Thailand Natural History Museum Journal 20(2): 173–191 (2026)

Diversity of trees and forest structure in Talangisog Forest Park and Viewpoint, Gingoog City, Misamis Oriental, Northern Mindanao, Philippines

Francis John G. Felecis[1], Victor B. Amoroso[2], Noel E. Lagunday[1,2], Maria Melanie P. Medecilo-Guiang[1,2], Carrel Debonnaire Naces[1,2], Joseph Paquit[3], Fulgent P. Coritico[1,2]

[1] Plant Biology Division, Institute of Biological Sciences, College of Arts and Sciences, Central Mindanao University, Musuan, Maramag, Bukidnon, 8710, Philippines

[2] Center for Biodiversity Research Extension in Mindanao (CEBREM), and Department of Biology, Central Mindanao University, Musuan, Bukidnon, 8710, Philippines

[3] Department of Forest Biological Sciences, College of Forestry and Environmental Science, Central Mindanao University, Musuan, Bukidnon, 8710, Philippines

Article history
Received: 11 December 2025
Accepted: 27 May 2026
Published online: 20 July 2026

Corresponding author
Francis John G. Felecis
E-mail: francisjohn0123@gmail.com

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

ABSTRACT

Talangisog Forest Park and Viewpoint, located in Eureka, Gingoog City, Misamis Oriental, is one of the remaining tropical lowland evergreen rainforests in Mindanao; however, its forest composition and structure remain poorly studied. This study aimed to establish baseline data on tree species composition, diversity, description of sampling stations, forest structure, and conservation status. A total of 32 sampling plots, each measuring 20 x 20 meters, were established for tree surveys. Floristic studies from four stations documented a total of 803 individual trees representing 66 species (116 morpho-species), 48 genera, and 36 families. The dominant families were the Dipterocarpaceae (15%), Fagaceae (8%), and Moraceae (6%). The four study stations differed in species composition, elevation, and structure in terms of tree height and diameter classes. Three stations exhibited a high diversity value and 1 moderate diversity value, indicating that the area harbors diverse species of trees and a relatively even distribution. Most trees were categorized as lower canopy (1–15 m) and high diameter classes (≥ 40 cm). The highest Importance Value Index was observed at higher elevations and declined toward lower elevations, with *Shorea* sp. 3 recording the highest IVI at 44.7. The study identified 13 Philippine endemic tree species, 13 classified as threatened, 22 listed as Least Concern (LC), and *Shorea malibato* Foxw. which is categorized as Critically Endangered by the DENR. Talangisog Forest Park and Viewpoint is home to various lifeforms and native forest cover, and implementing stronger protection and sustainable forest management is recommended.

Keywords: conservation status, diversity, endemism, forest structure

Citation. Felecis, F.J.G., V.B. Amoroso, N.E. Lagunday, M.M.P. Medecilo-Guiang, C.D. Naces, J. Paquit and F.P. Coritico. 2026. Diversity of trees and forest structure in Talangisog Forest Park and Viewpoint, Gingoog City, Misamis Oriental, Northern Mindanao, Philippines. *Thailand Natural History Museum Journal* 20(2): 173–191.

INTRODUCTION

Tropical forests are dense, evergreen ecosystems characterized by high rainfall and warm temperatures throughout the year. It is among the most complex ecological communities on Earth, featuring a variety of habitats, multilayered canopies, and intricate ecological interactions that support an immense diversity of plants and animals (Richards, 1996). The tropical forest is considered the most species-rich biome, with over 50% of all species residing on just 7% of the Earth's land surface area (Wilson, 1988). Among the 17 megadiverse countries, three are in Southeast Asia: Indonesia, Malaysia, and the Philippines (Keong, 2015). The Philippines is the world's second-largest archipelago, comprising more than 7,100 distinct islands that span an estimated 30 million hectares (Ambal *et al*., 2012). It is one of Earth's most important biodiversity hotspots with high degrees of endemism and species richness (Langenberger, 2004).

Philippine forests are increasingly threatened by deforestation, mainly because of illegal logging, agricultural expansion, and rapid urbanization. In 1903, the Philippines had a total forest cover of about 21 million hectares sprawled on about 70% of the total national land area (Moya and Malayang, 2004). However, between 2003 and 2010, the total forest cover of the country decreased by 328,682 hectares, dropping from 7,168,400 hectares to 6,839,718 hectares (Sibucao *et al*., 2014), and based on the 2015 land cover data, the country's total forest cover was 23.4% of the total land area (Food and Agriculture Organization, 2020). This is inadequate since at least 45% of forest cover is needed on an island level to sustain its natural ecological processes (De Alban *et al*., 2004). This wide-scale reduction in the Philippines' forest cover significantly contributes to the country's ecological disruptions, such as drought, flooding, and climate change. The intensity and magnitude of these impacts are further influenced by factors including topography, soil characteristics, geological conditions, post-deforestation land use, and rainfall patterns (Moya and Malayang, 2004).

Several biological surveys in Barangay Eureka were recently conducted by Medina *et al*. (2023), Lagunday and Amoroso (2024), and Lagunday *et al*. (2025), resulting in the discovery of new species of darkling beetles and pitcher plants found in Talangisog Forest, along open ridges, and within upper montane forests. Sitio Talangisog is a tropical lowland evergreen rainforest situated in Barangay Eureka, Gingoog City, Misamis Oriental, Philippines. The forest is primarily dominated by a dipterocarp–lithocarpus assemblage, with the majority of its vegetation adapted to clay-loam and semi-ultramafic substrates. This structure contributes to the area's unique topography that supports the region's rich biodiversity (Coritico *et al.,* 2025).

The unique forest composition of Sitio Talangisog underscores its importance as a site for forest species inventory and conservation studies. However, previous research in the area has been limited to the taxonomic description of new plant species and did not include assessments at the forest community level. Thus, comprehensive information on tree species composition, diversity, and forest structure remains lacking. The absence of these floristic and structural baseline data highlights a vital gap in understanding the ecological condition and conservation status of the forest. Therefore, this study aimed to provide data on the tree species composition, diversity, description of sampling stations, forest structure, and conservation status at Sitio Talangisog. Additionally, this study will contribute to the broader understanding of forest ecosystems and biodiversity and guide policymakers in developing more effective forest management and conservation strategies.

MATERIALS AND METHODS

Study Site

The study was conducted at Talangisog Forest Park and Viewpoint, Barangay Eureka, Gingoog City, Misamis Oriental, Philippines (Figure 1). It is geographically located at 08.70719ºN, 125.24010ºE, with an elevation ranging from 500–700 m above sea level (asl). A total of four stations were identified, and the vegetation type was classified as tropical lowland evergreen rainforest.

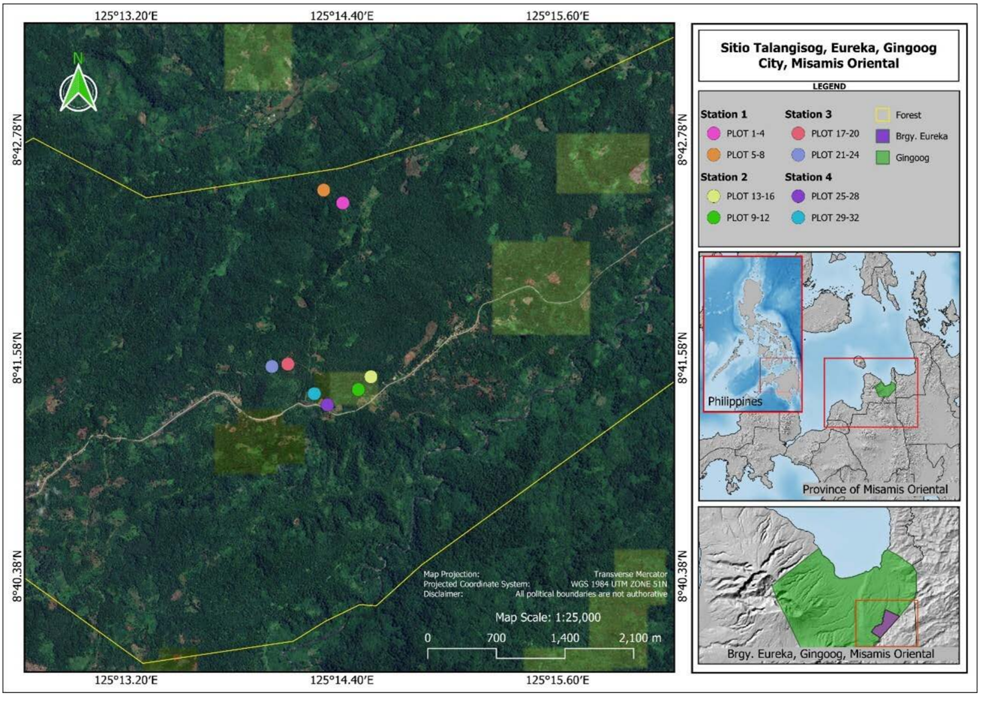

Figure 1. Location map of study stations and sampling plot distribution in Talangisog Forest Park and Viewpoint.

Establishment of Study Stations and Sampling

Tree species were surveyed in the study area. A total of thirty-two sampling plots were established within Talangisog Forest Park and Viewpoint, with eight plots designated per station. Each plot measured 20 x 20 meters (400 m^2) with a 20 m distance apart. Transect lines were also established within Sitio Talangisog, and trees were inventoried by following the established trails in the area.

The diameter at breast height (DBH), tree height, and basal area (BA) were measured for trees with a DBH of at least 10 cm. DBH measurements were taken with the use of measuring tape by wrapping them around the tree trunk at 1.3 meters above the ground. The trees were categorized following the method considered by Coritico *et al*. (2020) based on their sizes, namely 10–19 cm, 20–29 cm, 30–39 cm, and ≥ 40 cm. Additionally, tree height in each station was grouped into three categories: lower canopy (1–15 m), upper canopy (16–30 m), and emergent (31 m and up).

Collection of Specimens and Herbarium

The voucher plant specimens were collected, preserved, and tagged using the method of Coritico *et al*. (2022). Three to four voucher specimens were collected using pruning shears and trimming cutters, and each specimen was placed in plastic bags. Relevant data, including elevation, plot number, collection number, and collection date, was recorded in a field notebook. The herbarium specimens were then pressed and dried with the use of customized mechanical driers and were deposited at the Central Mindanao University Herbarium (CMUH).

Classification and Identification

The classification and identification of trees was done with the use of online databases such as JSTOR, Co's Digital flora of the Philippines, taxonomic keys, published journal articles, and monographs.

Data Treatment and Analysis

The biodiversity index values were determined by following Simpson (1949), Shannon and Wiener (1949), and Magurran (2004). The Shannon-Wiener index (H') was utilized to measure both species abundance and richness to calculate the diversity of tree species, while Simpson's diversity index was used to quantify the probability that any two randomly selected individuals from a community will be the same species. The calculation of frequency, relative frequency (RF), density, relative density (RD), dominance, relative dominance (RDom), and Importance Value Index (IVI) were done by following Nguyen *et al*. (2014). For the analysis of diversity indices and species accumulation curve, statistical analysis software such as, Paleontological Statistics (PAST), and BioDiversity Professional version 2 were used.

The following formulae were used:

$$\text{Shannon-Wiener Index (H')} = -\sum_{i=1}^{s} \text{Pi ln Pi}$$

$$\text{Frequency} = \frac{\text{Total no. of plots where the species was present}}{\text{Total no. of plots sampled}}$$

$$\text{Density} = \frac{\text{Total no. of individual species}}{\text{Total area sampled}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative Dominance (RDom)} = \frac{\text{Total basal area of one species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Relative Density (RD)} = \frac{\text{Density of one species}}{\text{Total density of all species}} \times 100$$

$$\text{Basal Area (m}^2\text{)} = \frac{\pi \times DBH^2}{40{,}000}$$

Species Importance Value Index (IVI) = RD + RF + RDom.

Assessment of Conservation Status

The conservation status of trees was assessed based on the national list of threatened Philippine plants (DENR Administrative Order, 2017, Fernando *et al*., 2022) and the International Union for the Conservation of Nature (IUCN, 2025).

RESULTS AND DISCUSSION

Species Richness and Composition

A total of 803 individual trees, representing 36 families, 48 genera, and 66 species (116 morpho-species) (Table 1), were recorded across the four sampling stations in

Talangisog Forest Park and Viewpoint, Misamis Oriental. The most represented families are Dipterocarpaceae with ten species (15%), followed by Fagaceae (5 species; 8%), Moraceae (4 species; 6%), Annonaceae, Euphorbiaceae, Lauraceae, and Myrtaceae, each with three species (4.5%), Burseraceae, Dilleniaceae, Lamiaceae, Primulaceae, Phyllanthaceae, and Rutaceae, each with two species (3%), and the remaining families are represented by a single species. Among the genera, *Shorea* is the most represented, with seven species, followed by *Ficus, Lithocarpus*, and *Macaranga*, each comprising three species. The recorded families are also economically and ecologically important. Notably, Dipterocarpaceae, the dominant family in the study area, is a major source of both timber and non-timber products (Rachmat *et al*., 2021) and supports a diverse array of lifeforms (Thüs *et al*., 2021).

The tree species richness recorded in the present study is comparable to that documented in Pasonanca Natural Park in Zamboanga City, which has 66 species (Pasion *et al*., 2021), and to the sites in Barangay Baganihan, Mt. Malambo, and Barangay Datu Salumay, Marilog District, which reported 65 species (Coritico *et al*., 2022). However, it is relatively lower than the richness recorded in other mountains in Mindanao, including Mt. Agad-Agad with 127 species (Medecilo-Guiang *et al*., 2021), Mt. Tago Range with 121 species (Coritico *et al*., 2020), the permanent monitoring plots of natural forests located at Musuan, Bukidnon, with 96 species of trees (Olpenda *et al*., 2013), and Mt. Malindang, which had documented 86 species (Arances *et al*., 2004). Conversely, the documented species richness is higher than that reported in Prosperidad, Agusan del Sur, with 54 species (Lleno *et al*., 2023), the adopted forest of Barangay Verdy in Bayugan City, with 31 species (Baynosa-Montera, 2024), and the Bicol Kalikasan Park Forest fragment, which recorded only 25 tree species (Galias *et al*., 2018).

The number of tree species documented in Sitio Talangisog can be attributed to several environmental factors. The area's semi-ultramafic substrate is known for being deficient in essential nutrients, which limits plant growth (Kidd *et al*., 2018). Its low elevation may also influence species composition and structure (Lalbiaknunga and Lalbiaknii, 2025). Additionally, anthropogenic disturbances such as illegal logging, conversion of forest into agricultural land, and habitat fragmentation contribute to lower tree species diversity.

Table 1. Abundance of trees per family.

Family	No. of Genera	No. of species	Family	No. of Genera	No. of Species
Anacardiaceae	1	1	Lecythidaceae	1	1
Annonaceae	2	3	Loranthaceae	1	1
Arecaceae	1	1	Magnoliaceae	1	1
Apocynaceae	1	1	Malvaceae	1	1
Araucariaceae	1	1	Melastomaceae	1	1
Burseraceae	1	2	Meliaceae	1	1
Calophyllaceae	1	1	Moraceae	2	4
Clusiaceae	1	1	Myrtaceae	3	3
Dilleniaceae	1	2	Pandanaceae	1	1
Dipterocarpaceae	3	10	Pentaphylacaceae	1	1
Ebenaceae	1	1	Podocarpaceae	1	1
Euphorbiaceae	1	3	Phyllanthaceae	2	2
Escalloniaceae	1	1	Primulaceae	2	2

Table 1. Continue.

Family	No. of Genera	No. of species	Family	No. of Genera	No. of Species
Gentianaceae	1	1	Rubiaceae	1	1
Fagaceae	2	5	Rutaceae	2	2
Gnetaceae	1	1	Sapindaceae	1	1
Lamiaceae	2	2	Sapotaceae	1	1
Lauraceae	2	3	Urticaceae	1	1

Total number of families: 36, Total number of genera: 48, Total number of species: 66.

Diversity Index Values

The species diversity values using Shannon-Weiner (Figure 2) and Simpson's diversity index (Figure 3) revealed that three of the study stations fall under the "high" category and one under the "moderate" category of diversity, based on the classification scheme developed by Fernando (1998). Station 1 (*H'* = 3.279) has the highest diversity, followed by Station 3 (*H'* = 3.173) and Station 4 (*H'* = 3.092). Station 2, with an *H'* value of 2.911, exhibits the lowest diversity.

The results indicate that Station 1 have a high floral diversity, harbors more species, and a relatively even distribution of individuals. In comparison to the other stations, it shows comparable diversity values to the lowland forest in Agusan del Sur (*H'* = 3.32) (Lleno *et al*., 2023), where the area was also dominated by dipterocarp trees. Moreover, the diversity recorded is higher than that of the mossy-pygmy forest of Mt. Tago range reported by Coritico *et al*. (2020), with an *H'* value of 1.2. Notably, the mossy-pygmy forest was composed of an ultramafic substrate, while the present site had a combination of semi-ultramafic, clay-loam, and limestone soil, suggesting that soil characteristics also influence the species richness.

Station 2 showed the lowest diversity values (*H'* = 2.911), with only 37 recorded morpho-species. While this represents the least diverse site in the area, it falls within the range of "moderate" diversity values, indicating that the site maintains a significant level of tree richness. The sampling station was dominated by timber trees such as *Lithocarpus* sp. 3 (Fagaceae) and *Shorea* sp. 3 (Dipterocarpaceae), with 17% dominance each. Evidence of small-scale logging activity in the area may have contributed to the relatively lower diversity recorded. The diversity indices of station 2 are higher than those recorded in two sites within the forest patches of Marilog Forest Reserve, where both sites exhibited an *H'* value of 1.22 (Coritico *et al*., 2022). Similarly, the area was also dominated by *Lithocarpus* species.

The species accumulation curve shows that Station 1 had the highest species richness (Figure 4). The graph shows that all 4 sampling stations exhibit an ascending trend in species richness as the number of individuals increases. This ascending pattern indicates that more species can be recorded with more sampling efforts. Station 2 shows the lowest rate of species accumulation, suggesting it has the lowest diversity among the stations, while stations 3 and 4 both show similar patterns reflecting a moderate level of species richness. The high species diversity in Talangisog forest park and viewpoint, may be attributed to the area's unique topography and stable environmental conditions.

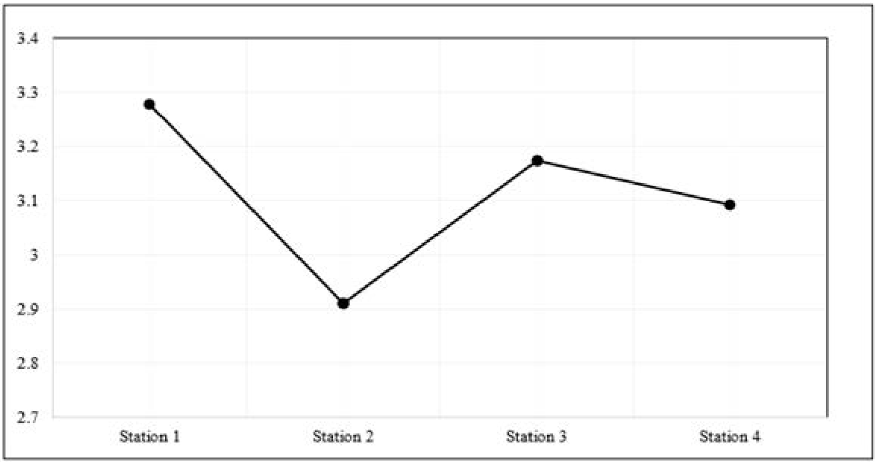

Figure 2. Shannon-Weiner Diversity index for the four stations in Talangisog forest park and viewpoint.

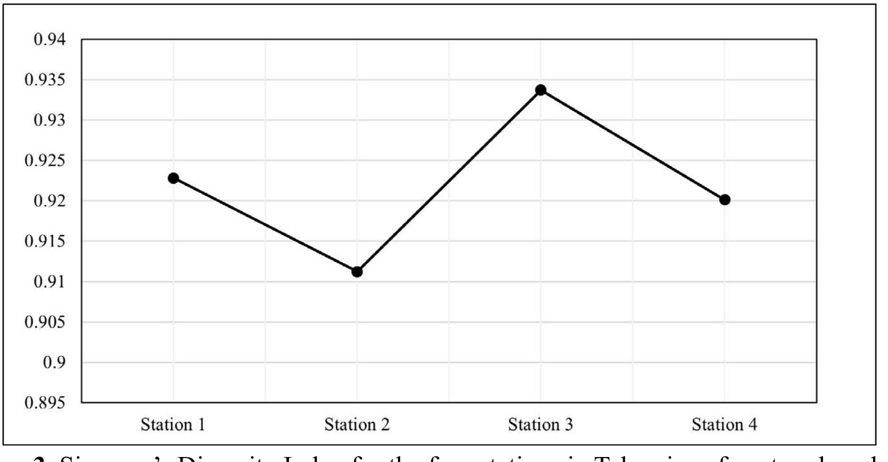

Figure 3. Simpson's Diversity Index for the four stations in Talangisog forest park and viewpoint.

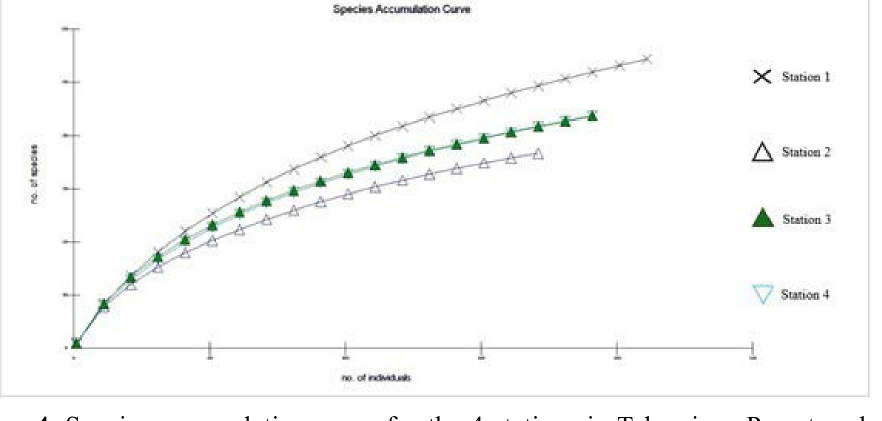

Figure 4. Species accumulation curve for the 4 stations in Talangisog Porest park and Viewpoint.

Cluster Analysis

The hierarchical cluster analysis grouped the four stations into two main clusters based on their compositional dissimilarity (Figure 5). Station 3 and Station 4 formed the first cluster, indicating a high degree of similarity in their species composition. Station 1 and Station 2 formed the second cluster, suggesting that these sites share moderate similarity. The two clusters were joined at a relatively higher dissimilarity level, implying that the community structure or environmental conditions of Station 3–4 differ substantially from those of Station 1–2. This pattern suggests that spatial or environmental gradients, such as soil properties, microclimatic conditions, or successional stages, may be influencing the observed differences among sites (Shang *et al.,* 2021).

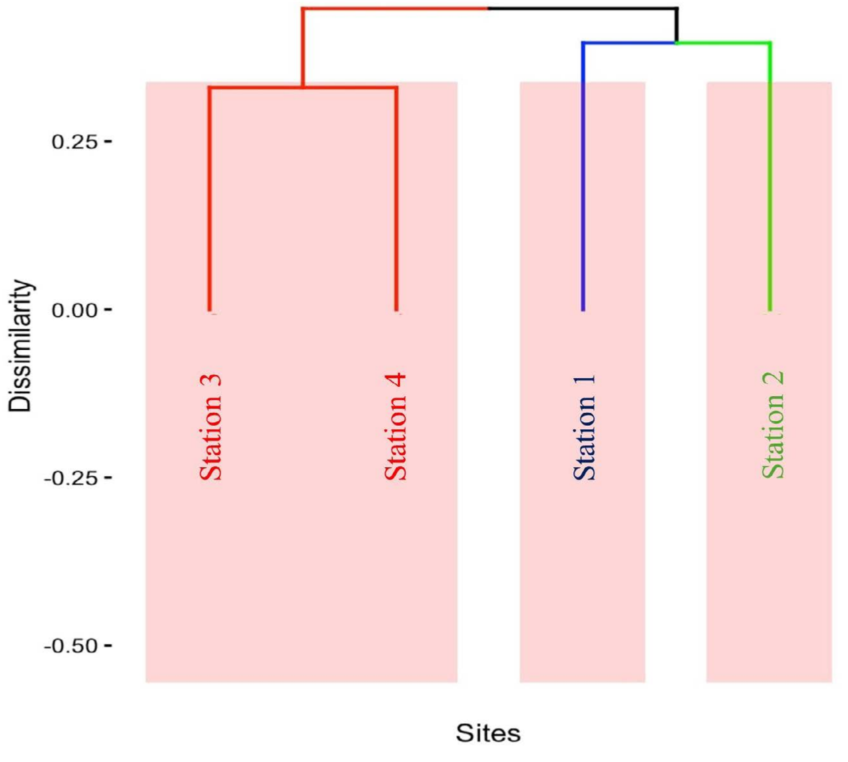

Figure 5. Cluster dendrogram of the four stations.

Non-metric Multidimensional Scaling

Non-metric multidimensional scaling (NMDS) ordination revealed that the four sampled stations (Station 1–Station 4) grouped closely within a single confidence ellipse (group "S") in the reduced two-dimensional space (Figure 6). Stations 3 and 4 were positioned nearest to the group centroid, while Stations 1 and 2 showed slightly greater dissimilarity yet remained within the group's overall compositional envelope. The NMDS ordination indicates a high degree of similarity in community composition among all four sites, with limited within-group variation as depicted by the compact ellipse encompassing all points. The close proximity of sites to the group centroid suggests that compositional differences are minor, especially for Stations 3 and 4. The absence of outliers or sites outside the confidence ellipse demonstrates that no site exhibits strong compositional deviation from the group.

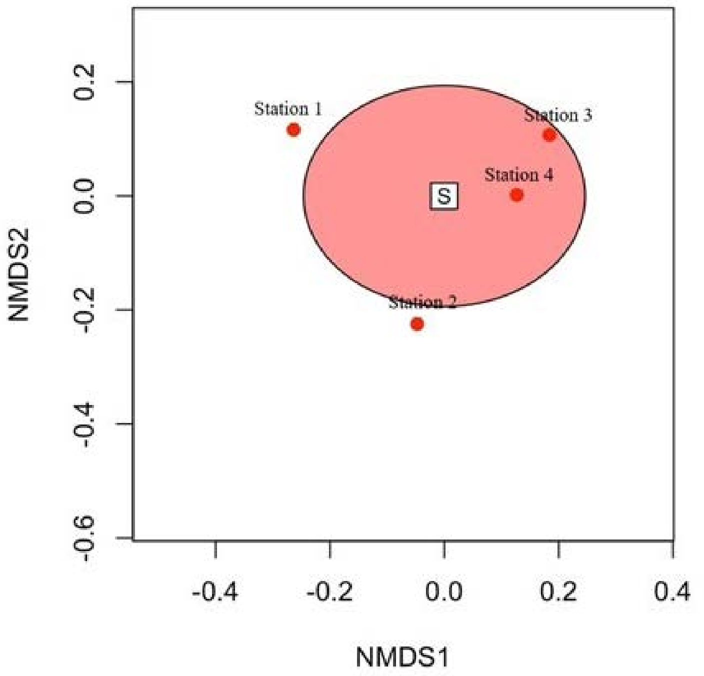

Figure 6. Non-metric Multidimensional Scaling (NMDS) of the four Stations.

Description of Sampling Stations

Talangisog Forest Park and Viewpoint is classified as a tropical lowland evergreen rainforest (Fernando *et al*., 2008), with most of its vegetation growing on clay-loam and semi-ultramafic soil, and woody vine trees are rarely present. The study area was composed of 4 sampling stations, namely: Station 1 (590–650 m asl), Station 2 (570–580 m asl), Station 3 (640–650 m asl), and Station 4 (580–610 m asl) (Figure 7), each consisting of eight sampling plots.

Station 1

Station 1, with an elevation of 596–648 meters above sea level (m asl), was characterized by semi-ultramafic and clay-rich substrate. The majority of the trees were 1 to 15 m tall, had a Diameter at Breast Height (DBH) of ≥40 cm (circumference) (85%), and showed an average basal area (BA) of 70.5 m^2/ha (Table 3). Dominant tree species were *Shorea* sp. 3, with a dominance of 21.7%, and *Lithocarpus* sp. 3, with a dominance of 12.5% (Table 2). These findings are similar to observations in other areas, such as the southern portion of Mt. Malindang Range Natural Park (Pito *et al*., 2019), in Mts. Palay-palay/ Mataas na Gulod Protected Landscape (Luyon and Medecilo, 2006), and the remaining forests of upland Cavite (Medecilo and Lagat, 2017), all of which are also dominated by dipterocarp species.

Other dominant tree species include *Shorea almon* Foxw., along with the trees with the highest DBH and height in the area, such as *Parashorea malaanonan* (Blanco) Merr. (94.8 cm) (26 m), *Shorea polysperma* H.G.Keith (111 cm) (35 m), and *Shorea* sp. 1 (30 m). The dominant understory vegetation documented in the area included the economically important climbing bamboo *Dinochloa* sp., as well as *Sararanga philippinensis* Merr., *Calamus discolor* Mart., *Alocasia zebrina* Schott ex Van Houtte, *Scleria* sp., *Calamus* sp., and *Plagiostachys* sp.

Table 2. Dominant tree species in the four stations of Talangisog Forest Park and Viewpoint.

Study Stations	Plots	Elevation (m asl)	Dominant Species	Dominance (%)
Station 1	P01	648	*Parashorea malaanonan* (Blanco) Merr.	16.67
	P02	648	*Shorea* sp. 3	29.55
	P03	648	*Shorea* sp. 3	33.33
	P04	648	*Shorea* sp. 3	42.86
	P05	596	*Lithocarpus* sp. 3	27.78
	P06	596	*Shorea* sp. 3	12.9
	P07	596	*Lithocarpus* sp. 3	23.53
	P08	596	*Shorea almon* Foxw.	16.67
Station 2	P09	573	*Teijsmanniodendron ahernianum* (Merr.) Bakh.	26.92
	P10	573	*Lithocarpus* sp. 3	19.23
	P11	573	*Shorea* sp. 3	50
	P12	573	*Goniothalamus* sp.	19.05
	P13	576	*Shorea* sp. 3	27.03
	P14	576	*Lithocarpus* sp. 3	31.58
	P15	576	*Lithocarpus* sp. 3	33.33
	P16	576	*Lithocarpus* sp. 3	25
Station 3	P017	639	*Shorea* sp. 3	23.81
	P018	639	*Lithocarpus* sp. 3	26.09
	P019	639	*Astronia* sp., *Shorea malibato* Foxw., and *Lithocarpus* sp. 3	12.5
	P020	639	*Shorea assamica* Dyer and *Shorea malibato* Foxw.	15
	P021	645	*Shorea* sp. 3	13.33
	P022	645	*Shorea malibato* Foxw.	12.5
	P023	645	*Shorea malibato* Foxw.	15.38
	P024	645	*Shorea* sp. 3	28
Station 4	P025	582	*Shorea* sp. 3	21.05
	P026	582	*Lithocarpus* sp. 3	22.58
	P027	582	*Swietenia macrophylla* King and *Shorea* sp. 3	26.09
	P028	582	*Shorea* sp. 3 and *Lithocarpus* sp. 3	18.75
	P029	611	*Shorea* sp. 3 and *Lithocarpus* sp. 3	22.73
	P030	611	*Shorea* sp. 3	25
	P031	611	*Shorea* sp. 3	23.33
	P032	611	*Lithocarpus* sp. 3	34.62

Table 3. Basal area and frequency of trees in terms of diameter and height classes per station.

Study Sites	Basal Area (Average)	Frequency						
		Diameter classes (cm)				Height classes (m)		
		10–19	20–29	30–39	≥ 40	1–15	16–30	≥ 31
Station 1	70.5 m^2/ha	0	1	31	184	142	70	4
Station 2	37 m^2/ha	0	0	15	160	109	65	1
Station 3	42.9 m^2/ha	0	0	17	176	116	76	1
Station 4	43.1 m^2/ha	0	2	22	171	124	70	1

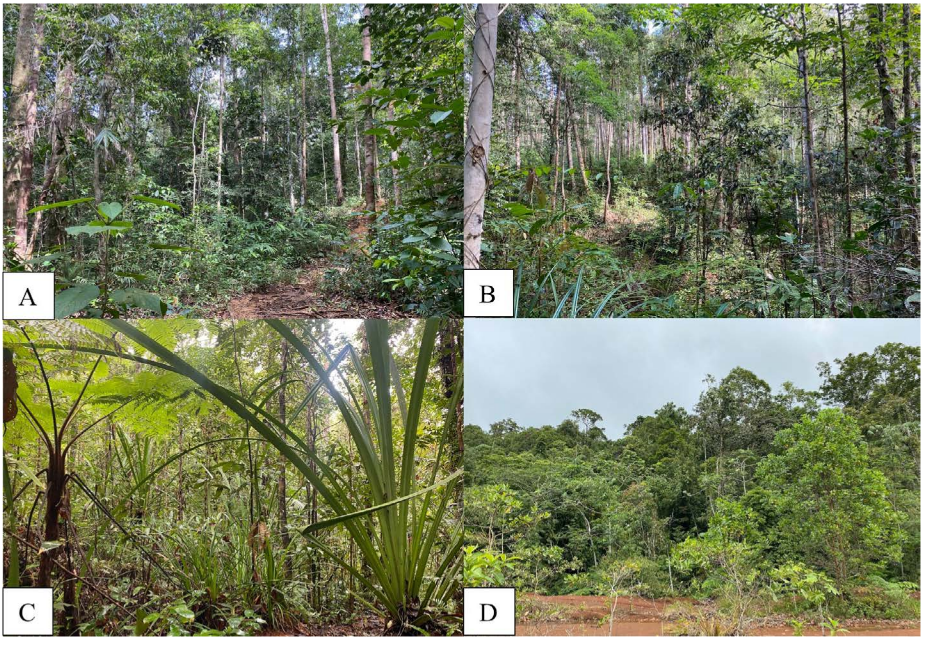

Figure 7. study Stations. (A) Station 1, (B) Station 2, (C) Station 3, and (D) Station 4 in Talangisog Forest Park and Viewpoint.

Station 2

The type of substrate observed in Station 2 was comparable to that of Station 1, similarly characterized as semi-ultramafic, with a slightly lower elevation of 573–576 m asl. Approximately 62% of the trees in the area were classified within the lower canopy category (1–15 m), with 91% exhibiting a DBH of ≥ 40 cm (circumference) and an average basal area of 37 m^2/ha. The dominant tree species were identified as *Shorea* sp. 3 and *Lithocarpus* sp. 3, both of which exhibited a dominance of 17.7%, and *Teijsmanniodendron ahernianum* (Merr.) Bakh., which showed a dominance of 8.5%.

Other species-rich trees were *Goniothalamus* sp. and *Shorea* sp. 2, along with the trees that exhibit the largest DBH in the area, *S. polysperma* H.G. Keith (143 cm) and *Shorea assamica* Dyer (66.8 cm). Upper canopy trees were *S. almon* Foxw. (27 m), *Palaquium* sp.

(26 m), and *Calophyllum* sp. (26 m). The dominant understory plants present in the area are *S. philippinensis* Merr., *Freycinetia multiflora* Merr., *C. discolor Mart., Calamus* sp., *Scleria* sp., and *Dinochloa* sp. Ferns were also present, with *Dicranopteris linearis* (Burm.f.) Underw., *Syngramma alismifolia* (C.Presl) J. Sm., and *Stenochlaena palustris* (Burm.f.) Bedd. identified as the most dominant species. Additionally, the presence of bryophytes such as *Bazzania* and *Schistochilla* was also observable in the area, indicating that the site is characterized by a much cooler and humid climate compared to the other sites (Löbs *et al*., 2020).

Station 3

Station 3, located at an elevation of 639–645 m asl, was characterized by semi-ultramafic and clay-loam substrate. Most of the trees were classified within the lower canopy category (60%), 91% had a DBH of greater than 40 cm (circumference), and 42.9 m^2/ha average BA.

The dominant tree species include *Lithocarpus* sp. 3 and *Shorea* sp. 3, each with a dominance of 13.9%, followed by *S. malibato* Foxw, which exhibited a dominance of 9.8%. Other notable tree taxa included *Ochrosia* sp. and "Salunganan", along with *S. polysperma* H.G. Keith (103 cm), which was the largest recorded tree in the station in terms of DBH. Emergent trees observed included *Shorea* sp. 1 (31 m), *S. almon* Foxw. (30 m), and upper canopy *Mangifera* sp. (27 m). Dominant fern species include *Pronephrium* sp., *Taenitis blechnoides* (Willd.) Sw., and *Pleocnemia irregularis* (C. Presl) Holttum, along with bird's nest fern (*Asplenium nidus* L.). Other understory plants documented include *A. zebrina* Schott ex Van Houtte, *Aglaonema* sp., *Astrocalyx calycina* (S. Vidal) Merr., *Saribus rotundifolius* (Lam.) Blume, and some species of rattan palms.

Station 4

Located at an elevation of 582–611 m asl, station 4 exhibited similar vegetation and substrate characteristics to station 3. The trees were categorized as lower canopy (64%), with most individuals (88%) having a DBH greater than 40 cm (circumference) and an average BA of 43.1 m^2/ha. Dominant tree species include *Shorea* sp. 3 and *Lithocarpus* sp. 3, each with a dominance of 17.4%.

Other dominant tree species include *Swietenia macrophylla* King, along with *Utania philippinensis* (K.M. Wong and Sugau) K.M. Wong, Sugumaran and Sugau, and *S. assamica* Dyer, both of which recorded the highest DBH at 95.4 cm. Emergent tree was *S. polysperma* H.G. Keith (35 m), and upper canopy trees were *Lithocarpus* sp. 3 (27 m), and *P. malaanonan* (Blanco) Merr. (26 m). Dominant understory plants include *Pinanga philippinensis* Becc. *S. rotundifolius* (Lam.) Blume., *F. multiflora* Merr., and some species of ferns.

Forest Stand Structure

The findings across four sampling stations (Table 3) reflect a general pattern of a tropical lowland evergreen rainforest, with slight differences that show different degrees of disturbances and structural complexity among sites. Most of the tree species (86%) are classified under the diameter class ≥ 40 cm DBH, followed by 30–39 cm DBH (11%). In terms of height classes, most of the trees were categorized as lower canopy 1–15 m (61%), followed by trees with a height of 16–30 m (35%). The varying DBH classes among the tree population reflect how well the forest is using structural resources, and tree diameter has often been utilized to indicate the forest population structure (Rao *et al*. 1990). Lower canopy trees were more frequently observed at higher elevations within the study stations between 600–700 m asl, upper canopy trees at 580–640 m asl, and a few emergent trees were recorded at 640 m asl and above. Talangisog Forest Park and Viewpoint, Eureka, closely resembles dominance in family of trees with other mountain ecosystems in the Philippines, such as secondary forest along the Sierra Madre Mountain Range (Llait, 2024), Mt. Kitanglad (Amoroso *et al*., 2011), selected disturbed habitats in Mt. Apo (Zapanta *et al*., 2019), and Mt. Malindang range (Pito *et al*., 2019).

Species Importance Value Index

The findings showed that the Importance Value Index (IVI) of tree species ranges from 1.2–39.7 in Station 1; 1.75–43.9 in Station 2, 1.46–36.1, Station 3; and Station 4, 1.58–44.7. The highest IVI values recorded were higher than those reported in the mid-montane forest in Sipit Watershed, Mount Makiling (0.26–40.40) (Castillo *et al*., 2021) and in Dinagat Island (1.54–9.85) (Lillo *et al*., 2019). The top 5 species with the highest IVI were: *Shorea* sp. 3 (Dipterocarpaceae, 44.7), *Lithocarpus* sp. 3 (Fagaceae, 43.9), *S. polysperma* H.G. Keith (33.1), *S. assamica* Dyer. (27.5), and *S. malibato* Foxw. (24.8) (Table 4). Collectively, these species accounted for 46% of the total IVI, while the remaining 87 morpho-species comprised 54%. These results were comparable to Mt. Kitanglad, where *Lithocarpus* species also exhibited high IVIs (Amoroso *et al*., 2011). A high level of mean dominance and IVI can be interpreted as the most ecologically significant trees, and these tree species remarkably influence the structure of the forest.

Some tree taxa had IVIs below 2, reflecting a low dominance within the forest community. These trees include *Ficus nota* Merr., *F. variegata* Blume, *F. Ampelos* Burm. fil., *Artocarpus blancoi* Merr. (Moraceae), *Dillenia philippinensis* Rolfe (Dilleniaceae), *Goniothalamus* sp. (Annonaceae), *Calophyllum* sp. (Calophyllaceae), *Macaranga sinensis* Müll.Arg. (Euphorbiaceae), *Pandanus* sp. (Pandanaceae), *Canarium luzonicum* (Blume) A.Gray (Burseraceae), *Cinnamomum* sp. (Lauraceae), and *Alphitonia philippinensis* Braid (Malvaceae).

Table 4. Tree species with high importance value index in 4 stations.

Study Sites	Species	IVI
Station 1	*Shorea* sp. 3	39.7
	Shorea polysperma H.G.Keith	30.5
	Lithocarpus sp. 3	30.3
Station 2	*Lithocarpus* sp. 3	43.9
	Shorea sp. 3	41
	Shorea polysperma H.G.Keith	33.1
Station 3	*Lithocarpus* sp. 3	37.8
	Shorea sp. 3	29.5
	Shorea assamica Dyer	25.2
Station 4	*Shorea* sp. 3	44.7
	Lithocarpus sp. 3	38.9
	Shorea assamica Dyer	27.5

Conservation Status and Endemicity

The conservation status and endemicity assessment of trees revealed that, out of the 66 species recorded, 13 are classified as Threatened, and 22 as Least Concern. (International Union for Conservation of Nature, 2025; DERN Administrative Order, 2017) (Table 5). Notably, some trees such as *Shorea polysperma* H.G. Keith and *Tristaniopsis decorticata* (Merr.) Peter G. Wilson and Waterhouse are categorized as Least Concern by International Union for Conservation of Nature (IUCN, 2025) yet are listed as Vulnerable by DERN Administrative Order (2017). Similarly, *Canarium luzonicum* (Blume) A. Gray and *Shorea almon* Foxw., which are categorized as Near Threatened by International Union for Conservation of Nature (IUCN, 2025), are classified by DERN Administrative Order (2017) as Other Threatened Species and Vulnerable, respectively. Furthermore, *Dipterocarpus grandiflorus* Wall., is listed as Endangered internationally but is classified as Vulnerable locally, and *Shorea malibato*

Foxw., is listed as Vulnerable by International Union for Conservation of Nature (2025), but is categorized as Critically Endangered within the country.

Thirteen (13) Philippine endemic tree species were documented in the study area based on Pelser *et al*. (2011), comprising about 20% of the tree species recorded in Talangisog Forest Park and Viewpoint. This level of endemism is similar to that of Barangay Baganihan and Mt. Malambo in Barangay Salumay, Marilog District, where 14 endemic species were reported (Coritico *et al*., 2022). However, the endemism is comparatively low to the 18 endemic species documented in Mt. Agad-Agad (Medecilo-Guiang et al., 2021), and to the 16 Philippine endemic trees in Mt. Tago Range (Coritico *et al*., 2020).

The findings indicate that Talangisog Forest Park and Viewpoint require strict implementation of laws and regulations to protect and conserve its biodiversity, particularly its native and endemic tree species. Trees are vital in maintaining the health of forest ecosystems and support numerous species (Zhu *et al*., 2023). Threats, including forest conversion and urbanization, will continue to endanger the long-term sustainability of the tropical lowland evergreen rainforest without the establishment of conservation policies. Furthermore, threatened and endemic tree species must be protected to ensure their survival in the wild, especially given their vulnerability to habitat loss (Medecilo-Guiang *et al*., 2021).

Table 5. Threatened and endemic tree species in Talangisog Forest Park and Viewpoint. Abbreviations: IUCN, International Union for Conservation of Nature; DENR, DERN Administrative Order.

Family	**Species**	**Conservation Status**		
		IUCN (2025)	**DENR (2017)**	**Endemicity (Pelser *et al.* 2011)**
Annonaceae	*Drepananthus apoensis* Elmer	VU		PE
Arecaceae	*Saribus rotundifolius* (Lam.) Blume		OTS	
Araucariaceae	*Agathis philippinensis* Warb.		VU	
Burseraceae	*Canarium asperum* Benth.	LC		
	Canarium luzonicum (Blume) A.Gray	NT	OTS	
Clusiaceae	*Garcinia binucao* (Blanco) Choisy	LC		PE
Dilleniaceae	*Dillenia philippinensis* Rolfe	NT		PE
Dipterocarpaceae	*Dipterocarpus grandiflorus* Wall.	EN	VU	
	Parashorea malaanonan (Blanco) Merr.	LC		
	Shorea assamica Dyer	LC		
	Shorea polysperma H.G.Keith	LC	VU	PE
	Shorea almon Foxw.	NT	VU	
	Shorea malibato Foxw.	VU	CR	PE
Escalloniaceae	*Polyosma piperi* Merr.			PE

Table 5. Continue.

Family	Species	Conservation Status		
		IUCN (2025)	**DENR (2017)**	**Endemicity (Pelser *et al.* 2011)**
Euphorbiaceae	*Macaranga sinensis* Müll. Arg.	NT		
	Macaranga gigantea (Rchb.f.andZoll.) Müll.Arg.	LC		
Fagaceae	*Castanopsis motleyana* King	LC		
Gentianaceae	*Utania philippinensis* (K.M.Wong and Sugau) K.M.Wong, Sugumaran and Sugau	LC		
Gnetaceae	*Gnetum gnemon* L.	LC		
Lamiaceae	*Callicarpa pentandra* (DC.) R.F.Almeida and M.Pell.	LC		
	Teijsmanniodendron ahernianum (Merr.) Bakh.	LC		
Lauraceae	*Cinnamomum iners* Wight	LC		
	Litsea urdanetensis Elmer	VU		PE
Lecythidaceae	*Barringtonia racemosa* (L.) Spreng.	LC		
Magnoliaceae	*Magnolia pubescens* (Merr.) Figlar and Noot.	EN		PE
Malvaceae	*Alphitonia philippinensis* Braid	LC		
Meliaceae	*Swietenia macrophylla* King	EN		
Moraceae	*Artocarpus blancoi* Merr.	LC		PE
	Ficus ampelos Burm.f.	LC		
	Ficus nota Merr.	LC		
	Ficus variegata Blume	LC		
Myrtaceae	*Tristaniopsis decorticata* (Merr.) Peter G. Wilson and Waterhouse	LC	VU	PE
Podocarpaceae	*Nageia wallichiana* Kuntze	LC	OTS	
Primulaceae	*Maesa denticulata* Mez	LC		
	Myrsine mindanaensis (Elmer) Pipoly			PE
Phyllanthaceae	*Antidesma curranii* Merr.	LC		PE
	Glochidion triandrum (Blanco) C.B.Rob.	LC		PE

Table 5. Continue.

Family	Species	Conservation Status		
		IUCN (2025)	**DENR (2017)**	**Endemicity (Pelser *et al.* 2011)**
Rutaceae	*Melicope triphylla* Merr.	LC		
Urticaceae	*Dendrocnide meyeniana* (Walp.) Chew	LC		

Notes: LC, Least Concern; NT,Near threatened; EN,Endangered; VU,Vulnerable; CR,Critically Endangered; OTS,Other threatened species; PE,Philippine Endemic.

CONCLUSION AND RECOMMENDATION

Floristic surveys in Talangisog Forest Park and Viewpoint, documented a total of 803 individual trees, representing 66 species (116 morpho-species), 48 genera, and 36 families. Among these species, *Shorea* sp. 3, *Lithocarpus* sp. 3, *S. polysperma, S. malibato,* and *S. assamica* were the dominant and frequently occurring tree species recorded in the area. The tree diversity index was highest at higher elevation areas and declined toward lower elevations. Overall, the study area exhibited a high diversity value, with a mean Shannon-Weiner index of 3.11, reflecting a diverse flora and a relatively even distribution. The forest type was characterized as a tropical lowland evergreen rainforest, with most trees classified as lower canopy and individuals within higher diameter classes. The majority of the tree population belonged to the families Dipterocarpaceae and Fagaceae, which also recorded the highest IVIs, particularly for *Shorea* sp. 3 and *Lithocarpus* sp. 3, which highlights their ecological importance in the area.

The assessment of conservation status and endemicity showed that 13 of the recorded tree species are Philippine endemics, 13 are classified as threatened, and 22 species are Least Concern (LC), indicating a need for conservation measures. Current threats include small-scale logging, agricultural land conversion, and the absence of conservation efforts. Talangisog Forest Park and Viewpoint is home to valuable biodiversity that provides shelter to numerous lifeforms. Strengthened protection and sustainable forest management are recommended to preserve its remaining native forest cover and ecologically important tree species.

ACKNOWLEDGEMENTS

This research was made possible through the generous support of the National Academy of Science and Technology (DOST–NAST) under the project "Plant Diversity, Assessment, and Forest Structure in Talangisog, Eureka, Gingoog, Misamis Oriental: Basis for Management and Conservation." The authors are also grateful to Central Mindanao University for providing logistical support throughout the conduct of this study. We express our sincere appreciation to Datu Lumiliwan Ramil Ansihagan of Sitio Talangisog, who formally granted the Prior Informed Consent (PIC) for the conduct of this study, and to the local guides, whose assistance was essential during the fieldwork. We are likewise grateful to DOST–SEI for the financial assistance that was vital to the completion of this research. The authors extend our gratitude to the DOST–NRCP CareeR Mentoring Program for providing mentoring support in the development of this manuscript.

The study was conducted under the Gratuitous Permit (GP) issued by the DENR Region 10 Office (GP No. 2024-43), which authorized our team to carry out the survey and collect specimens within the study area.

REFERENCES

Ambal, R., M. Duya, M. Cruz, O. Coroza, S. Vergara, N. De Silva, N. Molinyawe and B. Tabaranza. 2012. Key biodiversity areas in the Philippines: Priorities for conservation. *Journal of Threatened Taxa* 4(8): 2788–2796.

Amoroso, V.B., S.H. Laraga and B.V. Calzada. 2011. Diversity and assessment of plants in Mt. Kitanglad range natural park, Bukidnon, Southern Philippines. *Garden's Bulletin Singapore* 63(1–2): 219–236.

Arances, J.B., V.B. Amoroso, W.S. Gruezo, C. Ridsdale, L. Visser, B.C. Tan and S. Sacal. 2004. Development of a participatory methodology for inventory and assessment of floral resources and their characterization in the montane forests of Mt. Malindang. *PDM Press Incorporated Quezon City, Philippines* 1: 15–94.

Baynosa-Montera, C.A. 2024. Tree species diversity in the adopted forest of Barangay Verdu, Bayugan City, Agusan Del Sur, Philippines. *International Journal of Ecology and Ecosolution* 10(1): 1–9.

Coritico, F. P., F.M. Acma, R.M. Tubongbanua Jr., N.P. Mendez and V.B. Amoroso. 2022. Tree species diversity and stand structure in selected forest patches of Marilog Forest Reserve, Southern Philippines. *Journal of Tropical Biology and Conservation* 19: 143–166.

Coritico, F. P., V.B. Amoroso, J.C. Paquit, N.E. Lagunday and K.B.M.L. Caballes. 2025. *Plant Diversity, Assessment and Forest Structure in Talangisog, Eureka, Gingoog, Misamis Oriental: Basis for Conservation and Management.* Technical Report. Central Mindanao University. Mindanao Page: 96 pp.

Castillo, L. A., N.C. Bantayan, M.S. Canceran, L.D. Barua, A.C. Alegre, K.J.P. Gonzalvo and M.L. Castillo. 2021. Tree Composition, Diversity and Stand Structure of Mid-montane Forest in Sipit Watershed, Mount Makiling Forest Reserve ASEAN Heritage Park, Philippines. *Philippine Journal of Science* z: 150(S1): 271–288.

Coritico, F.P., N.E. Lagunday, J.M.M. Galindon, D.N. Tandang and V.B. Amoroso. 2020. Diversity of trees and structure of forest habitat types in Mt. Tago Range, Mindanao, Philippines. *Philippine Journal of Systematic Biology* 14(3): 1–11.

De Alban, J. D. T., C.D. Bernabe and B.E. de la Paz. 2004. Analyzing mining as a threat to forests and sustainable development. *Proceedings of the National Conference on Integrating Forest Conservation with Local Governance in the Philippines*, *9-12 November 2004 Subic, Zambales, Philippines*. 28 pp.

DENR Administrative Order. 2017. *Updated National List of Threatened Philippine Plants and Their Categories*. Downloaded from https://www.philippineplants.org/Resources/dao-2017-11.pdf on 05 November 2025.

Fernando, E. S. 1998. *Resource inventory and assessment of biodiversity in the Subic Bay Metropolitan Authority*. Terminal Report. University of the Philippines Los Baños- PCARRD-SBMA, Los Baños. 283 pp.

Fernando, E.S., M.H. Suh and D.K. Lee. 2008. *Forest Formations of the Philippines*. ASEAN-Korea Environmental Cooperation Unit (AKECU). City: Seoul 232 pp.

Fernando E.S., V.B. Amoroso, D.N. Tandang, C.I. Banag, A.B. Lapis, W.S. Gruezo, F.P. Coritico, F.A. Pollisco Jr., A.M. Palijon, M.D. Ching, F.P. Lansigan, C. Garcia-Francisco, N.M. Lita, A.M. Tagtag and J.L. De Leon. 2022. *Threatened Plants of the Philippines*. Department of Environment and Natural Resources–Biodiversity Management Bureau. 149 pp.

Food and Agriculture Organization. 2020. *Global Forest Resources Assessment (FRA) 2020 Report Philippines*. Downloaded from https://openknowledge.fao.org/server/api/core/bitstreams/373017a8-27c1-4843-9374-b917ee33fd78/content on 26 November 2025.

Galias, D. C., J.J. Guerrero, M. General, E. Bañares and J. Serrano. 2018. Diversity of tree species within an urban forest fragment in Albay Province, Eastern Philippines.: *BU R&D Journal 21 (1): 33-44.*

International Union for Conservation of Nature (IUCN). 2025. *The IUCN Red List of Threatened Species* (Version 2025-2). Downloaded from https://www.iucnredlist.org. on 26 February 2026.

Keong, C. Y. 2015. Sustainable resource management and ecological conservation of mega-biodiversity: the Southeast Asian Big-3 reality. *International journal of environmental science and development* 6(11): 876–882.

Kidd, P. S., A. Bani, E. Benizri, C. Gonnelli, C. Hazotte, J. Kisser and G. Echevarria. 2018. Developing sustainable agromining systems in agricultural ultramafic soils for nickel recovery. *Frontiers in Environmental Science* 6, 44.

Lagunday, N. E. and V.B. Amoroso. 2024. Emended Description of *Nepenthes Surigaoensis* (Nepenthaceae), a poorly known species from Mindanao (Philippines). *Phytotaxa* 666 (1): 67–72.

Lagunday, N. E., M.J.G. Baul, R.P. Ansihagan and V.B. Amoroso. 2025. *Nepenthes higaonon* (Nepenthaceae), a new species of pitcher plant from northern Mindanao, Philippines. *Phytotaxa* 689 (2): 285–290.

Lalbiaknunga, L.J. and P.C. Lalbiaknii. 2025. Influence of altitude on tree species diversity, structure and composition in a protected area of the Eastern Himalayas, Mizoram, India. *Flora* 327: 152741.

Langenberger, G. 2004. A review of research on Philippine forest vegetation, particularly work since 1990. *Agham Mindanaw* 2: 11–24.

Lillo, E. P., E.S. Fernando and M.J.R. Lillo. 2019. Plant diversity and structure of forest habitat types on Dinagat Island, Philippines. *Journal of Asia-Pacific Biodiversity* 12(1): 83–105.

Llait, C. O. 2024. Tree species composition and diversity in a secondary forest along the Sierra Madre Mountain Range in Central Luzon, Philippines. *Journal of Zoological and Botanical Gardens* 5(1): 51–65.

Lleno, J. V., R.J. Ligalig, R.T. Sarmiento and A.A. Along. 2023. Tree diversity, composition and stand structure of lowland tropical forest in Prosperidad, Agusan del Sur, Philippines. *Journal of Survey in Fisheries Sciences* 10: 4810–4830.

Löbs, N., D. Walter, C.G. Barbosa, S. Brill, R.P. Alves, G.R. Cerqueira and B. Weber. 2020. Microclimatic conditions and water content fluctuations experienced by epiphytic bryophytes in an Amazonian rain forest. *Biogeosciences* 17(21): 5399–5416.

Luyon, H. and M. Medecilo. 2006. The lowland evergreen dipterocarp forest of Mts. Palay-palay/Mataas na Gulod National Park, Luzon Island, Philippines. *Sinag* 10(2): 121–147.

Magurran, A. E. 2004. *Measuring Biological Diversity*. Blackwell, Malden, Massachusetts. 71 pp.

Medecilo, M. M. P. and M.N. Lagat. 2017. Floristic composition of the remaining forests in Upland Cavite, Luzon Island, Philippines. Philippine Journal of Systematic Biology 11(1): 74–94.

Medecilo-Guiang, M. M. P., F.P. Coritico, J.C. Nobleza, N.G.B. Casinillo and V.B. Amoroso. 2021. Tree species inventory and their economic uses in Mt. Agad-Agad, Iligan City, Philippines. *Philippine Journal of Systematic Biology* 15(1): 1–20.

Medina, M. N. D., R.B. Cudera, J.P. Villegas and A.A. Cabras. 2023. Two new species of darkling beetles of the genus *Gauromaia* Pascoe, 1866 (Coleoptera: Tenebrionidae) from Mindanao, Philippines. *Philippine Journal of Science* 152(3): 1189–1196.

Moya, T. B. and B.S. Malayang. 2004. Climate variability and deforestation–reforestation dynamics in the Philippines. *Environment, Development and Sustainability* 6(1): 261–277.

Nguyen, H., D. Lamb, J. Herbohn and J. Firn. 2014. Designing mixed species tree plantations for the tropics: Balancing ecological attributes of species with landholder preferences in the Philippines *PLoS ONE* 9(4): e95267.

Olpenda, A. S., A.M. Tulod, G.R. Puno and R.O. Villarta. 2013. Tree species diversity assessment and spatial analysis in a permanent monitoring plot of natural forest in Musuan, Bukidnon. *Proceedings of the 2nd Philippine Geomatics Symposium (PhilGEOS) 2013: Geomatics for a Resilient Agriculture and Forestry November 28-29, 2013 | University of the Philippines, Diliman, Quezon City. Downloaded from http://dge.upd.edu.ph/philgeos2013. 26 November 2025.*

Pasion, B. O., C.D. Barrias, M.P. Asuncion, A.H. Angadol, R.R. Pabiling, A. Pasion Jr. and A.M. Baysa Jr. 2021. Assessing tree diversity and carbon density of a riparian zone within a protected area in southern Philippines. *Journal of Asia-Pacific Biodiversity* 14(1): 78–86.

Pelser, P.B., J.F. Barcelona and D.L. Nickrent. 2011 onwards. Co's Digital Flora of the Philippines. Downloaded from https://www.philippineplants.org on 26 November 2025.

Pito, E., B. Alaman, Y. Labajo-Villantes, J. Calago, H. Tomatao, G. Villanueva and F. R. Garrido Jr. 2019. Species abundance, importance, conservation status and regenerative potential of Philippine endemic dipterocarp trees in the southern portion of Mt. Malindag Range Natural Park, Mindanao, Philippines. *Journal of Multidisciplinary Studies* 8(2): 35–52.

Rachmat, H. H., K. L. Ginoga, Y. Lisnawati, A. Hidayat, R. A. Fambayun, K. S. Yulita and A. Susilowati. 2021. What can native trees provide in revegetating tropical degraded land? An Experience of Man-Made Dipterocarp Forest in Indonesia. *Environmental Sciences Proceedings* 3(1): 79.

Rao, P., S. K. Barik, H. N. Pandey and R. S. Tripathi. 1990. Community composition and tree population structure in a sub-tropical broad-leaved forest along a disturbance gradient. *Vegetatio* 88(2): 151–162.

Richards, P.W. 1996. *The Tropical Rain Forest: An Ecological Study*. Cambridge University Press. Cambridge. xxiii + 575 pp.

Shang, R., S. Li, X. Huang, W. Liu, X. Lang and J. Su. 2021. Effects of Soil Properties and Plant Diversity on Soil Microbial Community Composition and Diversity during Secondary Succession. *Forests* 12(6): 805.

Shannon, C. E. and W. Wiever. 1949. A mathematical model of communication. *Urbana, IL: University of Illinois Press* 11, 11–20.

Sibucao Jr., A., L.F. Aggabao, D.R. Gopez, J.A. Obejas and R. Velloza. 2014. *Analysis of land cover change: 2003–2010.* Unpublished report. Forest Management Bureau, Department of Environment and Natural Resources, Quezon City. 19 pp.

Simpson, E. H. 1949. Measurement of diversity. *Nature* 163 (4148): 688–688.

Thüs, H., P. Wolseley, D. Carpenter, P. Eggleton, G. Reynolds, C.S. Vairappan and R. J. Mrowicki. 2021. Key roles of Dipterocarpaceae, bark type diversity and tree size in lowland rainforests of northeast Borneo using functional traits of lichens to distinguish plots of old growth and regenerating logged forests. *Microorganisms* 9(3): 541.

Wilson, E. O. 1988. The current state of biological diversity. *Biodiversity* 521(1): 3–18.

Zapanta, B.R., M.J.M.M. Achondo, A.F.M. Raganas, A.G.D. Delima, J.A. Mantiquilla and F.R.P. Salvaña. 2019. Species richness of trees in disturbed habitats within a protected area and its implications for conservation: The case of Mt. Apo Natural Park, Mindanao Island, Philippines. Biodiversitas Journal of Biological Diversity 20(7): 2059–2067.

Zhu, Y., X. Xu, Z. Xi and J. Liu. 2023. Conservation priorities for endangered trees facing multiple threats around the world. *Conservation Biology* 37(6): e14142.