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Structure, composition and diversity of tree species in Martelu Purba Nature Reserve, North Sumatra, Indonesia

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Abstract. *Rangkuti AB, Hartini KS, Susilowati A, Rambey R, Harahap MM, Arinah H, Irmayanti L, Pamoengkas P, Indriani F, Peniwidiyanti, Ruhidi A. 2023. Structure, composition and diversity of tree species in Martelu Purba Nature Reserve, North Sumatra, Indonesia. Biodiversitas 24: 78-85.* Martelu Purba Nature Reserve is one of the conservation areas in North Sumatra that functions to protect biodiversity. However, there is limited information related to the vegetation community contained in the nature reserve. This study aimed to assess the diversity, structure and composition of tree species in the Martelu Purba Nature Reserve as well as to reveal the conservation status of the species in reserve. The research used the line transect method with a total of 112 observation plots representing various vegetation and environmental conditions. The results showed that there were 39 tree species belonging to 25 families, with 31, 25, 24, and 26 species at the tree, pole, sapling, and seedling stages, respectively. *Shorea platyclados* and *Syzygium cerasiforme* were species with the highest Important Value Index (IVI) at the tree and pole stages with 173.04% and 31.01%, respectively, while *Gamblea malayana* was the most important at the sapling and seedling stages with IVI of 66.43%, and 30.00%, respectively. The Shannon-Wiener diversity index (H') was categorized as low (1.58), the Margalef species richness index (DMg) was high at all growth stages, and the Evenness index (E) was high, indicating that all species were evenly distributed across the research plots. The distribution of tree diameter classes ranged from 20 - 40 cm for trees with the smallest diameter to 81-110 cm for trees with the largest diameter. Based on their conservation status, there were two species with conservation concerns, namely *Coffea arabica* (Endangered) and *Lithocarpus maingayi* (Vulnerable). The application of good silvicultural methods needs to be carried out in the context of conservation efforts. One example is through vegetative propagation of species with long flowering periods.

Keywords: Floral diversity, Martelu Purba, nature reserve, *Shorea platyclados*, vegetation analysis

INTRODUCTION

The Martelu Purba Nature Reserve (MPNR) is a conservation area located in Simalungun District, North Sumatra Province, Indonesia. It was previously a watershed protection forest that was changed its status into a nature reserve by the decree of the Ministry of Forestry No. 471/Kpts-II/1993. It plays a key role in preserving biodiversity and delivering ecosystem services, including regulating the hydrological system, conserving water and soils, maintaining microclimate, eliminating pollution, providing a food source, and serving as a habitat for animals (Beninde et al. 2015; Derkzen et al. 2015; Hunter and Luck 2015; Livesley et al. 2016). The nature reserve also has high flora diversity and contains some important species such as *Shorea platyclados*, *Altingia excelsa*, *Styrax benzoin*, *Ficus benjamina*, etc. (Rangkuti et al. 2022; Rambey et al. 2021).

While important for biodiversity conservation, the Martelu Purba Nature Reserve is pressured by anthropogenic activities, especially due to its location which, is dissected by a highway and fragmented by road networks. The position of the nature reserve makes it easily accessible to humans. Some issues occurring in Martelu Purba Nature Reserve include the removal of topsoil, which causes vegetation disturbance, land clearing for motorized vehicles in the forest, collecting decorative plants, and cutting trees or branches as firewood. These problems were reported directly by the conservation area management.

Many studies on the composition of flora, forest structure, and vegetation have been carried out in tropical forests (Lutz et al. 2012; Neelo et al. 2015; Noumi 2013; Zhong et al. 2015). While there were some studies on plant

ecology conducted in conservation areas and protected forests in Sumatra, such as in Gunung Leuser National Park (Nayasilana et al. 2015; Susilowati et al. 2020; Susilowati et al. 2021), Mursala Island (Fambayun et al. 2019) and Barumun Watershed (Rambey et al. 2021), there is still few research on vegetation analysis conducted in the Martelu Purba Nature Reserve. Such studies are not only important to assess the diversity of vegetation at a landscape scale, but also in some cases, it reveals biodiversity with conservation importance, as in the case of the re-discovery of *Dipterocarpus cinereus* in Mursala Island, which had been previously reported extinct (Rachmat et al. 2018). Besides its essential role in biodiversity conservation, the existence of vegetation in a tropical forest ecosystem is important to maintain the balance of carbon dioxide and oxygen concentrations in the air, improving the physical, chemical and biological properties of soil, regulating groundwater systems and performing other beneficial functions (Basrowi et al. 2018). Therefore, the existence of undisturbed vegetation in a landscape will positively impact the balance of the ecosystem with greater impacts within a region.

In the context of Martelu Purba Nature Reserve, information on vegetation is essential for the effective management of biodiversity and the protection of rare and promising species since the reserve is predicted to harbor endemic plant species but not yet widely disclosed. Further, community activities that cause disturbances to the forest ecosystem necessitate an urgent effort to assess vegetation diversity for its conservation. The importance of vegetation analysis has been reported in Keppel et al. (2010) to provide information regarding the sustainability of environmental services in an ecosystem. Wani and Mughal (2012) stated that vegetation analysis is important to assess the structure and the composition of stands which is useful for informing the regeneration ability. Mawazin and Subiakto (2013) argued that species diversity determines the stability and integrity of vegetation communities in an ecosystem. Therefore, this study aimed to assess the diversity, structure and composition of tree species in the Martelu Purba Nature Reserve as well as to reveal the conservation status of the species in reserve.

MATERIALS AND METHODS

Study area

The research was conducted in the Martelu Purba Nature Reserve located in Purba Tongah Village, Simalungun District, North Sumatra Province, Indonesia (Figure 1). Based on the geographical location, it is located at coordinates 2º53'-2º54' N, 98º42-98º43' E, with an altitude of 1,320 masl. The topography is mostly flat to undulating with a slope of up to 8%, but the north side has a very steep topography with a slope of up to 80%. The type of soil is brown and grey podzolic with igneous rocks as the parent material and volcanic physiography with a soil pH of 6.38. The climate has an average annual rainfall of 2,194 mm and 125 rainy days. The dry and rainy seasons last from December to September and March to November, respectively. The average maximum and minimum temperatures are 21.7 and 14.7ºC, respectively. Martelu Purba Nature Reserve has been gazetted as a watershed protection forest since the colonial period from 1916 to 1993. In 1993 the status of the area was changed from a protected forest into a nature reserve. It is the youngest nature reserve in North Sumatra, with an area of 195 ha.

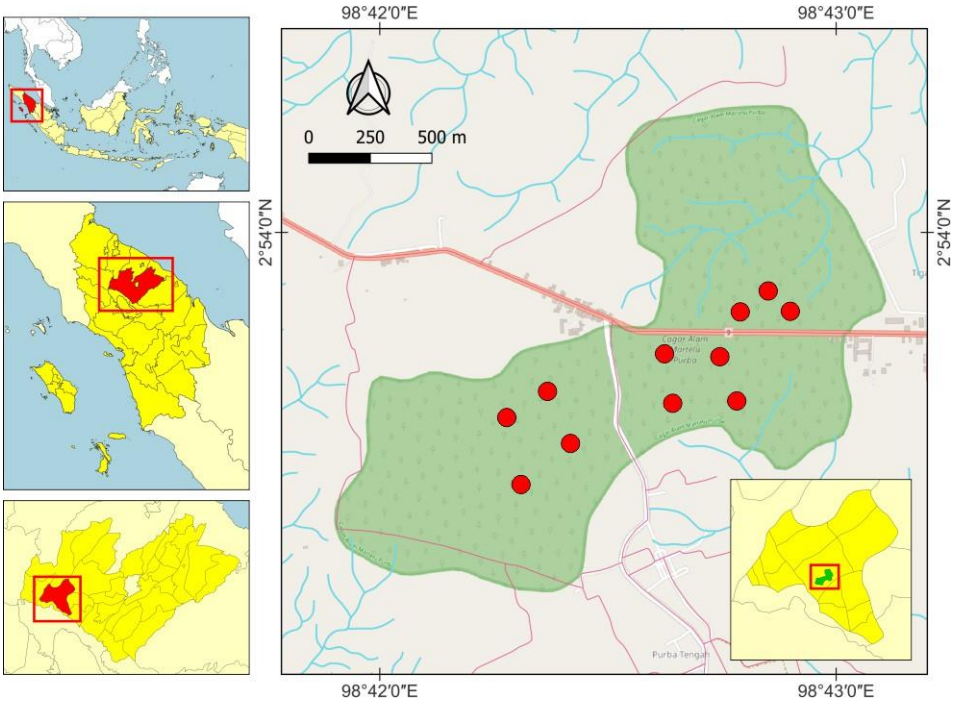

Figure 1. Map of research site and observation plots in Martelu Purba Nature Reserve, North Sumatra, Indonesia

Data collection

A total of 112 observation plots along 11 line transects were established for vegetation analysis. Plots were determined using a purposive sampling method based on the vegetation and environmental condition. The size of each observation plot was 20 x 20 m^2 using a strip plot method (Kusmana 1997), resulting in an observation area of 4.5 Ha or 2.3% of the total area of the nature research. Species of trees or woody plants were observed at four growth stages: tree (woody plants with a diameter ≥ 20 cm), pole (young trees with a diameter of 10-20 cm), sapling (young trees with a height > 150 cm, diameter < 10 cm), and seedling (juvenile tree with a height < 150 cm) in plots measuring 20 x 20 m^2, 10 x 10 m^2, 5 x 5 m^2, and 2 x 2 m^2, respectively. Data on species name, number of individuals, height, diameter, information on benefits, and conservation status were collected. Validation and updating of the latest scientific names refer to the Plants of The World Online (POWO, 2022).

Data analysis

A vegetation analysis was conducted to determine the species composition at each plot. Vertical and horizontal structure, composition, Importance Value Index (IVI), abundance, diversity, and basal area were obtained from the vegetation data (Pamoengkas et al. 2017).

Importance Value Index (IVI)

The important value index (IVI) is a parameter that can define the dominance or importance of a plant species within a vegetation community. IVI values of the tree and pole stages were obtained by adding relative density (RD), relative dominance (RDo), and relative frequency (RF). Meanwhile, the IVI values of the sapling and seedling stages were obtained by adding relative density (RD) and relative frequency (RF).

The formula used to calculate RD, RDo and RF were as follows:

$$\text{RD} = \frac{\text{Number of Individual of the species}}{\text{Number of individual of all the species}} \text{ x } 100\ \%$$

$$\text{RDo} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \text{x } 100\ \%$$

$$\text{RF} = \frac{\text{Number of occurence of the species}}{\text{Number of occurence of all the species}} \text{ x } 100\ \%$$

Diversity Indices

Diversity indicators were assessed using three indices, namely the Shanon Wiener, Margalef, and Evenness Index. The formula used was as follows:

Shanon Wiener species diversity index (Magurran 1988)

$$\text{H}' = \sum_{i=1}^{S} (\text{pi})\ (\ln \text{pi})$$

Where:

pi : $\sum ni/N$

H' : Shanon Wiener Diversity Index

Pi : Number of individuals of the species / total number of all species

ni : Number of individuals of the first species

N : Total number of individuals

Margalef species diversity index (Magurran 1988)

$$\text{Dmg} = \frac{\text{S} - 1}{\text{LnN}}$$

Where:

Dmg : Margalef Species Diversity Index

S : Number of observed species

N : Total number of observed individuals

Ln : Natural logarithm

Evenness index (Magurran 1988)

$$E = \frac{H'}{Ln\ S}$$

Where:

E : Evenness Index

H' : Diversity Index

S : Number of species

RESULTS AND DISCUSSION

Floristic composition, diversity, conservation status and potential uses of tree species in Martelu Purba Nature Reserve

Plant species in the Martelu Purba Nature Reserve area were found from the seedling to the tree stages (Table 1). Within the observation plots, there were 39 plant species from 27 families, consisting of 31, 25, 24, and 26 at the tree, pole, sapling, and seedling stages, respectively. There were 10 species that were recorded across all stages of growth (from seedlings, saplings, poles, and trees), namely *Cinnamomum subavenium*, *Gamblea malayana*, *Lasjia hildebrandii*, *Leea angulata*, *Liquidambar excelsa*, *Litsea elliptica*, *Macaranga tanarius*, *Pterospermum diversifolium*, *Syzygium cerasiforme*, and *Zanthoxylum rhetsa*. Some species were only found at one growth level, including *Artocarpus heterophyllus* and *Scolopia spinosa* at the tree stage and *Mussaenda* sp. and *Xylopia* sp. at the pole stage. Dipterocarpaceae, Lauraceae, Moraceae, and Rubiaceae were the dominant families in the Martelu Purba Nature Reserve which consisted of 2 genera. These families are commonly found to dominate tropical rainforests in Sumatra and Borneo.

Table 1. List of tree species in the Martelu Purba Nature Reserve, North Sumatra, Indonesia, with information on potential uses and conservation status

Family and species	Vernacular name	IUCN Status	Growth stage			
			Tree	Pole	Sapling	Seedling
Altingiaceae						
Liquidambar excelsa (Noronha) Oken	Hulasar	LC	+	+	+	+
Annonaceae						
Xylopia sp.	Horbo-horbo	-		+		
Araliaceae						
Gamblea malayana (M.R.Hend.) C.B.Shang, Lowry	Akhirsap	LC	+	+	+	+
Cannabaceae						
Celtis rigescens (Miq.) Planch.	Bittatar	LC	+			+
Dipterocarpaceae						
Shorea acuminata Dyer	Meranti bunga	LC	+		+	+
Shorea leprosula Miq.	Meranti tembaga	NT	+		+	+
Shorea platyclados Slooten ex Endert	Meranti batu	NT	+		+	+
Ericaceae						
Vaccinium varingiifolium (Blume) Miq.	Simar leu-leu	-	+		+	+
Euphorbiaceae						
Macaranga tanarius (L.) Müll.Arg.	Sitarak	LC	+	+	+	+
Fabaceae						
Acacia decurrens (J.C.Wendl.) Willd.	Hau kowa	-	+	+		+
Leucaena leucocephala (Lam.) de Wit	Lamtoro	-	+	+		
Fagaceae						
Lithocarpus elegans (Blume) Hatus. Ex	Hoting bunga	-		+	+	+
Lithocarpus maingayi (Benth.) Rehder	Hoting batu	VU	+		+	
Flacourtiaceae						
Scolopia spinosa (Roxb.) Warb.	Mapat	LC	+			
Hypericaceae						
Cratoxylum formosum (Jack) Benth. & Hook.f. ex Dyer	Arang	LC	+	+		+
Lauraceae						
Cinnamomum iners (Reinw. ex Nees & T.Nees) Blume	Kayu manis	LC	+		+	+
Cinnamomum subavenium Miq.	Sabal	LC	+	+	+	+
Litsea elliptica Blume	Modang	LC	+	+	+	+
Malvaceae						
Pterospermum diversifolium Blume	Balangkoras	LC	+	+	+	+
Melastomataceae						
Bellucia pentamera Naudin*	Jambu-jambuan	LC	+		+	
Moraceae						
Artocarpus heterophyllus Lam.	Nangka	-	+			
Ficus benjamina L.	Beringin	LC	+	+		+
Ficus padana Burm.f.	Landorung	LC				+
Myrtaceae						
Syzygium cerasiforme (Blume) Merr. & L.M.Perry	Hanawe	LC	+	+	+	+
Syzygium pycnanthum Merr. & L.M.Perry	Hauandolok	-	+	+		+
Phyllanthaceae						
Bischofia javanica Blume	Sikam	LC	+	+		
Proteaceae						
Lasjia hildebrandii (Steenis) P.H.Weston & A.R.Mast*	Makadame	-	+	+	+	+
Rubiaceae						
Coffea arabica L.*	Kopi arabika	EN			+	+
Coffea canephora Pierre ex A.Froehner*	Kopi robusta	LC			+	+
Coffea sp.*	Kopi	-			+	
Mussaenda sp.	Mussaenda	-		+		
Rutaceae						
Zanthoxylum rhetsa (Roxb.) DC.	Dap-dap	LC	+	+	+	+
Salicaceae						
Scolopia spinosa (Roxb.) Warb.	Mapat	LC		+	+	+
Sapotaceae						
Palaquium hexandrum (Griff.) Baill.	Mayang	NT	+	+		+
Styracaceae						
Styrax benzoin Dryand.	Kemenyan	-	+	+	+	
Theaceae						
Schima wallichii (DC.) Korth.	Simartolu	LC	+	+	+	
Urticaceae						
Dendrocnide stimulans (L.f.) Chew	Dong-dong	LC	+	+		
Verbenaceae						
Tectona grandis L.f.*	Jati	-	+	+		
Vitaceae						
Leea angulata Korth. ex Miq.	Rajamatan	LC	+	+	+	+

Note: *: alien/introduced species, +: present; CR: Critical Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern

The higher number of species at the tree stage is in accordance with Fahey (2013) that state a forest is dominated by trees. The fewer number of species at the younger lower stages is likely caused by the existence of tree canopies which prevented sunlight from entering the forest. The low light intensity on the forest floor made it difficult for intolerant plants to grow, resulting in fewer species at the pole, sapling, and seedling stages in the Martelu Purba Nature Reserve area.

Based on IUCN Red List, there were two threatened species found in this study, namely *Coffea arabica* (Endangered, EN) and *Lithocarpus maingayi* (Vulnerable, VU). *Coffea arabica* has a natural distribution in Ethiopia, Kenya, and Sudan (POWO 2022). This species has a long history of cultivation and product development in Indonesia. However, the latest conservation status states that the native population of this species is threatened by various factors such as deforestation, climate change, genetic erosion, pests, and diseases, so it is feared that this species may become extinct in the wild (Moat et al. 2020). *Lithocarpus maingayi* has a natural distribution in Thailand, the Malaya Peninsula to Sumatra (POWO 2022) and is threatened by the overexploitation of its wood and clearing of land areas for settlement, as described in the latest results of the assessment for this species (Chua 1998). This species also has a high ecological role, especially in Sumatra, where Orangutans in Batang Toru use this tree as a nest, and the fruit is consumed (Kuswanda et al. 2020; Kuswanda et al. 2021). In addition to the two threatened species, as many as 56% (22 species) have Least Concern (LC) status, 7.7% (3 species) have Near Threatened (NT) status, and 31% (12 species) have not been evaluated. Species included in the Near Threatened status, namely *S. leprosula*, *S. platyclados* and *Palaquium hexandrum* are species commonly used for construction by the community, so it needs to be a concern so that the population is not decreasing due to illegal logging.

There were introduced species in the nature, reserve such as *jambu-jambuan* (*Bellucia pentamera*) and varieties of coffee (*Coffea* spp.) which are native to Central America and Africa, respectively. They pose the risk of spreading across the nature reserve area because the fruit is relatively favored by various species of birds and diurnal mammals (Haryono et al. 2019). Therefore, periodic monitoring becomes very important and should be conducted. Solfiyeni et al. (2022) explained that *B. pentamera* is an introduced plant with negative impacts on biodiversity and microclimate in secondary forest areas in West Sumatra. The existence of a negative association between *B. pentamera* and surrounding plants is due to the allelopathic compounds possessed by this species which inhibit the growth of other species and make this species able to invade an area rapidly (Inayah and Solfiyeni 2021).

This study found 22 tree species with the Least Concern (LC) conservation status. There were one species with the vulnerable (VU) status, namely *L. maingayi.* Furthermore, three species were in Near Threatened (NT) status, namely *Shorea leprosula*, *S. platyclados* and *Palaquium hexandrum*. There were one species with Endangered (EN) status, namely *C. arabica.* Meanwhile, 12 tree species were found in Not Evaluated (NE) status, according to Table 1.

The important value index (IVI) indicates the role and dominance of a species in a vegetation community (Pamoengkas 2017). Dominant species utilize their environment more efficiently than others, as indicated by the highest IVI (Haileab et al. 2011). The IVI value of a species is directly proportional to the level of control over the community. In this study, five tree species with the highest IVI at each growth stage are presented in Table 2.

At the tree stage, *S. platyclados*, or light red meranti, had the highest IVI in the Martelu Purba Nature Reserve, with 173.044%. *Shorea platyclados* in reserve were planted by the community for decades (Martelu Purba Nature Reserve Manager, pers. comm.). This explanation is reasonable since the dominance of *S. platyclados* in reserve was found only at the tree stage and not at the pole and sapling stages. The limited occurrence of this species at the younger stages indicates that there is a problem with its natural regeneration. This is likely caused by the rare flowering period of *S. platyclados*. The other trees that dominated the nature reserve area were *Cratoxylum formosum*, *Styrax benzoin*, *Ficus benjamina*, and *L. elliptica*.

Table 2. Five tree species with the highest important value index (IVI) in the Martelu Purba Nature Reserve, North Sumatra, Indonesia

Species	RD	RF	RDo	IVI
Tree				
Shorea platyclados	66.484	38.406	68.155	173.044
Cratoxylum formosum	7.830	9.058	7.721	24.609
Styrax benzoin	3.571	7.609	3.519	14.699
Ficus benjamina	2.610	5.797	2.951	11.358
Litsea elliptica	2.335	3.986	2.261	8.581
Pole				
Syzygium cerasiforme	9.884	10.606	10.525	31.015
Liquidambar excelsa	9.302	9.848	8.720	27.871
Macaranga tanarius	9.302	6.818	7.800	23.920
Cinnamomum subavenium	7.558	6.818	8.830	23.206
Gamblea malayana	7.558	6.818	8.290	22.666
Sapling				
Gamblea malayana	35.821	30.612		66.433
Coffea sp.	7.463	6.122		13.585
Lasjia hildebrandii	7.463	5.102		12.565
Liquidambar excelsa	4.478	6.122		10.600
Litsea elliptica	5.224	5.102		10.326
Seedling				
Gamblea malayana	13.725	16.279		30.005
Coffea arabica	11.111	17.442		28.553
Shorea platyclados	13.725	5.814		19.539
Cinnamomum iners	5.229	9.302		14.531
Liquidambar excelsa	5.229	8.140		13.368

Notes: RD: relative density, RDo: relative dominance, RF: relative frequency, IVI: Important value index

At the pole stage, *Syzygium cerasiforme*, with the local name Hanawe was the most dominant tree species with an IVI of 31.015%, followed by *L. excelsa*, *Macaranga tanarius*, *Cinnamomum subavenium*, and *Gamblea malayana*. The most abundant and dominant tree at the sapling stage in reserve was *G. malayana*, with IVI of 66.433%, followed by *Coffea* sp., *L. hildebrandii*, *L. excelsa*, and *L. elliptica*. At the seedling stage, the most dominant tree species was *G. malayana*, with IVI of 30.005%, followed by *C. arabica*, *S. platyclados*, *Cinnamomum inners*, and *L. excelsa*.

Species diversity can be used to indicate community stability when impacted by disturbances (Indriyanto 2006). According to Wilsey and Sterling (2007), diversity has two basic components, namely richness and evenness. The high and low diversity index of a plant community is determined by the number of individuals of each species. The individual richness and abundance of each species will reflect the level of heterogeneity or stability of the vegetation (Anbarashan and Parthasaranthy 2013).

The Shannon-Wiener diversity index (H') at the tree stage in the Martelu Purba Nature Reserve was 1.58 (low), while the other growth stages (the poles, saplings, and seedlings) were classified as moderate (Table 3). This was presumably because of the overdominance of *S. platyclados* planted by the community, resulting in other tree species being unable to grow properly due to competition for soil nutrients and sunlight. In most ecological studies, the Shannon-Wiener diversity index (H') is between 1.5 and 3.5. Odum (1971) stated that species diversity tended to be high in older communities compared to younger and plantation forests.

The Margalef index (Dmg) is classified as high in all growth stages, ranging from 4.47 to 4.77. At the tree stage, the Margalef index was 4.5, which is likely influenced by the number of tree species within the wider observation plot. The value of the species richness is directly proportional to that of the Margalef index (Nahlunnisa 2016).

The species Evenness index (E) indicates the dispersion or distribution of individual plants in the community (Susilowati et al. 2019). In this study, the evenness index ranged from 0-1 in, with an index close to 0 if the number of species between plots consists of only similar species and an index close to 1 if the number of species found between plots is almost the same. The evenness index is high when all species have the same number of individuals in each location. This condition is rarely found in nature because each species has a special ability to adapt and tolerate natural environmental conditions, which are very complex. In this study, the species Evenness index (E) at all growth stages had a value close to 1, indicating that almost every plot has similar species composition, except the Evenness index at the tree stage, which was only 0.46.

Stand structure and forest regeneration

Stand structure

The distribution of tree diameter classes ranged from 20-40 cm for trees with the smallest diameter to 81-110 cm for trees with the largest diameter. The diameter classes of trees in Martelu Purba Nature Reserve were predominantly 41-60 cm and 20-110 cm. The tree species with the largest diameter and the tallest reaching more than 30 m were *S. platyclados*, *S. leprosula*, and *Shorea acuminata*.

The tree stand structure in the Martelu Purba Nature Reserve is shown in Figure 2. The diameter classes from the smallest to the largest formed an inverted J curve. In general, the forest stand structure in this reserve was still considered normal. The distribution of diameter classes that resemble the inverted J-curve indicated that the forest stands varied in terms of age (Pamoengkas 2017). According to Wahjono (2007), the condition of the stands was still quite good for forest regeneration.

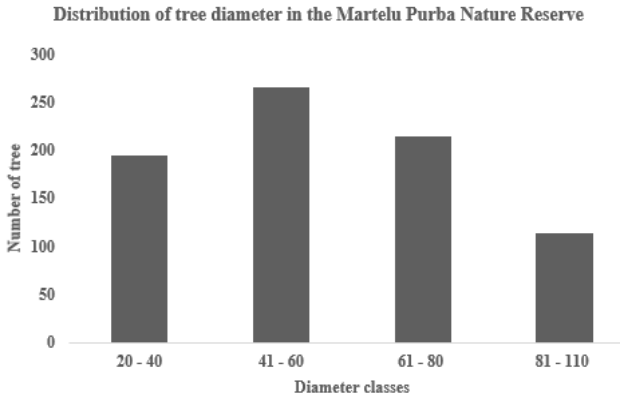

Figure 2. Distribution of tree diameter classes in the Martelu Purba Nature Reserve, North Sumatra, Indonesia

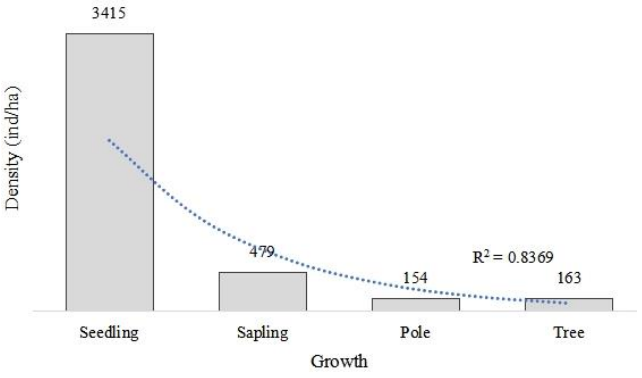

Figure 3. The number of individuals at each growth stage in the Martelu Purba Nature Reserve, North Sumatra, Indonesia

Table 3. Diversity indicators of tree species in Martelu Purba Nature Reserve, North Sumatra, Indonesia

Index	Seedling	Sapling	Pole	Tree
Shannon Wienner (H')	2.76	2.51	2.91	1.58
Margalef (Dmg)	4.77	4.70	4.47	4.55
Pielou's Evenness (E)	0.86	0.79	0.92	0.46

Potential regeneration

The availability of sufficient natural regeneration is necessary to sustain the existence of new trees in natural forests. Natural regeneration is an important process in forest ecosystem dynamics, maintenance and preservation of biodiversity, and it is essential to achieve forest sustainability (Dey et al. 2014). It is a natural phenomenon that occurs when young plants replace mature trees due to various factors, such as being cut down, burned, falling, or physiologically dead (Samsoedin and Heriyanto 2010). Successful regeneration is achieved when there is an adequate number of seedlings, saplings, and pole-size trees of a species in competitive positions throughout forest development (Saikia and Khan 2013; Singh et al. 2020).

As shown in Table 1, few tree species were present at every growth stage, and only 10 out of the 39 had complete stages. The population structure shows a reverse J-shaped distribution (Figure 3), indicating that this nature reserve was healthy. Human disturbances may affect seed dispersal mechanisms, fruiting, germination, and regeneration (Gebeyehu et al. 2019). Therefore, some tree species in the nature reserve failed to regenerate naturally, which caused them to exhibit discontinuous population structures. The absence of early growth stage(s) indicates the urgent need for a forest management plan to enhance natural regeneration.

This study concludes that Rubiaceae, Dipterocarpaceae, Lauraceae, and Moraceae were the families with the highest number of species in the Martelu Purba Nature Reserve. *Shorea platyclados* was the most dominant species at the tree stage, with the highest IVI. The forest stand structure in the reserve was normal because the distribution of diameter classes resembled the inverted J-curve, with the stand structure dominated by trees with a diameter of 41-60 cm. The diversity index at each growth stage was low to moderate due to the high level of dominance of a few species. Two species with conservation importance were found in the Martelu Purba Nature Reserve, namely *Coffea arabica* (Endangered) and *Lithocarpus maingayi* (Vulnerable). The presence of invasive alien plant species, such as *Bellucia pentamera*, needs attention to prevent them from spreading across the nature reserve.

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