Thailand Natural History Museum Journal 20(1): 89–104 (2026)

Diversity of pteridophytes in a protected watershed, Mount Apo Natural Park, Cotabato, Philippines

Cherie Cano-Mangaoang[1,2], Diane Erika E. Tabar[2], Rachel L. Zamora[1,3] and Mark Jobert C. Ellaga[1]

[1] Graduate School, University of Southern Mindanao, Kabacan, Cotabato, 9407, Philippines

[2] Department of Biological Sciences, College of Science and Mathematics, University of Southern Mindanao, Kabacan, Cotabato, 9407, Philippines

[3] Protected Area Management Office, Mount Apo Natural Park, Kidapawan City, Cotabato, 9400, Philippines

Article history
Received: 28 January 2026
Accepted: 8 May 2026
Published online: 30 May 2026

Corresponding author
Cherie Cano-Mangaoang
E-mail: ccmangaoang@usm.edu.ph

Editor
Dr. Weeyawat Jaitrong
E-mail: polyrhachis@yahoo.com/
weeyawat@nsm.or.th

ABSTRACT

Pteridophytes are valuable bioindicators of ecosystem health, and their presence, particularly endemic and threatened species, can inform conservation strategies for protected areas. This study assessed pteridophyte diversity in the Saguing Watershed (western side of Mount Apo Natural Park, Mindanao, Philippines) across three ecosystem types: agricultural, tropical lowland evergreen and tropical lower montane forest formations. Eight 20 m x 20 m quadrats were established per ecosystem and analyzed diversity using Shannon-Weiner Diversity Index, Simpson's Index, species richness, evenness, dominance, and abundance. Bray-Curtis similarity was used to compare species assemblages. A total of 70 pteridophyte species, spanning 32 genera and 15 families, were identified. The tropical lowland evergreen forest exhibited the highest diversity, with 59 species and 303 individuals, followed by agroforest (29 species) and montane forest (24 species). While Shannon-Weiner Diversity Index was generally low across all sites, the tropical lower montane forest displayed a more even distribution of pteridophyte populations. The study recorded eight endemics, four endangered, and one rare species within the watershed. Bray-Curtis similarity revealed a high similarity between tropical lower montane and tropical lowland evergreen forests (55–60%), while the agricultural ecosystem showed a distinct species composition (approximately 40% similarity to the other two). In conclusion, the Saguing Watershed is a crucial habitat for various pteridophyte species. However, the observed diversity indices suggest that its pteridophyte community structure may be vulnerable to environmental changes. It is then recommended to enhance habitat protection and monitoring through policy implementation and community involvement in watershed management.

Keywords: *Diplazium*, ferns, lycophytes, tropical lowland evergreen forest, Polypodiaceae

Citation. Cano-Mangaoang, C., D.E.E. Tabar, R.L. Zamora and M.J.C. Ellaga. 2026. Diversity of pteridophytes in a protected watershed, Mount Apo Natural Park, Cotabato, Philippines. *Thailand Natural History Museum Journal* 20(1): 89–104.

INTRODUCTION

The Philippines is a globally recognized megadiverse nation, distinguished by exceptional levels of flora and faunal endemism (Ong *et al.*, 2022). Within this biological hotspot, pteridophytes (ferns and lycophytes) represents a significant portion of the country's botanical wealth, with approximately 1,080 species across 174 genera and 40 families (Pelser *et al*., 2011). Accordingly, 25.1% (269) of these species are found nowhere else on Earth. This number continues to climb as frequent new discoveries expand the known pteridophyte flora of the archipelago (Amoroso *et al*., 2009; 2020; 2021; 2023; Barcelona *et al*., 2013; Coritico, 2024), emphasizes the dynamic and yet-to-be-fully realized nature of Philippine pteridology. Despite their richness, these plants face severe threats for unregulated anthropogenic activities—such as logging and agricultural land conversion—which continue to fragment and destroy the natural habitats they rely on (Magtoto and Austria, 2018; Zapanta *et al*., 2019).

Beyond their aesthetic and cultural value, pteridophytes served as critical ecological indicators due to their heightened sensitivity to environmental shifts (Bergeron and Pellerin, 2014). Research indicates that fern richness and abundance decrease at the edges of tropical montane forests (Silva *et al*., 2018). Furthermore, this group of plants is recognized for its artistic characteristics (Banaticla and Buot, 2004), ornamental qualities (Amoroso *et al.,* 2022), nutritional and dietary fibers (Amoroso *et al*., 2014), and medicinal applications (Ho *et al.,* 2010, Muhammad *et al.*, 2020). However, their economic utility often leads to illegal extraction (Amoroso *et al.,* 2022), despite being identified as a keystone plant for woodland restoration (Banaticla and Buot, 2004).

While various pteridological studies have explored Mindanao's Mountain ecosystems—revealing high concentrations of threatened and newly record species in ranges such as Mt. Hamiguitan and Mt. Tago (Amoroso *et al*., 2016; Coritico and Amoroso, 2020)—Mt. Apo remains unevenly documented. Previous research within Mt. Apo Natural Park (MANP) has been largely confined to the Makilala side and the vicinity of the Energy Development Corporation (EDC) permanent plots (Amoroso *et al*., 2015; 2020; Cano-Mangaoang *et al*., 2020). Consequently, large portion of the park, particularly the Saguing Watershed, currently lacks a comprehensive pteridophyte inventory. This geographic knowledge gap is significant; without site-specific data on endemic and threatened species, local conservations cannot craft precise management strategies to protect the remaining resources within this vital watershed.

Consequently, further study of the Saguing Watershed is essential to provide a concrete picture of the status of pteridophyte species in this part of the Mt. Apo Natural Park (MANP) ecosystem. The primary objective of this study is to document diversity of pteridophytes within the Saguing Watershed, identifying the species composition and identifying those of high conservation priority. By establishing a comprehensive species list, the study aims to provide the necessary scientific baseline for crafting data-driven protection and conservation strategies to safeguard the biological integrity of this mountain ecosystem.

MATERIALS AND METHODS

Entry Protocol

The field sampling was preceded by a series of stakeholder consultations to ensure full regulatory compliance. This process primarily involved presenting the research proposal to the Mt. Apo Natural Park-Protection and Management Board (MANP-PAMB) to secure a gratuitous permit for biological collection. Following the issuance of the permit, a formal courtesy call was made to the Barangay Local Government Unit (BLGU) prior to actual field sampling.

Sampling Area

This study was conducted across three distinct ecosystem types—agricultural, tropical lowland evergreen, and tropical lower montane forests—within the Saguing Watershed of MANP (6.999410°N, 125.189975°E). Situated in Barangay Perez, Kidapawan City, Cotabato, the Saguing Watershed serves as a primary catchment area in the western portion of the park, The specific study sites are located within the strict protection zone (SPZ), spanning an elevational gradient from 900 m to 1,200 m above sea level (asl). The agricultural site is characterized by the presence of fruit orchard, coconut trees, banana plants, plantation of *Hevea brasiliensis* and land cultivation to cater vegetable gardens. Ecological characterization of tropical lowland evergreen and montane forests followed the classification system established by Fernando *et al*. (2008) (Figure 1).

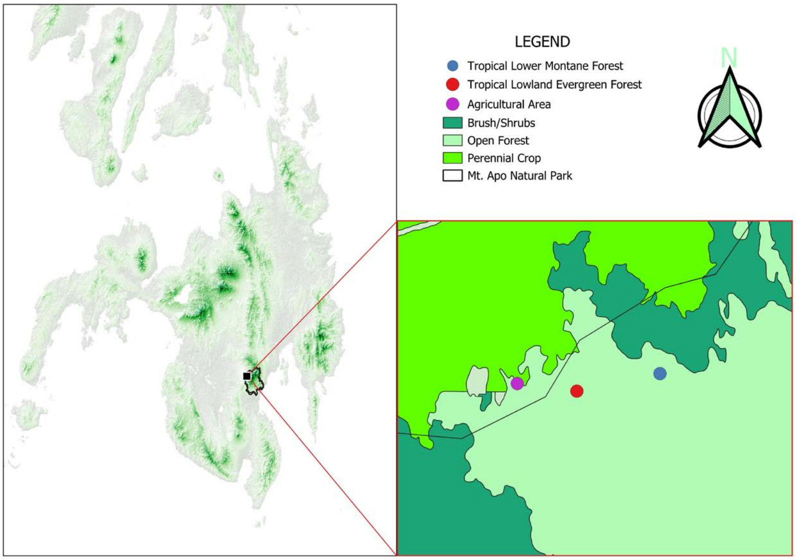

Figure 1. Map showing the sampling site in Saguing Watershed, Mt. Apo Natural Park, Cotabato, Philippines.

Species inventory and diversity indices

The establishment of sampling plots followed the protocol employed by Cano-Mangaoang *et al*. (2020). This was done by laying down four 20 x 20 m^2 quadrats on each side of the established human trail with a total of eight plots within each ecosystem. This is to ensure variation of species. All the species within the quadrat and between the quadrats were noted for the species richness. Diversity indices considered in the study were the following: species richness, Shanon-Weiner diversity index, evenness, dominance, and abundance. Species richness refers to the total number of taxa documented within the study sites, while abundance represented the cumulative number of individuals per species. Diversity metrics, including the Shannon-Weiner Index (H'), Simpson's Index, and Pielou's Evenness Index (J'), were calculated alongside Bray-Curtis similarity dendrogram using BioDiversity Professional (Version 2). The resulting Shannon-Weiner values were interpreted following the qualitative classification proposed by Magurran (1998).

Identification of Species

Preliminary identification of the species was done on-site by using photographs, taxonomic keys, and pictorial guide. Furthermore, online sources were also used in confirming the identity of photographed species such as the Co's Digital Flora of the Philippines (Pelser *et al*., 2011), Kew Botanic Garden (Plants of the world online) (Pelser *et al*., 2011) and e-herbarium found in the JSTOR Plants. Morphological characterization and identification of pteridophytes up to the lowest possible level were carried out. The taxonomic classification used for this study is the Pteridophyte Phylogeny Group I (2016). A voucher specimen was taken for species that can't be identified in the field for further confirmation of its identity. Plant voucher specimens were deposited at the University of Southern Mindanao, College of Science and Mathematics, Department of Biology.

Determination of the Conservation and Ecological Status of Pteridophytes

The conservation status of the collected pteridophytes was determined and categorized as critically endangered, endangered, vulnerable, other threatened species, and other wildlife species based on Department of Environment and Natural Resources (DENR) Administrative Order (DAO) No. 2017-11 and cross-checked with IUCN (Version 2025-2). The geographical distribution was based on the online database of the Co's Digital Flora of the Philippines (Pelser *et al*., 2011).

RESULTS

This study identified 70 species, 32 genera, and 15 families of pteridophytes thriving in the three ecosystem types of the Saguing Watershed Area. Most of the species identified fall under family Polypodiaceae (13 species), followed by Athyriaceae with nine species and the least numbered family are Cyatheaceae, Dennstaedtiaceae, and Hypodematiaceae with one species each. Among the genera recorded, *Diplazium* has the highest species identified which is nine, followed by *Asplenium* with seven species, next is *Selaginella* having six species recorded, then *Lindsaea* and *Microsorum* with five species.

Species of pteridophytes identified in this study vary in every ecosystem type. In the agricultural area, 29 species were found, comprising ten genera and 11 families. Meanwhile, the tropical lowland evergreen forest harbors 59 species belonging to 22 genera and 14 families. The tropical lower montane forest has recorded 24 species, 17 genera, and 13 families of ferns and lycophytes. The family of ferns with the most identified species is Polypodiaceae with eight species for both agroforest and tropical lowland evergreen forest (Table 1).

Table 1. Pteridophyte species in different ecosystem types in Saguing Watershed, Mt. Apo Natural Park, Kidapawan City, Philippines. Abbreviations: AG, Agricultural; GD, Geographical Distribution; TLEF, Tropical Lowland Evergreen Forest; TLM, Tropical Lower Montane.

Family	**Species**	**GD**	**Conservation Status**	**Ecosystem Types**		
				AG	**TLEF**	**TLM**
Aspleniaceae	*Asplenium affine* Sw.	Native	Other Wildlife Species	-	+	-
	Asplenium colubrinum Christ.	Endemic	Other Wildlife Species	-	+	+
	Asplenium cuneatum Lam.	Native	Other Wildlife Species	-	+	-
	Asplenium nidus L.	Native	Other Wildlife Species	-	+	+
	Asplenium nigrescens Blume	Native	Other Wildlife Species	-	+	-
	Asplenium cymbifolium Christ	Native	Other Wildlife Species	-	+	-
	Asplenium tenerum G.Forst.	Native	Other Wildlife Species	+	+	+
Athyriaceae	*Diplazium cordifolium* Blume	Native	Other Wildlife Species	-	+	-
	Diplazium costulisorum (Copel.) C.Chr.	Native	Endangered (DAO category)	-	+	-
	Diplazium esculentum (Retz.) Sw.	Native	Least Concern (IUCN 3.1)	+	-	-
	Diplazium dilatatum Blume	Native	Other Wildlife Species	+	+	-
	Diplazium forbessi (Baker) C.Chr.	Native	Other Wildlife Species	-	+	+

Table 1. Continue.

Family	Species	GD	Conservation Status	Ecosystem Types		
				AG	**TLEF**	**TLM**
	Diplazium fraxinifolium C.Presl	Native	Other Wildlife Species	-	+	+
	Diplazium griffithii T.Moore	Native	Other Wildlife Species	-	+	-
	Diplazium oligosorum Copel	Endemic	Other Wildlife Species	-	+	-
	Diplazium pseudocyatheifolium Rosenst	Endemic	Other Wildlife Species	-	+	-
Cyatheaceae	*Sphaeropteris glauca* (Blume) R.M. Tryon	Native	Least Concern (IUCN 3.1) Endangered (DAO category as *Cyathea contaminans*)	+	-	-
Davalliaceae	*Davallia denticulata* (Burm.f.) Mett.	Native	Other Wildlife Species	+	-	-
	Davallodes hymenophylloides (Blume) M.Kato & Tsutsumi	Native	Other Wildlife Species	+	+	-
Dennstaedtiaceae	*Histiopteris incisa* (Thunb.) J.Sm.	Native	Other Wildlife Species	-	+	+
Dryopteridaceae	*Bolbitis heteroclita* (C.Presl) Ching	Native	Other Wildlife Species	-	+	-
	Dryopteris formosana (Christ) C.Chr.	Native	Other Wildlife Species	-	+	-
	Dryopteris hendersonii (Bedd.) C.Chr.	Native	Other Wildlife Species	+	+	-
	Pleocnemia irregularis (C.Presl)	Native	Other Wildlife Species	+	-	-
	Polystichum elmeri Copel.	Endemic	Other Wildlife Species	-	+	-
Hymenophyllaceae	*Hymenophyllum badium* Hook. & Grev.	Native	Other Wildlife Species	-	+	-
	Hymenophyllum emarginatum Sw.	Native	Other Wildlife Species	-	+	+
	Hymenophyllum reinwardtii Bosch	Native	Other Wildlife Species	-	-	+
	Trichomanes apiifolium C. Presl	Native	Other Wildlife Species	-	+	-
	Trichomanes brevipes (C.Presl) Baker	Native	Other Wildlife Species	-	+	-

Table 1. Continue.

Family	Species	GD	Conservation Status	Ecosystem Types		
				AG	TLEF	TLM
	Trichomanes obscurum Blume	Native	Other Wildlife Species	-	+	-
Hypodematiaceae	*Leucostegia immersa* C.Presl,	Native	Other Wildlife Species	-	+	-
Lindsaeaceae	*Lindsaea apoensis* Copel.	Endemic	Other Wildlife Species	-	+	-
	Lindsaea cultrata (Willd.) Sw.	Native	Other Wildlife Species	-	+	-
	Lindsaea oblanceolata Alderw.	Native	Other Wildlife Species	-	+	-
	Lindsaea pulchella (J.Sm. ex Fielding & Gardner) Mett.	Native	Other Wildlife Species	-	+	-
	Lindsaea repens (Bory) Thwaites	Native	Other Wildlife Species	-	-	+
Marattiaceae	*Angiopteris evecta* (G. Forst) Hoffm.	Native	Other Threatened Species (DAO Category as *Angiopteris palmiformis)*	+	+	+
	Ptisana sylvatica (Blume) Murdock	Native	Other Wildlife Species	-	+	+
Nephrolepidaceae	*Nephrolepis falcata* (Cav.) C.Chr.	Native	Other Wildlife Species	+	+	+
	Nephrolepis biserrata (Sw.) Schott	Native	Other Wildlife Species	+	+	-
Polypodiaceae	*Drynaria heracleum* (Kunze) T.Moore	Native	Vulnerable (DAO Category as *Aglaomorpha heraclea*)	+	+	-
	Goniophlebium persicifolium (Desv.) Bedd.	Native	Other Wildlife Species	-	+	-
	Lepisorus accedens (Blume) Hosok.	Native	Other Wildlife Species	+	+	-
	Lecanopteris deparioides (Cesati) Baker,	Native	Endangered (DAO category)/ Rare Species	-	+	-
	Leptochilus macrophyllus (Blume) Noot.	Native	Other Wildlife Species	-	+	-
	Loxogramme avenia (Blume) C. Presl	Native	Other Wildlife Species	+	+	-

Table 1. Continue.

Family	**Species**	**GD**	**Conservation Status**	**Ecosystem Types**		
				AG	**TLEF**	**TLM**
	Microsorum heterocarpum (Blume) Ching,	Native	Other Wildlife Species	-	+	-
	Microsorum longissimum Fée	Native	Other Wildlife Species	-	-	+
	Microsorum punctatum (L.) Copel.	Native	Other Wildlife Species	+	-	-
	Phymatosorus commutatus (Blume) Pic.Serm.	Native	Other Wildlife Species	+	+	-
	Phymatosorus membranifolius (R.Br.) S.G.Lu	Native	Other Wildlife Species	+	-	-
	Pyrrosia longifolia (Burm.f.) C.V.Morton	Native	Other Wildlife Species	+	-	-
	Pyrrosia sphaerosticha (Mett.) Ching	Native	Other Wildlife Species	+	-	-
Pteridaceae	*Antrophyum callifolium* Blume	Native	Other Wildlife Species	+	+	-
	Antrophyum sessilifolium (Cav.) Spreng.	Native	Other Wildlife Species	-	+	-
	Haplopteris alternans (Copel.) S.Linds. & C.W.Chen	Native	Other Wildlife Species	-	+	+
	Haplopteris ensiformis (Sw.) E.H.Crane	Native	Other Wildlife Species	-	+	+
Selaginellaceae	*Selaginella cupressina* (Willd.) Spring	Native	Other Wildlife Species	+	+	-
	Selaginella engleri Hieron.	Native	Other Wildlife Species	+	+	+
	Selaginella gastrophylla Warb.	Native	Other Wildlife Species	+	+	+
	Selaginella intermedia (Blume) Spring	Native	Other Wildlife Species	-	+	+
	Selaginella magnifica Warb.	Endemic	Endangered (DAO Category)	-	+	-
	Selaginella uncinata (Desv.) Spring	Naturalized		-	+	-
Tectariaceae	*Tectaria membranacea* (Hook.) Fraser-Jenk. & Kholia	Native	Other Wildlife Species	+	+	+
	Tectaria dissecta (G.Forst.) Lellinger	Native	Other Wildlife Species	+	+	+

Table 1. Continue.

Family	Species	GD	Conservation Status	Ecosystem Types		
				AG	TLEF	TLM
	Tectaria melanocaulos (Blume) Copel.	Native	Other Wildlife Species	+		
Thelypteridaceae	*Thelypteris laevis* (Mett.) C.F.Reed	Endemic	Other Wildlife Species	+	+	+
	Thelypteris ramosii (Christ) C.M.Kuo	Native	Other Wildlife Species	+	+	+
	Thelypteris viridis (Copel.) C.F.Reed	Endemic	Other Wildlife Species	+	+	+
			Total	29	59	24

Legend: + present, – absent

The assemblage patterns of pteridophytes within the Saguing watershed appear to be influenced by various environmental factors and habitat disturbance across the different ecosystems. Based on the Bray-Curtis Cluster Analysis, the tropical lower montane and tropical lowland evergreen forests exhibited the highest degree of floristic similarity. The dendrogram reveals a primary node connecting these two habitats at approximately 55% to 60% similarity. In contrast, the agricultural habitat emerged as the most distinct site within the study area. It clustered with the natural forest habitats at a lower similarity level of approximately 40% (Figure 2).

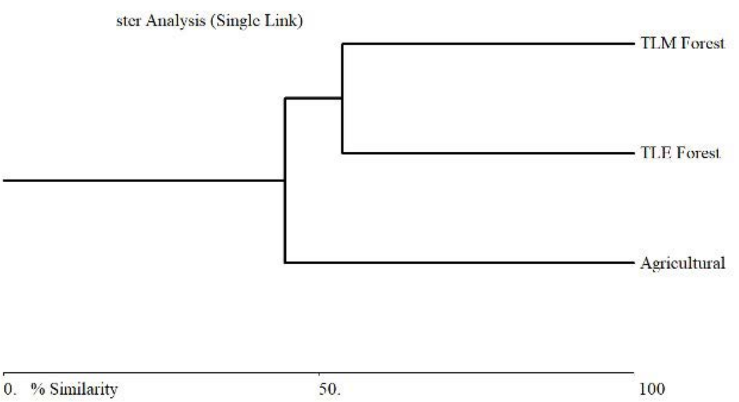

Figure 2. Dendogram of Similarity of species in the three ecosystem types of Saguing Watershed, Mt. Apo Natural Park, Cotabato, Philippines.

The assessment of diversity indices across the study sites revealed that the tropical lowland evergreen forest harbors the highest species richness and abundance of pteridophytes in Saguing Watershed. When evaluating the Shannon-Weiner Diversity Index (H'), the tropical lowland evergreen forest again yielded the highest value at 1.23. However, according to the classification scales of this index proposed by Magurran (1998), the overall pteridophyte diversity across the watershed is classified as low.

Further analysis of dominance and distribution provided deeper insights into the community structure of the different land-use types. The Simpson's Index (D) for the agricultural site was 0.113, indicating the presence of specific dominant species that may better adapted to the higher light intensity or disturbed conditions of that ecosystem. In contrast, the tropical lower montane forest exhibited a more even distribution of pteridophyte population (J' 0.864). This suggest that individuals are distributed more uniformly among the species present in this high-altitude habitat compared to the other forest type.

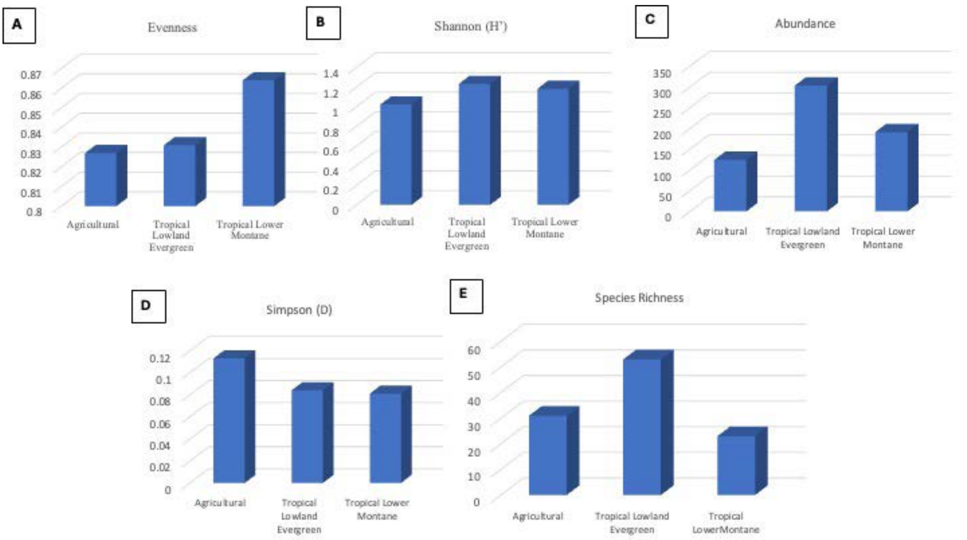

Figure 3. Result of Diversity Indices of Pteridophytes in Saguing Watershed, MANP, Kidapawan City, Philippines. A, evenness; B, Shannon (H'); C, Abundance; D, Simpson (D); E, species richness.

Geographic Distribution and Conservation Status

A total of four species is endangered, one Other Threatened Species, one Vulnerable, two Least Concern and 63 were Other Wildlife Species. Based on DAO 2017-11 that all other species of plants native to the Philippines but not listed in the order are considered non-threatened and fall under the category of other Wildlife species. On the other hand, eight species were identified as endemic to the Philippines, one Naturalized and 61 Native species. Moreover, it is quite alarming because *Diplazium* species which are endemic and with conservation status were found thriving along the established human trail and are prone to cutting and removal (Figure 4).

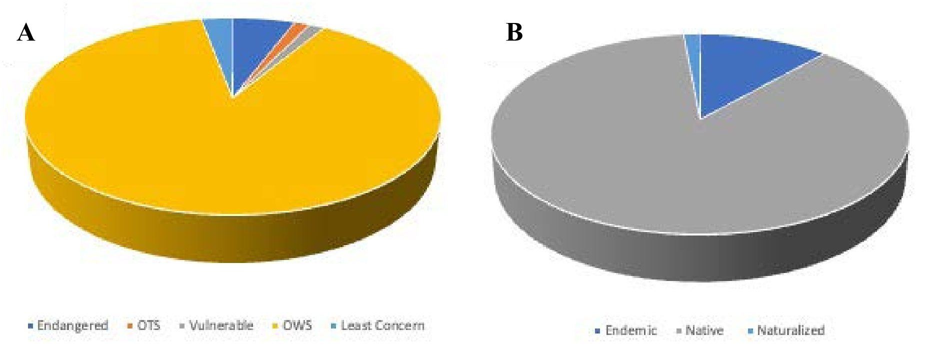

Figure 4. A, Conservation Status and B, Geographic Distribution of Pteridophytes in Saguing Watershed, Mt. Apo Natural Park, Cotabato, Philippines.

DISCUSSION

The pteridophyte richness in the Saguing Watershed is notably higher than in previous studies conducted within Mt. Apo Natural Park, such as those by Madronero (2013) and Amoroso *et al*. (2015), which recorded 62 and 54 species, respectively, while these results are comparable to the 72 species identified in the Pasonanca Protected Landscape (Andas, 2015), they remain lower than the species found in other Mindanao highlands. For instance, studies on Mt. Musuan (Amoroso, 2007), Timolan Protected Landscape (Cudal *et al*., 2021), and the Mt. Tago Range (Coritico *et al*., 2020) reported between 102 and 203 species. These mountains ecosystems mentioned were of similar elevation to the sampling sites of this study. Moreover, similar to the trends observed by Cano-Mangaoang *et al*. (2020) and Rufila *et al.* (2022), Polypodiaceae emerged as the most diverse family. This high species rich of the family is likely due to the family's broad altitude, which peaks at intermediate altitudes between 1,000 and 3,500 meters above sea level (Hoovenkamp *et al.,* 1998). Furthermore, as the largest fern family with approximately 1, 650 species (Pteridophyte Phylogeny Group I, 2016), their presence is expected in such tropical ecosystems.

The highest species richness was observed in the tropical lowland evergreen with 57 species, a result that deviates from the findings of Cano-Mangaoang *et al*. (2020) and Coritico *et al*. (2020), where montane forests typically harbor the greatest diversity. This shift may be explained by the interplay of various factors like the size of the area sampled, climatic conditions, soil type, and geographical location (Kessler, 2010) and disturbances. According to Sharma *et al*. (2017), anthropological activities such as clearing, land cultivation and tree cutting lead to the depletion of pteridophyte diversity. However, the presence of large canopy trees like *Lithocarpus* spp., *Shorea* spp., *Dipterocarpus* spp., *Lithocarpus* spp., and

Cinnamomum mercadoi provides the necessary shade (Sharma *et al*., 2017; Magtoto and Austria, 2018) and humidity for understory pteridophytes to flourish (Kluge *et al*., 2006) thus providing a suitable condition for both terrestrial and epiphytic species to thrive. Meanwhile, agricultural ecosystem is higher compared with tropical lower montane forest despite land cultivation. The reason might be that most of the species documented in the agricultural ecosystem were epiphytes such as *Asplenium* spp., *Pyrrosia* spp., and *Phymatosorus* spp. In this site, the presence of agricultural plants like coconut, mangosteen, marang, and other crops provides mechanical support for these epiphytic ferns. According to Zotz *et al*. (2014) that host tree existence is more important than climatic reasons for the presence of epiphytic pteridophytes above the tree line and their distribution is affected only by two factors—dispersal and establishments (Hirata *et al.* 2009). Meanwhile, in the tropical lower mountain, clearing in some areas is evident and a number of bamboo plants are present. Though the climatic condition allows for pteridophytes to thrive, but disturbances decrease the number of species that might thrive (Cano-Mangaoang *et al*., 2020) (Figure 5).

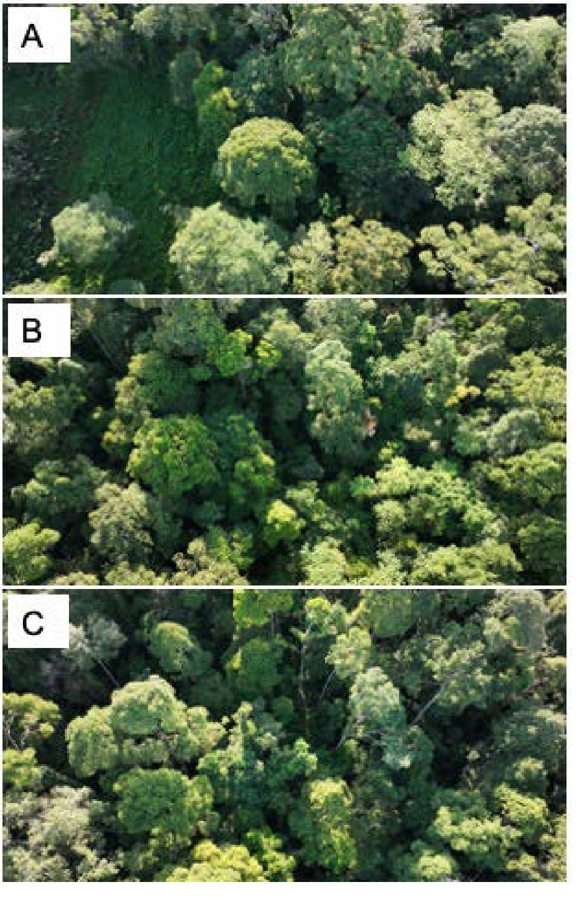

Figure 5. Drone shots of the three sampling sites. A, Agricultural (clearing is evident); B, Tropical Lower Evergreen Forest (canopy is more intact); C, Lower Tropical Montane Forest (lesser canopy cover).

The formation of pteridophyte assemblages in the Saguing Watershed is influenced by anthropogenic activities. The agricultural ecosystem, characterized by fruit orchards and plantations of *Hevea brasiliensis*, *Cocos nucifera*, and *Musa* spp., showed the lowest similarity to forested areas. This suggest that converting natural forests into farmland leads to distinct shift in species composition and the potential loss of forest specialists (Magtoto and Austria, 2018). In contrast, the tropical lowland evergreen and tropical lower montane forests shared more species due to limited human disturbance and the presence of moist-indicator families like Hymenophyllaceae. Moreover, the high similarity between the tropical lowland evergreen and montane forests suggest that despite their distinct altitudinal gradients, they maintain a substantial overlap in pteridophyte composition. This shared assemblage likely reflects the presence of generalist forest species that thrive in the relatively intact canopy conditions common to both forest types (i.e. *Asplenium* spp, *Hymenophyllum* spp, *Haplopteris* spp, *Diplazium* spp and Thelypteridaceae spp). On the other hand, the low similarity of the agricultural ecosystem emphasizes the impact of anthropogenic disturbance and land use conversion. The removal of natural forest cover and subsequent shifts in microclimate—specifically increased light intensity and reduced humidity leading to a unique assemblage dominated by disturbance-tolerant species like *Nephrolepis* spp.

Based on Shannon-Weiner Index, the overall diversity of pteridophytes in the Saguing Watershed is low, likely due to the observed disturbances such as vegetation clearing (Cano-Mangaoang *et al*., 2020). This aligns with findings by Delos Angeles *et al*. (2020), which noted that land-use intensity directly influences species richness. Interestingly, the montane forest exhibited the highest species evenness despite having the fewest species. According to Pyron (2010), species evenness is highest when all species in the sample have the same abundance and based on the data gathered, there's no species of pteridophytes that dominate the montane forest of the Saguing watershed area.

Both forest types within the Saguing Watershed are traversed by an established trail frequently used by nearby communities to access the forest interior. It is particularly concerning that local residents routinely clear vegetation along this path, unaware of the ecological significance of the flora removed. Field documentation revealed that several endemic and threatened ferns, including *Diplazium costulisorum*, *D. oligosorum*, *D. pseudocyatheifolium*, *Lindsaea apoensis*, and *Lecanopteris deparioides*, thrive specifically along these human-made clearings. Personal communication with local guides indicated common perception of these species as weeds, leading to the belief that their removal is irrelevant. Consequently, the data from this study should be utilized to develop conservation strategies that advocate for the protection of not only timber species but also the vital, yet often overlooked, pteridophyte species in the area.

CONCLUSION AND RECOMMENDATION

The study concludes that the Saguing Watershed serves as an important habitat for a wide range of pteridophytes, hosting 70 species classified under 32 genera and 15 families. The tropical lowland evergreen forest was identified as the most species-rich ecosystem with 59 species, while the tropical lower montane forest shows the most even population distribution despite having fewest species (24). Notably, the presence of eight endemic species, four endangered and one rare species highlights the watershed's high conservation value. However, over all Shannon-Weiner diversity index remains low across all sites, suggesting that while species richness is present, the community structure may be vulnerable to environmental shifts or disturbances. Based on the result, it is further recommended that there will be enhanced habitat protection and monitoring of the flora communities in the area specifically pteridophytes. Policy formulation and community integration could also be done to ensure that water sourcing activities do not compromise the micro-habitats required by pteridophytes.

ACKNOWLEDGMENTS

We would like to express our gratitude to the Department of Environment and Natural Resources Region XII for their issuance of the gratuitous permit that made this research possible. We also would like to thank to the Mount Apo Natural Park Protected Area Management Bureau for their assistance in the processing of documents and accommodation. Special thanks to PASu Shirley Uy for facilitating the issuance of the necessary permits.

REFERENCES

Amoroso, V.B., A.J.D. Lagumbay, R.A. Mendez, R.Y. De la Cruz and A.P. Villalobos. 2014. Bioactives in three Philippine edible ferns. *Asia Life Sciences* 23(2): 445–454.

Amoroso, V.B., F.M. Acma, R. Cruz, F.P. Coritico, A. Nietes, G. Hamo and H. Lumista. 2015. Diversity of herbaceous pteridophytes in four long-term ecological research sites in Mindanao, Philippines. *Asia Life Sciences* 24(1): 68–85. DOI: 10.5680/asia_life_sci_2015_24_1_68

Amoroso, V.B., F.P. Coritico and P.W. Fritsch. 2016. Species richness and conservation status of ferns and lycophytes in Mt. Hamiguitan Range Wildlife Sanctuary, Davao Oriental, Philippines. *Philippine Journal of Science* 145(2): 17–23. DOI: 10.17348/jbrit.v16.i1.1247

Amoroso, V.B., F.P Coritico and F.W. Fritsch. 2020. *Actinostachys minuta*, a new species of grass ferns fr*om Mindanao,* Philippines. *Phytokeys* 151: 59–66. DOI: 10.3897/phytokeys.151.153100

Amoroso, V.B., M. Acola, M.M.M. Guiang, F.M. Acma, P.W. Fritsch and F.P. Coritico. 2023. A new species of grass fern, Schizaea erecta (Schizaeaceae), from Dinagat Island, Mindanao, Philippines. *Phytotaxa* 618(3): 265–273. DOI: 10.11646/phytotaxa.618.3.4

Amoroso, V.B., M.M.M. Guiang, A.B. Mohagan, R.R. Patano Jr., F.P. Coritico, E.P.T. Maglangit, J.C. Nobleza and O.M. Nuñeza. 2022. Threatened and endemic flora and fauna from Mt. Agad-Agad, Iligan City, southern Philippines. *NRCP Research Journal* 21(2): 71–1*02.*

Amoroso, V.B., Y.V.L. Cariño, J.C. Nobleza and F.C. Coritico. 2021. A new species of Actinostachys (Schzaeaceae) from Mindanao, Philippines. *Phytotaxa* 508(1): 101–106. DOI: 10.11646/phytotaxa.508.1.10

Amoroso, V.B. 2007. Pteridophyte and gymnosperm diversity in Musuan, Bukidnon. *Philippine Journal of Systematic Biology* 1(1): 1–14.

Andas, S.T. 2015. *Diversity of Trees and Pteridophytes in Pasonanca Natural Park, Zamboanga City*. Ph.D. Dissertation. Musuan, Bukidnon, Philippines: Central Mindanao University, Mindanao. 326 pp.

Banaticla, M.C.N. and I.E. Buot Jr. 2004. Fern patch structure and species diversity along the altitudinal gradient of Mt. Banahaw de Lucban, Luzon Island, Philippines. *Philippine Agricultural Scientist* 87: 49–60.

Barcelona, J.F., D.L. Nickrent, J.V. Lafrankie, J.R.C. Callado and P.B. Pelser. 2013. Co's Digital Flora of the Philippines: plant identification and conservation through cyber taxonomy. *Philippine Journal of Science* 142(special issue): 57–67.

Bergeron, A. and S. Pellerin. 2014. Pteridophytes as indicators of urban forest integrity. *Ecological Indicators* 38: 40–49. DOI: 10.1016/j.ecolind.2013.10.015

Cano-Mangaoang, C., B.L.P. Bretaña and V.B. Amoroso. 2020. Rapid assessment of epiphytic pteridophyte biodiversity in Mt. Apo Natural Park, North Cotabato Province, Philippines: a comparison of disturbed and undisturbed forests. *Philippine Journal of Systematic Biology* 14: 1–13. DOI: 10.26757/pjsb2020c14004.

Coritico, F.C. 2024. Rediscovery of *Ctenitis atrorubens* Holltum (Dryopteridaceae) after more than a century, with notes on morphology, anatomy, and ecology. *Philippine Journal of Science* 152(1): 347–352. DOI: 10.1016/j.prep.2024.104058

*Co*ritico, F.C. and V.B. Amoroso. 2020. Threatened lycophytes and ferns in four protected areas of Mindanao, Philippines. *Nature Conservation Research* 5(44): 78–88. DOI: 10.24189/ncr.2020.061

Coritico, F.P., V.B. Amoroso, F.M. Acma, Y.L.L. Cariño and P.W. Fritsch. 2020. Ferns and lycophytes of Mt. Tago Range, Bukidnon, Southern Philippines: species richness, distribution and conservation s*tatus. Philippine Journal of S*cience 149(3-a): 773–790. DOI: 10.56899/149.3A.07

Cudal, M.G., L.G.L. Calimbo, D. Sumibay Jr., J. Salise, J. Gomez, M. Pagaling, J.M. Locson., J. Cahayagan, J. Seno and J.N. Daculio. 2021. Diversity of pteridophytes in Mount Timolan Protected Landscape, Zamboanga del Sur, Philippines. *Journal of Tropical Life Science* 11(2): 621–170. DOI: 10.11594/jtls.11.02.05.

Delos Angeles, M.D., A.A. Alcala and I.E. Buot, Jr. 2020. Ecological diversity of pteridophytes across land use types in Mt. Makiling Forest Reserve, Luzon Island, Philippines. *Journal of Marine and Island Cultures* 9(2): 105–123. DOI: 10.21463/jmic.2020.09.2.08

Department of Environment and Natural Resources (DENR) Administrative Order [DAO]. 2017. Updated National list of Threatened Philippine Plants and Their Categories. Downloaded from http://www.denr.gov.ph. on 10 March, 2026

Fernando, E.S., M.H. Suh, J. Lee and D.K. Lee. 2008. *Forest Formations of the Philippines*. ASEAN-Korea Environmental Cooperation Unit. 232 pp.

Hirata, A., T. Kamijo and S. Saito. 2009. Host trait preferences and distribution of vascular epiphytes in a warm-temperate forest. *Plant Ecology* 201: 247–254. DOI: 10.1007/978-90-481-2795-5_19

Ho, R., T. Teai, J.P. Bianchini, R. Lafont and . Raharivelomanana. 2010. Ferns: from traditional uses to pharmaceutical development, chemical identifiation of active principles, pp. 321–346. In: Kumar, A., Fernández, H., Revilla, M. (eds). *Working with Ferns*. Springer, New York, NY. DOI: 10.1007/978-1-4419-7162-3_23

Hoovenkamp, P.H., M.T.M. Bosman, E. Hennipman, H.P. Nooteboom, G. Rödl-Linder and M.C. Roos. 1998. Polypodiaceae. *Flora Malesiana Series* 2(3): 1–234.

IUCN. 2025. *The IUCN Rea list of the Threatened Species*. Downloaded from https://www.iucnredlist.org/ on 15 November 2025.

Kessler, M. 2010. Biogeography of ferns, pp. 22–60. In: K. Mehltreter, L.R. Walker, J.M. Sharpe (eds.). *Fern Ecology*. Cambridge University Press, Cambridge.

Kluge, J., M. Kessler and R.R. Dunn. 2006. What drives elevational patterns of diversity? A test of geometric constraints, climate and species pool effects for pteridophytes on an elevational gradient in Costa Rica. *Global Ecology Biogeograophy* 15: 358–371. DOI: 10.1111/j.1466-822X.2006.00223.x

Madronero, M.A. 2013. *Ex-situ Conservation and Diversity of Pteridophytes in One Hectare Plot in Mt. Apo, North Cotabato*. BS Biology Thesis, Central Mindanao University, Musuan, Maramag, Bukidnon.

Magtoto, L.M. and C.M. Austria. 2018. The pteridophytes of Adams, Northern Luzon, Philippines and their ecosystem services. *Philippine Journal of Systematic Biologists in the Philippines* 11(2): 43–51.

Magurran, A.E. 1998. *Ecological diversity and its measurements*. Princeton University Press, Princeton. 192 pp. DOI: 10.1007/978-94-015-7358-0.

Muhammad, M., Z.S. Ismail, H. Schneider and J.A. Hawkins. 2020. Medicinal use of ferns: An ethnobotanical review. *Sains Malaysiana* 49(5): 1003–1014. DOI: 10.17576/jsm-2020-4905-05

Ong, P., L.E. Afuang and R.G. Rosell-Ambal. 2002. Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan, 18–113 pp. In: P. Ong, L.E. Afuang, and R.G. Rosell-Ambal (eds.). *Philippine Department of the Environmental and Natural Resources*. Quezon.

Pelser, P.B., J.F. Barcelona and D.L. Nickrent. 2011. *Co's Digital Flora of the Philippines*. Downloaded from www.philippineplants.org on March 11 2026

Pteridophyte Phylogeny Group I. 2016. A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution* 54(6): 563–603. DOI: 10.1111/jse.12229. S2CID 39980610

Pyron, M. 2010. Characterizing communities. *Nature Education Knowledge* 3(10): 39.

Rufila, L.V., F.C. Coritico, H.P. Lumista, F.M. Acma, N.P. Mendez, J.C. Nobleza and V.B. Amoroso. 2022. Diversity of ferns and lycophytes in the Mt. Malambo, Southern Philippines. *Ruhuna Journal of Science* 13(2): 150–166. DOI: 10.4038/rjs.v13i2.122

Sharma, S., B.S. Kholia, R. Kumar and A. Kumar. 2017. Pteridophytic diversity in human-inhabited buffer sone of Murlen National Park, Mizoram, India. *Checklist* 13(2): 2081. DOI: https://doi.org/10.15560/13.2.2081

Silva, V.L., K. Mehltreter and J.L. Schmitt. 2018. Ferns as potential ecological indicators of edge effects in two types of Mexican Forests. *Ecological Indicators* 93: 669–676. DOI: 10.1016/j.ecolind.2018.05.029

Zapanta, B.R., M.J.M.M. Achondo, A.F.M. Raganas, F.A. Camino, A.G.D. Delima, J.A. Mantiquilla, R.P. Puentespina Jr. and F.R.P. Salvaña. 2019. Species richness of tress in disturbed habitats within a protected area and its implications for conservation: The case of Mt. Apo Natural Park, Mindanao Island, Philippines. *Biodiversitas*, 20: 2081–2091. DOI: 10.13057/biodiv/d200740.

Zotz, G., G. Mendieta-Leiva and K. Wagner. 2014. Vascular epiphytes at the treeline-composition of species assemblages and population biology. *Flora—Morphology, Distribution, Functional Ecology of Plants,* 209(8) 385–390. DOI: 10.1016/j.flora.2014.06.001