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# Characterization of Riparian Tree Communities along a River Basin in the Pacific Slope of Guatemala

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**Abstract:** Ecosystem conservation in Mesoamerica, one of the world's biodiversity hotspots, is a top priority because of the rapid loss of native vegetation due to anthropogenic activities. Riparian forests are often the only remaining preserved areas among expansive agricultural matrices. These forest remnants are essential to maintaining water quality, providing habitats for a variety of wildlife and acting as biological corridors that enable the movement and dispersal of local species. The Acomé river is located on the Pacific slope of Guatemala. This region is heavily impacted by intensive agriculture (mostly sugarcane plantations), fires and grazing. Most of this region's original forest is now restricted to forest remnants concentrated along the riverbank. However, the botanical composition and species diversity of the riparian communities has not been characterized. This baseline information is essential to develop restoration strategies and management plans. This study aimed to characterize the riparian tree communities along the Acomé riverbank by systematically collecting herbarium specimens and photographic material for trees over 10 cm DBH (diameter at breast height). Cluster analysis was used to identify the main riparian communities, and diversity indices were calculated for each community. A total of 115 tree species were identified, belonging to 91 genera and 43 families. The cluster analysis suggested the presence of four riparian tree communities along an altitudinal gradient. *Rhizophora mangle*, *Cecropia obtusifolia*, *Guazuma ulmifolia*, and *Brosimum costaricanum* were the dominant species of the identified communities. This research will support ongoing restoration efforts and biological connectivity plans in this region.

**Keywords:** arboreous species; riparian forest; plant communities; secondary forest; richness; diversity; biodiversity conservation; regional diversity

## 1. Introduction

Agricultural expansion (i.e., crops and livestock) is one of the main drivers of habitat change and biodiversity loss in the tropics [1,2]. Central America is considered a biodiversity hotspot and is particularly vulnerable to anthropogenic influence and climate change [3]. However, there are multiple challenges to conservation efforts in this region (e.g., socio-economic, political, and scientific) [4]. There is a paucity of scientific studies assessing the biodiversity status of vulnerable areas and such studies are urgently needed to prioritize conservation efforts and monitor biodiversity and habitat change over time.

Riparian zones are usually the only areas with natural vegetation cover within large agricultural matrixes. These are maintained in order to protect water resources vital to agricultural practices [5,6]. Riparian zones are ecotones in transition areas between terrestrial and aquatic ecosystems [7], and may also be referred to as azonal vegetation, i.e., plant communities that are more severely influenced by edaphic factors than by climate [8]. These ecotones provide multiple ecosystem services that support biological diversity, carbon storage and water quality [7,9]. The topography and soil properties of such riparian zones are extremely diverse, contributing to the high level of structural and compositional diversity of their vegetation [10,11].

Riparian forests provide habitat to many wildlife species and may assist with preservation of biological corridors by connecting the upper and lower parts of the basins. A diverse range of wild fauna can use the resources provided by plants, streams and rivers within such corridors to support the maintenance of regional biodiversity [6,12]. However, riparian forests are also highly vulnerable to invasion and anthropogenic impact [13,14]. In addition to the protection, restoration and rehabilitation of riparian corridors (i.e., plant communities) current riparian zone management includes fencing out livestock and forbidding agricultural activities along riverbanks as widely used approaches to achieve this aim [15–17]. To develop successful management plans, however, a baseline assessment of the plant species within these riparian forests is essential [11].

Guatemala, a developing country in Central America, has very fragmentary information about its plant species. *The Flora of Guatemala* was first published in 1946, and since then, a detailed botanical study has not been carried out. Combined with scarce information on the existing plant species, intensive agriculture, grazing, and fires have dramatically reduced forest cover in many areas [18]. Furthermore, introduction of exotic species and climate change may add potential threats to the survival of numerous native species in this country [3].

Within this context, the overarching goal of this study was to characterize the riparian arboreous vegetation of the Acomé river basin, located among sugarcane plantations in the Pacific slope of Guatemala. To this end, we collected herbarium specimens and photographic material from trees greater than 10 cm DBH (diameter at breast height) along the riverbank. We then identified the species and the main riparian tree communities in this area through cluster analysis and calculated diversity indicators to describe each community. Finally, we discussed potential drivers affecting vegetation at the local landscape level. This study represents a valuable contribution to our knowledge of riparian tree communities in Central America and will support ecological restoration efforts and riparian connectivity plans in this highly biodiverse, yet vulnerable, region.

## 2. Materials and Methods

### *2.1. Study Site*

The Acomé river is 58.48 km in length. The Acomé river basin covers an area of 893.4 km$^2$ (344.9 sq mi) [19] and is located on the Pacific slope of Guatemala, which extends from the foothills of the volcanic mountains to the Pacific Ocean [20]. It is located in the Escuintla department, on the jurisdiction of La Democracia, La Gomera, Santa Lucía Cotzumalguapa, Sipacate and Siquinalá. Its geographical coordinates range from 13°54′00′′ to 14°22′00′′ North, and 90°57′00′′ to 91°13′00′′ West with an altitudinal range of 0 to 570 m above sea level (m a. s. l.) [21]. The mean annual rainfall ranges from 800 mm at its lowest altitude to 4600 mm in the upper regions. Maximum temperatures vary between 32 and 34 °C, while the minimums oscillate between 20 and 21 °C [22]. According to the L. Holdridge classification proposed by De la Cruz [23,24], the Acomé basin has three life zones: very humid subtropical warm-forest (bmh-S), humid subtropical warm-forest (bh-S) and dry subtropical forest (bs-S). According to the *Forest Cover Map of Guatemala of 2010*, only 3% of the Acomé basins area was reported to have forest cover [18]. The most important activity within the region is agriculture: predominantly sugarcane (*Saccharum officinarum* L.) production. The forest remnants are mainly riparian, being located along the Acomé riverbank and its tributaries and there are also mangrove forests near the sea.

## 2.2. Plant Sampling

Fifty-six rectangular plots of 10 × 100 m (1000 $m^2$) were assessed. These were systematically located at 1 km intervals along the Acomé riverbank (Figure 1). At each plot, geographical coordinates and altitude were recorded using a handheld GPS (Table S1). Within each plot, measurements of all trees >10 cm diameter at breast height (DBH) were recorded as well as tree height. We photographed and collected herbarium specimens to enable identification of each plant species. The herbarium specimens consisted of branch(es) with leaves, flowers and fruits. Additional riparian tree specimens were collected *ad hoc* outside the plots along the river basin for identification purposes. At least 5 specimens were collected from each of the sampled tree species. Specimens were dried using a portable dryer, consisting of an electric fan heater and a metallic base. The botanical presses were placed on the base and covered with a cotton canvas (Figure S1) [25]. Most of the specimens required approximately 24 h for drying, while those with more succulent tissues required up to 60 h.

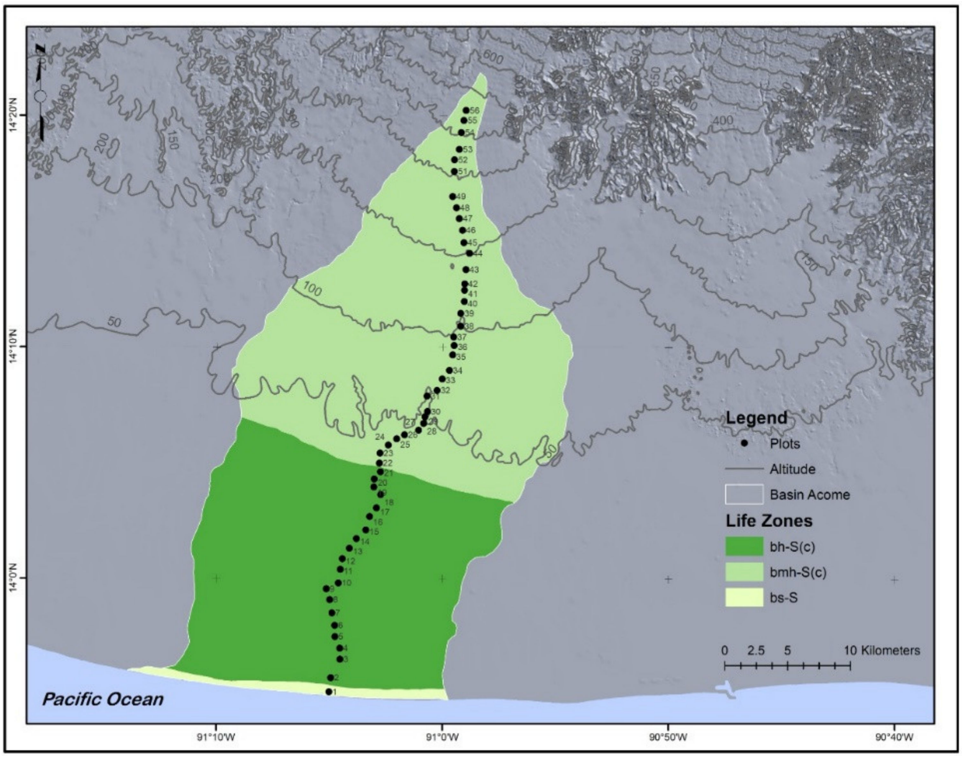


**Figure 1.** Acomé river basin with its life zones and distribution of the sampling plots.

## 2.3. Plant Identification

Identification of plant specimens was achieved in the AGUAT Herbarium 'Professor José Ernesto Carrillo' of the Agronomy Faculty of the University of San Carlos of Guatemala. For identification, we used the dichotomous keys of the Flora of Guatemala [26], Flora of Nicaragua [27], Flora Mesoamericana [28] and the online databases *The Plant List* and *World Flora Online* [29,30].

## 2.4. Vegetation Classification

Cluster analysis on the abundance of species per plot was used to identify vegetation groups (plant communities) using Euclidean distance (as the distance measure) and Ward's method (as a group linkage measure) [31]. The packages 'dendextend', 'ggplot2' and 'stats' for the R environment were used [32–34]. An analysis of similarity (ANOSIM) of the package 'vegan' was used to validate the groups obtained by cluster analysis [32,35]. To represent the ordination of the groups obtained from the cluster analysis, non-metric multidimensional scaling was performed with data on the abundance of species per tree community, using Bray–Curtis dissimilarity index through 'vegan' package for R [32,35].

*2.5. Floristic Composition and Species Diversity*

The importance value index (IV) was estimated for the species in each community with data on the abundance and basal area per species per plot with the package 'BiodiversityR' [32,36]. Diversity indices were estimated for each plot using the package 'vegan' to thereafter estimate the average value per tree community [32,35].

## 3. Results

*3.1. Tree Species Identification*

One hundred and fifteen (115) tree species were identified along the Acomé riverbank, belonging to 91 genera and 43 families (Table 1).

**Table 1.** Updated list of the tree species found in the Acomé riverbank (nomenclature following Angiosperm Phylogeny Group system).

| Family | Species | Common Name |
|---|---|---|
| Acanthaceae | *Avicennia germinans* (L.) L. | Mangle negro |
| Anacardiaceae | *Spondias mombin* L. | Jocote jobo |
| Annonaceae | *Annona purpurea* Moc. & Sessé ex Dunal | Chincuya |
| | *Rollinia mucosa* (Jacq.) Baill. | Anona |
| Apocynaceae | *Aspidosperma megalocarpon* Müll.Arg. | Chichique |
| | *Tabernaemontana donnell-smithii* Rose ex J.D.Sm. | Cojón |
| Araliaceae | *Dendropanax arboreus* (L.) Decne. & Planch. | Mano de león |
| Bignoniaceae | *Crescentia cujete* L. | Morro |
| | *Spathodea campanulata* P.Beauv. | Llama del bosque |
| | *Tabebuia rosea* (Bertol.) Bertero ex A.DC. | Matilisguate |
| Boraginaceae | *Cordia alba* (Jacq.) Roem. & Schult. | Tigüilote, Upay |
| | *Cordia alliodora* (Ruiz & Pav.) Oken | Laurel |
| Burseraceae | *Bursera simaruba* (L.) Sarg. | Palo de jiote |
| Cactaceae | *Cynometra retusa* Britton & Rose | |
| Cannabaceae | *Celtis iguanaea* (Jacq.) Sarg. | |
| | *Trema micrantha* (L.) Blume | Capulín |
| Chrysobalanaceae | *Chrysobalanus icaco* L. | Icaco |
| Clethraceae | *Clethra mexicana* DC. | Zapotillo |
| Clusiaceae | *Calophyllum brasiliense* var. rekoi (Standl.) Standl. | Palo mario |
| | *Clusia guatemalensis* Hemsl. | |
| Combretaceae | *Conocarpus erectus* L. | Botoncillo |
| | *Laguncularia racemosa* (L.) C.F.Gaertn. | Mangle blanco |
| | *Terminalia arborea* Koord. | Volador |
| Dichapetalaceae | *Dichapetalum donnell-smithii* Engl. | |
| Ebenaceae | *Diospyros nigra* (J.F.Gmel.) Perrier | |
| Fabaceae | *Acacia cornigera* (L.) Willd. | Ixcanal blanco |
| | *Acacia hindsii* Benth. | Ixcanal negro |
| | *Acacia polyphylla* DC. | Alacrán |
| | *Albizia adinocephala* (Donn.Sm.) Record | Conacaste blanco |
| | *Albizia saman* (Jacq.) Merr. | Cenicero |
| | *Andira inermis* (Wright) DC. | Almendro cimarrón |
| | *Calliandra magdalenae* var. colombiana (Britton & Killip) Barneby | Chalí |
| | *Dalbergia cuscatlanica* (Standl.) Standl. | Granadillo |

**Table 1.** *Cont.*

| Family | Species | Common Name |
|---|---|---|
| | *Delonix regia* (Hook.) Raf. | Flambollano |
| | *Diphysa americana* (Mill.) M.Sousa | Guachipilín |
| | *Enterolobium cyclocarpum* (Jacq.) Griseb. | Conacaste |
| | *Erythrina mexicana* Krukoff | Palo de pito |
| | *Gliricidia sepium* (Jacq.) Walp. | Madrecacao |
| | *Hymenaea courbaril* L. | Guapinol |
| | *Inga edulis* Mart. | Cuje |
| | *Inga laurina* (Sw.) Willd. | Caspirol |
| | *Inga paterno* Harms | Paterna |
| | *Inga sapindoides* Willd. | Cushin |
| | *Lonchocarpus macrocarpus* Benth. | Quebracho |
| | *Lonchocarpus salvadorensis* Pittier | Chaperno |
| | *Lonchocarpus sericeus* (Poir.) DC. | Matabuey |
| | *Pithecellobium dulce* (Roxb.) Benth. | Guachimol |
| | *Platymiscium dimorphandrum* Donn.Sm. | Hormigo |
| | *Poeppigia procera* C.Presl | Tepemisque |
| | *Schizolobium parahyba* (Vell.) S.F.Blake | Plumillo |
| | *Senna reticulata* (Willd.) H.S.Irwin & Barneby | Varajito, Arípin |
| | *Senna spectabilis* (DC.) H.S.Irwin & Barneby | |
| | *Vatairea lundellii* (Standl.) Record | Palo negro |
| Lamiaceae | *Gmelina arborea* Roxb. | Melina |
| Lauraceae | *Nectandra membranacea* (Sw.) Griseb. | |
| | *Ocotea sinuata* (Mez) Rohwer | Canoj |
| Lythraceae | *Lagerstroemia indica* L. | |
| Malpighiaceae | *Bunchosia guatemalensis* Nied. | |
| | *Bunchosia odorata* (Jacq.) Juss. | |
| | *Byrsonima crassifolia* (L.) Kunth | Nance |
| Malvaceae | *Guazuma ulmifolia* Lam. | Caulote |
| | *Hampea rovirosae* Standl. | |
| | *Heliocarpus donnellsmithii* Rose | |
| | *Pachira aquatica* Aubl. | Pumpujush, zapotón, pumpo |
| | *Quararibea funebris* (La Llave) Vischer | Molinillo |
| | *Sterculia apetala* (Jacq.) H.Karst. | Castaño |
| | *Trichospermum mexicanum* (DC.) Baill. | Cajete |
| Melastomataceae | *Conostegia xalapensis* (Bonpl.) D. Don ex DC. | |
| | *Miconia laevigata* (L.) D. Don | Cacho de venado |
| Meliaceae | *Guarea glabra* Vahl | Anicillo |
| | *Guarea megantha* A.Juss. | Trompillo |
| | *Swietenia macrophylla* King | Caoba |
| | *Trichilia havanensis* Jacq. | |
| | *Trichilia martiana* C.DC. | Chile amate |
| Moraceae | *Brosimum costaricanum* Liebm. | Ujushte, Ramón |
| | *Castilla elastica* Cerv. | Palo de hule |
| | *Ficus aurea* Nutt. | Amate |
| | *Ficus benjamina* L. | Amate |
| | *Ficus costaricana* (Liebm.) Miq. | Amate |
| | *Ficus crocata* (Miq.) Mart. ex Miq. | Amate |
| | *Ficus hemsleyana* King | Amate |
| | *Ficus insipida* Willd. | Amate |
| | *Ficus maxima* Mill. | Amate |
| | *Ficus obtusifolia* Kunth | Amate |
| | *Ficus pertusa* L.f. | Amate |
| | *Ficus* sp. | Amate |
| | *Maclura tinctoria* (L.) D.Don ex Steud. | Mora |
| | *Trophis racemosa* (L.) Urb. | |

**Table 1.** *Cont.*

| Family | Species | Common Name |
|---|---|---|
| Muntingiaceae | *Muntingia calabura* L. | Capulín blanco |
| Nyctaginaceae | *Neea psychotrioides* Donn.Sm. | Siete camisas |
| Olacaceae | *Ximenia americana* L. | |
| Phyllanthaceae | *Astrocasia austinii* (Standl.) G.L.Webster | Pimiento |
| Polygonaceae | *Coccoloba barbadensis* Jacq.<br>*Coccoloba escuintlensis* Lundell<br>*Triplaris melaenodendron* (Bertol.) Standl. & Steyerm. | Papaturro<br>Papaturro<br>Mulato |
| Primulaceae | *Bonellia macrocarpa* (Cav.) B.Ståhl & Källersjö | Naranjillo |
| Rhamnaceae | *Colubrina arborescens* (Mill.) Sarg. | Coshte |
| Rhizophoraceae | *Rhizophora mangle* L. | Mangle Rojo |
| Rubiaceae | *Hamelia patens* Jacq.<br>*Psychotria limonensis* K.Krause<br>*Simira salvadorensis* (Standl.) Steyerm. | Chichipín<br><br>Puntero |
| Rutaceae | *Zanthoxylum riedelianum* subsp. kellermanii (P.Wilson) Reynel ex C.Nelson | Lagarto |
| Salicaceae | *Casearia arguta* Kunth<br>*Salix humboldtiana* Willd. | Raspa lengua<br>Sauce |
| Sapindaceae | *Sapindus saponaria* L. | Jaboncillo |
| Sapotaceae | *Pouteria sapota* (Jacq.) H.E.Moore & Stearn<br>*Sideroxylon capiri* subsp. tempisque (Pittier) T.D.Penn.<br>*Sideroxylon celastrinum* (Kunth) T.D.Penn.<br>*Sideroxylon capiri* (A.DC.) Pittier | Zapote<br>Tempisque<br><br>Tempisque |
| Simaroubaceae | *Simarouba amara* Aubl. | Aceituno |
| Solanaceae | *Cestrum racemosum* Ruiz & Pav.<br>*Solanum diphyllum* L. | Huele de noche |
| Staphyleaceae | *Turpinia occidentalis* (Sw.) G.Don | |
| Urticaceae | *Cecropia obtusifolia* Bertol. | Guarumo |
| Verbenaceae | *Citharexylum affine* D.Don | Cola de iguana |

### *3.2. Vegetation Classification*

Classification of the vegetation was made through cluster analysis on the abundance of species per plot. Five of the 56 plots (3, 6, 7, 14 and 27) were not included in the analysis, as they were located on heavily disturbed areas. The cluster analysis identified four groups of vegetation along an altitudinal gradient (Figure 2). The analysis of similarity (ANOSIM) showed that the formed clusters were well separated (R = 0.55), and that the separation was significant ($p$ = 0.001). To verify and validate the groups obtained through cluster analysis, a non-metric multidimensional scaling was performed. The results support the grouping in the ordination graph (Figure S2).

### *3.3. Floristic Composition in the Riparian Tree Communities*

Of the 115 species collected along the river basin, only 69 were within the sampling plots, which represents 60% of the species. Riparian tree community 1 is located at sea level on the Pacific coast, where 118 trees were sampled belonging to 12 species. Riparian community 2 is located above 100 m a.s.l., where 167 trees were sampled belonging to 28 species. Community 3 is located at around 50 m a.s.l., where 172 trees were sampled belonging to 31 species, and community 4 is located between 50 and 546 m a.s.l., where 463 trees were sampled belonging to 54 species (Figure 3).

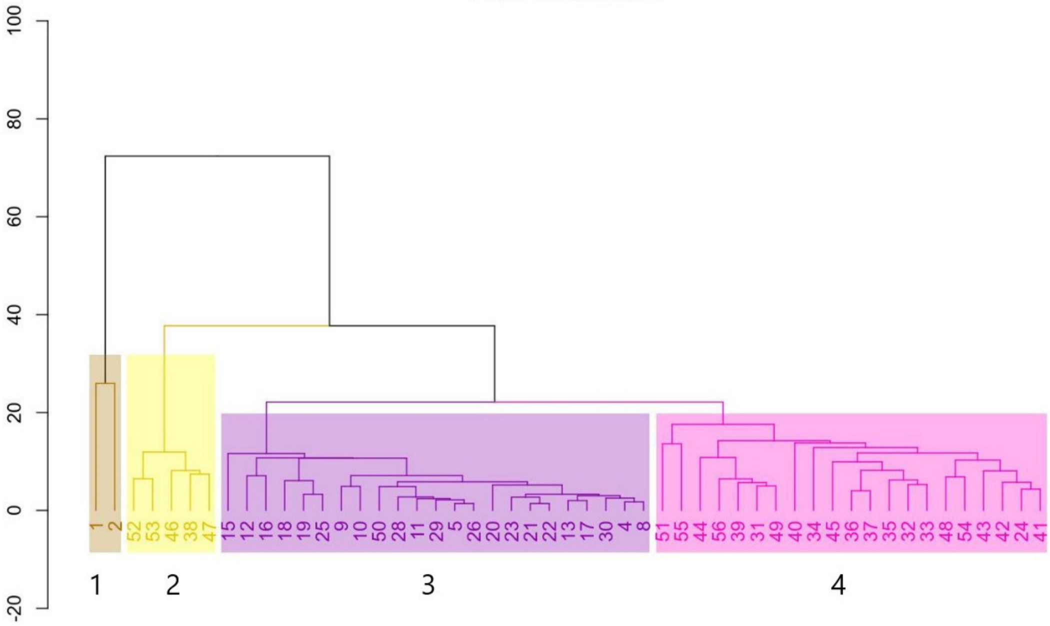


**Figure 2.** Cluster analysis based on species abundance data, in 51 0.1-hectare plots on the banks of the Acomé River, using Euclidean distance and Ward's method. Plots are grouped on the horizontal axis, while the vertical axis indicates the degree of proportional similarity between the species within the plots. Clusters are numbered 1 to 4.

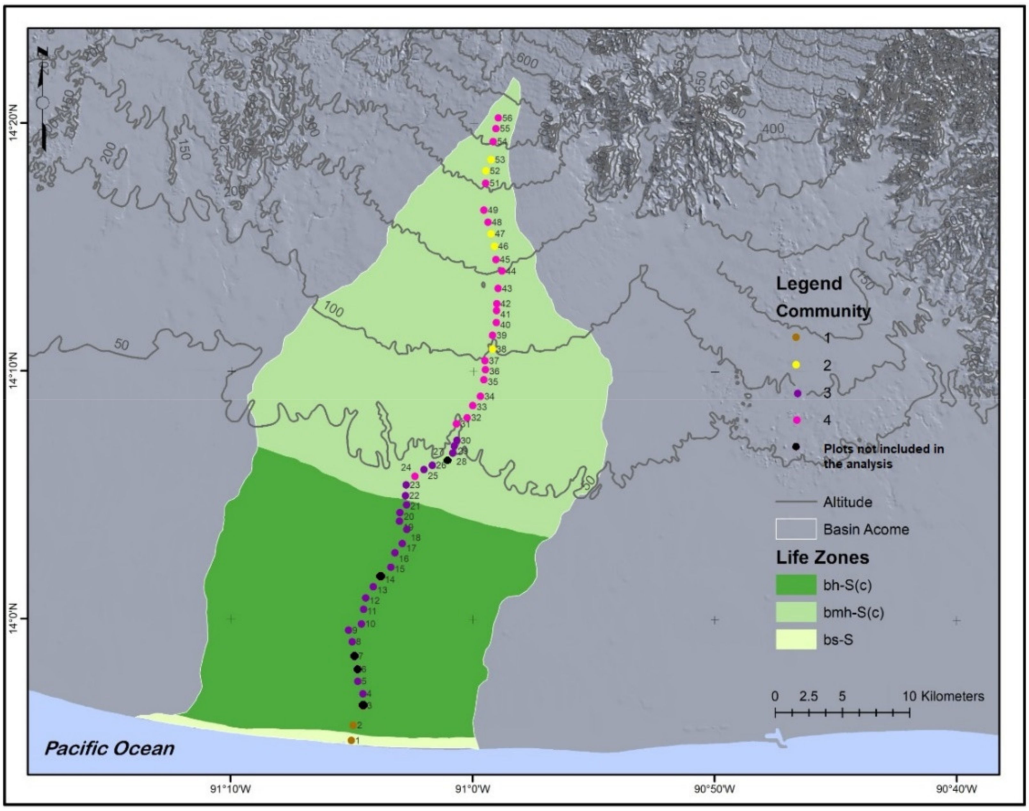


**Figure 3.** Distribution of tree communities on the banks of the Acomé River.

The four major or dominant species in each riparian tree community and their importance values are shown in Table 2.

**Table 2.** Importance values (IVs) of dominant species of the riparian tree communities along the Acomé riverbank.

| Community | Species | IV (%) |
|---|---|---|
| 1 | *Rhizophora mangle* L. | 41.6 |
| | *Avicennia germinans* (L.) L. | 22.7 |
| | *Pithecellobium dulce* (Roxb.) Benth. | 6.8 |
| | *Laguncularia racemosa* (L.) C.F.Gaertn. | 5.6 |
| 2 | *Cecropia obtusifolia* Bertol. | 19.1 |
| | *Guazuma ulmifolia* Lam. | 10.9 |
| | *Andira inermis* (Wright) DC. | 8.8 |
| | *Ficus aurea* Nutt. | 7.7 |
| 3 | *Guazuma ulmifolia* Lam. | 18.4 |
| | *Ceiba pentandra* (L.) Gaertn. | 17.3 |
| | *Enterolobium cyclocarpum* (Jacq.) Griseb. | 11.3 |
| | *Salix humboldtiana* Willd. | 7.2 |
| 4 | *Brosimum costaricanum* Liebm. | 9.2 |
| | *Acacia polyphylla* DC. | 7.7 |
| | *Cecropia obtusifolia* Bertol. | 7.0 |
| | *Ceiba pentandra* (L.) Gaertn. | 5.9 |

### *3.4. Species Diversity of the Riparian Tree Communities*

Table 3 shows the diversity indices for each riparian tree community of the Acomé river. According to the indices, community 1 had the lowest diversity and evenness values, with *R. mangle* as a dominant species. Community 2 had intermediate diversity and evenness values, with *C. obtusifolia* being the dominant species. Communities 3 and 4 had the highest evenness values (above 0.9), but diversity was ranked second lowest for community 3 and highest for community 4. *G. ulmifolia* and *B. costaricanum* were the dominant species in communities 3 and 4, respectively.

**Table 3.** Species diversity indices for the riparian tree communities of the Acomé riverbank.

| Diversity Index | Riparian Tree Community | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Number of plots | 2 | 5 | 23 | 21 |
| Total number of species | 12 | 28 | 31 | 54 |
| Richness per plot (s) * | 8 | 10.8 | 4.2 | 11.3 |
| Evenness (J′) * | 0.64 | 0.78 | 0.92 | 0.91 |
| Simpson diversity ($D_s$) * | 0.63 | 0.77 | 0.7 | 0.89 |

Note: Fields marked with asterisk (*) represent mean values for each group.

## 4. Discussion

This study provides a detailed tree characterization of the Acomé riverbank, reporting 115 tree species belonging to 91 genera and 43 families. A study investigating tree diversity in tropical riparian forest fragments in the Mountain Pine Ridge savannah in Belize (400 to 1000 m a.s.l.) found similar numbers, with 106 morphospecies, 78 genera and 42 families in micro-forests and 117 morphospecies, 71 genera and 41 families in tree thickets [37]. However, the floristic composition of both studies is remarkably different, possibly due to differences in the altitudinal and latitudinal range.

Most of the tree species reported in this study such as *A. hindsii*, *A. purpurea*, *C. guatemalensis* and *S. salvadorensis* are native to Mesoamerica, with one, *S. salvadorensis*, being listed in the *Red List of Trees of Guatemala* [38]. However, there are non-native species in the list, such as *G. arborea* (originally from Asia) *D. regia* (originally from Madagascar), *L. sericeus* (originally from Mexico) and *S. campanulate* (originally from Africa) indicating that at least some of the species found in this region are introduced or exotic. Introduced species are usually the result of anthropogenic activities, and the vicinity of riparian habitats may facilitate their establishment and spread [39]. Therefore, efforts to predict their occurrence, manage areas of high abundance and prevent further spread must be included in future management programs [39].

We identified four riparian tree communities in the Acomé river basin along an altitudinal gradient, where the species *R. mangle, C. obtusifolia, G. ulmifolia*, and *B. costaricanum* were dominant. The communities are very consistent with the bioclimatic classification of life zones at the recognition level inferred by L. Holdridge as suggested by De la Cruz [23,24]. Community 1 overlaps with the dry subtropical forest life zone (bs-S). Community 3 coincides with the humid subtropical warm-forest zone (bh-S) and has secondary forest trees as its dominant species. Riparian tree communities 2 and 4 are included in the very wet subtropical warm-forest zone (bmh-S) and have different dominant species, but these are all distinctive of secondary forests [26,27], suggesting intermediate successional stages.

Dominant species may naturally differ between communities due to the azonal condition of the vegetation inherent to the riparian habitat [8]. Factors affecting the distribution and composition of the species in these communities include altitude, edaphic factors and anthropogenic intervention (especially fires) [40]. Therefore, we strongly suggest that future studies incorporate ecological predictors including soil properties, distance from river course, depth of the groundwater table, landscape cover surrounding the plot and disturbance effects (e.g., fire history) in order to explain the observed differences.

We estimated the average species richness or number of species (s), the average evenness that indicates the relative abundance of species (J') and the average Simpson diversity (Ds) for each tree community. Community 1, located in the mangrove ecosystem, had a lower richness (8 species), evenness (0.64) and diversity (0.63) when compared with the other communities. This is expected, as only a few halophytic species, such as mangroves, can survive under the high-salinity conditions of river estuaries [41]. However, despite having a low diversity and evenness, mangroves serve important ecological roles, providing mating and nesting habitats for a variety of birds and aquatic fauna [41]. Furthermore, from the four identified communities, the mangrove community is the least disturbed by anthropogenic activities, as it is located within a protected area (the Sipacate-Naranjo Natural Park).

The remaining communities include tree species characteristic of secondary forests which are surrounded by sugarcane plantations, urban zones and grazing areas. Despite being located near heavily disturbed areas, communities 2, 3 and 4 have a relatively high evenness (0.78, 0.92 and 0.91, respectively) and diversity (0.77, 0.7 and 0.89, respectively).

Currently, secondary forests cover extensive areas across Central America. These mostly originate from the natural regeneration of previously deforested land from the native seedbank rather than from intentional reforestation efforts [42]. Secondary forests are positioned among the most significant sources of biodiversity and carbon reservoirs on earth, serving as both habitats for wildlife and regulators of the carbon cycle [2]. However, the capability of these secondary forests in regaining the biological features and diversity of an undisturbed primary forest is still poorly understood [2,9], as is the contribution of secondary forest remnants in fragmented landscapes in maintaining diversity across agricultural matrices [43].

This study can be used as a reference for the riparian tree vegetation of the Pacific lowlands of Guatemala. Further studies are needed to characterize secondary forests of the region in detail to monitor change over time, create predictive models, and establish conservation priorities. We acknowledge that this work is limited by the lack of ecological data (e.g., soil properties, distance from a river course and disturbance effects) needed to explain the observed patterns and suggest that future research incorporates ecological predictors in order to address this. We also suggest the inclusion of other vegetation strata, such as shrubs, herbs, lianas, epiphytic plants and aquatic plants, in future studies. A more accurate representation of the riparian vegetation composition is essential to support future ecological restoration projects, the reintroduction of native species, the management of exotic species and other in situ conservation efforts.

## 5. Conclusions and Future Outlook

Presently, the loss and fragmentation of forests due to changes in land use is considered one of the greatest threats to global biodiversity, particularly in the tropics. In tropical regions that have lost most of their forest cover, it is essential to consider the remaining forest patches as a priority for conservation [37,44,45]. In the Pacific lowlands of Guatemala, most of the remnant forests are located along riverbanks. However, their riparian tree community composition and biodiversity status are poorly known. This study provided a list of plant species and identified tree communities along the Acomé river, in the Pacific slope of Guatemala. We found many native tree species, but exotic tree species were also recorded along the river basin, supporting the need for urgent conservation and restoration efforts. This study can be used as a reference by local landscape managers and government or conservation organizations. We consider that restoring riparian forests should be a priority in the region, with a focus on native species, as they are more likely to support native fauna. More studies at a local and regional scale, including detailed ecological information and disturbance impacts, are needed to accurately assess and monitor biodiversity and identify conservation priorities [46].

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/10.3390/f12070898/s1, Table S1: Location of the sampling plots along the Acomé riverbanks; Figure S1: System used to dry botanical specimens; and Figure S2: Non-metric multidimensional scaling with data on the abundance of species per tree community.

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