INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 24, No. 3, p. 174-184, 2024
http://www.innspub.net

RESEARCH PAPER

OPEN ACCESS

Diversity assessment of fruit-bearing tree species in Don Mariano Marcos Memorial State University forest reserve

Angelo L. Lozano*[1], Mark Jerome L. Gimeno[1], Cindy E. Poclis[1,2], Jayric F. Villareal[1,2], Jay Mark G. Cortado[1]

[1] *Don Mariano Marcos Memorial State University, Bacnotan, La Union, Philippines*

[2] *College of Forestry and Environmental Studies, Mindanao State University, Maguindanao, Philippines*

Article published on March 18, 2024

Key words: Biodiversity conservation, Diversity indices, Native fruit trees

Abstract

This study was conducted to determine the diversity of fruit-bearing tree species in Don Mariano Marcos Memorial State University (DMMMSU) Forest Reserve. Specifically, the study aimed to inventory the fruit bearing tree species present in DMMMSU Forest Reserve, classify the fruit-bearing tree species in the study area, identify their conservation status, compute their importance value, and determine their distribution through diversity indices. There were 12 quadrats established with a dimension of 20 m x 20 m each. The study area was selected based on the presence of wide range of vegetation in DMMMSU Forest Reserve. There are 473 individual species identified at DMMMSU Forest Reserve belonging to 14 families with 24 species. One species recorded, *Tectona philippinensis* Benth. & Hook. f. Verbenaceae, was listed as endangered species. *Coffea* spp. had the highest density and importance value, and *Mangifera indica* L. had the highest frequency. The diversity indices had a relative value of moderate and high degree of diversity. Continuous protection of the Forest Reserve is therefore recommended. Planting of additional fruit-bearing tree species in the area with low diversity indices are recommended to increase diversity. Areas within the Forest Reserve with low plant diversity were recommended for planting and assisted natural regeneration programs using species with high importance value. Regular monitoring should be conducted in the Forest Reserve to assess the changes in diversity of fruit-bearing tree species to support decision-making and policy formulations.

***Corresponding Author:** Angelo L. Lozano ✉ alozano@dmmmsu.edu.ph

Introduction

Over the years, the forest has been a continuous source of fruits, wood, charcoal, and land for agricultural purposes that have led to present depletion (Kunwar and Sharma, 2004; Asifat *et al.*, 2019). Armenteras *et al.* (2009) reported that fruit trees have provided many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals. However, overexploitation of floristic composition has resulted in the rapid loss of tree diversity, which has been recognized as a major environmental and economic threat around the world (Mani and Parthasarathy, 2006). The quantification of tree species diversity is an essential aspect as it provides resources for many species (Suratman, 2012).

Philippine is one of the most important countries with potential of conserving the diversity of life on Earth (Ong *et al.*, 2002). Being one of the most mega diverse country in the world, Philippines holds a wide variety of lifeforms in both aquatic and terrestrial a wide variety of life forms in both aquatic and terrestrial ecosystems. The country is also one of the hottest biodiversity hotspots with exceptional concentrations of endemic species but is experiencing a continuous and exceptional loss of habitat (Biodiversity, 2014). A number of threatened plant species can be found in the Philippines (Fernando *et al.*, 2008). According to Tyrvainen *et al.* (2005), Philippines rank 23rd in the world and 6th in Southeast Asia in being diverse with 5,832 endemic species out of 7620 documented species in the country. The country has more than 300 edible fruits but only few are commercially cultivated. However, modest efforts are being implemented to develop fruit varieties that can be registered and recommended for planting (Villegas, 2021).

According to SF Gate Contributor (2016), fruit bearing trees are trees that bear fruit for human and animal consumption. All trees that are flowering plants produce fruit, which are the ripened ovaries of flowers containing one or more seeds. The many benefits of growing fruit trees include their yield of fresh, locally grown food. As another advantage, fruit trees grow well in urban and suburban settings. From a social aspect, fruit trees help people become connected to the growing process while also providing a nutritious food source and food security. Planting fruit trees also has many helpful environmental benefits, from cleaner air to reduced energy costs and green jobs. Fruit trees also produce food even during difficult times when other garden produce may be hard to obtain. They also provide other benefits that include lumber, poles, medicine, income, shade, firewood, ornamental value, soil improvement, reforestation, and protection of the environment (Echo Community, 2014).

Tree species diversity is defined as the number of species and abundances of each species that live in a particular location (Tyvainen *et al.*, 2005). Assessing the tree diversity in an area is essential in analysing forest stand status considering that trees play vital roles in maintaining ecological processes and in providing a source for human consumption. Performing such assessment can provide necessary information in identifying problems with respect to the trees present in the country. Appropriate measures will only be possible if species present in an area are identified. Also, increasing forest tree species diversity is an important component in building resilience to climate change and reducing the risk from pests. Measuring species diversity allows us to identify forests with lower or higher species diversity (Mace, 2004).

The DMMMSU Forest Reserve is located in Sapilang, Bacnotan La Union. It has approximate area of 1,147 hectares. There is scarcity on the availability of updated data on the diversity of fruit trees in the forest reserve. This may hinder efforts to harness the full potential of fruit tree species in enhancing forest productivity, promoting sustainable land management practices, mitigating the impacts of climate change, and poses a considerable information barrier to various stakeholders, including policymakers and forestry extension agents. Hence, the study was conducted.

Materials and methods

Research design

The study was conducted using descriptive statistics. There were four areas selectively sampled in the forest reserve of DMMMSU considering aspect directions (N, S, E, W) with the campus oval as a point of reference. In each area, there were three quadrats established with a dimension of 20 m x 20 m each with 250 m intervals following the methodology of Coracero and Malabrigo (2020).

Determination of conservation status

Reliable data resources were used to check the International Union for Conservation of Nature (IUCN) conservation status and distribution of fruit bearing tree species such as the official website of Botanical Gardens Conservation International (tools.bgci.org), and IUCN (iucnredlist.org). The Department Administrative Order 2017-11 showing the list of Threatened Philippine Plants and their Categories will be downloaded from the official website of the Department of Environment and Natural Resources (denr.gov.ph). Moreover, Co's Digital Flora of the Philippines (philippineplants.org) was also used to classify the fruit bearing tree species.

Data gathered

Species name: The fruit bearing tree species inside the quadrats were identified and recorded.

Species population: The fruit bearing tree species were counted and recorded.

Density: This was done by calculating the number of individuals divided by the total area sampled.

Density= (Number of individuals)/(Total area sampled)

Relative density: This was gathered by calculating the number no. of individuals species divided by the total no. of individuals of all species, multiplied by one hundred (100).

Relative density= {(No. of individuals of a species)/(Total no. of individuals)}×100

Frequency: This was gathered by calculating the number of plots in which species occurs divided by the total of plots sampled.

Frequency= (Number of plots in which a species occurs)/ (Total number of plots sampled)

Relative frequency: This was gathered by calculating the frequency divided by the total frequency of all species in different plots, multiplied by one hundred (100).

Relative frequency= {(Frequency of species)/(Total frequency)}×100

Importance value: This was gathered by adding relative density and relative frequency.

Importance value (IV) = relative density + relative frequency

Diversity indices: These were gathered following the formula of the Shannon-Weiner index and Simpson's diversity index.

Simpson's Index of Diversity

$D= (\Sigma\ ni\ (ni-1)/N\ (N-1)$

Where

n- the number of organisms that belong to species i

N- the total number of organisms

Shannon- Wiener Index

$H' = -\Sigma\ pi \times \ln pi$

Where

Pi- proportion of individual

ln- natural logarithm

The formula used was based on the study of Curtis & Mclntosh (1995).

Data analysis

The data gathered were arranged, tabulated, processed and statistically analyzed using the Microsoft excel software for the computation of vegetational analysis of density, relative density, frequency, relative frequency, and the importance value. Also, Shannon Weiner and Simpson diversity indices were used to analyze the diversity of the study area.

Results and discussion

Fruit bearing tree species

There were 14 families recorded in this study wherein Moraceae family recorded six (6) species, Myrtaceae, and Rutaceae each recorded three (3) species, Lamiaceae recorded two (2) species, while Euphorbiacaea, Malvaceae, Rubiaceae, Annonaceae, Araliacaea, Anacardiaceae, Clusiaceae, Fabaceae, Meliaceae and Sapindaceae each with only one (1) species, as presented in Table 1.

Table 1. List of identified fruit-bearing tree species in the DMMMSU forest reserve

Family Name	Common Name	Scientific name	No. of individual fruit trees
Anacardiaceae	Mangga	*Mangifera indica* L.	34
Annonaceae	Guyabano	*Annona muricata* L.	35
Araliacaea	Malapapaya	*Polyscias nodosa* (Blume) Seem.	55
Clusiaceae	Mangosteen	*Garcinia mangostana* L.	4
Euphorbiaceae	Binunga	*Macaranga tanarius* (L.) Muell.-Arg.	24
Fabaceae	Sampalok	*Tamarindus indica L.*	1
Lamiaceae	Gmelina	*Gmelina arborea* Roxb.	15
Lamiaceae	Philippine Teak	*Tectona philippinensis* Benth. & Hook. f. Verbenaceae	4
Malvaceae	Cacao	*Theobroma cacao* L.	5
Meliaceae	Santol	*Sandoricum koetjape* Merr.	10
Moraceae	Alim	*Melanolepis multiglandulosa* (Reinw. Ex Blume) Rchb. & Zoll	1
Moraceae	Hauili	*Ficus septica* Burm. F.	16
Moraceae	Kalukoi	*Ficus callosa* Willd.	28
Moraceae	Kamansi	*Artocarpus altilis* (Park.) Fosb.	13
Moraceae	Tibig	*Ficus nota* (Blanco) Merr.	35
Moraceae	Upling Gubat	*Ficus ampelas* Burm.	10
Myrtaceae	Bayabas	*Psidium guajava* L.	7
Myrtaceae	Duhat	*Syzygium cumini* (L.) Skeels	10
Myrtaceae	Hagis	*Syzygium tripinnatum* (Blanco) Merr.	33
Rubiaceae	Coffee	*Coffea spp.*	60
Rutaceae	Calamansi	*Citrufotunella microcarpa* (Bunge) Wijnands	18
Rutaceae	Mandarin	*Citrus reticulate* L.	8
Rutaceae	Suha	*Citrus maxima* (Burm.) Merr.	10
Sapindaceae	Rambutan	*Nephelium lappaceum* L.	37

References: Co's Digital Flora of the Philippines, & IUCN Red List of Threatened Species (2021).

Table 2. Classification of fruit-bearing tree species in the study area

Classification/categorization	Common name	Scientific name
Endemic	Alim	*Melanolepis multiglandulosa* (Reinw. Ex Blume) Rchb. & Zoll
Endemic	Hauili	*Ficus septica* Burm. F.
Endemic	Tibig	*Ficus nota* (Blanco) Merr.
Endemic	Upling Gubat	*Ficus ampelas* Burm.
Endemic	Philippine Teak	*Tectona philippinensis* Benth. & Hook. f. Verbenaceae
Exotic	Coffee	*Coffea spp.*
Exotic	Gmelina	*Gmelina arborea* Roxb.
Exotic	Guyabano	*Annona muricata* L.
Exotic	Rambutan	*Nephelium lappaceum* L.
Native	Bayabas	*Psidium guajava* L.
Native	Binunga	*Macaranga tanarius* (L.) Muell.-Arg.
Native	Cacao	*Theobroma cacao* L.
Native	Calamansi	*Citrufotunella microcarpa* (Bunge)Wijnands
Native	Duhat	*Syzygium cumini* (L.) Skeels
Native	Hagis	*Syzygium tripinnatum* (Blanco) Merr.
Native	Kalukoi	*Ficus callosa* Willd.
Native	Kamansi	*Artocarpus altilis* (Park.) Fosb.
Native	Malapapaya	*Polyscias nodosa* (Blume) Seem.
Native	Mandarin	*Citrus reticulate* L.
Native	Mangga	*Mangifera indica* L.
Native	Mangosteen	*Garcinia mangostana* L.
Native	Sampalok	*Tamarindus indica L.*
Native	Santol	*Sandoricum koetjape* Merr.
Native	Suha	*Citrus maxima* (Burm.) Merr.

Reference: Co's Digital Flora of the Philippines & IUCN Red List of Threatened Species (2021).

On the other hand, *Coffea* spp. recorded the highest number of individual fruit trees accounting 60 trees while *Melanolepis multiglandulosa* (Reinw. Ex Blume) Rchb. & Zoll and *Tamarindus indica* L. recorded the fewest number of individuals with both one tree. Moraceae trees exhibit remarkable adaptability to diverse environmental conditions, including tropical, subtropical, and temperate regions. They can thrive in a wide range of soil types and climates, making them widespread across different habitats (Berg, 2003). According to Harrison (2005), many species within the Moraceae family have evolved effective reproductive strategies, such as prolific fruit production and varied dispersal mechanisms. This enhances their ability to colonize new areas and establish stable populations.

According to Comita and Hubbell (2009), High competition for resources such as light, water, and nutrients can lead to certain tree species being outcompeted by others, resulting in lower individual frequencies. Tree species with limited dispersal mechanisms or low reproductive rates may naturally occur at lower frequencies within a given area (Leimu & Fischer, 2008). In ecosystems where competition for resources is intense, dominant tree species often outcompete less abundant species like *Melanolepis multiglandulosa* (Reinw. Ex Blume) Rchb. & Zoll and *Tamarindus indica* L. This competitive exclusion can occur due to differences in growth rates, resource utilization efficiency, or allelopathic interactions, leading to the suppression of low-frequency species (Connell, 1980).

Classification of fruit bearing trees

There were 15 (62.50%) native trees, four (5) (20.80%) endemic trees, and four (4) (16.70%) exotic trees identified in the study area (Table 2).

The result of the study indicated that DMMMSU Forest Reserve area is in good condition considering the abundance of native fruit trees. Interactions with other organisms, such as mutualistic relationships with pollinators and seed dispersers, can enhance the reproductive success and spread of native trees (Parker *et al.*, 2006). Also, the university had implemented various programs and initiatives to promote environmental sustainability and conservation, such as planting a variety of tree species, including fruit trees, timber trees, and other native species, waste segregation and management, and other environmental awareness campaigns. Moreover, the campus is considered as a “green campus” because of its diverse floral species.

Conservation status

There are 23 species fall under the status of least concerned, and one (1) species identified is endangered and that species is Philippine (Fig. 1 &2).

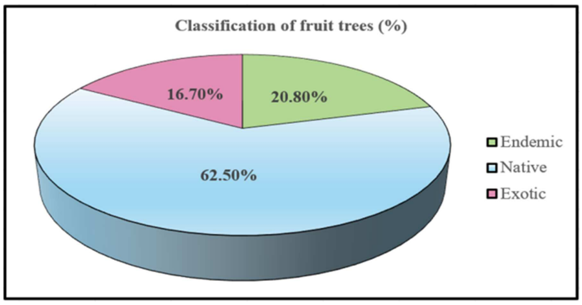

Fig. 1. Classification of fruit bearing tree species in the study area

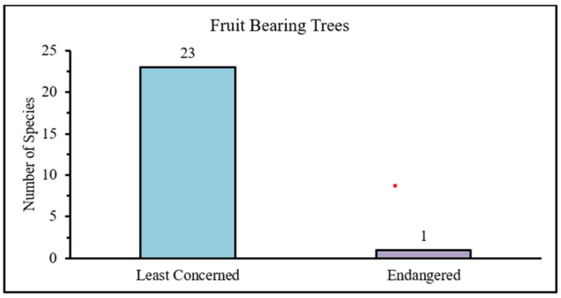

Fig. 2. Conservation status of fruit bearing tree species in the study area

Most of the tree species identified as "Least Concerned," it indicates that these species are currently in a stable condition with healthy populations and minimal threats to their survival. This could be due to various factors such as effective conservation efforts, suitable habitat conditions, and absence of significant human-induced disturbances. According to International Union for Conservation of Nature (2022), When a species is categorized as "Least Concern" in terms of conservation status, it implies that the species is not currently facing any significant threats to its survival. This classification is used to assess the risk of extinction faced by different species.

Table 3. Frequency, relative frequency, density, relative density, and importance value of identified fruit trees in the DMMMSU forest reserve

Common Name	Frequency (%)	Relative Frequency (%)	Rank	Density	Relative Density	Rank	Importance Value	Rank
Mangga	100	10.53	1	0.0142	7.19	5	17.72	2
Kamansi	75	7.89	2	0.0054	2.75	12	12.65	7
Tibig	75	7.89	2	0.0146	7.4	4	15.29	3
Binunga	50	5.26	3	0.01	5.07	8	10.33	9
Coffee	50	5.26	3	0.025	12.68	1	17.94	1
Guyabano	50	5.26	3	0.0146	7.4	4	12.66	6
Hagis	50	5.26	3	0.0138	6.98	6	12.24	8
Hauili	50	5.26	3	0.0067	3.38	10	8.64	10
Rambutan	50	5.26	3	0.0154	7.82	3	13.08	5
Upling Gubat	50	5.26	3	0.0042	2.11	13	7.37	12
Alim	25	2.63	4	0.0004	0.21	18	2.84	20
Bayabas	25	2.63	4	0.0029	1.48	15	4.11	17
Cacao	25	2.63	4	0.0021	1.06	16	3.69	18
Calamansi	25	2.63	4	0.0075	3.81	9	6.44	13
Duhat	25	2.63	4	0.0042	2.11	13	4.74	15
Gmelina	25	2.63	4	0.0063	3.17	11	5.8	14
Kalukoi	25	2.63	4	0.0112	5.92	7	8.55	11
Malapapaya	25	2.63	4	0.0229	11.63	2	14.26	4
Mandarin	25	2.63	4	0.0033	1.69	14	4.32	16
Mangosteen	25	2.63	4	0.0017	0.85	17	3.48	19
Sampalok	25	2.63	4	0.0004	0.21	18	2.84	20
Santol	25	2.63	4	0.0042	2.11	13	4.74	15
Suha	25	2.63	4	0.0042	2.11	13	4.74	15
Philippine Teak	25	2.63	4	0.0017	0.85	17	3.48	19
Total		100		0.19708	100			

Tectona philippinensis (Benth. & Hook. family Verbenaceae.) commonly known as teak, is a species of tree endemic to Philippines. It is highly valued for its durable timber, which is used in various applications such as furniture, shipbuilding, and construction (CABI, 2019). The Philippine teak populations have declined significantly in recent decades due to a range of factors, including deforestation, habitat loss, and overexploitation for its valuable timber (Kollert and Kleine, 2017). Similarly, Hallett *et al.* (2011), found that the natural populations of Philippine teak have been declined drastically because mainly of overexploitation and deforestation.

Importance value

The Table 3 shows the Frequency, Relative Frequency, Density, Relative Density, and Importance Value of Identified Fruit Trees. The result showed that the highest frequency and relative frequency was obtained by *Mangifera indica* L., while the highest density, relative density, and importance value was obtained by *Coffea* spp.

Mangifera indica L. possess ecological adaptations that allow it to thrive in the environmental conditions of the tropical dry deciduous forest. These adaptations could include tolerance to drought, resistance to pests and diseases, or efficient resource utilization strategies (Raha, 2023). Mango by the virtue of its perennial nature of woody framework locks major proportion of nutrients in stems, branches, and leaves. Their extended physiological stages of growth, differential root distribution pattern, growth stages from the point of view of nutrient requirement and preferential requirement of some nutrients like calcium, boron etc., collectively make it nutritionally more efficient than any annual crops. Mango has the ability for colonization in low fertility soils and dry-land areas by virtue of long leaf life span, leaf nutrient resorption efficiency, nutrient use efficiency and nutrient proficiency (Ganeshamurthy and Reddy, 2015). According to Akin-Idowu *et al.* (2020), Mango is cultivated on all soil types like alluvial soils, red soils, laterite soils, black soils and both in hills and plains and plateau regions and on both shallow and deep-rooted soils. Being a very hardy crop mango tolerates a varying degree of flooding, drought, salinity and acidity. This wide adoptability of mango is because of existence of both calcicole and calcifuge mangos in India and they occupy such regions suitable to those genotypes.

According to Food and Agriculture Organization of the United Nations (2015), Mango trees can adapt to a range of environmental conditions, including varying soil types, moisture levels, and climatic conditions. This adaptability allows them to thrive in diverse locations. Moreover, Mango trees develop a deep and extensive root system, which enables them to access water and nutrients from deeper soil layers, enhancing their ability to survive in regions with limited rainfall or drought conditions.

Meanwhile, the high density of *Coffea* spp. corresponds to an existing coffee plantation adjacent to the area where the study was conducted. The area was observed to have dominant tree species that provide shading to understory species like the coffee. According to Craves (2006), most varieties of coffee are naturally intolerant of direct sunlight and grow well under a canopy of sun-filtering shade trees. Avila *et al.* (2013) found that the high density of coffee trees is due to their ability to grow and reproduce rapidly under shade conditions, as well as their economic importance for local farmers. Coffee is an exotic species of trees to the Philippines. Exotic trees are known for their ability to become nuisance due to their rapid growth abilities. If these plants can grow and thrive in an area, there is a very high chance that they could outgrow the native plants and takeover the soil, causing any native plants or trees in the area to die (Oliveria, 2020). Exotic species are one of the most serious threats for native ecosystems by directly limiting the growth of native species sapling, as well as by increasing competition in the regeneration layer by self-sowing (Brundu, 2016).

Furthermore, *Coffea* spp. has the highest importance value, a common fruit tree species and scattered within the vicinities of DMMMSU. The fruits can be consumed by human and animals (Grant, 2019). Also, Amponsah *et al.* (2017) found that the high importance value of *Coffea* spp. may be due to its ability to tolerate a wide range of environmental conditions, its widespread distribution, and its economic value as a fruit tree. They also noted that the species has a long history of cultivation and may have been introduced to the region by humans.

Diversity index

The Shannon Weiner Diversity obtained a value of 2.85 with a relative value of moderate diversity, while the Simpson Diversity Index's result obtained 0.93 with a relative value of high degree of diversity. The high diversity index in the research study area could be an indication of a relatively healthy and well-preserved forest ecosystem, despite the overall declining forest cover in the Philippines. It could also mean that conservation efforts, such as reforestation and sustainable forestry practices, have been effective in study area. According to Krebs (2014), Moderate diversity levels often correlate with ecosystem stability. A diverse ecosystem can better withstand environmental changes and disturbances, as it has a greater variety of species with different ecological roles and functions. Similarly, Gotelli and Colwell (2011) indicate that a moderate diversity level implies that the habitat provide suitable conditions for a range of species to coexist, including those with different ecological requirements.

Studies have shown that degraded forests in the Philippines have lower diversity indices compared to healthy forests. Moreover, the diversity index of degraded forests in Bukidnon, Philippines for Shannon Weiner Diversity is 1.2 and for Simpson Diversity Index is 0.7 (Coritico *et al.*, 2020), and in Mount Makiling ranged from 1.41 to 3.19 (Abraham *et al.*, 2010) which are relatively lower than the diversity index of the present study with respect to Shannon Weiner Diversity. Furthermore, a study by Mallinis *et al.* (2020) showed that the Shannon Weiner Diversity index had a value of 0.44 and for Simpson Diversity Index is 0.37 which relatively lower than the diversity index of the study conducted in DMMMSU Forest Reserve. The results also comparable to the study of Ifo *et al.* (2016), a study conducted in degraded forest in tropical rainforest of Congo Basin where the result is 0.75 which relatively lower than the diversity index of the study with respect to Simpson Diversity Index. However, it is important to note that diversity indices are only one aspect of forest health and cannot provide a complete picture of the overall health and biodiversity of a forest. Other factors, such as forest structure, soil quality, and ecosystem functions, should also be considered.

According to the Forest Management Bureau (FMB), the estimated forest cover of the Philippines as of 2023 is 7,226,394 hectares and it increase 3% for the 5 years. In this context, a Shannon Weiner of moderate and Simpson Diversity of high diversity suggest that the forest area of DMMMSU has a relatively moderate and high level of species richness and evenness, despite the overall decline in forest cover in the Philippines. It may also indicate that the studied forest area has a higher conservation value than other areas that have experienced greater levels of deforestation and habitat degradation. However, it is important to note that the specific location and characteristics of the forest area studied may have a significant impact on the interpretation of the diversity index.

Conclusion

There were 473 individual tree species identified at DMMMSU Forest Reserve belonging to 14 families with 24 species. The Moraceae family was recorded as the most abundant family in the study area. There were 16 native trees, five (5) endemic trees, and four (4) exotic trees were classifieds. There were 23 species classified as least concerned and one (1) species classified as endangered. *Coffea* spp. obtained the highest relative density and importance value, while *Mangifera indica* L. obtained the highest relative frequency; and Shannon Weiner Diversity revealed that there is a moderate value of tree species diversity in DMMMSU Forest Reserve, while Simpson Diversity Index's revealed that there is a high degree of diversity of fruit trees in DMMMSU Forest Reserve.

Recommendations

Continuous protection of the Forest Reserve is therefore recommended. Planting of additional fruit-bearing tree species in the area with low diversity indices are recommended to increase diversity. Areas within the Forest Reserve with low plant diversity were recommended for planting and assisted natural regeneration programs using species with high importance value. Regular monitoring should be conducted in the Forest Reserve to assess the changes in diversity of fruit-bearing tree species to support decision-making and policy formulations, such as forest conservation measures.

References

Aban JL. 2015. Parents attitudes on the environment and their familiarity and perspectives on environmental education: A thrust to DMMMSU-NLUC's status as the most eco-friendly campus in Region 1. 3rd National Multidisciplinary Research Conference, University of Northern Philippines - Vigan City, Ilocos Sur, April 27- 29, 2015. pp. 1-17.

Abraham ERG, Gonzalez JCT, Castillo ML, Lit Jr IL, Fernando ES. 2010. Forest cover and biodiversity profile of the crater area of Mt. Makiling, Luzon, Philippines. Asia Life Sciences-The Asian International Journal of Life Sciences **4**, 49-82.

Akin-Idowu PE, Adebo UG, Egbekunle KO, Olagunju YO, Aderonmu OI, Aduloju AO. 2020. Diversity of mango (*Mangifera indica* L.) cultivars based on physicochemical, nutritional, antioxidant, and phytochemical traits in Southwest Nigeria. International Journal of Fruit Science **20**(sup2), S352-S376.

Amponsah IG, Cobbinah JR, Ayivor JS. 2017. Tree species diversity, structure and regeneration in a tropical forest reserve in Ghana. International Journal of Biodiversity and Conservation **9**(9), 281-293.

Armenteras D, Rodríguez N, Retana J. 2009. Are conservation strategies effective in avoiding the deforestation of the Colombian Guyana Shield? Biological Conservation **142**, 1411-1419. https://doi.org/10.1016/j.biocon.2009.02.002.

Asifat JT, Oyelowo O, Orimoogunje OI. 2019. Assessment of Tree Diversity and Abundance in Selected Forest Reserves in Osun State, Southwestern Nigeria. Open Access Library Journal **6**, 1-16.

Avila JM, López-Sánchez CA, Romo-Vázquez R. 2013. Diversity and composition of woody plant species in a shade coffee agroecosystem in Veracruz, Mexico. Agroforestry Systems **87**(5), 1169-1180.

Berg CC. 2003. Flora Malesiana precursor for the treatment of Moraceae 1: the main subdivision of Ficus: the subgenera. Blumea-Biodiversity, Evolution and Biogeography of Plants **48**(1), 166-177.

Biodiversity A-Z. 2014. Megadiverse Countries. Retrieved on May 16, 2022 from http://www.biodiversitya.org/content/megadiverse-countries.

Brundu G, Richardson DM. 2016. Planted forests and invasive alien trees in Europe: A Code for managing existing and future plantings to mitigate the risk of negative impacts from invasions. NeoBiota **30**, 5-47.

CABI DIGITAL LIBRARY. (2019). *Tectona grandis*. Retrieved on https://doi.org/10.1079/cabicompendium.52899

Comita LS, Hubbell SP. 2009. Local neighborhood and species' shade tolerance influence survival in a diverse seedling bank. Ecology ***90***(2), 328-334.

Coracero EE, Malabrigo Jr PL. 2020. Diversity Assessment of Tree Species in Sitio Dicasalarin, Barangay Zabali, Baler, Aurora, Philippines.

Coritico FP, Lagunday NE, Galindon JMM, Tandang DN, Amoroso VB. 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.

Conservation International. 2005. Biodiversity Hotspots. Retrieved on May 20, 2022 from http://www.cnrs.fr/inee/recherche/fichiers/Biodiversite_hotspots.pdf.

Connell JH. 1980. Diversity and the coevolution of competitors, or the ghost of competition past. Oikos 131-138.

CO, L., JR. (2017). Digital Flora of the Philippines. Retrieved from http://philippineplants.org/

Curtis JT, Mclntosh RP. 1950. The interrelations of certain analytic and synthetic phytosociological characters. Ecology **31**(3), 434-455. https://doi.org/10.2307/1931497

Craves J. 2006. What is shade-grown coffee? Retrieved on April 5, 2023 from https://www.coffeehabitat.com

Echo Community. 2014. Fruit Trees. Retrieved on June 08, 2022 from https://www.echocommunity.org/en/resources/a7fl5d-539-4daa-aa65 2131c05e322a

Forest Management Bureau (FMB). 2023. Administrative Order No. 01, Series of 2011: Guidelines on the Establishment and Management of the National and Provincial Forest Tree Parks. Forest Management Bureau, Department of Environment and Natural Resources, Republic of the Philippines.

Food And Agriculture Organization of The United Nations. 2015. Mango growing. Retrieved from http://www.fao.org/3/a-i7846e.pdf

Fernando ES, Co LC, Lagunzad DA, Gruezo BJ, Madulid DA, Zamora PM. 2008. Threatened plants of the Philippines: a preliminary. Asia Life Sci. **3**, 1-52.

Ganeshamurthy AN, Reddy YTN. 2015. Fitness of mango for colonization in low fertility soils and dry lands: Examination of leaf life-span, leaf nutrient resorption, and nutrient use efficiency in elite mango varieties. Agricultural research **4**, 254-260.

Gotelli NJ, Colwell RK. 2011. Estimating Species Richness. In: Biological Diversity: Frontiers in Measurement and Assessment, Oxford University Press, United Kingdom, 39-54.

Global Forest Watch. 2022. Philippine Deforestation Rate and Statistics. Retrieved on February 10, 2024 from https://www.globalforestwatch.org/dashboards/country/PHL/

Grant B. 2019. Information About Mango. Retrieved on April 1, 2023 from https://www.gardeningknowhow.com

Hallett JT, Díaz-Calvo J, Villa-Castillo J, Wagner MR. 2011. Teak plantations: economic bonanza or environmental disaster? Journal of Forestry **109**(5), 288-292.

Harrison RD. 2005. Figs and the diversity of tropical rainforests. Bioscience **55**(12), 1053-1064.

Ifo SA, Moutsambote JM, Koubouana F, Yoka J, Ndzai SF, Bouetou-Kadilamio LNO, Joel LJ. 2016. Tree species diversity, richness, and similarity in intact and degraded forest in the tropical rainforest of the Congo Basin: case of the forest of Likouala in the Republic of Congo. International Journal of Forestry Research, 2016.

International Union for Conservation of Nature (IUCN). 2021. The IUCN Red List of Threatened Species. Version 2021-1. Retrieved from https://www.iucnredlist.org

Kacholi DS. 2014. Analysis of structure and diversity of the Kilengwe forest in the Morogoro region, Tanzania. International Journal of Biodiversity.

Kollert W, Kleine M. 2017. The Global Steak Study "Analysis, Evaluation and Future Potential of Teak Resources. IUFRO World Series Volume 36. Vienna. 108p.

Kunwar RM, Sharma SP. 2004. Quantitative Analysis of Tree Species in Two Community Forests of Dolpa District, Mid-West Nepal. Himalayan Journal of Sciences **2**, 23-28. Retrieved on April 27, 2022 from https://doi.org/10.3126/hjs.v2i3.226

Krebs CJ. 2014. Ecological Methodology. 3. ed. In preparation. Available: Retrieved on May 06, 2022 from http://www.zoology.ubc.ca/~krebs/books.html [2014, 10.10.].

Krebs CJ. (2014). Ecology: The Experimental Analysis of Distribution and Abundance. Benjamin Cummings.

Lafrankie JV, Primavera JH, Paragas-Parayno L, Bandiola D, Vergara S, Siringan F. 2006. Assessment of degraded lowland dipterocarp forest in Samar Island Natural Park, Philippines. Silliman Journal **47**(2), 110-136.

Leimu R, Fischer M. 2008. A meta-analysis of local adaptation in plants. PloS one **3**(12), e4010.

Mace GM. 2004. The Role of Taxonomy in Species Conservation. Philosophical Transactions of the Royal Society **359**, 711-719. https://doi.org/10.1098/rstb.2003.1454

Mallinis G, Chrysafis I, Korakis G, Pana E, Kyriazopoulos AP. 2020. A random forest modelling procedure for a multi-sensor assessment of tree species diversity. Remote Sensing **12**(7), 1210.

Mani S, Parthasarathy N. 2006. Tree Diversity and Stand Structure in Inland and Coastal Tropical Dry Evergreen Forests of Peninsular India. Current Science 1238-1246.

Oliveira W. 2020. Urban Forestry and Urban Greening. Retrieved on March 28, 2023 from https://doi.org/10.1016/j.ufug.2020.126659

Ong PS, Afuang LE, Rosell-Ambal RG. 2002. Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan. Retrieved on April 27, 2022 from https://www.fishbase.de/References/FBRefSummary.php?id=45694&lang=laos

Parker JD, Burkepile DE, Hay ME. 2006. Opposing effects of native and exotic herbivores on plant invasions. Science **311**(5766), 1459-1461.

Raha D. 2023. Tree diversity, stand structure and species composition in three tropical dry deciduous forests of Madhya Pradesh, Central India. Proceedings of the International Academy of Ecology and Environmental Sciences **13**(4), 158.

Suratman MN. 2012. Tree Species Diversity and Forest Stand Structure of Pahang National Park, Malaysia. Biodiversity Enrichment in a Diverse World **19**, 45-56.

SF Gate Contributor. 2016. How do Fruit Trees Help Environment. Retrieved on June 10, 2022 from https://homeguides.sfgate.com/fruit-trees-environment-59135.html

Tyrväinen L, Pauleit S, Seeland K, Vries SD. 2005. Benefits and uses of urban forests and trees. In *Urban forests and trees* (pp. 81-114). Springer, Berlin,Heidelberg.

Villegas Violeta N. 2021. Breeding new fruit varieties in the Philippines. Journal Article, 3204. https://www.ukdr.uplb.edu.ph/journal-articles/3204