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Forest species of ecological importance in tropical dry forest fragments associated with a cultivation matrix of *Gossypium herbaceum* L. (La Guajira, Colombia) †

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Abstract: The tropical dry forest is a dynamic ecosystem that develops in warm areas between 0-1000 meters of altitude with high genetic variability and supply of ecosystem services. The objective of the work was to identify forest species of conservation interest present in two remnants of tropical dry forest associated with a cultivation matrix of *Gossypium herbaceum* in the department of Guajira, Colombia. Ten transects of 100 m^2 were established in each of the remnants and ad libitum trails to record the tree species and their abundances. Also, data on repetition height, total height, diameter at breast height (DBH), cover, and phenological notes (vegetative state, presence of flowers, presence of fruits) of each individual were taken; the specimens were determined with specialized bibliography and database. The families with greater species richness were Leguminosae, Anacardiaceae, Euphorbiaceae, and Moraceae; the species with greater abundance were *Albizia saman*, *Leucaena leucocephala*, *Gliricidia sepium*, *Anacardium excelsum*, *Astronium graveolens*, *Hura crepitans*, *Ficus* sp, *Guazuma ulmifolia*, and *Casearia corymbosa*; in the neighboring tree vegetation, the following species were registered: *Mangifera indica*, *Persea americana*, *Annona muricata*, *Azadirachta indica* and palms such as *Attalea butyracea* and *Cocos nucifera*; the remnants showed a relatively homogeneous species composition, but with variable dominances; in the agricultural matrix of cotton cultivation, forest species have emerged that provide shade and maintenance of the humidity of the agricultural system. The forest inventory of the zone contributes to the knowledge of the diversity of the tropical dry forest that is drastically reduced in the south of La Guajira and represents inputs for the formulation of environmental management and conservation plans.

Keywords: Tropical dry forest; species; conservation; cultivation; sustainability

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1. Introduction

Forest fragmentation is considered one of the main causes of biodiversity loss [1,2,3,4,5,6]. Research has provided a wide range of information on its effects, magnitude, and scale through different measured factors and measurement methods in habitats around the world [7,8]. For example, in the Brazilian Atlantic forest, through a database with 2.230 richness estimates of different species and 1.097 sampling sites, it was determined that habitat fragmentation generates a large negative impact on species richness [9]. In Kenya, an investigation was shown that the structure, diversity, and richness of species varies in forest fragments from its edge towards its interior, using samplings in 5 remnants of similar flora communities and proximity no greater than 21 km [10]. In Paraná, Brazil, selective logging in forest fragments has inhibited the regen-

eration of sensitive and specialized species, giving rise to more aggressive species, which impoverishes the diversity of forest ecosystems [11].

In fauna, a study carried out in crop patches in the coastal region to the north of Israel, found alterations in the hunting hours of predators and the presence of prey [12]. In South Africa, some mammals showed sensitivity to crop-associated habitat loss, suggesting conservation practices in agricultural mosaics [13]. In dung beetles, a strong negative response was found to the modification of the tropical forest and the reduction in the size of the forest fragments [14].

Abiotic factors have also been studied. In the coastal dune forests of southern Africa, changes in structure and functionality in fragmented forests have been shown to affect their capacity to store carbon [15] however, it was also shown that forest-steppe fragmentation in Mongolia did not have any effect on carbon stocks [16]. On the other hand, a study by Zhang and others [17] evaluated forest cover in Nanjing, China using satellite data from 1987 to 2017, allowing them to propose sustainable forest growth models. Lassalle and others [18] proposed a methodology to model the potential for fragmentation in regions around the world to plan the land use and prioritize areas for protection and restoration.

Vieira et al. [19] evaluated two models used to determine the species richness of fragmented landscapes (habitat quantity model and patch size and isolation models), concluding that the appropriate metrics should be applied to arrive at values less skewed. In turn, Arce and others [20], in Chile, showed that the fine-grained scale compared to the coarse-grained scale allows a more detailed characterization of the structure of habitats altered with forest plantations to understand much better the relationship of carnivorous species with the landscape to reach more effective conservation decisions. In contrast, it has been reported that the tropical forest fragments in Singapore are resistant to the environmental impacts of humans by maintaining their basic processes such as seed dispersal and pollination [21]. In the Mediterranean, a positive relationship was found between forest fragmentation and maintenance of tree functionality in times of drought [22].

Taking into account the repercussions that the fragmentation of forests can have for the conservation of biodiversity and the different measurement methods that can be applied, in this study the flora of two remnants of tropical dry forest associated with a matrix of cultivation of *Gossypium herbaceum* in the department of La Guajira, Colombia.

2. Materials and Methods

Study area: The study was conducted in two remnants of tropical dry forest surrounded by a matrix of cotton (*Gossypium herbaceum*), located in the farm La Esperanza, municipality of Villanueva, south of the department of La Guajira, Colombia.

Sampling, collecting and determination: A tour of the study area was made to locate the sampling units randomly [23]; using the 0.1 ha transect method [24] and according to modifications suggested by various floristic studies [25], 10 transects of 50x2 m (100m^2) were established in each forest remnant. All the individuals of the transects with a diameter at breast height (DBH) ≥ of 2.5 cm were censused, their height of reiteration, total height, cover, and phenological state (vegetative, presence of flowers, presence of fruits) were recorded. The plant material was collected on newspaper and preserved in 75% ethyl alcohol. For taxonomic identification, dichotomous keys from specialized texts, online pages, and virtual botanical collections were used.

Data analysis: The Margalef richness index, the dominance index, and the Shannon-Wiener diversity index [26,27] were calculated using the statistical package PAST version 1.78 [28].

3. Results and Discussion

A total of 165 individuals were recorded, grouped into 7 families and 16 ecologically important tree species. The Leguminosae, Anacardiaceae, Euphorbiaceae, Moraceae, and Arecaceae families presented the highest number of species (Figure 1) and the most

abundant species were *Albizia guachapele*, *Leucaena leucocephala*, and *Gliricidia sepium* (Figure 2). *Mangifera indica*, *Persea americana*, *Annona muricata*, *Azadirachta indica*, and *Cocos nucifera* were found in the tree vegetation surrounding the remnants.

According to the alpha diversity indices (Figure 3), the remnants presented a relatively homogeneous species composition, but with variable dominance. In the agricultural matrix of the cotton crop, some of the reported forest species were observed, which provide shade and maintain the humidity of the agricultural system, and are also a source of food for the permanent fauna of the area and transitory during crop rotation periods.

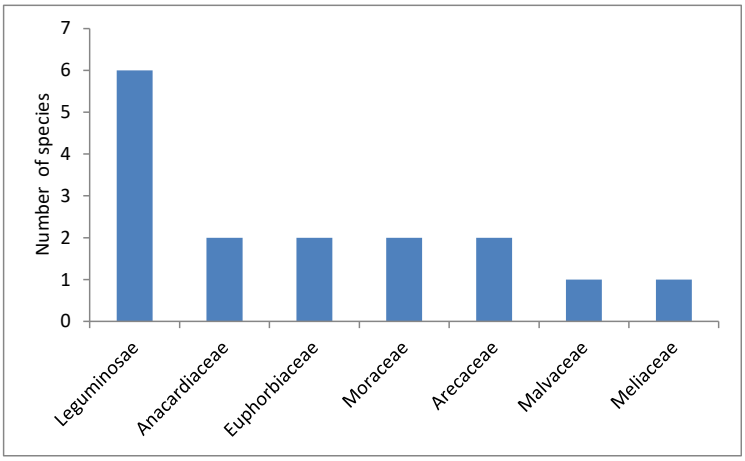

Figure 1. Representative families in the study area.

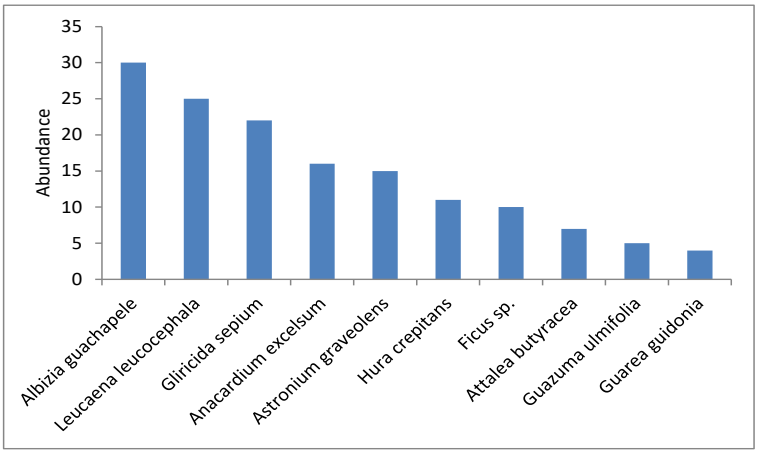

Figure 2. Most abundant species in the study area.

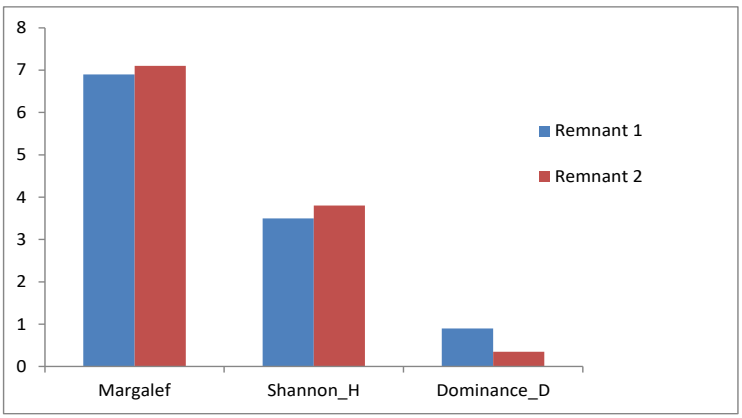

Figure 3. Alpha diversity indexes.

The species present in the remnants are part of the floristic assemblage characteristic of the tropical dry forest in the basins of northern Colombia, organized especially in the gallery and riparian forests, fragmented forests with pastures and crops, and fragmented forests with secondary vegetation [29]; however, the forests of the department of La Guajira show an important heterogeneity favored by geographical distances and environmental conditions [30].

On the other hand, despite the reduced size of the remnants surrounded by the agricultural matrix, the diversity of forest plant taxa contrasts with that reported in tropical dry forest fragments with extensive cattle ranching intervention in silvopastoral and conventional systems [31]; also, the remnants comprise landscape elements that, together with studies of structure, dispersion type and statistical analysis of species grouping, can favor the delimitation of ecological restoration strategies [32].

4. Conclusions

The forest remnants studied present a species composition representative of the tropical dry vegetation formation, highlighting forest species of ecological importance.

Despite the small size of the forest remnants, they contain a significant number of species that support the implementation of conservation programs that contribute to the sustainability of ecological processes and factors.

The floristic diversity present in the tropical dry forest remnants can be considered as medium-high despite the existence of species that present higher abundances than the rest of the species, causing certain processes of competition and dominance.

This study strengthens the knowledge of Colombian diversity and the implementation of environmental activities for its recognition by the population.

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Conflicts of Interest: The authors declare no conflict of interest.

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