la República de Cuba. http://juriscuba.com› uploads › 2015/10 ›

Margalef, R. (1968). *Perspectives in ecological theory*. The University of Chicago Press. Chicago, Londres, 111 pp.

Moreno, C. E., Barragán F., Pineda, E. y Pavón, N. P. (2011). Reanálisis de la Diversidad

Alfa: alternativas para interpretar y comparar información sobre comunidades ecológicas. *Revista Mexicana de Biodiversidad* 82: 1249-1261.

Sánchez, F. J. (2015). *Acciones silvícolas para la rehabilitación del bosque pluvisilva de baja altitud sobre complejo metamórfico del sector Quibiján-Naranjal del Toa.*[Tesis de doctorado, Universidad dePinar del Río]. https://www.eumed.net/libros-gratis/2011c/983/983.pdf.

Shannon, C. E. (1948). *The Mathematical theory of communication*. (pp. 3-91). En Shannon & Weiner (eds.). The mathematical theory of communication. Univ. Illinois Press. Urbana, (pp.117)

Urquiola, A., González, L., Novo,R. y Acosta.Z. (2010). *Libro rojo de la flora vascular de la provincia Pinar del Río*. Publicaciones Universidad de Alicante, (pp.457-458).

Zúñiga, I.y Crespo, E. (2015). *Meteorología y Climatología*. UNED.