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Floristic composition, vegetation structure and hill number diversity of a lowland riparian forest in Bohol, Philippines

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ABSTRACT

This study assessed the floristic composition, vegetation diversity, stand structure, and conservation status of riparian vegetation in Barangay Canlusong, Valencia, Bohol. It was hypothesized that the riparian corridor supports high plant diversity, exhibits active forest regeneration, and harbors threatened plant species. Vascular plants from the canopy, intermediate, and ground vegetation layers were inventoried. Species diversity was evaluated using the Hill number framework (q = 0, q = 1, and q = 2), while stand structure was assessed through diameter at breast height and height class distributions. The study was conducted along the riparian corridor of Barangay Canlusong, Valencia, Bohol, Philippines, from October to December 2024. Thirty randomly distributed 10 × 10 m plots with nested 5 × 5 m and 1 × 1 m subplots were established to sample vegetation across three vertical strata. Plant species were identified, diversity metrics were computed, stand structure was analyzed, and conservation status was determined using national and international reference lists. A total of 1,759 individuals representing 91 species, 81 genera, and 37 families were recorded. Fabaceae was the most species-rich family, whereas *Ficus* was the dominant genus. Trees constituted the largest functional group. The ground vegetation layer exhibited the highest diversity across all Hill number orders, while the canopy had the lowest diversity. Diameter and height distributions followed a reverse J-shaped pattern, indicating continuous recruitment and an actively regenerating secondary riparian forest. Five threatened plant species were documented. The riparian vegetation of Barangay Canlusong serves as an important biodiversity reservoir and demonstrates substantial regenerative capacity. These findings provide baseline ecological information to support riparian conservation, ecological restoration, and sustainable watershed management in tropical island ecosystems.

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INTRODUCTION

The Philippine archipelago is globally recognized as one of the world's megadiverse countries and ranks among the top biodiversity hotspots (Myers *et al.,* 2000). Comprising more than 7,100 islands, the country supports exceptionally high levels of species richness and endemism, with an estimated 6,694 endemic species (Mittermeier *et al.,* 2011). Despite this extraordinary biological wealth, biodiversity across the archipelago continues to decline due to habitat loss, land-use change, environmental degradation, and the limited availability of site-specific ecological data needed to inform effective conservation planning.

Within this national context of high diversity and increasing pressure, Bohol, the tenth-largest island in the Philippines, exemplifies both the ecological value and the vulnerability of island ecosystems in the Visayas region. Approximately 21% of the province's land area is designated as protected, and nearly one-fourth is classified as environmentally critical (PPDO Bohol, 2024).

The island encompasses a mosaic of landscapes, including limestone formations and multiple watershed systems that support agricultural production and human settlements. However, despite these natural assets and protection measures, growing pressures from pollution, overexploitation of natural resources, and ecosystem conversion continue to threaten ecological integrity, particularly in areas outside formally protected zones.

Among the ecosystems most affected by these pressures are riparian zones, which form transitional interfaces between terrestrial and aquatic environments (Capon and Dowe, 2012).

Riparian ecosystems play a disproportionate ecological role by providing essential services such as bank stabilization, sediment and nutrient regulation, maintenance of water quality, moderation of microclimate, and habitat for diverse plant and animal communities (Wantzen and Jan, 2013). Their structural complexity is shaped by periodic disturbances, such as flooding and erosion, that generate heterogeneous environmental conditions and promote high biodiversity. Paradoxically, these same characteristics also make riparian zones highly vulnerable, rendering them among the most altered and degraded ecosystems worldwide (Nilsson and Svedmark, 2002; Brookes 1994).

Despite their ecological significance, riparian ecosystems in the Philippines remain poorly studied, particularly at local scales. Existing research has largely emphasized qualitative species inventories, with relatively few studies integrating quantitative analyses of floristic composition, vegetation structure, diversity patterns, and conservation status (Santiago and Buot, 2017; Ordas *et al.,* 2019). This lack of comprehensive baseline data limits managers' and policymakers' ability to design effective conservation, restoration, and watershed management strategies, especially in human-modified tropical landscapes where ecological processes and anthropogenic pressures interact.

Addressing this gap requires site-specific studies that explicitly link floristic composition with vegetation structure and conservation status. Barangay Canlusong, located in the Municipality of Valencia, Bohol, represents a typical lowland riparian system embedded within an actively cultivated agricultural landscape. The area is traversed by a perennial stream that serves as an important irrigation source for local communities, resulting in sustained interaction between riparian vegetation and human land use. Combined with a tropical rainforest climate characterized by high annual rainfall and minimal seasonality, these conditions provide an ideal setting for examining floristic composition, vegetation structure, regeneration dynamics, and conservation status in a disturbed yet functionally important riparian corridor.

In response to these ecological and knowledge-based considerations, this study conducted a quantitative floristic assessment of the riparian zone in Barangay Canlusong. Specifically, it aimed to: (1) document

plant species composition and vegetation structure; (2) analyze vertical stratification, dominance patterns, and diversity across vegetation layers; (3) evaluate stand structure and successional status using diameter and height class distributions; and (4) assess the conservation status, endemicity, and regeneration patterns of native and threatened species. By integrating floristic, structural, and conservation analyses, this study provides baseline information essential for riparian forest conservation, restoration planning, and sustainable watershed management in Bohol and comparable tropical island landscapes.

MATERIALS AND METHODS

Environment

This study was conducted in Barangay Canlusong, Municipality of Valencia, Bohol, located at approximately 9.6248° N, 124.1993° E, with an estimated elevation of 44.8 m (147.0 ft) above sea level from October to December 2024 (Fig. 1). The barangay is bounded by Barangays Adlawan, Limocon, Canmanico, Cansibao, and Simang, and is traversed by a perennial stream that serves as one of the primary irrigation water sources for local agricultural activities. This spatial context situates the riparian zone at the interface between natural vegetation and sustained human use, providing a relevant setting for examining plant–environment interactions. The study area was selected because it represents a typical riparian system within a human-modified tropical landscape. Agricultural expansion, settlement development, and continuous water extraction exert varying levels of pressure on riparian vegetation, creating a disturbance gradient well suited for examining floristic composition, vegetation structure, and regeneration dynamics.

Consequently, Barangay Canlusong offers an appropriate natural laboratory for assessing how riparian plant communities respond to both ecological processes and anthropogenic influence.

Climatic conditions further reinforce the site's suitability for floristic assessment. Valencia experiences a tropical rainforest climate (Af) under the Köppen–Geiger classification, characterized by consistently high rainfall and the absence of a pronounced dry season. Mean annual temperature is approximately 25.3 °C, while average annual precipitation reaches about 2,278 mm. These conditions promote continuous plant growth and high species diversity, allowing vegetation patterns to be shaped largely by disturbance regimes and habitat structure rather than seasonal climatic constraints. Taken together, the combination of favorable climatic conditions, an actively functioning riparian system, and sustained human use makes Barangay Canlusong an ecologically and socioeconomically relevant study site. This integrated setting allows the findings of this study to contribute not only to local conservation and riparian management efforts but also to broader discussions on riparian forest dynamics and resilience in tropical island landscapes.

Sampling design

To systematically capture vegetation across vertical strata, thirty (30) randomly distributed sampling plots measuring 10 m × 10 m were established within the study area. Within each main plot, a 5 m × 5 m nested subplot was centrally positioned to sample smaller trees and regenerating individuals, while a 1 m × 1 m subplot was further established at the center of the 5 m × 5 m plot to document ground cover species. This hierarchical sampling design ensured consistent and comparable data collection across canopy, intermediate, and ground vegetation layers. Vegetation data were collected using the plot method, which is widely applied in floristic and ecological studies due to its practicality and reliability. The method requires minimal specialized equipment, and the use of uniform plot sizes, combined with a random spatial distribution, enhances sampling representativeness across the study area. Although physically demanding, the plot method is non-destructive, making it particularly suitable for ecological assessments in sensitive riparian environments.

Collection of primary data

A global positioning system (GPS) was used to determine the geographic coordinates of each 10 m × 10 m sampling plot within the study area, ensuring

accurate spatial documentation of all plots. Following plot establishment, a comprehensive floristic inventory was conducted. All plants with a diameter at breast height (DBH) ≥ 10 cm were identified and recorded within each 10 m × 10 m plot. To document smaller vegetation and regeneration, plants with a DBH of < 10 cm were identified and recorded within nested 5 m × 5 m subplots, while ground cover species were sampled using 1 m × 1 m plots. This hierarchical sampling design enabled systematic documentation of vegetation across different vertical strata. For each recorded plant, both common and scientific names were documented together with quantitative measurements. DBH was measured at 1.3 m above ground level, following standard forestry procedures (Husch *et al.,* 2003). In addition, total tree height was estimated using a 5-m pole combined with ocular estimation. All measurements were conducted consistently across plots to ensure standardized data collection for subsequent analyses.

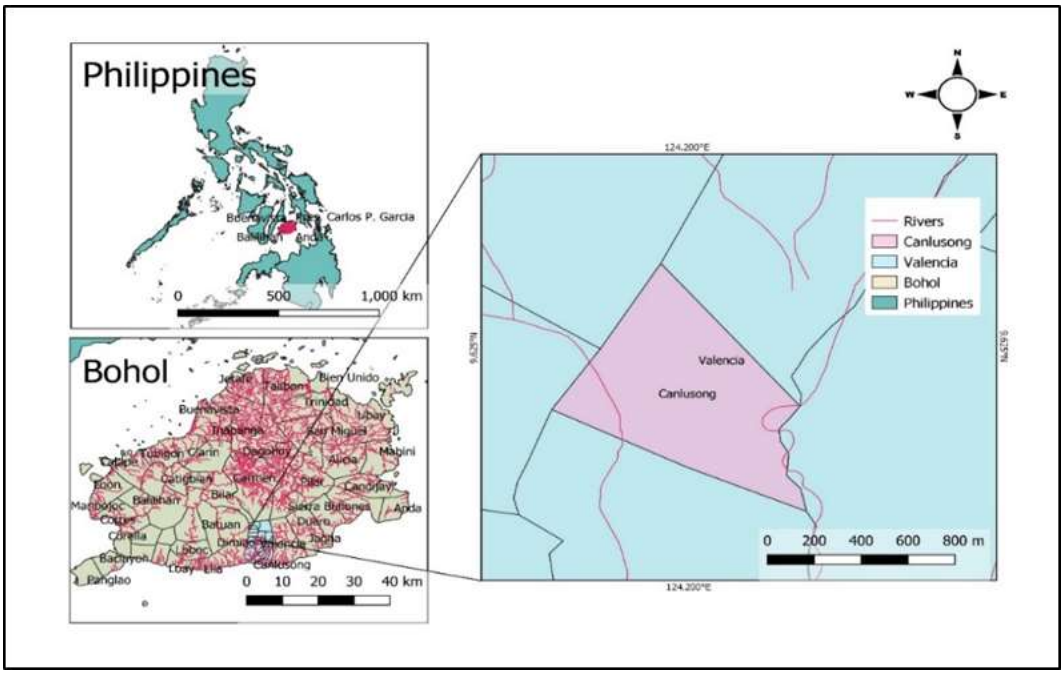

Fig. 1. Map showing the site location

Plant identification and conservation status assessment

Co's Digital Flora of the Philippines, together with other relevant published literature, was used as the primary reference for taxonomic identification of the collected plant samples. Species identification was based on observable morphological characteristics. Following taxonomic confirmation, the conservation status of each identified species was assessed to determine its level of vulnerability and ecological significance within the study area. Conservation status assessment was conducted using internationally and nationally recognized references, specifically the IUCN Red List of Threatened Species and the Department of Environment and Natural Resources (DENR) Administrative Order No. 2017-11. Species were classified according to the following categories and definitions, which represent varying degrees of extinction risk.

Diversity analysis

Species diversity was assessed using the Hill number framework, which expresses diversity as the effective number of species and facilitates meaningful comparisons among vegetation strata. Three orders of diversity were evaluated: species richness (q = 0), representing the total number of species; diversity of common species (q = 1), which gives greater weight to species according to their relative abundance; and diversity of dominant species (q = 2), which emphasizes the contribution of the most abundant species in the community. Species evenness was also calculated to evaluate the distribution of individuals among species. The Hill number approach was

adopted because it provides an intuitive and comparable measure of biodiversity by expressing diversity in units of effective species numbers (Hill 1973; Jost 2006).

RESULTS

Floristic composition and vegetation structure

A total of 1,759 plant individuals representing 91 species, 81 genera, and 37 families were documented within the riparian zone of Barangay Canlusong. Angiosperms accounted for 85 species, whereas the remaining recorded taxa consisted of pteridophytes. At the family level, Fabaceae was the most species-rich family, followed by Poaceae, Moraceae, and Asteraceae. Based on functional groups, trees represented 43.3% of all recorded species, followed by herbs (27.8%), grasses (11.1%), shrubs (10%), ferns (5.6%), and vines (2.2%).

Fabaceae was represented by thirteen (13) species, followed by Poaceae with ten (10) species, while Moraceae and Asteraceae each contained eight (8) species. All remaining families contained fewer than four species. This distribution indicates a marked concentration of species within a small number of dominant plant families, with Fabaceae contributing the largest proportion of family-level richness. Ficus was the most dominant genus within Moraceae at the study site. Its occurrence was particularly noticeable within the riparian vegetation, where individuals were recorded in areas characterized by moist conditions near the stream. The prominence of Ficus therefore contributed substantially to the observed genus-level composition of the surveyed vegetation.

In terms of plant type, Fig. 2 showed that trees constituted the largest group, with thirty-nine species (43.3%), forming the principal structural component of the vegetation. Herbs ranked second, with twenty-five species (27.8%), and were widely represented in the ground layer. Grasses included ten species (11.1%), while shrubs accounted for nine species (10%). Ferns and vines were comparatively less abundant in species richness, representing 5.6% and 2.2%, respectively. Although these two groups contributed smaller proportions, their presence added to the structural and functional complexity observed across the riparian vegetation layers.

Overall, the recorded composition demonstrates that the riparian area supports a varied assemblage of trees, herbs, grasses, shrubs, ferns, and vines, with trees and herbs collectively accounting for the majority of species and shaping the overall vegetation structure of the site. The distribution across these functional groups also demonstrates clear vertical differentiation, with woody and herbaceous plants occupying complementary structural positions that together characterize the floristic organization of the sampled lowland riparian forest community.

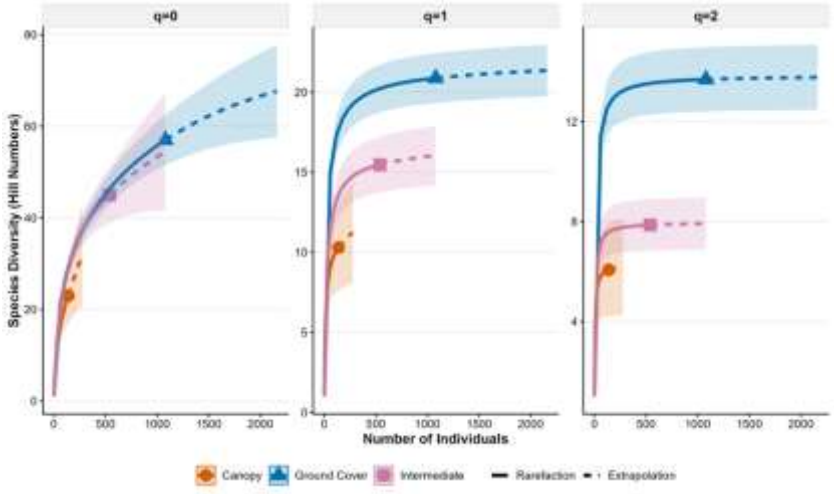

Fig. 2. Sample-size-based rarefaction (solid lines) and extrapolation (dashed lines) curves for species richness (q = 0), diversity of common species (q = 1), and diversity of dominant species (q = 2) in the canopy, intermediate, and ground cover layers of the riparian zone in Barangay Canlusong, Valencia, Bohol. Shaded areas represent 95% confidence intervals, while symbols indicate reference sample sizes

Table 1. Diameter at breast height (DBH) class distribution of tree species in the riparian zone of Barangay Canlusong, Valencia, Bohol

Diameter at breast height	Frequency	Percent
10-20	72	51.8
21-30	41	29.5
31-40	20	14.39
41-50	4	2.88
51-60	0	0
61-70	2	1.44
71-80	1	0.7

Table 2. Height class distribution of tree species in the riparian zone of Barangay Canlusong, Valencia, Bohol

Total Height	Frequency	Percentage
21-25	3	2.2
16-20	30	21.6
11-15	35	25.2
6-10	56	40.2
3-5	16	11.5

Table 3. List of threatened species recorded in the study área

Species	Scientific name	Family	DAO 2017-11	IUCN 2025-1	Endemicity
Anislag	*Flueggea flexuosa* Müll.Arg.	Phyllanthaceae	OTS	LC	Native
Malasaging	*Aglaia edulis* (Roxb.) Wall.	Meliaceae	OTS	NT	Native
Mahogany	*Swietenia macrophylla* King	Meliaceae	NE	EN	Naturalized
Molave	*Vitex parviflora* Juss.	Lamiaceae	EN	LC	Native
Narra	*Pterocarpus indicus*	Fabaceae	VU	EN	Native

Species diversity across vegetation layers based on hill numbers

The rarefaction and extrapolation curves revealed differences in diversity among vegetation layers across all Hill number orders (Fig. 2). Species richness (q = 0) was highest in the ground cover layer, followed by the intermediate and canopy layers. The same pattern was observed for the diversity of common species (q = 1) and dominant species (q = 2), with the ground cover layer consistently exhibiting the highest diversity values and the canopy layer the lowest.

For q = 0, the rarefaction curves showed a rapid increase in species richness with increasing sample size, followed by a gradual decline in the rate of accumulation. Extrapolation curves indicated a continued increase in estimated richness beyond the observed sample size. Among the vegetation layers, the ground cover layer attained the highest estimated richness values, whereas the canopy layer recorded the lowest. The diversity of common species (q = 1) increased sharply at smaller sample sizes before approaching an asymptote. The ground cover layer exhibited the highest effective diversity of common species, followed by the intermediate layer and canopy layer. A similar trend was observed in the extrapolated estimates.

For dominant species diversity (q = 2), the curves reached asymptotes more rapidly than those for q = 0 and q = 1. The ground cover layer consistently showed the highest diversity of dominant species, while the canopy layer exhibited the lowest values. The intermediate layer maintained intermediate diversity values throughout the observed and extrapolated sample sizes. The rarefaction and extrapolation analyses demonstrated consistent differences in species diversity among vegetation layers, with the ground cover layer exhibiting the highest diversity across all Hill number orders, followed by the intermediate and canopy layers.

Diameter and height distribution

Diameter at breast height (DBH) ranged from 10 cm to 72 cm. The 10–20 cm DBH class was most represented (51.8%), followed by the 21–30 cm class

(29.5%), while larger size classes exceeding 50 cm were rare (Table 1). Most trees were within the 6–10 m height class (40.2%), followed by 11–15 m (25.2%) and 16–20 m (21.6%). Only 2.2% of individuals reached 21–25 m. The DBH and height distributions exhibited a reverse-J pattern (Table 2).

Conservation status

Five species were listed under national and/or international conservation frameworks: *Vitex parviflora*, *Swietenia macrophylla*, *Pterocarpus indicus*, *Aglaia edulis*, and *Flueggea flexuosa*. These species were primarily recorded in the intermediate layer as saplings or poles (Table 3).

DISCUSSION

Floristic composition and vegetation structure

The observed floristic composition reflects the dynamic nature of tropical riparian ecosystems, where periodic flooding (Martiniello *et al.,* 2024), sediment deposition (Vincy and Brilliant, 2024), and spatial variation in soil moisture (Badry *et al.,* 2019) continually shape habitat conditions, creating diverse ecological niches that facilitate the coexistence of multiple plant species (Gonzaga *et al.,* 2019). This environmental heterogeneity promotes high plant diversity by providing a mosaic of habitats that accommodate species with varying ecological requirements and life-history strategies, often resulting in greater species richness than in adjacent terrestrial ecosystems.

The predominance of Fabaceae is ecologically expected because many leguminous species possess broad ecological amplitudes and symbiotic nitrogen-fixing capabilities that enable them to establish and persist in nutrient-limited and disturbed environments (Raza *et al.,* 2020). Their rapid seed germination and early establishment provide a competitive advantage, particularly in seasonal environments where resource availability fluctuates (Vargas *et al.,* 2015). Moreover, by enhancing soil fertility through biological nitrogen fixation and facilitating vegetation recovery, Fabaceae species contribute to the resilience and stability of plant communities following environmental disturbances (Siddiqui, 2025). Similar dominance of Fabaceae has been reported in tropical secondary forests and riparian ecosystems throughout Southeast Asia, where the family contributes substantially to forest resilience following disturbance. The high diversity of Fabaceae species supports ecological stability by enhancing vegetation recovery and promoting ecosystem resilience in secondary forests (Deenadayal and Aalum, 2025).

The abundance of *Ficus* species further emphasizes the ecological integrity of the riparian corridor. Members of this genus are widely recognized as keystone resources because their asynchronous fruiting provides a reliable year-round food supply for birds, bats, and other mammals, thereby sustaining seed dispersers during periods of seasonal food scarcity (Pothasin *et al.,* 2014; Chaturvedi, 2025). Beyond their role in supporting faunal communities, *Ficus* species contribute to ecosystem functioning by providing habitat for numerous organisms and enhancing biodiversity (Pothasin *et al.,* 2014). Their extensive root systems also stabilize streambanks, regulate hydrological processes, promote groundwater recharge, and improve water quality, reinforcing the ecological functions and resilience of riparian ecosystems (Kusuma *et al.,* 2024; Chaturvedi, 2025).

These findings suggest that conserving the floristic composition of riparian forests is essential for maintaining ecosystem stability, biodiversity, and key ecological functions. In particular, the dominance of Fabaceae and the abundance of *Ficus* species indicate that these taxa play important roles in forest recovery, nutrient cycling, wildlife support, and watershed protection. Consequently, riparian restoration and management efforts should prioritize the protection and incorporation of these ecologically important species to enhance the resilience and long-term sustainability of tropical riparian ecosystems.

Species diversity across vegetation layers

The observed vertical differences in diversity demonstrate that vegetation layers contribute differently to ecosystem functioning. Greater diversity within the ground vegetation is consistent with ecological theory, as this layer experiences the greatest environmental variability through fluctuations in light availability (Su *et al.,* 2019) and soil moisture (Sagar *et al.,* 2008). Such environmental heterogeneity creates a mosaic of microhabitats that supports the establishment of species with diverse ecological requirements. In particular, variation in light availability promotes understorey species richness and abundance, while differences in soil moisture influence the composition and distribution of ground vegetation (Su *et al.* 2019; Sagar *et al.,* 2008). In mixed overstorey environments, greater nutrient availability further enhances ground-layer diversity (Su *et al.,* 2019). This high diversity increases habitat complexity, provides resources for a wide range of organisms, facilitates nutrient cycling and energy flow, and supports natural forest regeneration, thereby contributing to the overall functioning and resilience of riparian forest ecosystems (Lio and Dewi, 2018). These environmental gradients create diverse microhabitats that facilitate species coexistence, enhance ecosystem resilience, and support continuous vegetation regeneration.

The lower diversity of the canopy reflects the outcome of long-term competitive exclusion, where only relatively few tree species successfully occupy the upper forest strata after prolonged competition for light and space. This pattern has been documented across both temperate and tropical forests, where competitive interactions and successional processes often lead to the dominance of a few canopy species. Species with superior growth rates, greater resource-use efficiency, or higher tolerance to environmental stressors tend to outcompete less competitive species, resulting in reduced canopy diversity over time (Connell and Lowman, 1989). Similar trends have been observed in Central Appalachian forests, where the increasing dominance of yellow-poplar has been associated with declining canopy species diversity (Brashears *et al.,* 2004). During forest succession, particularly in the stem exclusion stage, competitive exclusion and stochastic demographic processes further reinforce the dominance of a limited number of species while reducing functional diversity (Tiwari *et al.,* 2024; Harms *et al.,* 2024). Nevertheless, the understorey often retains relatively high species diversity because its distinct microenvironment provides additional regeneration niches that support species coexistence despite canopy dominance (Bohlman and Bohlman, 2015).

In contrast, the intermediate vegetation layer represents a transitional stratum where juvenile trees, shrubs, and understorey species contribute to vertical structural complexity and serve as the future canopy cohort. Juvenile trees are typically well distributed across height classes, ensuring continuous canopy recruitment and maintaining understorey density (Gomes-Westphalen *et al.,* 2012). The coexistence of permanent and transient species within this layer enhances vertical stratification, which supports essential ecosystem processes such as nutrient cycling and organic matter decomposition (Deng *et al.,* 2023). During secondary succession, the intermediate layer plays a crucial role in restoring forest structural complexity, with evidence showing that recovering forests can attain structural characteristics comparable to old-growth forests within approximately four decades (Ehbrecht *et al.,* 2025; Ehbrecht *et al.*, 2026). This recovery is driven largely by increasing tree species diversity, which promotes the development of multiple canopy layers and improves overall forest ecosystem functioning (Ehbrecht *et al.,* 2025).

The application of Hill numbers provides stronger ecological inference than traditional diversity indices because it quantifies diversity across different abundance-weighting scenarios, enabling simultaneous evaluation of species richness, common species, and dominant species (Gotelli and Chao, 2013). This framework facilitates direct comparisons among taxonomic, functional, and phylogenetic diversity, providing a more comprehensive

understanding of community structure (Gotelli *et al.,* 2024). The consistent diversity patterns observed across Hill numbers indicate that the ecological importance of the ground layer extends beyond the presence of numerous rare taxa, reflecting the substantial contribution of common and dominant species to ecosystem functioning. By accounting for species abundances and reducing sampling biases, Hill numbers provide more reliable estimates of true biodiversity across ecological contexts (Gotelli and Chao, 2013). Consequently, the prominence of common species in the ground layer highlights their important role in maintaining ecosystem processes and overall community stability (Mantoni *et al.,* 2021; Roswell *et al.,* 2023).

Stand structure

The observed stand structure is characteristic of a regenerating secondary riparian forest, where continuous recruitment has maintained a high proportion of younger trees within the population.

The predominance of younger individuals is indicative of continuous regeneration, suggesting that the forest is self-sustaining and capable of replacing individuals lost through natural mortality or disturbance. Similar regeneration patterns have been reported in riparian forests, where younger individuals dominate tree populations under favorable environmental conditions (Wu *et al.*, 2012). The reverse J-shaped diameter distribution, a common feature of regenerating forests, further reflects continuous recruitment and a balanced age structure that supports long-term population persistence (Hart *et al.,* 2008). Moreover, localized disturbances that create canopy gaps facilitate the establishment and growth of younger cohorts (He *et al.,* 2009), while suitable groundwater conditions enhance seedling establishment and regeneration success in riparian ecosystems (Yusup *et al.,* 2022).

In tropical forests, the predominance of small-diameter individuals generally reflects continuous recruitment and secondary succession, particularly in ecosystems recovering from past disturbances. Following disturbance events, these younger individuals drive forest recovery by rapidly occupying newly available growing spaces, increasing species diversity, and contributing to nutrient cycling (Chazdon, 2012). Their recruitment is often enhanced in disturbed areas where reduced competition and greater light availability favor seedling establishment and growth (Saenz-Pedroza *et al.,* 2020). Long-term monitoring of small-diameter trees, saplings, and seedlings has further demonstrated that their recruitment and survival patterns are reliable indicators of regeneration dynamics and the trajectory of forest recovery (Comita *et al.,* 2024).

The height distribution of trees in regenerating tropical forests is strongly influenced by competition for light, which intensifies as succession progresses. During early succession, relatively uniform light conditions promote rapid vertical growth as trees compete for canopy access (Matsuo *et al.,* 2024). As the forest matures, increasing canopy closure creates greater vertical light heterogeneity, resulting in slower height growth, particularly among sub-canopy and shade-tolerant species (Matsuo *et al.,* 2021; Matsuo *et al.,* 2024). Consequently, height growth often lags behind diameter growth because trees allocate biomass differently in response to light availability, with reduced light limiting vertical growth (Sterck, 1997). These growth responses vary among species according to their ecological strategies and successional status, with shade-tolerant species generally exhibiting slower height growth than light-demanding species (Burda *et al.,* 2021; Bohlman and O'Brien, 2006). Accordingly, the relatively low proportion of emergent trees suggests that canopy development is still incomplete, supporting the interpretation that the riparian forest is in an intermediate stage of succession rather than a mature forest condition.

Conservation implications

The ecological importance of riparian corridors extends beyond their floristic diversity, as they function as critical habitats for threatened species and ecological linkages within fragmented landscapes.

By connecting otherwise isolated habitat patches, riparian forests facilitate wildlife movement, gene flow, species dispersal, and recolonization, thereby enhancing landscape connectivity and ecosystem resilience (Teixeira *et al.*, 2024; Hauser *et al.,* 2021). Their conservation value is well documented across tropical regions. For example, riparian forests in West Sumatra supported at least 20 mammal species, including several globally protected taxa (Virdana *et al.* 2025), while well-preserved riparian corridors in Brazil maintained significantly higher bird and mammal diversity than degraded corridors (Lees and Peres, 2008). These findings emphasize the importance of protecting and restoring riparian forests to conserve biodiversity, mitigate habitat fragmentation, and maintain ecological connectivity through effective management and enforcement of conservation policies (Lees and Peres, 2008; Rolle, 2017).

The regeneration of threatened native species indicates that the environmental conditions required for their establishment and persistence remain intact. Habitat integrity is a fundamental prerequisite for successful regeneration, as degraded ecosystems often limit the recovery of threatened species, whereas intact habitats provide suitable conditions for natural recruitment (Dalrymple *et al.,* 2023). Similar patterns have been reported in agroforestry systems, where native species such as *Cordia trichotoma* exhibit enhanced growth and natural regeneration under favorable environmental conditions (Insfrán Ortiz *et al.,* 2022). Likewise, restoration efforts in the Pannonian Basin have demonstrated that establishing functionally diverse native species improves ecological stability and resilience when appropriate site conditions are maintained (Milosavljević *et al.,* 2026). The long-term persistence of native species in Organ Pipes National Park further highlights the importance of sustained habitat quality and effective management in supporting natural regeneration despite ongoing ecological pressures (McDougall and Morgan, 2005).

The occurrence of *Swietenia macrophylla* (big-leaf mahogany) in Philippine riparian forests illustrates the complex legacy of past reforestation programs involving introduced tree species.

Although globally listed as endangered because of population declines within its native range, the species has become widely established outside its natural distribution, where it may adversely affect native ecosystems. In the Philippines, *S. macrophylla* is recognized as an invasive alien plant species because of its ability to establish self-sustaining populations and outcompete native flora (Coracero, 2023). Its extensive naturalization, with thousands of individuals documented in mixed land-use areas following its introduction for reforestation, demonstrates its capacity to spread beyond plantation boundaries (Coracero, 2023). Despite these concerns, management strategies specifically addressing *S. macrophylla* in protected areas remain limited, highlighting the need for coordinated monitoring, early intervention, and collaborative management to minimize further encroachment into ecologically sensitive habitats (Coracero, 2023).

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