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RESEARCH ARTICLE

Diversity assessment of tree species in Mount Mayapay, Buenavista, Agusan del Norte, Philippines

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ABSTRACT

High tree species diversity is generally considered a positive indicator of ecosystem health and resilience. This study provides the diversity assessment of the tree species in the part of Mount Mayapay situated in Barangay Sangay, Buenavista, Agusan del Norte, including its conservation status. The assessment documented a total of 23 species belonging to 17 different families. *Falcataria falcata*, *Swietenia macrophylla*, and *Polyscias nodosa* were the most abundant species in the area, and most of the species belong to the Moraceae family. Notably, the *Pterocarpus indicus*, which is listed as Endangered by the IUCN Red List and Vulnerable under DENR Administrative Order 2017-11, and *Litsea philippinensis*, categorized as Near Threatened by the IUCN, were recorded, highlighting key local conservation priorities. A Shannon–Wiener Index of 2.798 indicates moderate floristic diversity, while importance value analysis identified *F. falcata* and *S. macrophylla* as the most ecologically significant species. Small trees' random distribution pattern and dominance suggest a relatively young stand shaped by natural regeneration and deliberate planting. These findings provide crucial insights into species composition, ecological significance, and diversity, and they underscore the need for comprehensive research across the entire area—including steep slopes—to guide conservation strategies for threatened species in the area.

1.0 INTRODUCTION

Tree species diversity is a vital sign of the health and functionality of a forest ecosystem. It has an impact on important ecological processes such as microclimate regulation, nitrogen cycling, decomposition, and the provision of habitat for different species of flora and fauna (Schnabel et al., 2023; Schnabel et al., 2025; Zhang et al., 2022; Joly et al., 2017; Esquivel-Gómez et al., 2017). However, a confluence of anthropogenic pressures, including habitat fragmentation, climate change, and unsustainable resource extraction, has led to an unprecedented decline in global biodiversity (Buckle et al., 2020; Jaureguiberry et al., 2022; Prakash & Verma, 2022; Newbold et al., 2015; Pereira et al., 2012). This alarming trend has heightened the need for localized assessments of species richness and composition, particularly in tropical biodiversity hotspots such as the Philippines (Myers et al., 2000). Understanding these diversity patterns is essential for monitoring ecosystem integrity and designing and implementing effective conservation strategies (FAO, 2020).

The Philippines is acknowledged as a megadiverse nation and a worldwide biodiversity hotspot, exhibiting significant species diversity and endemism (Amoroso, 2012; Galindon et al., 2017; Alcala et al., 2006). Despite this ecological wealth, the country's forests remain vulnerable due to deforestation, land use change, and poor policy enforcement (Boquet, 2017; Domingo & Manejar, 2018). Many ecologically important areas in the Philippines remain understudied regarding floristic composition. One such area is Mount Mayapay in Buenavista, Agusan del Norte, a forested landscape with cultural, geological, and biological significance but without formal ecological documentation. It is the tallest mountain in the Butuan-Buenavista mountain range with an elevation of approximately 675 meters above sea level (Sarmiento & Casas, 2015). It is also an isolated plateau-like landform that dominates the surrounding lowland areas of Butuan City and its neighboring municipalities. It is believed to have volcanic origins and is considered part of the northeastern Mindanao geologic formation, contributing to the region's rugged terrain and rich natural resources (MGB, 2014).

Forest diversity assessments commonly employ biodiversity indices such as the Shannon-Wiener and Simpson indices, which provide insights into species richness and evenness—two key components of biodiversity (Lakićević &

Srđević, 2018). These indices not only help describe community composition but also allow for the evaluation of ecological disturbance (Nguyen, 2007; Dornelas, 2010). Given the ecological significance of Mount Mayapay and the limited scientific information available about its forest composition, this study seeks to assess the diversity of tree species in selected portions of the mountain. The findings will contribute to the scientific understanding of the site's biodiversity status and support localized conservation actions amidst ongoing ecological challenges.

2. MATERIALS AND METHODS

2.1. Study area

The study was conducted in a portion of Mount Mayapay located in Barangay Sangay, Buenavista, Agusan del Norte, at coordinates 8.8150°N, 125.3576°E. Mount Mayapay is a prominent mountain in the Caraga Region and a well-known hiking and mountaineering destination, particularly among visitors from Butuan City. According to the Provincial Environment and Natural Resources Office (PENRO) of Agusan del Norte, the mountain has an estimated total land area of approximately 2,028 hectares. It has been a natural landmark for Butuan City for over a thousand years. Mount Mayapay's area within the jurisdiction of Barangay Sangay covers about 1,015 hectares.

Climatically, the entire province of Agusan del Norte falls under Type II of the Corona Classification System, characterized by the absence of a distinct dry season and a pronounced rainy period from November to March. The area experiences a mean annual rainfall of 1,950 mm, an average monthly temperature of 28.2 °C, and a relative humidity of 81.0% to 88.1% (Sarmiento & Casas, 2015).

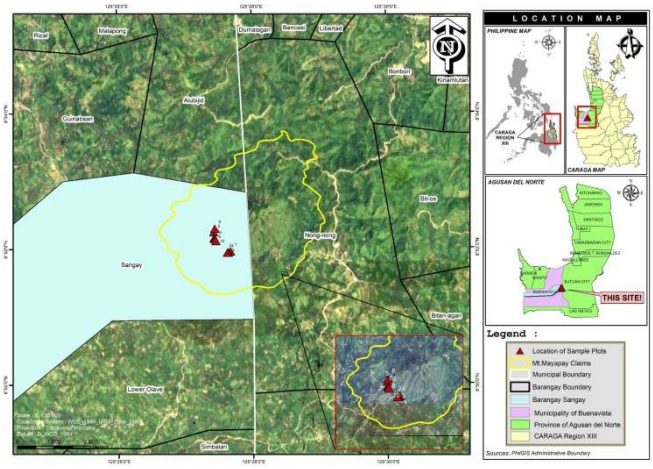

Figure 1: Map showing the study site located at Brgy. Sangay, Buenavista, Agusan de Norte.

2.2. Sampling technique

The study employed random and purposive sampling techniques to achieve a strategically relevant yet unbiased representation of the study area. Given the steep and rugged terrain, which presented significant logistical constraints for site access and plot establishment, ten (10) sample plots measuring 10 × 10 meters (100 m² each) were established. Despite the limited sample size, these plots were distributed across various elevations and slope gradients to capture spatial variability in vegetation structure and composition. All trees with a breast height (DBH) diameter greater than 5 cm within each plot were identified, measured, and recorded to assess species diversity and distribution patterns.

2.3. Tree data collection and species identification

Trees with a diameter at breast height (DBH) of at least 5 cm within each plot were identified, measured, and recorded. Specimens not reliably identified in the field were collected as voucher samples—photographed, pressed, and stored in herbarium bags for later verification. Taxonomic determination drew on multiple authoritative sources, including Co's Digital Flora of the Philippines, Rojo's Lexicon of Philippine Trees, and Leonard Co's Philippine Vascular Plants Checklist.

2.4. Data analysis

The collected data were subjected to quantitative ecological analysis to evaluate the composition of the tree species of Mt. Mayapay. The study employed vegetation analysis methods, following the procedures outlined by Coracero & Malabrigo (2020b), to quantify key ecological parameters. Specifically, the analysis included the computation of density, frequency, dominance, relative density, relative frequency, relative dominance, and species importance value (SIV). These parameters provided an integrated measure of each species' contribution to the forest ecosystem in terms of abundance and distribution.

Diversity indices, including evenness and the Shannon-Weiner Diversity Index, were analyzed using the Paleontological Statistical Software Package (PAST v.4.03). The computed values for the Shannon-Weiner Diversity Index were interpreted following the biodiversity scale established by Fernando (1998), as presented in Table 1. The conservation status of each species was assessed and verified using the International Union for Conservation of Nature (IUCN) Red List (IUCN 2017) for the global category, while the Philippine list of threatened species under DAO 2017-11 (DENR 2017) was used for the local conservation status.

Table 1: Biodiversity scale.

Relative Interpretation	Shannon's (H') Index	Evenness Index
Very High	>3.5	0.75-1.00
High	3.00-3.49	0.50-0.74
Moderate	2.50 - 2.99	0.25-0.49
Low	2.00 - 2.49	0.15-0.24
Very Low	<1.99	0.05 – 0.14

3. RESULT AND DISCUSSION

3.1 Species composition

The results presented in Table 2 highlight the species composition of the tree community within the study area of Mt. Mayapay, revealing a moderately diverse assemblage of indigenous and exotic species. A total of 23 species representing various taxonomic families were recorded within the established sample plots. The most abundant species was *F. falcata* (11 individuals), a fast-growing exotic species commonly utilized in reforestation and agroforestry for its economic value and adaptability (Hughes et al., 2024). Its predominance points to the influence of planting operations mediated by humans, which aligns with findings in other secondary or recovering forests where alien species are reintroduced for restoration. Similarly, *with nine individuals, S. macrophylla*, another economically significant species valued for its timber (Gilbero et al., 2019), was also somewhat dominant. These two species' notable occurrence suggests a diverse landscape history influenced by manmade interventions and natural regeneration.

Numerous indigenous plants, including *Polyscias nodosa* (6 individuals) and *Cratoxylum formosum* (5 individuals), were also abundant, demonstrating the enduring presence of native vegetation in the forest matrix. Meanwhile, species such as *Cananga odorata* (4 individuals) contribute to the diversity of native species in the area. It is particularly valued for its essential oils, which are widely used in perfumery and traditional medicine, while its timber serves various local utilitarian purposes (Datiles, 2022). The remaining species exhibited lower frequencies, with eight species represented by only one individual. This low abundance may indicate their natural rarity within the study area or reflect the localized scope of the sampling plots. While this limited sampling coverage may not fully capture the site's total diversity, it nonetheless provides valuable insights into the presence of rare or less common species, underscoring the ecological complexity of the area and offering a baseline for future, more extensive assessments.

The Moraceae emerged as the most species-rich at the family level, contributing four species to the overall assemblage. This finding aligns with the known ecological characteristics of the Moraceae, a family that commonly thrives in tropical environments and plays a crucial role in forest dynamics through its contributions to fruit production and faunal interactions (Shanahan et al., 2001; Ramirez et al., 2022). Two species from the families Meliaceae and Fabaceae add to the site's ecological variety, following trends seen in other lowland and mid-elevation forests in the Philippines, where these families are common.

Table 2: List of Plant Species in Mt. Mayapay located in Brgy. Sangay, Buenavista, Agusan del Norte.

Species No.	Scientific Name	Family	No. of Individuals	Plot
1	*Falcataria falcata*	Fabaceae	11	2,6,7,8,10
2	*Swietenia macropylla*	Meliaceae	9	1,3,4
3	*Polyscias nodosa*	Araliaceae	6	3,4,10
4	*Cratoxylum formosum*	Hypericaceae	5	3,4,5,7
5	*Cananga odorata*	Annonaceae	4	2,3,10
6	*Ficus benjamina*	Moraceae	4	8,9
7	*Litsea philippinensis*	Lauraceae	3	2,4
8	*Pterocarpus indicus*	Fabaceae	3	5,8
9	*Caryota furfuracea*	Arecaceae	3	7,9
10	*Syzygium aqueum*	Myrtacea	2	1,3
11	*Macaranga tanarius*	Euphorbiaceae	2	1,2
12	*Artocarpus heterophyllus*	Moraceae	2	5,9
13	*Tambebuia acrophylla*	Bignonaceae	2	6
14	*Gmelina arborea*	Verbenaceae	2	7
15	*Gnetum gnenom*	Gnetaceae	2	7,9
16	*Ficus nota*	Moraceae	1	2
17	*Artocarpus blancoi*	Moraceae	1	2
18	*Trema orientalis*	Cannabaceae	1	6
19	*Averrhoa bilimbi*	Oxalidaceae	1	3
20	*Leocosyke capitellata*	Urticaceae	1	4
21	*Cratoxylum sumatranum*	Hypericaceae	1	1
22	*Sandoricum koetjape*	Meliaceae	1	7
23	*Pandanus tectorius*	Pandaceae	1	8

3.2. Species importance value (SIV)

The species importance values (SIV) were computed as the sum of the relative dominance, relative density, and relative frequency (Coracero & Malabrigo, 2020). Relative dominance reflects the proportional abundance of species within a given community, indicating their contribution to the overall structure and composition of the ecosystem (Avolio et al., 2019; Magurran, 2004). In this study, *F. falcata* exhibited the highest relative dominance at 48.15%, followed by *S. macrophylla* at 14.21% (Table 3). The lowest values were recorded for *L. capitellata* and *P. tectorius*, each with 0.10%. Hancock and Legg (2012) highlighted that high species dominance, while associated with greater resilience, may also lead to reduced resistance and lower overall ecosystem stability due to the system's reliance on a few dominant species. Similarly, Lohbeck et al. (2016) emphasized that species dominance, rather than specific functional traits, plays a more significant role in determining a species' contribution to ecosystem functioning. This underscores the importance of dominance in shaping ecosystem processes, often outweighing the influence of species-level traits.

Relative density refers to the abundance and distribution of different tree species within a given area,

expressed as the proportion of individuals of a particular species relative to the total tree population (Ishoro & Aja, 2017). In this study, *F. falcata* recorded the highest relative density at 16.18%, followed by *S. macrophylla* at 13.24%. A high relative density indicates that a species occurs in greater numbers or occupies a larger proportion of the habitat than other species within the same community. Conversely, low relative density reflects a smaller or more limited population size within the area.

Relative frequency quantifies the occurrence or distribution of a particular tree species within a given area or community. Based on the results, *F. falcata* exhibited the highest relative frequency at 11.4%, followed by *S. macrophylla* at 6.8%. A high relative frequency indicates that a species is widely distributed across the area, though it is not necessarily abundant within each site (Martin & Canham, 2020). In contrast, a low relative frequency suggests that a species is rarely encountered and occurs in small numbers, which may reflect its rarity or potential vulnerability within the ecosystem.

Among all recorded species, *F. falcata* exhibited the highest Species Importance Value (SIV) at 47.61%, primarily due to its high dominance (basal area), frequency of occurrence, and density. As a typical fast-growing exotic plantation species, *F. falcata* is often favored in reforestation projects for its rapid biomass accumulation and economic value. However, it also has the potential to become invasive and pose threats to native forest ecosystems (Hughes et al., 2024b). Its prevalence in the study area suggests that anthropogenic activities, particularly deliberate planting, have significantly influenced the composition of the current species. The second most important species was *S. macrophylla* with an SIV of 30.95%. Like *F. falcata*, this species is an economically valuable exotic tree, commonly introduced for timber production. It also demonstrated better adaptability and potential for rehabilitating degraded mining sites (Goyo et al., 2025). Its importance underscores its ecological and silvicultural role, contributing substantially to canopy structure and habitat provision.

In contrast, native species such as *P. nodosa* (SIV = 22.68%) and *C. formosum* (SIV = 23.04%) still maintain a notable presence, suggesting that portions of the native flora persist and continue to contribute to the ecosystem structure and function of Mt. Mayapay. Mainstream ecological wisdom suggests that native species are essential to preserving and promoting ecological health or the integrity of a particular habitat (Foster, 2004), as they provide food and habitat for endemic fauna and help sustain natural regeneration processes.

Several species recorded SIVs below 5%, including *P. tectorius, C. sumatranum*, and *L. capitellata*. These low values may reflect their rarity or limited ecological dominance within the sampled plots. However, species with low abundance can still hold significant ecological roles, such as supporting specialist species, contributing to genetic diversity, and enhancing ecosystem stability. Rare species can play an important role in ecosystem stability through strong indirect effects (Säterberg et al., 2019). Their scattered occurrence aligns with findings in other studies, where such species often exist as part of the understory or in specific microhabitats within disturbed or recovering forests (Spyreas & Matthews, 2006).

Table 3: Species Importance Value (SIV).

No.	Species	RDen (%)	RDom (%)	RFre (%)	SIV (%)
1	*Falcataria falcata*	16.18	48.15	11.4	47.61
2	*Swietenia macropylla*	13.24	14.21	6.8	30.95
3	*Polyscias nodosa*	8.82	5.93	6.8	22.68
4	*Cratoxylum formosum*	7.35	5.20	9.1	23.04
5	*Cananga odorata*	5.88	5.65	6.8	19.58
6	*Ficus benjamina*	5.88	3.16	4.5	15.57
7	*Litsea philippinensis*	4.41	5.03	4.5	15.44
8	*Pterocarpus indicus*	4.41	1.26	4.5	12.20
9	*Caryota furfuracea*	4.41	2.64	4.5	13.65
10	*Syzygium aqueum*	2.94	0.43	4.5	9.39
11	*Macaranga tanarius*	2.94	0.41	4.5	9.33
12	*Artocarpus heterophyllus*	2.94	1.17	4.5	10.62
13	*Tambebuia acrophylla*	2.94	0.54	4.5	9.61
14	*Gmelina arborea*	2.94	0.54	4.5	9.61
15	*Gnetum gnenom*	2.94	1.30	4.5	10.78
16	*Ficus nota*	1.17	0.54	2.3	5.87
17	*Artocarpus blancoi*	1.47	2.51	2.3	8.33
18	*Trema orientalis*	1.47	0.29	2.3	5.31
19	*Averrhoa bilimbi*	1.47	0.46	2.3	5.70
20	*Cratoxylum sumatranum*	1.47	0.11	2.3	4.69
21	*Leocosyke capitellata*	1.47	0.10	2.3	4.64
22	*Sandoricum koetjape*	1.47	0.29	2.3	5.31
23	*Pandanus tectorius*	1.47	0.10	2.3	4.64

3.3. Diversity indices

Table 4 presents the computed diversity indices for the tree species in Mount Mayapay. The Shannon Diversity Index (H' = 2.798) indicates a moderate level of species diversity based on the Fernando Biodiversity Scale (1998). This suggests that while a fair variety of species exists within the study area, the distribution of individuals among these species is uneven, with particular species such as *F. falcata* and *S. macrophylla* demonstrating clear dominance in abundance and basal area. In Amazonian forests, primary forests exhibited higher species richness (36.4 vs 21 species per 1,000 m²) and diversity indices (3.43 vs 2.61) compared to secondary forests under different silvicultural systems (Yared et al., 2000). Disturbance intensity affects these patterns, with species diversity-functional diversity relationships varying across disturbance gradients (Biswas & Mallik, 2011). In boreal forests, species richness and

Shannon's index decrease while evenness increases with time since fire disturbance (Yeboah et al., 2016). However, unlike primary forests where native canopy-forming species typically drive dominance, our results reveal that the two introduced species, *F. falcata* and *S. macrophylla*, are the most abundant in stem density and basal area. This dominance likely reflects historical plantation establishment and selective management practices rather than natural successional processes. In contrast, a secondary forest along the Sierra Madre Mountain Range reported a Shannon-Weiner index of 3.269 and a Simpson's Evenness value of 0.9453, with diversity patterns largely shaped by native species dominance (Llait, 2024). While Mount Mayapay shows moderate diversity under the influence of introduced species, the Sierra Madre site exhibited higher evenness and stronger representation of native taxa, signifying that native-dominated secondary forests may sustain broader ecological balance.

Despite this, the Evenness Index (E = 0.74) reflects a high degree of evenness, indicating that most species are still reasonably well-represented across the sampling plots. This level of evenness implies that no single species overwhelmingly dominates the entire area, contributing positively to the forest ecosystem's ecological balance and potential resilience. The combination of moderate diversity and high evenness suggests that the forest stand is in a state of recovery or transition, likely shaped by a mixture of natural regeneration and anthropogenic influences such as reforestation activities.

These findings underscore the importance of sustaining both species' richness and evenness to maintain ecological integrity, while also highlighting the need for continued conservation efforts to promote the regeneration and persistence of native species within the area.

Table 4: Diversity indices.

Diversity Indices	Value
Shannon Diversity indices	2.798
Evenness	0.74

3.4 Conservation status

The conservation status of the 23 tree species recorded from Mount Mayapay was assessed based on two references: the International Union for Conservation of Nature (IUCN) Red List for the global status, and the Philippine Department of Environment and Natural Resources Administrative Order (DAO) 2017-11 for the national/local status.

Among the species identified, *P. indicus* holds significant conservation concern. It is classified as Endangered (EN) under the IUCN Red List and Vulnerable (VU) under DAO 2017-11. This dual listing highlights the species' global and national decline due to habitat loss, overexploitation, and limited regeneration in natural habitats. Similarly, *L. philippinensis* is categorized as Near Threatened (NT) by the IUCN Red List, though it does not appear on the DAO 2017-11 list. Its classification reflects its sensitivity to habitat disturbances and restricted distribution.

Table 5: Conservation Status of Documented Tree Species in the Study Area Based on IUCN Red List and DAO 2017-11.

No.	Species	Conservation Status	
		IUCN	DAO 2017-11
1	*Falcataria falcata*	LC	ND
2	*Swietenia macropylla*	LC	ND
3	*Polyscias nodosa*	LC	ND
4	*Cratoxylum formosum*	LC	ND
5	*Cananga odorata*	LC	ND
6	*Ficus benjamina*	LC	ND
7	*Litsea philippinensis*	NT	ND
8	*Pterocarpus indicus*	EN	Vu
9	*Caryota furfuracea*	LC	ND
10	*Syzygium aqueum*	LC	ND
11	*Macaranga tanarius*	LC	ND
12	*Artocarpus heterophyllus*	NE	ND
13	*Tabebuia rosea*	LC	ND
14	*Gmelina arborea*	LC	ND
15	*Gnetum gnenom*	LC	ND
16	*Ficus nota*	LC	ND
17	*Artocarpus blancoi*	LC	ND
18	*Trema orientalis*	LC	ND
19	*Averrhoa bilimbi*	LC	ND
20	*Cratoxylum sumatranum*	LC	ND
21	*Leucosyke capitellata*	LC	ND
22	*Sandoricum koetjape*	LC	ND
23	*Pandanus tectorius*	LC	ND

LC – Least Concern, NT – Near Threatened, EN – Endangered, Vu – Vulnerable, NE – Not Evaluated, ND – No Data.

The remaining species, such *as F. falcata, S. macrophylla, P. nodosa, C. odorata, F. benjamina, C. formosum, C. sumatranum*, and others, are generally categorized as Least Concern (LC) or are not evaluated (NE) under the IUCN Red List. Many of these species, particularly the exotics like *F. falcata* and *S. macrophylla*, are widely cultivated and not considered at risk globally. However, they may impact local ecosystems through dominance and potential invasiveness. Additionally, DAO 2017-11 does not include these species under its list of threatened Philippine trees, further supporting their current stability within the country. The presence of species such as *A. blancoi, A. heterophyllus*, and *F. nota*, though not currently flagged as threatened, plays a vital ecological role as part of the native forest composition,

contributing to habitat complexity and supporting various faunal species.

The documentation of both globally and nationally threatened species in Mount Mayapay underscores the area's ecological value and the necessity for ongoing conservation initiatives. The presence of *P. indicus* and *L. philippinensis* is an important indicator for localized conservation strategies, emphasizing the need to protect remnant populations through habitat management, protection from exploitation, and enrichment planting where feasible.

4. CONCLUSION

The diversity assessment conducted in Mount Mayapay documented a moderately diverse tree community composed of 23 species across 17 families. The dominance of exotic species such as *F. falcata* and *S. macrophylla* reflects the influence of past human interventions, particularly through deliberate planting and reforestation efforts. Despite this, the presence of native species, including *P. nodosa* and *C. formosum*, indicates the persistence of natural forest elements and contributes positively to the site's ecological balance.

The computed Shannon Diversity Index (H' = 2.798) and Evenness (E = 0.74) suggest a moderately diverse and relatively stable ecosystem. However, the apparent dominance of a few species highlights the transitional nature of the forest, shaped by both natural regeneration and anthropogenic factors. Conservation assessments reveal the presence of species with recognized conservation importance, notably *P. indicus* and *L. philippinensis*, emphasizing the area's role in biodiversity conservation. While most species are categorized as Least Concern or have not been evaluated, threatened species underline the need for sustained conservation actions and habitat management. Overall, this study provides critical baseline data for future biodiversity monitoring and forest management strategies aimed at conserving both native species and ecosystem functions in Mount Mayapay.

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