Open Journal of Ecology, 2023, 13, 387-408
https://www.scirp.org/journal/oje
ISSN Online: 2162-1993
ISSN Print: 2162-1985

Quantifying Arborescent Flora Diversity in a Secondary Forest Ecosystem: A Comprehensive Assessment in Nambalan, Mayantoc, Tarlac, Philippines

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How to cite this paper: Herbulario, B.J.L., Tano, R.L. and Omaney, M.P. (2023) Quantifying Arborescent Flora Diversity in a Secondary Forest Ecosystem: A Comprehensive Assessment in Nambalan, Mayantoc, Tarlac, Philippines. *Open Journal of Ecology*, **13**, 387-408.
https://doi.org/10.4236/oje.2023.136024

Received: July 24, 2022
Accepted: June 23, 2023
Published: June 26, 2023

Abstract

Forest plays a crucial role in providing essential ecosystem services, including water supply, climate regulation, and biodiversity conservation. This study aimed to assess the current state of the forest in Barangay Nambalan, Mayantoc, Tarlac. The specific objectives were to identify tree species in the area and determine the tree diversity index, with a focus on endemism and conservation status. Two transect lines, each spanning one kilometer, were established and a total of 10 sampling quadrats were surveyed. Ecological parameters (relative frequency, relative density, relative dominance, and importance value index) and diversity indices (Shannon-Weiner index, Simpson's index) were computed using the Paleontological Statistic Software Package for Educational Analysis (PAST 4.03). A comprehensive inventory revealed a total of 756 individuals representing 52 species, 46 genera, and 25 families. Among the recorded species, 10 (17.2%) were endemic and 11 (21.6%) were classified as threatened. The Fabaceae (20.8%), Moraceae (14.6%), and Euphorbiaceae (8.3%) were identified as the most abundant families. The computed diversity indices indicated that Barangay Nambalan retains a diverse forest cover; however, species composition was found to be relatively low. Based on the finding, this study recommends the strict enforcement of protective measures and legislation to mitigate further degradation of the remaining forest in Barangay Nambalan.

Keywords

Forest Diversity, Tree Species, Endemism, Conservation Status, Transect Survey, Diversity Indices

1. Introduction

Arborescent flora, comprising trees, plays a crucial role in forest ecosystems, serving as a key component for resource conservation and management in both rural and urban areas [1]. Forest provide a wide range of valuable services, including water supply and rainfall maintenance, security and nutrition, climate control, and biodiveristy conservation [2], which are essential for meeting immediate human needs. However, the future of global forests and trees is confronted by significant environmental and development challenges on a global scale [3].

The Philippines is recognized as one of the world's megadiverse countries, harboring a rich diversity of life forms in both aquatic and terrestrial ecosystems [4]. Nevertheless, biodiversity is currently under critical threat as human activities contribution to the degradation of natural resources, particularly forests [5]. According to the DENR-FMB [6], the Philippines has witnessed a staggering 70 percent decline in forest cover from 1900 to 2007, with forest area decreasing from 21 million hectares to a mere 6.5 million hectares due to extensive logging activities.

Central Luzon, a significant contribution to the country's economic growth, has witnessed the ongoing degradation of its remaining forestlands and watersheds due to rapid urbanization and development [7]. In Tarlac, located in Central Luzon, a substantial decrease in closed forest area has been observed, declining from 5407 hectares in 2010 to a mere 4.0 percent of the total tree cover by 2020. This decline can be primarily attributed to forest fires and extensive logging activities [6] [8]. Notably, Mayantoc, one of the municipalities in Tarlac, has experienced considerable tree cover loss compared to other regions [9]. Consequently, there exists an urgent imperative to undertake a comprehensive inventory and assessment aimed at identifying the trees species in the area, evaluation their conservation status, and formulating informed plans to safeguard the remaining forest cover. Hence, the main objective of this research was to assess the diversity of tree species in Barangay Nambalan, Mayantoc, Tarlac. Specifically, the study aimed to 1) Identify and Quantify tree species in the area; 2) Determine the tree diversity index and ecological parameters of forest communities; 3) Determine the endemism and conservation status of the tree species present in the area; and 4) To provide a recommendation regarding the present condition of forest in Barangay Nambalan, Mayantoc.

2. Review of Related Literature

2.1. Tree Diversity

An essential aspect of tree diversity research is the assessment of species richness, which refers to the number of tree species present in a given area. High species richness is frequently linked to various ecological functions, such as increased productivity, nutrient cycling, and resistance to disturbances [10]. Chao *et al.* [11] discovered that areas with higher tree species richness exhibited more significant biomass accumulation and carbon storage in a tropical rainforest.

In addition to species richness, tree diversity studies often examine species composition and evenness. Species composition refers to the specific combination of tree species present in an area, while evenness refers to the relative abundance of different species. Both factors are crucial in understanding community dynamics and ecosystem processes [12]. For instance, a study by Baraloto *et al.* [13] in a neotropical forest revealed that changes in species composition and evenness influenced the functional diversity of tree communities, affecting key ecosystem processes such as nutrient cycling and productivity.

Furthermore, research into the factors that influence tree diversity has provided insights into the mechanisms that shape forest ecosystems. Climate, topography, and soil characteristics have all been shown to influence tree species distribution and diversity [14]. Quesada *et al.* [15] found that tree species composition and diversity varied with soil fertility and hydrological conditions in the Amazon rainforest, highlighting the importance of edaphic factors in shaping forest communities.

Human activities and land-use changes also significantly impact tree diversity. Deforestation, habitat fragmentation, and conversion of forests to agricultural or urban areas have led to the loss of tree species and the homogenization of tree communities [16]. Studies have shown that human disturbances can decrease tree diversity and alter community dynamics, disrupting ecosystem functions [17]. For instance, a study by Laurance *et al.* [18] revealed that selective logging reduced tree species diversity and altered community composition in a tropical forest, affecting carbon storage and nutrient cycling.

Overall, research on tree diversity has emphasized its importance for ecosystem functioning and conservation. Understanding the patterns, drivers, and ecological implications of tree diversity is crucial for effective forest management, conservation strategies, and the sustainable use of forest resources.

2.2. Importance of Biodiversity

Biodiversity, the variety of life on Earth, is critical component of our planet's ecosystems and plays a fundamental role in sustaining the functioning and resilience of natural systems. According to Kanieski *et al.* [19], biodiversity is considered a key indicator of ecosystem well-being and directly reflects the conservation status of a particular area. A diverse and healthy biodiversity provides numerous natural services that are essential for human well-being. People living in rural areas near forests rely on a wide range of forest products for their subsistence, and the income generated from trees and forests is crucial for both rural and urban populations. Biodiversity conservation offers significant benefits in meeting immediate human needs, such as ensuring clean and reliable water resources, protection against floods and storms, and maintaining a stable climate. It also provides social benefits, including education, monitoring, recreation, tourism, and cultural values [20].

In the study conducted by Ludwig and Reynolds [21], several steps were identified in the investigation of biodiversity, including defining study objectives, delineating the study area, determining sampling methods, collecting and organizing data, measuring species similarity, and characterizing biotic factors. Inventory studies serve as the foundation for biodiversity conservation efforts, as they provide essential information for the sustainable use and protection of biodiversity components. Biodiversity assessments are globally recognized as fundamental activities in achieving sustainable biodiversity conservation [22].

Aureo *et al.* [23] emphasized the importance of understanding biogeographical patterns, species richness variations, and endemic trends in elevationally diverse areas for effective conservation strategies. By comprehending these patterns, conservation efforts can be targeted towards protecting and managing areas of high species richness and endemism.

Ganivet and Blomberg [24] highlighted the need for assessing both tree species diversity and forest structure at local and regional levels to gain insights into the current state of tropical forests and develop effective management strategies for their conservation. While assessments at local scales provide accurate estimates of species richness and forest structure, it is important to extrapolate these findings to regional scales to understand the broader picture of tree species diversity and forest structure.

2.3. Biodiversity Conservation

Biodiversity conservation is a crucial aspect of environmental management and sustainable development. One key aspect of biodiversity conservation is the recognition of the intrinsic value of biodiversity. Biodiversity encompasses a variety of life forms, including genes, species, and ecosystems, and its conservation is essential for maintaining ecological balance and resilience [17]. Biodiversity conservation efforts aim to prevent the loss of species and ecosystems and ensure their long-term survival.

The benefits of biodiversity conservation extend beyond ecological considerations. Biodiversity provides numerous ecosystem services that are vital for human well-being. For instance, intact ecosystems with high biodiversity can enhance water quality, regulate climate, and provide various industries with natural resources such as food, medicines, and materials [25]. Biodiversity conservation also plays a crucial role in supporting livelihoods, particularly for communities that rely on natural resources for their sustenance and income [26].

Biodiversity preservation is critical for ecosystems' continued functioning and resilience. Studies have shown that higher levels of biodiversity contribute to increased ecosystem productivity, stability, and resistance to disturbances [27]. Biodiversity conservation helps protect and restore vital ecological processes, such as pollination, nutrient cycling, and pest regulation, which are essential for maintaining the health and productivity of ecosystems [28].

Various strategies and approaches guide biodiversity conservation efforts. National parks and nature reserves are established to protect critical habitats and species [29]. Additionally, habitat restoration and rewilding initiatives aim to rehabilitate degraded ecosystems and reintroduce species to their historical ranges [30]. Collaborative efforts involving local communities, government agencies, and non-governmental organizations are crucial for effective biodiversity conservation, as they promote local participation and sustainable resource management [31].

Furthermore, incorporating indigenous knowledge and traditional practices into biodiversity conservation strategies has gained recognition. Indigenous communities often possess valuable knowledge about local ecosystems and have a deep understanding of sustainable resource use [32]. Engaging with indigenous communities can lead to more effective and culturally sensitive conservation practices.

Biodiversity conservation is paramount for maintaining ecological integrity, supporting human well-being, and ensuring sustainable development. It involves preserving species, ecosystems, and ecological processes and requires collaborative efforts and the integration of traditional knowledge. By conserving biodiversity, we can protect the planet's natural heritage and secure a more sustainable future for future generations.

2.4. Conceptual Framework

The INPUT-PROCESS-OUTPUT Model was used by the researcher to provide a general structure and direction for the study. **Figure 1** depicts the study's conceptual framework, in which the input consists of data collection through field inventory, transect and quadrat establishment, and specimen collection and preservation.

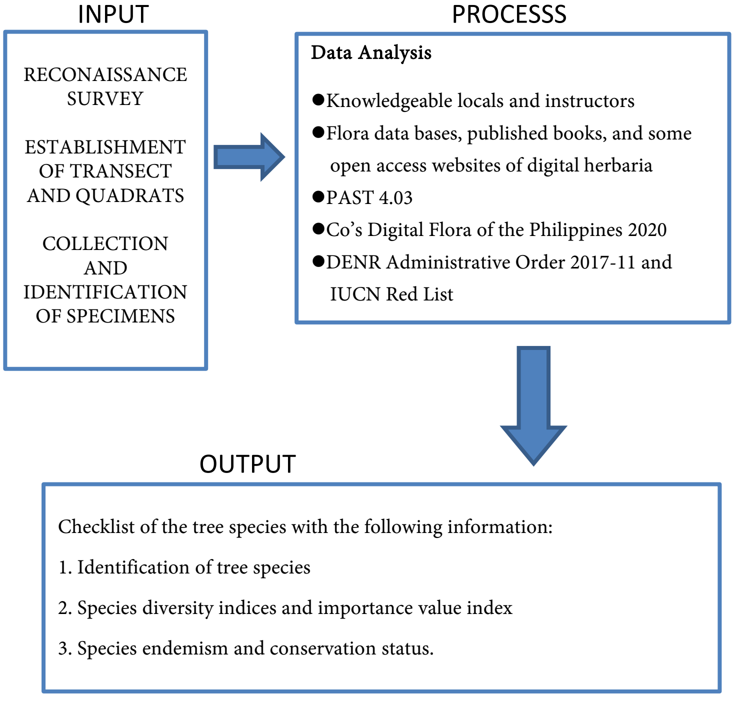


Figure 1. Conceptual framework of the study.

Plant names from family to species level are gathered, the number of individuals of each species, bio-measurements on diameter at breast height (cm), total height (m), and GPS coordinates of all corners of each quadrat. On the other hand, identification of the species was sought with the assistance of knowledgeable locals and instructors, as well as from databases, published books, and some open-access websites of digital herbaria.

For diversity indices, the Shannon Diversity Index formula was used as follows from the studies of Coracero *et al.*, [4]. Species endemicity and conservation status were determined using Co's Digital Flora of the Philippines 2020, D.E.N.R. Administrative Order 2017-11, and the I.U.C.N. Red List. The input and process resulted in identifying tree species present in the area, a tree diversity index, endemism, and the conservation status of tree species in Barangay Nambalan.

3. Methodology

3.1. Locale of the Study

This research was conducted in Barangay, Nambalan, Mayantoc, Tarlac, located in the Northwest part of the Tarlac Province. It is situated at approximately 15.3166 latitude, 120.3166 longitude on the island of Luzon. It is bounded on the west by the Zambales mountain ranges, on the south by the Municipality of San Jose, on the north by the towns of San Clemente and Camiling, and on the east by Santa Ignacia (**Figure 2**). Nambalan is generally a rough and mountainous area that falls under the climatic Type 1 of the Coronas system of classification, having two pronounced seasons: the dry season from November to May and the wet season during the rest of the year. Its population, as determined by the 2020 Census, was 1570. This represents 4.82% of the total population of Mayantoc as stated [33].

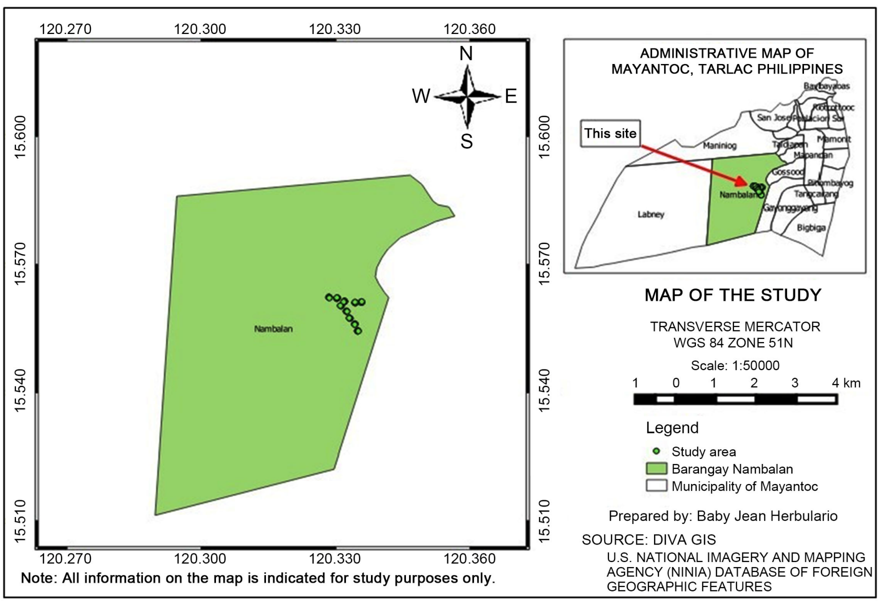


Figure 2. Map showing the location of the study area.

3.2. Data Collection Instruments

The instruments used in data collection were as follows: Procedural activities and formulas were obtained from references, such as previous studies by various researchers, specifically the study conducted [4]. Primary data gathering was through fieldwork activities, mapping and on-site observations, geotagging and tracking using locus map and GeoCam were used to document the activities within the research area.

3.3. Data Collection Procedure

Preliminary procedures were carried out before the conduct of the study. First, the researcher wrote an official letter informing the Barangay captain of the study's purpose and requesting permission to conduct it in the Barangay. This ensured the success of data collection while avoiding suspicion from members of the community. Second, prior to the plot's establishment, a reconnaissance survey was conducted. A mix of quantitative and qualitative analyses was performed. The qualitative component involved identifying the trees encountered per quadrat, while the quantitative component involved computing diversity indices and importance value indices for each species. Field visits, direct observation, and photo documentation were used to characterize the site's vegetation. Secondary data such as area, climatic data, soil, elevation, and other related information were gathered from the Barangay Nambalan Forest Land Use Plan and other online references. The study's mapping activity was created using Quantum GIS (QGIS 2.18) and data generated from the National Imagery and Mapping Agency (NIMA) database, which is accessible online through Diva GIS.

3.4. Transect and Quadrats Establishment

Two (2) transect lines were established with a length of one (1) kilometer each and with ten (10) sampling quadrats having a size of 20 × 20 meters (**Figure 3**). The sampling plots were established in alternating directions on the transect line with 250 meters regular interval.

3.5. Sampling and Data Collection

Biodiversity Assessment

A total of ten (10) 20 × 20-meter sampling plots were established for the identification of trees with at least 5 centimeter in diameter at breast height (DBH). **Figure 4** shows the actual establishment of the plot. Within the 20 m × 20 m sampling plot, tree species with a DBH of at least 5 centimeters were accounted for and measured. DBH, total height, and the number of individuals of each species found in the study area were collected, including GPS coordinates of all corners of each plot. DBH measurements were taken with a diameter tape. The total height of the trees was measured with the aid of an Abney hand level. The crown height and width were measured using estimation, as recommended by Lillo *et al.* [34]. Elevation and trees with flowers and fruits were also observed.

Figure 3. Location of 20 × 20 meters sampling plots.

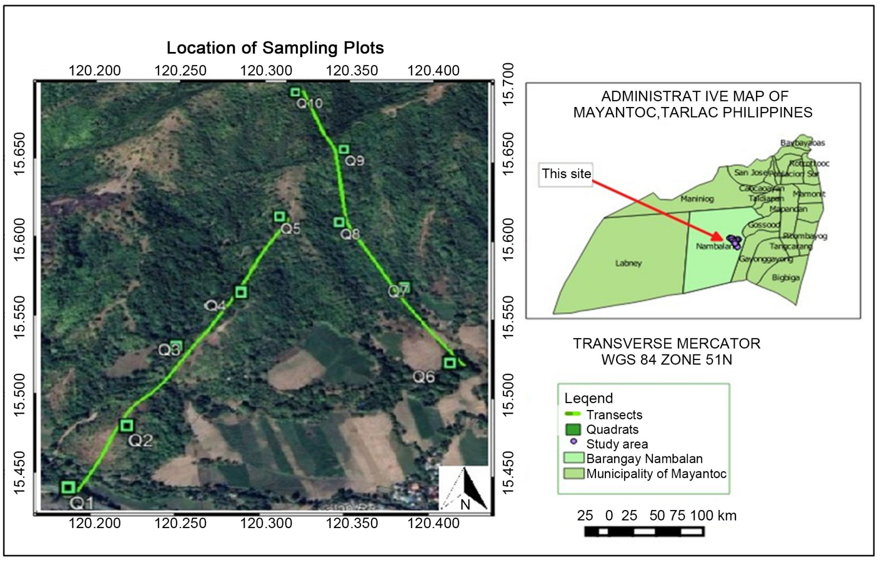


Figure 4. Location of 20 × 20 meters sampling plots.

3.6. Data Analysis

The process of vegetation analysis, including the assessment of tree diversity, computation of diversity indices, identification of tree species, determination of conservation status, and evaluation of species endemism, in this comprehensive discussion. The methods and references cited are based on the research of Coracero and Malabrigo [4], Aureo *et al.* [23], and Lillo *et al.* [34], as well as the use of various botanical resources.

The data collected for the study were utilized for vegetation analysis, specifically focusing on tree species. The evaluation of tree diversity involved the implementation of species abundance measures, such as density, frequency, and dominance. These measures are essential for determining the importance value of each species, which is a standard measurement in forest ecology to establish the rank relationship among different species [34].

The importance value was computed as the cumulative value of relative density, relative frequency, and relative dominance combined into a single metric [23]. This metric provides a comprehensive assessment of the significance of each species within the ecosystem.

Furthermore, diversity indices were computed using the Paleontological Statistics Software Package for Education and Data Analysis (PAST v.4.03). The interpretation of these diversity indices was based on the Fernando Biodiversity Scale (**Table 1**), as outlined in the study conducted by Coracero and Malabrigo [4]. This scale enables the researchers to understand the level of biodiversity present in the studied area.

To accurately identify tree species, a combination of resources was employed. Local experts, instructors, and knowledgeable locals were consulted to aid in species identification. Additionally, flora databases such as Co's Digital Flora of the Philippines [35] and the International Plant Name Index (IPNI) [36] were utilized. Published books, including Flora Malesiana [37] and Merrill [38], were also consulted. Furthermore, open-access websites of digital herbaria were referenced to access relevant information. The methodologies for species identification and the utilization of these resources were based on the studies conducted by Coracero and Malabrigo [4].

In order to determine the conservation status of each tree species in the Philippines, the researchers relied on the DENR Administrative Order 2017-11. This administrative order provides guidelines and regulations for the conservation of species in the Philippines. Additionally, the conservation status of the species worldwide was determined based on the IUCN Red List, which is maintained by the International Union for Conservation of Nature (IUCN) and provides a comprehensive assessment of the threatened species globally [39].

Furthermore, species endemism was determined using the plant species archive available in the Philippines, namely Co's Digital Flora of the Philippines [35], which is accessible online. This archive provides valuable information on the distribution and endemism of plant species within the Philippines.

The formulas for the computation of various parameters, including importance values, diversity indices, and other relevant metrics, were based on the studies conducted by Coracero and Malabrigo [4]. These studies provided the necessary mathematical frameworks for calculating these parameters accurately and effectively.

$$\text{Dominance} = (0.7854) \times \text{Diameter}^2$$

$$\text{Relative dominane} = \frac{\text{Dominance of a species}}{\text{Sum of the dominance of all species}} \times 100$$

$$\text{Frequency} = \frac{\text{Total number quadrats in which species occured}}{\text{Total number of quadrats studied}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Sum of frequency of all species}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of species}}{\text{Total number of individual of all species}}$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Sum of density of all species}} \times 100$$

$$\text{IV} = \text{Relative dominance} + \text{Relative frequency} + \text{Relative density}$$

Table 1. Fernando biodiversity scale.

Relative Values	Shannon Index	Evenness Index
Very high	3.5 and above	0.75 - 100
High	3.0 - 3.49	0.5 - 0.74
Moderate	2.5 - 2.99	0.25 - 0.49
Low	2.0 - 2.49	0.15 - 0.24
Very low	1.9 and below	0.05 - 0.14

4. Results and Discussion

4.1. Tree Species Diversity

The study identified a total of 756 individual trees belonging to 26 families, 46 genera, and 52 species within the two transects. The number of tree individuals per quadrat varied from 35 to 118, with DBH ranging from 5 centimeters to 80 centimeters. Remarkably, *Artocarpus blancoi* and *Syzygium cumini* were the only trees with a DBH of 80 centimeters, suggesting their potential significance in the ecosystem. The majority of species exhibited a DBH of less than 30 cm, indicating that the study area consists of secondary forests in the early stages of vegetation succession [4] [40].

The most abundant families observed were Fabaceae (20%) with ten identified species, Moraceae (13%) with seven identified species, and Euphorbiaceae (9%) with five identified species. This finding suggests that these families play a critical role in influencing the growth and survival of other species in the area [41]. Additionally, Fabaceae species were found to be easily germinating due to their nitrogen-fixing capability [42]. Moraceae and Euphorbiaceae were identified as important food sources for bats and birds, leading to high rates of seed dispersal and successful recolonization [43]. A similar study conducted by Cruz *et al.* [44] in Minalungao National Park in Nueva Ecija reported a high number of Fabaceae species (seven), followed by Moraceae and Euphorbiaceae with six and five species, respectively.

The dominance of Fabaceae, Moraceae, and Euphorbiaceae families highlights their significant role in shaping the vegetation dynamics and supporting the growth and survival of other species. Understanding these ecological relationships is crucial for effective forest management and conservation strategies.

Table 2 shows that quadrat 4 had the highest number of identified species and individual trees, with a total of 33 species and 118 individual trees. In terms of families, quadrat 5 had the highest number, with 23 families. While, quadrat 2, which is dominated by cogon (*Imperata cyclindrica*), was discovered to have the fewest number of individual trees, with a total of 35 individuals, and quadrat 10 was discovered to have the fewest number of families, with 12 families.

These findings demonstrated that variation in species richness was caused by differences in how different species respond to environmental conditions in each plot [45]. Furthermore, dominant species were more likely to maximize their

Table 2. Table summarizing the species composition of the ten sampling quadrats.

Number of Individual		No. of Species	No. of Families
Quadrat	Species		
1	35	19	16
2	37	14	113
3	59	23	21
4	118	33	22
5	94	31	23
6	73	28	20
7	93	32	21
8	100	27	18
9	95	31	19
10	52	22	12
TOTAL	**756**		

ability to capture more resources, resulting in the proliferation of their population over time compared to others [46]. Moreover, the density of species per area influences the development of stem diameter, but other factors such as edaphic and climatic factors may also influence the secondary growth of tree species [47].

Plant species identification was very much dependent on reproductive structures [48]. As a result, in order to perform a more accurate and convenient identification, the reproductive parts of the species must be collected in the field [4]. Furthermore, it could be a source of native species seeds for landscaping and seedling production in the area.

Out of the 52 tree species documented, 13 species were observed with reproductive parts within the sampling sites, as shown in **Figure 5**. These species include *Antidesma ghaesembilla* (Gaertn., Fruct), *Aglaia edulis* (Roxb) Wall., *Buchanania arborescens* (Blume), *Ficus nota* (Blanco) Merr., *Ixora philippinensis* Merr., *Macaranga grandifolia* (Blanco) Merr., *Melanolepis multiglandolusa* (Reinw. Ex Blume) Rchb.f. & Zoll., *Psychotria luzoniensis* (Cham. & Schltdl.) Fern.-Vill, and *Pittosporum pentandrum* (Blanco) Merr. It is noteworthy that all the recorded flowering plant species, like *Pittosporum pentandrum has the ability to suppress and inhibit the growth of Cogon* (*Imperata cylindrica*) *and Talahib* (*Saccharum spontaneum*); *it also produces good soil cover in denuded areas*, *which is useful for vegetative rehabilitation of degraded areas* [49]. This emphasizes the rich native floral diversity present within the study area and highlights the importance of conserving these native plant species to maintain the ecological balance and support local ecosystems.

In the study area, the presence of reproductive parts in a subset of tree species indicates active reproduction and ecological resilience. Understanding these species' reproductive patterns and characteristics adds to our understanding of their life history strategies and facilitates the development of effective conservation and management plans.

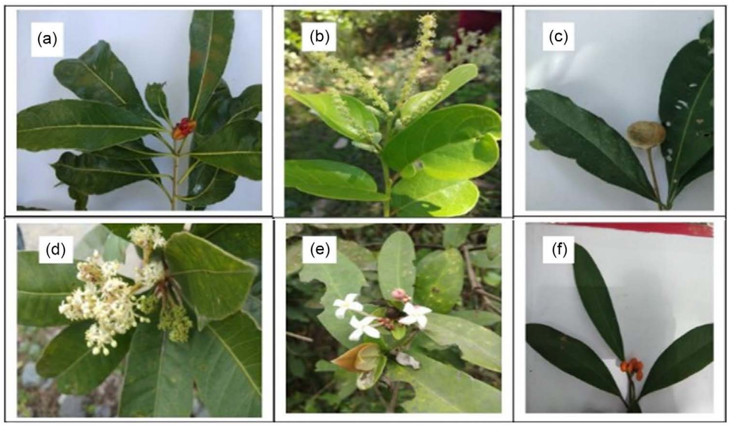


Figure 5. Tree species recorded with reproductive parts within the sampling site. (a) *Pittosporum pentandrum*, (b) *Antidesma ghaesembilla*, (c) *Aglaia edulis*, (d) *Buchanania arborescens*, (e) *Ixora philippinensis*, (f) *Psychotria luzoniensis*.

The predominance of native flowering plant species among the individuals recorded emphasizes the importance of native plant conservation. Native species are frequently better adapted to local environmental conditions and play critical roles in sustaining local biodiversity, ecosystem functions, and overall ecosystem stability.

4.2. Diversity Indices

In the case of Barangay Nambalan, the computed diversity index classifies it as a high diversity area based on the Fernando Biodiversity Scale, with a Shannon diversity index of 3.486 and an evenness index of 0.7098. This indicates a wide variety of species and an even distribution of individuals among them. According to Lillo *et al.* [34], high species diversity in an area contributes to a more stable and productive ecosystem, as diversity is associated with stability, productivity, and trophic structure [50].

Further analysis reveals that six quadrats, specifically two from Transect 1 and four from Transect 2 (**Table 3**), were classified as having high diversity per quadrat. This suggests that these specific areas within Barangay Nambalan contain a considerable number of different species. However, it is important to note that the diversity in Barangay Nambalan is primarily driven by the number of individual species rather than species composition.

This finding aligns with the assertion made by Guiang [51] that a forest community with a higher number of individual species is considered to have high diversity. Additionally, it is known that certain tree species develop specific adaptations that allow them to thrive better than others in a given area [52].

Figure 6 displays the quadrat with the highest number of identified species and individual counts, totaling 33 species and 118 individuals. Prominent species in this quadrat include Alibangbang (*Piliostigma malabaricum* Roxb.), Antipolo (*Artocarpus blancoi* El. Merr), Duhat (*Syzygium cumini* L.), Ipil-ipil (*Leucaena leucocephala*, Lam. De Wit), Kalios (*Streblus asper* Lour., Fl.), Niog-niogan (*Ficus pseudopalma*), Takip-asin (*Macaranga grandifolia*), Tibig (*Ficus nota*), and Yemane (*Gmelina arborea* Roxb).

Table 3. Diversity Indices per quadrats.

Quadrat	Species	Individual	Shannon	Simpson
1	19	35	2.837	0.9355
2	14	37	2.468	0.9028
3	59	23	2.943	0.9371
4	33	118	3.277	0.9563
5	31	94	3.213	0.9529
6	28	73	3.219	0.9559
7	32	93	3.307	0.9573
8	27	100	3.106	0.9472
9	31	95	3.264	0.9567
10	22	52	2.962	0.9423

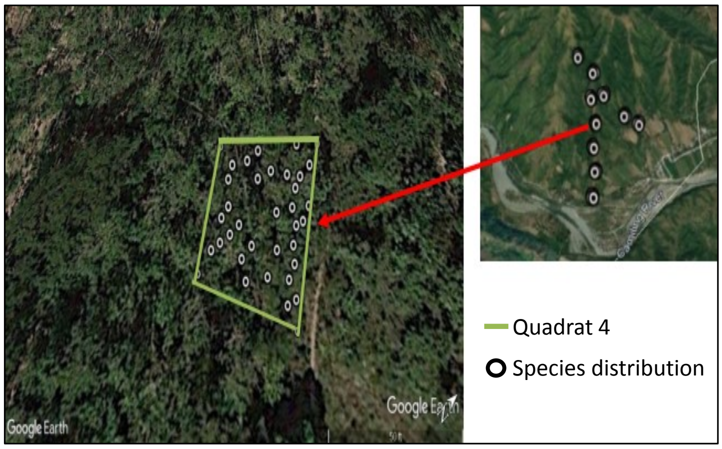


Figure 6. Quadrat with the highest species distributions in the study area.

The diversity observed in this particular plot can be attributed to various factors, including the type of soil, the presence of specific species, and the ground cover. As noted by Cordova *et al.* [53], the role of leaf litter in facilitating plant growth depends on the species. In the case of quadrat 4, which was characterized by a forest floor covered with leaf litter from dominant species, particularly the Fabaceae family, the high diversity observed was expected. Leaf litter promotes soil fertility through microbial activities that are essential for plant growth [53].

Figure 7 shows the plot with the lowest number of identified species and individual species. There were 14 identified species in the area, with 37 individual species. Alibangbang (*Piliostigma malabaricum* (Roxb.) Benth), Akleng parang (*Albizia procera* (Roxb.) Benth), Banato (*Mallotus philippensis* (*Lam.*) *Muell. Arg.*), Binayuyo (*Antidesma ghaesembilla Gaertn*), Hauili (*Ficus septic* (Blanco) Merr.), Lamio (*Dracontomelon edule* (Blanco) Merr.), Mamalis (*Pittosporum pentandrum* (*Blanco*) *Merr*), Molave (*Vitex parviflora* Juss.), Tagpong-gubat (*Psychotria luzoniensis* (*Cham.* & *Schltdl.*) *Fern.-Vill*, *Pitt*) and Takip-asin (*Macaranga grandifolia* (Blanco) Merr.).

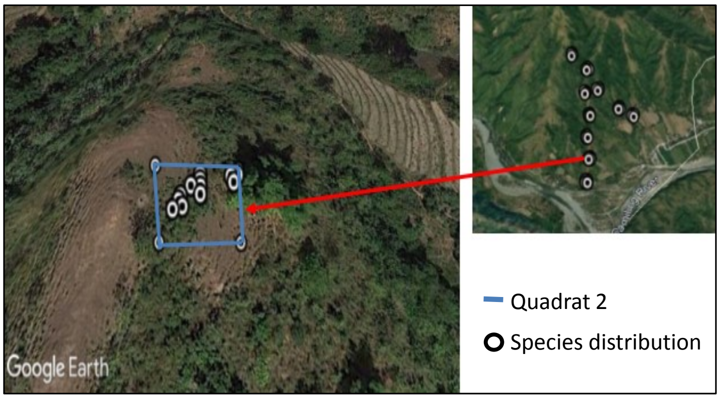


Figure 7. Quadrat with lowest number of identified species.

Based on the observations made during the establishment of the transect, this area was dominated by Cogon grass (*Imperata cylindrica*), which affects the species diversity in the ground cover because cogon commonly over-dominates the vegetation that is prone to burning or fire [53], as well as in areas that are overgrazed and intensively cultivated [54].

Table 4 shows that Transect 1 was more diverse compared to Transect 2, with an average species diversity of 3.46. In terms of species richness, transect 1 had the highest number with 44 species compared to transect 2 with only 41 species, but in terms of number of individual species, transect 2 had the highest number of individuals with 413 individuals, while transect 1 had only 343 individuals.

These findings demonstrated that forest structure varies from lowest to highest elevation in terms of tree diameter, height, and species composition. The type of soil in the area, ground cover, species types, elevation, and climatic conditions all had an impact on these findings. This result confirmed Amoroso *et al.* [55] finding that elevation influences species composition by providing complex environmental gradients such as temperature, rainfall, and relative humidity, as well as different nutrient requirements of the tree species in the area.

4.3. Species Importance Values Index (IVI)

The ten most important species in terms of dominance, frequency, and density were *Piliostigma malabaricum* (18.75), *Artocarpus blancoi* (17.28), *Gmelina arborea* (16.82), *Syzygium cumini* (15.64), *Mangifera indica* (12.64), *Ficus nota* (11.40), and *Psychotria luzoniensis* (Cham). **Figure 8** shows values for *Buchanania arborescens* (11.19), *Ficus septica* (9.74), and *Albizia procera* (9.36). These species are divided into seven (7) families. According to Lillo *et al.* [34], importance value is a quantity that measures the degree of significance of tree species in a given forest community and is derived from three variables, namely density, cover and frequency.

These results indicate that these plants were the most common and the most dominant species in the area [56]. It confirmed that the relative density of each species contributed most to their IV and the floristic composition and vegetation structure of this area were dependent from these species [53]. In addition, species with high importance value index as shown in **Figure 9**, indicates that the species was well-represented due to a large number of individuals observed compared with other species [57] at the same time it provides an overall estimate of the influence of these species in the community [53].

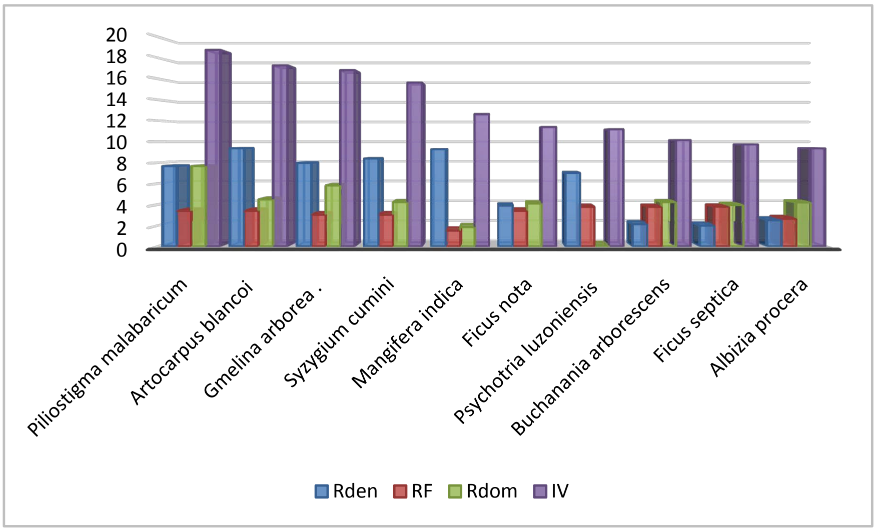
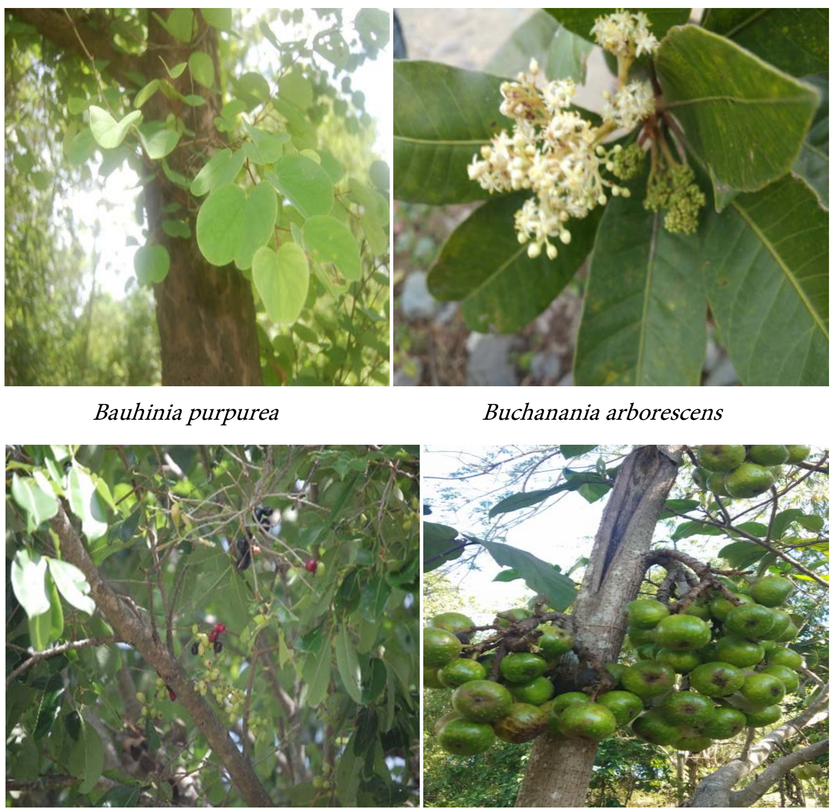


Figure 8. List of species with high Importance Value (IV).



Bauhinia purpurea *Buchanania arborescens*

Syzygium cumini *Ficus nota*

Figure 9. Tree species with high importance value index in the area.

Table 4. Diversity indices values per transect.

Diversity indices	Transect 1	Transect 2	Brgy. Nambalan
Taxa/Species	44	41	46
Individuals	343	413	756
Shannon	3.46	3.413	3.43
Simpson Evenness	0.9617	0.9602	0.9622

4.4. Species Endemism and Conservation Status

As shown in **Table 5** species endemicity assessment revealed nine (9) endemics species comprising 18.8% of the total tree species. It includes *Buchanania arborescens* (Blume), *Semecarpus cuneiformis* Blanco, *Canarium hirsutum* Willd, *Macaranga grandifolia*, *Artocarpus blancoi* (Elm.), *Broussonetia luzonica* Merr, *Ficus nota* (Blanco) Merr., *Ficus pseudopalma* Blanco, FL., *Psychotria luzoniensis* (Cham. & Schltdl.) Fern.-Vill. All endemic species was present both in transect 1 and 2 except for *Canarium hirsutum Willd* which was present only in Transect 2 as shown in **Table 5**.

This result confirmed that endemic species in the area should be given priority in conservation planning because these species are more vulnerable to threats due to their narrow range [58]. In addition, information on the geographic distribution of plant species in the area helps avoid species extinction and, at the same time, it plays an integral basis for the formulation of conservation and management strategies [53].

The conservation assessment was based on the International Union for the Conservation of Nature (2021-3) and DENR Administrative Order No. 2017-11. The assessment result showed that of the 52 species collected, only 11 (21.6%) of the total species were threatened as shown in **Table 6**.

In the IUCN Redlist, seven (7) species were categorized as Vulnerable, namely *Macaranga grandifolia*, *Afzelia rhomboidea*, *Vitex parviflora* Juss., *Sandoricum koetjape* (Burm.f.) Merr., *Artocarpus blancoi* (Elm.) Merr., and *Eucalyptus deglupta* Blume, while *Pterocarpus indicus* was listed as Endangered and *Aglaia edulis* was in the not threatened category (**Table 6**).

While in the DAO 2017-11, or the Updated National List of Threatened Philippine Plants and their Categories, only six (6) species were threatened. Apunan (*Diospyros cauliflora*), Rambutan (*Nephelium lappaceum*), and Narra (*Pterocarpus indicus*) were listed as vulnerable, while Tindalo (*Afzelia rhomboidea*) and Molave (*Vitex parviflora*) were endangered, and *Aglaia edulis* fell into the category of other threatened species, while the remaining five (5) species were not assessed. Among the notable species were Molave (*Vitex parviflora*) and Tindalo (*Afzelia rhomboidea*) (**Table 6**).

This result showed that there were eleven species recorded in this inventory that should be given priority for conservation because the ecological significance of any land formation relies not only on species richness but also on the number of native, endemic, and even threatened species present in the area [59].

Table 5. List of endemic species in the study area.

Family Name	Scientific Name	Common Name	Transect
Anacardiaceae	*Buchanania arborescens*	Balinghasai	1 & 2
	Semecarpus cuneiformis	Kamiring	1 & 2
Burseraceae	*Canarium hirsutum*	Pagsahingin	2
Euphorbiaceae	*Macaranga grandifolia*	Takip-asin	1 & 2
Moraceae	*Artocarpus blancoi*	Antipolo	1 & 2
	Broussonetia luzonica	Himbabao	1 & 2
	Ficus nota	Tibig	1 & 2
	Ficus pseudopalma	Niog-niogan	1 & 2
Rubiaceae	*Psychotria luzoniensis*	Tagpong-gubat	1 & 2

Table 6. Taxonomic list of Threatened species in the study area.

Family Name	Scientific Name	Common Name	DAO 2017-11	IUCN Redlist
Ebenaceae	*Diospyros cauliflora*	Apunan	VU	-
Euphorbiaceae	*Macaranga grandifolia*	Takip-asin	-	VU
Fabaceae	*Afzelia rhomboidea*	Tindalo	EN	VU
	Pterocarpus indicus	Narra	VU	EN
Lamiaceae	*Vitex parviflora Juss.*	Molave	EN	VU
Meliaceae	*Aglaia edulis*	Malasaging	OTS	NT
	Swietenia macrophylla	Mahogany	-	VU
	Sandoricum koetjape	Santol	-	VU
Moraceae	*Artocarpus blancoi*	Antipolo	-	VU
Myrtaceae	*Eucalyptus deglupta*	Bagras	-	VU
Sapindaceae	*Nephelium lappaceum*	Rambutan	VU	-

Legend: **VU**—Vulnerable; **EN**—Endangered; **OST**—Other Threatened Species; **NT**—Not assessed.

5. Conclusion and Recommendation

Based on the results, Barangay Nambalan is dominated by families Fabaceae, Moraceae, and Euphorbiaceae. There were 10 (17.2%) endemic species and 11 (21.6%) threatened species recorded in the area out of 52 species. From low to high elevation, the forest structure varies in terms of tree diameter, height, and species composition. These findings were influenced by the type of soil in the area, ground cover, types of species, elevation, and climatic conditions. The survey documented 52 species belong to 26 families and 46 genera, with 756 individuals. The most abundant, most frequent, and most important species found in the area was *Piliostigma malabaricum*, with 59 individual species, occurring in 9 out of 10 quadrats. In terms of species diversity, Barangay Nambalan is still diverse in terms of individual species but low in terms of species composition, with a Shannon-Weiner Index of 3.43 and Simpson Evenness of 0.7068.

The researcher recommends that laws governing timber cutting as stated in Section 77 of Presidential Decree (PD) 705 should be strictly enforced in order to reduce human activity in the area, such as illegal logging. Barangay local government units should craft a policy regarding land use plans to allocate their resources and protect the area's diversity. Also, the Barangay should conduct tree planting activities every year to conserve and protect their remaining resources in denuded forestland. Additionally, educate local residents, as well as the tourists who visit the area about the importance of native and endemic species through information education and communication publications. Furthermore, studies in other parts of the forest would be preferable to better assess its diversity so that the initial information gathered can be supplemented by additional survey data to create a good reference document for conservation and management in the area.

Acknowledgements

The authors sincerely thank the Barangay Local Government Unit (B.L.G.U.) and Hon. Arnold Reyes for granting permission to conduct the Diversity Assessment of Arborescent Flora. Special thanks are also extended to For. Julius G. Pascua, For. Mark Anthony L. Bagsit, and For. Christian Llait for their valuable assistance and suggestions throughout the research process. Finally, the authors would like to acknowledge the crucial support provided by the TAU CAF-Forestry Department, without which this publication would not have been possible.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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