INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 24, No. 1, p. 30-39, 2024
http://www.innspub.net

RESEARCH PAPER

OPEN ACCESS

Diversity and regeneration status of wildlings in Mt. Pangasugan, Philippines

Angelica P. Baldos*

Department of Forest Science, College of Forestry and Environmental Science,
Visayas State University, Visca, Baybay City, Philippines

Article published on January 06, 2024

Key words: Biodiversity, Tree recruitment, Forest restoration, Reforestation, Sustainable forest management

Abstract

Mt. Pangasugan is not only a refuge of endangered flora and fauna but also a source of water, food, wood and non-wood products. The pressure is considerably strong for Mt. Pangasugan since it is bounded by communities where its population is dependent on the forest for fuelwood, timber, and food. The composition, diversity, and regeneration status of wildlings in a secondary forest on Mt. Pangasugan were evaluated in this study. Three sites were studied, each of which was chosen and classed depending on elevation. Twenty-seven one-meter by one-meter subplots were used to obtain data on natural regeneration of tree species of less than one meter in height. A total of 24 species from 16 families were observed. The Shannon-Wiener index was used to describe species diversity, which showed that the site on the lower slope has the highest species composition with an H' value of 2.18 and is more diverse than the middle and upper slopes, with H' values of 1.93 and 1.69, respectively. Using the Jaccard similarity index, the lower and middle slopes shared 35 percent of the species composition, much more than the middle and upper slopeswhich was 23 percent, and the lower and upper slopes, 22 percent. Regeneration status of all sites was categorized as good suggesting of several positive ecological conditions and management practices. Assessing the regeneration status of a forest requires a comprehensive understanding of the local ecology, environmental conditions, and the specific species present in the forest. Regular monitoring and research are essential to ensure the continued health and sustainability of the forest ecosystem.

***Corresponding Author:** Angelica P. Baldos ✉ angelica.baldos@vsu.edu.ph

Introduction

The island of Leyte in the Philippines is part of the Mindanao-Eastern Visayas Ecoregion. It serves as a biodiversity corridor providing link on the assemblage of species between Mindanao and Luzon (Heaney *et al.*, 1989). Leyte has a remaining forest cover of 74,922 ha compared to the total forest cover of Region 8 (region comprising the islands of Leyte, Samar, and Biliran) which is 511,962 ha (Forest Management Bureau, 2018). Within Leyte are two proclaimed watershed forest reserves, the Palompon Watershed Forest Reserve with an area of 2,392 ha and Patag-Gabas Watershed Forest Reserve with an area of 582 ha (FMB, 2018). There are also three land-based protected areas (PAs) in Leyte namely: Lake Danao Natural Park in Ormoc City, Mahagnao Volcano Natural Park in Burauen and La Paz Leyte, and Kuapnit-Balinsasayao National Park in Abuyog and Baybay, Leyte. Leyte Island is vulnerable to and heavily impacted by effects of climate change. In the last 10 years, a number of extreme weather events (e.g. Supertyphoons Haiyan and Megi) have devastated the region. The region is also considered one of the most underdeveloped regions in the country with communities dependent on resources from its forests posing a threat to one of the last remaining intact forest ecosystems in Leyte island.

Several studies conducted before in Mt. Pangasugan were focused on soils (Sueta *et al.*, 2007; Susaya and Asio 2005, Zikeli *et al.*, 2000, Navarrete et al 2009, Villasica *et al.*, 2018, Batistel and Asio, 2008) but only very limited on its flora and fauna. Most of the researches especially on flora of Mt. Pangasugan were conducted under the ViSCA-gtz Ecology Program in the 1990s and researches thereafter were very limited or non-existing. The most important botanical studies so far conducted was that of Langenberger (2006) and Langenberger and Belonias (2011), although there were also studies that focused on specific group of plants such as pteridophytes (Belonias and Bañoc, 1994), dicot flora (Belonias, 2002), monocots (Po-Abit, 2008), and selected rare tree species (Peque, 2009). With the passage of time, there could have been changes in the ecological status of plants and animals in Mt. Pangasugan which were brought about by land use and landscape changes, climate change, and anthropogenic disturbances.

Mt. Pangasugan is not only a refuge of endangered flora and fauna but also a source of water, food, wood and non-wood products. The pressure is considerably strong for Mt. Pangasugan since it is bounded by communities where a number of its population is dependent on the forest for fuelwood, timber, and food. Currently, its management is under VSU with only minimal participation of its stakeholders. The conversion of land to satisfy societal needs has grown frequently, which is the primary cause of forestland loss. Excessive logging (both legal and illegal), conversion of forestland to agricultural land uses, recreational areas, and natural disturbances like typhoons and landslides have all contributed to the continued depletion of forests.

The ability of a tree species' seedlings and saplings to survive and thrive is critical to its regeneration and successful forest regeneration is the most crucial step toward long-term forest sustainability. Evaluating the natural regeneration potential of plants is essential for informed and sustainable ecosystem management contributing to biodiversity conservation, habitat restoration, and the overall health of natural systems (Dutta and Devi, 2013). This information is valuable for addressing environmental challenges and promoting the long-term resilience of ecosystems. Considering the economic value (Bulayog, 1998), high conservation status, and current threats to the biodiversity of Mt. Pangasugan, this study examined the floral composition and explored the regeneration condition of its tree species to give insight into the future forest composition of Mt. Pangasugan. The results will become a key input to the development of Biodiversity Conservation and Management Program for Mt. Pangasugan (BIOCAMP).

Materials and methods

Site description

The study was conducted on the western flank of Mt. Pangasugan, Baybay City Leyte (10°34'32" N, 125°1'30" E) located west of the Philippine fault line, which runs roughly through the middle of Leyte Island (Asio 1996), inside the forest that is 150 km^{-2} or more in size (Heaney *et al*., 1989) and managed by Visayas State University (VSU) (Fig. 1). Mt. Pangasugan is part of the so-called Leyte Cordillera, which is a long range of mountains from Capoocan to Baybay in Leyte Island where intact forest is still found (Langenberger, 2000). A portion of Mt. Pangasugan is within the Patag-Gabas Watershed Forest Reserve and is also part of the Anonang-Lobi Range which is considered an endemic bird area where threatened red and restricted-range species such as Samar Hornbill, Visayan Broadbill and Yellow-breasted Tailorbird have been recorded (BirdLife International, 2021).

Fig. 1. Location of the study conducted in (A) Leyte Island in the Philippines in (B) Baybay City, on three elevations marked Sites 1 to 3 (white dots) in (C) Mt. Pangasugan. Google Maps 2024.

On easily accessible areas of the forest are shifting cultivation farms interspersed with small plantations while the more difficult to access areas still contain undisturbed patches. The genuses *Shorea*, *Hopea,* and *Dipterocarpus*, and families Burseraceae, Malvaceae, and Dipetrocarpaceae dominate the area (Peque, 2009). Areas that are on the lower slopes contain mostly coconut plantations and abandoned kaingin plots.

The so-called Pangasugan formation of andesitic and basaltic pyroclastic composition make up the majority of its geology (Asio, 1996). Soils in the study site are Typic Hapludult or Haplic Acrisol (World Reference Base (WRB) System) and derived from andesitic and basaltic rocks of Quaternary and Tertiary origin.

The texture is clay loam to heavy clay and is acidic with pH (H_2O) ranging from 5.0 to 5.6., (Navarette *et al*., 2010). The climate of the region is tropical rainforest climate, monsoon type based on the Köppen's classification. Mean annual precipitation is at 2830 mm while mean annual temp is 28˚C. There is no distinct dry season and maximum rainfall is experienced during months of November to January (Baldos and Rallos, 2019).

Sampling design

The study used stratified sampling for the three sites, Site 1 at 200 masl, Site 2 at 350 masl, and Site 3 at 500 meters above sea level (masl). Three 20 m × 20 m sample plots in each sampling site were randomly chosen from the already established plots of the Biodiversity Conservation and Management of Mt. Pangasugan Project (BIOCAMP)for a total of nine 20 m × 20 m plots. Within each 20 m × 20 m plot, three 1m × 1m subplots were laid out randomly for a total of 27 subplots used for data collection.

Data collection

In each subplot, wildlings having a height of one meter and below (Aureo *et al*., 2020) were identified, counted, and recorded as the tree regenerants. The data recorded included the common names, family names, and scientific names of the wildlings. Aside from expert determination in the identification of wildlings of tree species, published guides and other related materials (Salvosa, 1963, De Guzman *et al*., 1986, Rojo and Aragones, 1997, Rojo 2011, Fernando et al 2004, Reyes 2007, Lapitan *et al*., 2010, Malabrigo *et al*., 2016), and online sources (Co's Digital Flora of the Philippines, 2011; International Plant Name Index (IPNI), 2016; Plants of the World Online, 2017; Flora Malesiana, 2019), and were also used. The same data was also collected for adult tree species (≤ 10 cm diameter at breast height (DBH)) found inside the 20 m × 20 m plots.

Data analysis and interpretation

Diversity

To describe the diversity status of the wildlings in each site, the Shannon-Wiener index (Magurran, 1988) was used, following the formula:

H' = ∑ pi (ln pi)

Where:
H' = Species diversity
Pi = Proportional abundance of the ith species (ni/N)
ni = Number of individuals in ith species
N = Total number of species
ln = Logarithm sign

The H' value generated was then interpreted as follows (Magurran, 1988).
<2 = Less Diverse
2 – 4 = Diverse
4 – above = Highly Diverse

Comparison of similarity between sites

The level of similarity among species between sites was assessed using the Jaccard Index (Magurran, 1988) following the formula indicated below:

Cj = j / (a + b - j)

Where:
Cj = index of similarity
j = the total number of species discovered at both sites.
a = the total number of species discovered at site A
b = the total number of species discovered at site B

The Jaccard index is a number that runs from zero to one. The closer the two species' sites Jaccard index is to 1, the more similar they are.

Table 1. Evaluation of regeneration status

Regeneration category	Indicator
1. Good regeneration	seedlings > or < saplings > adults
2. Fair	seedlings > or ≤ saplings ≤ adults
3. Poor	survives only in sapling stage , but no seedlings
4. Not regenerating	only found in adults, no saplings and/or seedling stages
5. New	only saplings and/or seedling stages, no adults

Evaluation of regeneration status

Evaluation of the regeneration status for each sampling site was done by comparing the total number of individuals of wildlings versus that of adults in each site (Gebrihiwot and Hundera, 2014) (Table 1).

Results and discussion

Composition and diversity

In all sites, a total of 24 species from 16 families were recorded (Table 2). On a per site basis, Site 1 (200 masl) was observed to contain 17 species from 14 families, Site 2 (350 masl) had 10 species from 10 families, and Site 3 (500 masl) had 12 species from nine families. The most common families among the three sites were Dipterocarpaceae and Fabaceae. This is reflective of families that can be observed in lowland secondary forests in the Philippines, which are mostly represented by tree species belonging to the family of Dipterocarpaceae and other premium tree families such as Anacardiaceae, Fabaceae, and Ebenaceae (Polinar and Muuss, 2010). These families can be also seen along with the families of Moreaceae, Meliaceae, Lauraceae, Rubiaceae, Myrtaceae, Phyllanthaceae, Araceae, and Lauraceae (Aureo *et al.*, 2020).

The species recorded in the study sites are mostly either pioneer or late succession species. The occurrence of pioneer species in this site may be reflective of the recent disturbances that the region has experienced in the form of supertyphoons (Haiyan and Megi) which may have opened gaps in the canopy hence making conditions for pioneers to thrive. Given that pioneer species are shade intolerant, adapted to disturbance, and capable of forming a persistent soil seed bank, their presence is an indication that these sites are in the early to middle stages of succession (Bossuyt *et al.*, 2002; Godefroid *et al.*, 2006). Pioneers initiate the chain of events in ecological succession leading to the natural recovery of a recently disturbed ecosystem and therefore can aid in natural reforestation (Tiebel *et al.*, 2018) and lessen negative effects of disturbances (Fischer *et al.*, 2016).

In all sites, nine species of wildlings are categorized in the Updated National List of Threatened Philippine Plants (Department of Environment and Natural Resources (DENR), 2017) as either Critically Endangered (CR), Vulnerable (Vu), or as Other Threatened Species (OTS) (Table 2). The occurrence of wildlings for species classified under these categories could serve as insurance that their populations may have the possibility to be sustained although models on the family Dipterocarpaceae in the Philippines and how deforestation and climate change affect this critical tree family suggest that those species inside protected areas may no longer be there in the future (Pang et al 2021). This suggests the importance of incorporating factors which drive land cover changes as well as climate change impacts into the development of protected area management plans.

In terms of species frequency distribution, bitanghol (*Calophyllum blancoi*) tanglin (*Adenanthera intermedia*), and yakal kaliot (*Hopea malibato*) can be observed in all three sites and occurs in 78%, 33%, and 29% of all the subplots. The occurrence of wildlings of *H. malibato*, which is classified as Cr and of *A. intermedia*, classified as OTS (DENR, 2017) (Table 2) in all three sites is important information for conservation managers in light of their status as threatened species. Under Target 7 of the Global Strategy for Plant Conservation (GSPC, 2011) of the Conference of Parties to the Convention on Biological Diversity (CBD), 75% of threatened plant species are required to be conserved in situ and also ex situ (Target 8; GSPC, 2011) via conventional seed banking but at least a third of the number of threatened species produce recalcitrant seeds which are not suitable using this method (Wyse *et al.*, 2018).

Anubing (*Artocarpus ovatus*), bakauan gubat (*Carallia brachiata*), bayok (*Pterospermum acerifolium*), malakauayan (*Podocarpus rumphii*), tambis (*Zysygium aqueum*), tanguile (*Shorea polysperma*) and ulaian (*Lithocarpus llanosii*) are only present in Site 1, lamio (*Dracontomelon edule*) was only found in Site 2, while amamali (*Leea aculeata*), antipolo (*Artocarpus blancoi*), mayapis (*Shorea palosapis*), and narra (*Pterocarpus indicus*) were observed only in Site 3. Species appearing in relatively large numbers across many sites may lead to larger populations, increased colonization, and decreased extinction. Conversely, species restricted to a few sites may lead to disappearance from the locality (Verberk, 2011) or perhaps, extinction. A number of the species (mayapis and narra) not found in the more accessible Site 1 are species much favored for the quality of wood for house construction and furniture. This is expected as no mother trees for these species were found in Site 1 either. The absence of mother trees for mayapis and narra in Site 1 may have been likely due to ease in accessibility to harvest. In addition, neighboring communities with farmer associations who engage in raising planting materials for use in various planting and reforestation activities favor the collection of wildlings over that of raising the planting materials from seeds as they claim this is faster and more cost-effective.

The species diversity index value for wildlings of the studied sites ranged from 1.69 to 2.18; Site 1 had the highest diversity index value, which means that this site is diverse (Magurran, 1988). This was followed by Sites 2 and 3, respectively, whose H' values (<2) are interpreted as less diverse (Magurran, 1988). Site 1 has many gaps or openings in the canopy which may have contributed to conditions allowing for the germination and growth of more wildling species. In general, though, the H' values for these sites may be considered as that are on the lower end of the scale for H' values for diversity (Magurran, 1988) and the values themselves are not far from each other. Though wildlings in these sites can still be qualitatively described as diverse, it may be prudent for forest managers to treat these numbers as a sort of borderline and to lean towards management options that aim to at least maintain these values, considering the numerous potential disturbance factors that this forest ecosystem faces.

Similarity

The similarity of the species composition of different sites can be described using the Jaccard similarity index. Sites 1 and 2 share 35% of the species composition, while Sites 1 and 3 only shared 22% of the species compositions, and Sites 2 and 3 share 23% of species (Table 4).

Table 2. Wildling species observed in all study sites including their category under Department of Environment and Natural Resources Administrative Order No. 2017-11 Updated National List Of Threatened Philippine Plants And Their Categories

Family name	Common name	Scientific name	Category under DAO 2017-11
Anacardiaceae	Lamio	*Dracontomelon edule*	
	Mangga	*Mangifera indica*	
Burseraceae	Pagsaingin bulog	*Canarium calophyllum*	
Clusiaceae	Bitanghol	*Calophyllum blancoi*	
Cornaceae	Malatapai	*Alangium longiflorum*	OTS
Dipterocarpaceae	Bagtikan	*Parashorea malaanonan*	
	Mayapis	*Shorea palosapis*	
	Tanguile	*Shorea polysperma*	Vu
	White lauan	*Shorea contorta*	Vu
	Yakal kaliot	*Hopea malibato*	CR
Ebenaceae	Kamagong	*Diospyros blancoi*	Vu
Euphorbiaceae	Apanang	*Neotrewia cumingii*	
Fabaceae	Bahai	*Ormosia calavensis*	
	Narra	*Pterocarpus indicus*	Vu
	Tanglin	*Adenanthera intermedia*	OTS
Fagaceae	Ulaian	*Lithocarpus llanosii*	
Leeaceae	Amamali	*Leea aculeata*	
Malvaceae	Bayok	*Pterospermum acerifolium*	
Moraceae	Antipolo	*Artocarpus blancoi*	
	Anubing	*Artocarpus ovatus*	
Myrtaceae	Tambis	*Zysygium aqueum*	
Podocarpaceae	Malakauayan	*Podocarpus rumphii*	Vu
Rhizophoraceae	Bakauan gubat	*Carallia brachiata*	OTS
Sapindaceae	Alahan	*Guioa koelreuteria*	

CR (Critically endangered), Vu (Vulnerable), OTS (Other threatened species)

Table 3. Shannon Index and regeneration status of each forest site

Forest site	Site 1	Site 2	Site 3
Elevation, masl	200	350	500
Number of Families	14	6	9
Number of Species	18	10	12
Shannon Index, H'	2.19	1.93	1.69
Regeneration Status	Good	Good	Good

Table 4. Similarity of species composition between sites

Forest Site	Jaccard Index
Site 1 and Site 2	0.35
Site 1 and Site 3	0.22
Site 2 and 3	0.23

The Jaccard similarity index values for these sites reflect how ~60% to ~80% of wildling species are not shared by two sites and support the interpretation based on H' values of the diversity of these sites. Wildling species shared between two sites were mostly those whose mode of seed dispersal are aided by wind (e.g. winged like the dipterocarps) or those with small-sized seeds which may also explain the relatively low similarity between sites. Factors like dispersion and niche hinder recruitment since during succession, the pattern of recruitment changes due to species-level seed deposition rates, seed limitation, followed by niche-based processes (Werden *et al.*, 2020).

Regeneration status

The regeneration status for all three sites is classified as good (Gebrihiwot and Hundera, 2014), where the number of seedlings are greater than saplings or adults. In each site, the numbers of wildlings are more than 55% of the number of adults (Table 3). A higher number of new recruits (wildlings) versus that of adults indicate good regeneration potential (Das *et al.*, 2021). The new recruits develop and become adults which in turn become sources of seeds in the future. Regeneration status in tropical forests is influenced by a variety of factors, both natural and human-induced. Natural disturbances such as extreme weather events (the recent Supertyphoons Haiyan and Megi) as well as anthropogenic disturbances like harvest, and/or shifting agriculture, can significantly impact regeneration. Some disturbances create opportunities for regeneration, while others may hinder it.

For example, the opening up of the canopy brought about by strong typhoons may provide opportunities for more sunlight to filter through hence allowing for the growth of shade-intolerant species. The light environment in the forest understory is a critical factor. Some tree species are adapted to low-light conditions, while others require more sunlight. Changes in the canopy structure due to harvest or natural events can alter light availability and influence regeneration dynamics. Second, the availability of seeds and their effective dispersal is crucial for regeneration. Some species may produce seeds that are easily dispersed by wind, water, or animals, while others may have seeds that are less mobile. Changes in seed availability and dispersal mechanisms can affect regeneration. In addition, the establishment of conservation initiatives (establishment of Forest Protection Unit managed by the Visayas State University) can positively impact regeneration by reducing human-induced disturbances and providing a conducive environment for natural processes. Effective forest management practices, such as controlled harvest of forest products, constant patrolling of the area, open communication with neighboring communities on policies affecting the resource use contribute to successful regeneration. Successful regeneration is indicative of sustainable forest management practices. It suggests that the forest is being used in a way that preserves its capacity to provide ecological, economic, and social benefits for future generations. Understanding the complex interplay of these factors is crucial for effective forest management and conservation strategies in this forest ecosystem.

Conclusion

This study examined the diversity of the wildlings and its regeneration status to give insight into the future forest composition of Mt. Pangasugan. Results showed that the studied forest has diverse species composition, albeit on the lower end of the scale for H' values, and good regeneration status. This can contribute to the conservation of various plants and animal species, including those species observed that are categorized as threatened. The good regeneration status of this forest indicates a healthy and resilient ecosystem and suggests that the forest is capable of sustaining and renewing its plant populations over time. Studying the interactions between different species can enhance our understanding of ecological processes and contribute to conservation and sustainable management practices, with the aim that the results will become a key input to the development of Biodiversity Conservation and Management Program for Mt. Pangasugan.

Recommendations

Forest management plays a crucial role in influencing tree species regeneration and shaping the future forest structure and composition. Enrichment planting is already being done on the lower and more accessible parts but to improve diversity in this forest, consider the natural species composition of the area and prioritize native species that are well-adapted to the local climate and soil conditions. Implement sustainable and ecologically sound silvicultural practices, such as the establishment of woodlots to minimize disturbance due to firewood collection to promote regeneration and maintain biodiversity. Since there is already a logging ban in place for the whole country, the use of low impact harvesting of non-wood forest products (bamboo, wildlings) should be utilized. The Forest Protection Unit of VSU should establish a robust monitoring system to assess the success of regeneration efforts and track changes in forest composition and structure over time. It is recommended to create a management plan for the conservation and management of Mt. Pagasugan and to involve local communities and stakeholders in forest management decisions to ensure a holistic approach that contribute to the long-term sustainability and health of forest ecosystems while promoting diverse tree species regeneration and ensuring a resilient future forest structure and composition.

References

Asio VB. 1996. Characteristics, weathering formation & degradation of Soils from volcanic rocks in Leyte, Philippines. Hohenheimer Bodenkundliche Hefte 33, Stuttgart, Germany.

Aureo WA, Reyes TD, Mutia FCU, Jose RP, Sarnowski MB. 2020. Diversity and composition of plantspecies in the forest over limestone of Rajah Sikatuna Protected Landscape, Bohol, Philippines. Biodiversity Data Journal **8**, e55790. https://doi.org/10.3897/BDJ.8.e55790.

Baldos AP, Rallos RV. 2019. Indications of enhanced soil ecosystem functions in polyculture reforested grassland. Annals of Tropical Research **41(1)**, 32-44. https://doi.org/10.32945/atr4114.2019.

Barcelona J, Nickrent D, Lafrankie J, Callado JR, Pilser P. 2013. Co's Digital Flora ofthe Philippines: plant identification and conservation through cybertaxonomy. Philippine Journal of Science (**142**), 57-67.

Batistel CC, Asio VB. 2008. Effects of leaf decomposition of selected exotic and native tree species on forest soil quality. Annals of Tropical Research **30(1)**, 29-39.

Belonias BS, Bañoc LD. 1994. Species diversity and distribution of pteridophytes in Mt. Pangsugan. Annals of Tropical Research Vol XVI. Special Issue on Tropical Ecology No. **2.**

Belonias BS. 2002. The dicot flora on the western slopes of Mt. Pangasugan, Leyte Island, Philippines. PhD Thesis, University of the Philippines, Los Banos, Philippines. 133p.

BirdLife International. 2021. Important Bird Areas factsheet: Anonang-Lobi Range. Downloaded from http://www.birdlife.org on 02/20/2021.

Bossuyt B, Heyn M, Hermy M. 2002. Seed bank and vegetation composition of forest stands of varying age in central Belgium: consequences for regeneration of ancient forest vegetation. Plant Ecology **162**, 33-48. DOI: 10.1023/A:10203 91430072.

Bulayog MS. 1998. Economic Implications of Biodiversity Preservation in Mount Pangasugan, Phlippines. PhD Thesis. University of the Philippines at Los Banos, College, Laguna.

Co's Digital Flora of the Philippines. 2011. https://www.philippineplants.org. Accessed on: 2023-10-06.

De Guzman ED, Umali RM, Sotalbo ED. 1986. Guide to Philippine Flora and Fauna: Dipterocarps and non-dipterocarps; Volume 3 of Guide to Philippine Flora and Fauna, Natural Resources Management Center (Philippines) Natural Resources Management Center 3.

DENR. 2017 Updated National list of threatened Philippine plants and their categories. Philippine Plant Conservation Committee (PPCC) BMB, DENR.

Das DS, Dash SS, Maity D, Rawat DS. 2021. Population structure and regeneration status of tree species in old growth *Abies pindrow* dominant forest: A case study from western Himalaya, India. Trees, Forests and People **5**, 100101.

Dutta G, Devi A. 2013. Plant diversity, population structure, and regeneration status in disturbed tropical forests in Assam, northeast India. Journal of Forestry Research **24**, 715 –72.

Fernando ES, Sun BY, Suh MH, Kong HY, Koh KS. 2004. Flowering plants and ferns of Mt. Makiling. ASEAN-Korea Environmental Cooperation Unit (AKECU). National Instrumentation Center for Environmental Management, College of Agriculture and Life Sciences, Seoul National University.

Flora Malesiana. 2019. https://floramalesiana.org/new. Accessed on: 2023-10-06.

Gordon EA, Franco OE, Tyrrell ML. 2005 Protecting Biodiversity: A Guide to Criteria Used by Global Conservation Organizations. Forestry & Environmental Studies.

Fischer H, Huth F, Hagemann U, Wagner S. 2016. Developing restoration strategies for temperate forests using natural regeneration processes. In: "Restoration of boreal and temperate forests" (Stanturf JA Ed.). CRC Press, Boca Raton, USA, pp. 103-164.

FMB. 2018. Philippine Forestry Statistics. Forest Management Bureau. Department of Environment and Natural Resources. Quezon City.

Gebrehiwot K, Hundera K. 2014. Species composition, plant community structure, and natural regeneration status of Belete moist evergreen montane forest, Oromia regional state, Southwestern Ethiopia. Momona Ethiopian Journal of Science **6(1)**, 97-101.

Global Strategy for Plant Conservation. 2011. The targets 2011-2020. Convention on Biological Diversity. https://www.cbd.int/gspc/targets.shtml. Accessed on: 2023-11-11.

Godefroid S, Phartyal SS, Koedam N. 2006. Depth distribution and composition of seed banks under different tree layers in a managed temperate forest ecosystem. Acta Oecologica **29**, 283-292. DOI: 10.1016/j.actao.2005.11.005.

Heaney LR. Heideman PD, Rickart EA, Utzurrum RB, Klompen JSH. 1989. Elevational zonation of mammals in the central Philippines. Journal of Tropical Ecology **5**, 259-280.

International Plant Name Index (IPNI). 2016 https://www.ipni.org/. Accessed on: 2023-9-08.

Langenberger G, Belonias BS. 2004. Status of floristic analysis of Mt. Pangasugan, Leyte, Philippines - a conservation priority area with extremely high importance. https://agris.fao.org/agris-search/search.do?recordID=PH2005000281. Accessed January 27, 2023.

Langenberger G. 2006. Habitat distribution of dipterocarp species in the Leyte Cordillera: An indicator for species-site suitability in local reforestation programs. Annals of Forest Science **63**, 149–156.

Langenberger G, Belonias BS. 2011. The Status of Floristic Analysis of Mt. Pangasugan, Leyte, Philippines- A Conservation Priority Area Classified as "Extremely High Critical". Annals of Tropical Research **33(2),** 1-21.

Lapitan PG, Fernando ES, Suh MH, Fuentes RU, Shin YK, Pampolina NM, Castillo ML, Cereno RP, Lee JH, Choi TB, Lee DK. 2010. Biodiversity and natural resources conservation in protected areas of Korea and the Philippines. ASEAN-Korea Environmental Cooperation Unit (AKECU). National Instrumentation Center for Environmental Management, College of Agriculture and Life Sciences, Seoul National University.

Magurran AE. 1988. Ecological Diversity and its Measurements. Chapman and Hall. 145-165p.

Malabrigo PL, David M, David-Pilar M. 2016. BINHI: Tree for the Future, A Greening Legacy. Energy Development Corporation. CGKformprint, Inc.

Navarrete IA, Tsutsuki K, Asio VB, Kondo R. 2009. Characteristics and formation of rain forest soils derived from late Quaternary basaltic rocks in Leyte, Philippines. Environmental Geology **58**, 1257–1268.

Pang SEH, De Alban JDT, Webb, EL. 2021. Effects of climate change and land cover on the distributions of a critical tree family in the Philippines. Scientific Reports **11**, 276. https://doi.org/10.1038/s41598-020-79491-9.

Peque DP. 2009. On using adaptive cluster sampling design in forest inventory: its implication to forest biodiversity status reporting. Science and Humanities **9**, 56-66.

Plants of the World Online. 2017. http://www.plantsoftheworldonline.org/. Accessed on: 2023-9-20.

Po-Abit P. 2008. Floristic inventory of monocots in Mt. Pangasugan, Baybay, Leyte, Philippines. Annals of Tropical Research **30(2)**, 56-71.

Polinar AN, Muuss, U. 2010. Tree species diversity in secondary forest of Mount Pangasugan, Baybay City, Philippines. Journal of Nature Studies, 105-111.

Reyes T. 2007. Checklist of forest plant species at CVSCAFT Forest Research Academic Area. Unpublished. CVSCAFT Main Campus, Bilar, Bohol, Philippines.

Rojo JC. 2011. Revised lexicon of Philippine trees. Forest Products Research and Development Institute (FPRDI), Department of Science and Technology (DOST).

Rojo JR, Aragones EGJ. 1997. Botanical identification handbook on Philippine dipterocarps. Forest Products Research and Development Institute (FPRDI)-Department of Environment and Natural Resources (DOST).

Salvosa FM. 1963. Lexicon of Philippine Trees. Forest Products Research Institute. Communications Media Division.

Sueta J, Asio VB, Tulin A. 2007. Chemical dynamics of a highly weathered soils under indigenous tree species in Mt. Pangasugan, Leyte, Philippines. Annals ofTropical Research **29**, 73–89.

Susaya JP, Asio VB. 2005. Status of phosphorus in the rain forest of Mt. Pangasugan, Leyte, Philippines. Annals of Tropical Research **27**, 70–82.

Tiebel K, Huth F, Wagner S. 2018. Soil seed banks of pioneer tree species in European temperate forests: a review. iForest **11**, 48-57.
DOI: 10.3832/ifor2400-011 [online 2018-01-25].

Verberk W. 2011. Explaining General Patterns in Species Abundance and Distributions. Nature Education Knowledge **3(10)**, 38.

Villasica LJD, Lina SB, Asio VB. 2018. Aggregate stability affects carbon sequestration potential of different tropical soils. Annals of Tropical Research **40(1)**, 71-88.

Werden LK, Holl KD, Rosales JA, Sylvester JM, Zahawi RA. 2020. Effects of dispersal- and niche-based factors on tree recruitment in tropical wet forest restoration. Ecological Applications Oct. **30(7)**, e02139. doi: 10.1002/eap.2139. Epub 2020 May 26. PMID: 32335980.

Wyse SV, Dickie JB, Willis KJ. 2018. Seed banking not an option for many threatened plants. Nature Plants **4**, 848–850.
https://doi.org/10.1038/s41477-018-0298-3.

Zikeli S, Asio, VB, Jahn R. 2000. Nutrient characteristics of soil in the rain forest of Mt. Pangasugan, Leyte, Philippines. Annals of Tropical Research **22**, 78–88.