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Diversity of tree vegetation in Mount Baung Natural Tourism Park utilization block, Pasuruan Regency

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ABSTRACT. The high diversity of tree species found in natural forests contributes to their ability to maintain ecological balance. Mount Baung Natural Tourism Park is the conservation area in Pasuruan Regency, East Java that functions to protect biodiversity. The research aims to identify tree species, analyze tree diversity, and determine tree dominance with the importance value index (IVI). The research was conducted from February to March 2023 in Mount Baung Natural Tourism Park utilization block (MBNTP UB), Pasuruan Regency, East Java, Indonesia. The observation location was determined to be 37 points and plots were made in the point with a size of 20 m × 20 m for the tree phase, 10 m × 10 m for pole phase, 5 m × 5 m for the sapling phase, and 2 m × 2 m for the seedling phase. Data collected from field observations were analyzed to determine the Shannon diversity index using PAST 4.01. Tree dominance was analyzed using IVI. The research showed that 14 species from 8 tree families are found in MBNTP UB. The Fabaceae family is found to be abundant compared to other families. The highest number of individuals found in the seedling phase is *Cassia glauca*. *Swietenia macrophylla* has the highest individual's number in the sapling, pole, and tree phases. The highest tree diversity is found in the tree phase. Diversity at the tree phase is classified as moderate, while at the seedling, pole, and sapling phase the diversity is low.

Keywords: conservation area; Fabaceae; IVI; Mount Baung; Shannon index albumin index

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INTRODUCTION

Indonesia's rich biological heritage is characterized by a high diversity of tree species, which, as long-lived woody plants (Dulamsuren *et al*., 2014), function as integral biotic components in forest ecosystems, shaping vegetation structure and contributing significantly to ecological processes (Carteron *et al*., 2020). Forests are an essential habitat for biodiversity and provide various ecosystem services for human welfare (Brockerhoff *et al*., 2017). Trees in forests have an essential role in avoiding erosion, regulating the hydrological cycle, maintaining global climate stability, and storing carbon. They can absorb carbon dioxide produced from various activities carried out by humans and other living things (Aba *et al.*, 2017). Trees can also eliminate air pollution through the interception of particulates on plant surfaces and the absorption of pollutant gases through leaf stomata (Nowak *et al*., 2014).

Natural forests have a wide variety of tree species. The high diversity of tree species helps the forest maintain ecological balance (Safe'i *et al*., 2018). Forest health status can be determined based on indicators of tree species diversity. The level of tree species diversity is closely related to an ecosystem's ecological stability level. The higher the number of tree species and the value of tree species diversity in a forest, the greater the complexity of the forest ecosystem (Sanjaya *et al*., 2021). Tree diversity assessment is of paramount importance due to its sensitivity to ecological changes, its role as an indicator of ecosystem health, its reflection of spatial-temporal heterogeneity, and its significance as a component of the food chain (Safe'i *et al*., 2021). Furthermore, the analysis of tree vegetation provides critical insights into the composition and structure of forest ecosystems, informing reforestation efforts, and facilitating the evaluation and sustainable development of forest resources (Cahyanto *et al*., 2014).

Mount Baung Natural Tourism Park (MBNTP) serves as a critical conservation area within Pasuruan Regency, East Java, dedicated to the preservation of biodiversity. Previous research conducted within MBNTP has documented a diverse array of plant species, including *Bambusa vulgaris* (bamboo), *Tabernaemontana macrocarpa* (Local: cembirit), *Adenanthera pavonina* (Local: saga), *Albizia* sp. (Local: sengon Jawa), and *Colocasia esculenta* (taro or elephant ears) (Furqoni *et al*., 2023). Notably, six bamboo species have been identified, exhibiting a clumped distribution pattern and predominantly characterized by a young population phase (Sofiah *et al*., 2013). Furthermore, MBNTP harbors six species of *Syzygium*, with *Syzygium pycnanthum* demonstrating the highest prevalence (Mudiana, 2016). The park also provides habitat for *Lepisanthes rubiginosa*, an indigenous Indonesian plant species with considerable potential for utilization, exhibiting a robust presence within MBNTP (Mudiana & Ariyanti, 2021). To support the long-term sustainability of MBNTP, park managers and local communities have implemented reforestation initiatives. This is crucial because forest loss represents a primary driver of species extinction, and reforestation serves as a vital mechanism for restoring these critical ecosystems (Kemppinen *et al*., 2020). Large-scale reforestation efforts exert a significant influence on plant species diversity, subsequently impacting the stability and resilience of vegetation communities (Wang *et al*., 2019). Reforestation demonstrably enhances species composition, density, and canopy cover (Osuri *et al*., 2019). Furthermore, reforestation is recognized as a fundamental strategy for climate change mitigation due to its substantial potential for carbon sequestration (Locatelli *et al*., 2015).

Despite its recognized importance, comprehensive information regarding the diversity of tree vegetation within Mount Baung Natural Tourism Park (MBNTP), specifically within the utilization block, remains limited. This research aims to identify tree species present within MBNTP UB, analyze tree diversity indices, and determine the dominance of individual tree species using the importance value index (IVI). The findings of this study will provide valuable insights into the structure and composition of tree species within MBNTP UB, ultimately informing the development of effective management strategies for conservation and restoration efforts within this critical conservation area.

MATERIALS AND METHODS

Study area. The research was conducted from February to March 2023 in MBNTP UB, Pasuruan Regency, East Java, Indonesia is located at 112°16'23" - 112°17'17" E and 07°46'09" - 07°47'23" S, at altitude 282 m asl. Environmental conditions varied widely, with temperatures around 28 - 32 °C, humidity around 51 - 60%, wind speeds around 1.5 - 9 m/s, and light intensity around 1766 - 6572 lux.

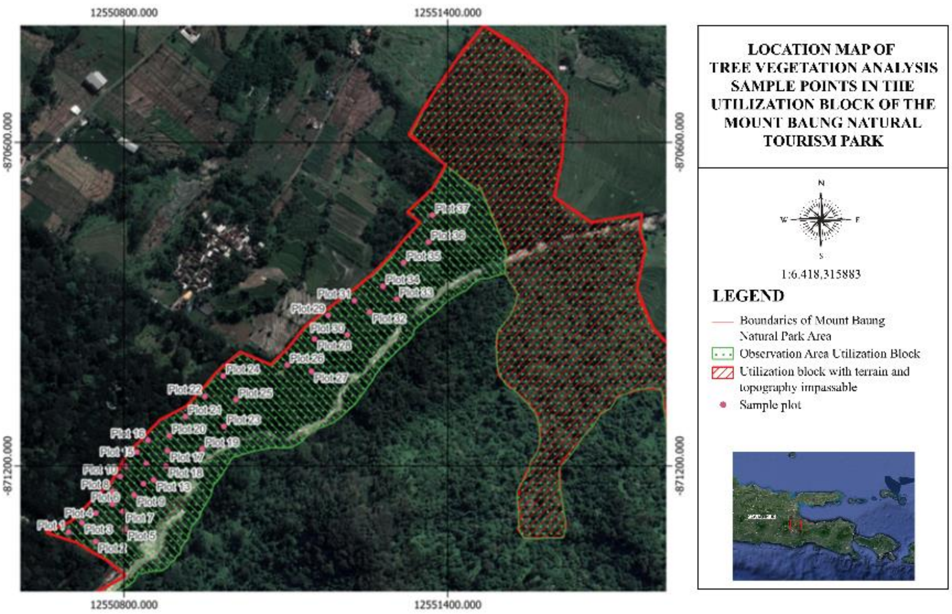

Fig. 1. Study area in the Mount Baung Natural Tourism Park Utilization Block.

Sampling. The vegetation analysis sampling begins with determining the research location point in the MBNTP UB area. Based on the survey results, the area that can be accessed is 15 ha. Sampling was carried out on 10% of the area using a quadratic plot. Plots were made in the point with a size of 20 × 20 m for the tree phase, 10 × 10 m for pole phase observations, 5 × 5 m for the sapling phase, and 2 × 2 m for the seedling phase. The number of sample poins in the MBNTP UB is 37 (Fig. 1). Observations were made and recorded regarding the type and number of trees in each plot and morphological observations of each fruit, seed, flower, and leaf. Then, the morphology of each fruit, seed, flower, and leaf sample was identified using Steenis (2005) and Sukarya (2013).

Tree dominance was analyzed using the important value index (IVI) (Fachrul, 2007). The IVI formula is as follows:

Density (D):

$$\mathrm{D} = \frac{\text{Number of Individuals}}{\text{total area sampled}}$$

Relative Density (RD):

$$\mathrm{RD} = \frac{\text{Density of a species}}{\text{Total density for all species}} \times 100\%$$

Frequency (F):

$$\mathrm{F} = \frac{\text{Number of plots in which species recorded}}{\text{Total number of plots sampled}}$$

Relative Frequency (RF):

$$\mathrm{RF} = \frac{\text{Frequency of a species}}{\text{Total frequency for all species}} \times 100\%$$

Dominance (Dom):

$$\mathrm{Dom} = \frac{\text{Total basal area of a species}}{\text{Total area sampled}}$$

Relative Dominance (RDom):

$$\mathrm{RDom} = \frac{\text{Dominance of a species}}{\text{Total dominance for all species}} \times 100\%$$

IVI formula for seedling and sapling:

IVI = RD + RF

IVI formula for pole and tree:

IVI = RD + RF + RDom

Data analysis. Data collected from field observations were analyzed to determine the Shannon diversity index using PAST 4.01. Shannon diversity index criteria: <1.5: low, 1.5-3.5: moderate, >3.5: high (Magurran, 1988).

RESULTS AND DISCUSSION

The tree identification. Based on research results, it is known that there are 14 species from 8 tree families found in MBNTP UB. The families found are Anacardiaceae, Euphorbiaceae, Fabaceae, Malvaceae, Meliaceae, Moraceae, Sapindacea, and Verbenaceae (Table 1).

Table 1. The tree identification results in Mount Baung Natural Tourism Park Utilization Block

Family	Species	Local name
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Mentaos
Euphorbiaceae	*Mallotus molissimus* (Geiseler) Airy Shaw	Tutup
Fabaceae	*Samanea saman* (Jacq.) Merr.	Trembesi
Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	Flamboyan
Fabaceae	*Cassia glauca* Lam.	Joar
Fabaceae	*Parkia timoriana* (DC.) Merr.	Kedawung
Fabaceae	*Enterolobium cyclocarpum* (Jacq.) Griseb.	Sengon buto
Fabaceae	*Butea monosperma* (Lam.) Taubert	Ploso
Fabaceae	*Vachellia nilotica* (L.) P.J.H.Hurter & Mabb.	Klampis
Malvaceae	*Ceiba pentandra* (L.) Gaertn.	Randu
Meliaceae	*Swietenia macrophylla* King.	Mahoni
Moraceae	*Ficus racemosa* L.	Elo
Sapindaceae	*Sapindus rarak* Dc.	Klerek
Verbenaceae	*Tectona grandis* L.f.	Jati

The Fabaceae family is found to be abundant compared to other families. There are 7 species of the Fabaceae family found in MBNTP UB. This family has much potential to be used. The Fabaceae family is an essential group of plants because humans use it as legumes, green manure, and forage. This plant also has many benefits in pharmacology (Ahmad *et al*., 2016). There are 23 genera from the Fabaceae family used in Bangladesh to treat various skin, respiratory, circulatory, digestive, and various diseases (Rahman & Parvin, 2014). In Zimbabwe, 101 species of the Fabaceae family are used for medicine. These plants are used as traditional medicine to treat 134 medical conditions related to respiratory, digestive, female reproductive, and sexually transmitted infections (Maroyi, 2023).

The tree diversity. Based on Table 2, The three highest numbers in the seedling phase are *C. glauca* (146 individuals), *S. macrophylla* (130 individuals), and *S. rarak* (66 individuals). In the sapling phase are *S. macrophylla* (121 individuals), *C. glauca* (146 individuals), and *S. rarak* (34 individuals). In the pole phase are *S. macrophylla* (71 individuals), *C. glauca* (55 individuals), and *S. rarak* (17 individuals). In the tree phase are *S. macrophylla* (112 individuals), *C. glauca* (44 individuals), and *T. grandis* (16 individuals). The seedling phase (385 individuals) is the highest individual number, followed by the sapling, tree, and pole with individual numbers 278, 252, and 157, respectively. The highest number of species is found in the tree phase, with 14 species, followed by the seedling phase, with 6 species, while the pole and sapling phase has the same number of species, namely 5. The highest Shannon diversity index value is in the tree phase (1.902), followed by the seedling phase (1.402), pole phase (1.219), and sapling phase (1.192). Diversity at the tree phase is classified as moderate, while at the seedling, pole, and sapling phase the diversity is low.

Table 2. The tree diversity in the Mount Baung Natural Tourism Park Utilization Block

Species	Seedling	Sapling	Pole	Tree
Lannea coromandelica (Houtt.) Merr.				3
Mallotus molissimus (Geiseler) Airy Shaw		4	2	5
Samanea saman (Jacq.) Merr.				2
Delonix regia (Bojer ex Hook.) Raf.				8
Cassia glauca Lam.	146*	106	55	44
Parkia timoriana (DC.) Merr.	11	13	12	14
Enterolobium cyclocarpum (Jacq.) Griseb.	15			6
Butea monosperma (Lam.) Taubert				5
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.				2
Ceiba pentandra (L.) Gaertn.				6
Swietenia macrophylla King.	130	121*	71*	112*
Ficus racemosa L.				14
Sapindus rarak Dc.	66	34	17	15
Tectona grandis L.f.	17			16
Individual number	385*	278	157	252
Species number	6	5	5	14*
Shannon index	1.402	1.192	1.219	1.902*

Note: * : the highest value

The research results show that *S. macrophylla* has the highest numbers in the pole, sapling, and tree phases. *S. macrophylla* is widespread in various forest types, from savanna to tropical rainforest, and is often found as a border tree in mixed hardwood forests and along river banks (Telrandhe *et al*., 2022). Adaptation capacity influences the species survival. *S. macrophylla* can live well in a variety of environmental conditions. They can tolerate various soils and is resistant to strong winds because it has strong roots (Krisnawati *et al.*, 2011). The ability to survive *S. macrophylla* in unsuitable conditions is good. This species is relatively tolerant to low rainfall and can survive in areas with sufficient soil moisture (Brown *et al*., 2003). The annual growth of *S. macrophylla* is susceptible to climate and is positively correlated with rainfall in the first six years (Susatya & Yansen, 2016).

Seedling dynamics can influence forest diversity. The high seed mortality rate and slow seedling growth make it difficult for trees to survive. The high mortality rate in the early seedling phase significantly limits seedling growth to the sapling phase. Seedlings with a fast and consistent growth rate can develop into trees (Chang-Yang *et al*., 2021). The occurrence of dynamic changes in the species number, density, and dominance of plants from the seedling phase to the tree phase indicates a reciprocal relationship in vegetation that is beneficial or otherwise. One of the reciprocal relationships in plant communities can be shown by the competition of individual plants between species and within the species itself. Therefore, vegetation is defined as a whole consisting of a combination of various plant species that interact dynamically with their physical and biological environments and influence each other (Misra, 2024; Vantarová *et al*., 2024).

The high diversity of tree phases compared to other phases shows that MBNTP UB as a conservation area has been established for a long time. The tree diversity level is directly proportional to the resilience level. The higher tree diversity level in a forest, the greater the resilience level of the forest (Safe'i *et al*., 2018). Tree diversity is the primary driver of biodiversity in forests, the functional composition of trees, forest structure, climate, and soil. Mixed forests have many taxa, resulting in high tree diversity (Ampoorter *et al*., 2020).

The tree dominance. Based on Table 3, it is known that the seedling phase is dominated by *C. glauca* (IVI = 69.27%). The sapling, pole, and tree phase is dominated by *S. macrophylla* with IVI = 81.53%, 134.51%, and 112.13%, respectively.

Table 3. Important Value Index of phases in the tree

Phase	Species	RD (%)	RF (%)	RDom (%)	IVI (%)
Seedling	*Cassia glauca* Lam.	37.92	31.34		69.27*
	Parkia timoriana (DC.) Merr.	2.86	5.97		8.83
	Enterolobium cyclocarpum (Jacq.) Griseb.	3.90	5.97		9.87
	Swietenia macrophylla King.	33.77	28.36		62.12
	Sapindus rarak Dc.	17.14	20.90		38.04
	Tectona grandis L.f.	4.42	7.46		11.88
Sapling	*Mallotus molissimus* (Geiseler) Airy Shaw	1.44	2.00		3.44
	Cassia glauca Lam.	38.13	42.00		80.13
	Parkia timoriana (DC.) Merr.	4.68	6.00		10.68
	Swietenia macrophylla King.	43.53	38.00		81.53*
	Sapindus rarak Dc.	12.23	12.00		24.23
Pole	*Mallotus molissimus* (Geiseler) Airy Shaw	1.27	1.47	1.24	3.98
	Cassia glauca Lam.	35.03	33.82	33.30	102.15
	Parkia timoriana (DC.) Merr.	7.64	13.24	5.56	26.44
	Swietenia macrophylla King.	45.22	41.18	48.11	134.51*
	Sapindus rarak Dc.	10.83	10.29	11.79	32.91
Tree	*Lannea coromandelica* (Houtt.) Merr.	1.20	2.63	0.46	4.29
	Mallotus molissimus (Geiseler) Airy Shaw	2.01	3.51	0.80	6.32
	Samanea saman (Jacq.) Merr.	0.80	0.88	3.94	5.62
	Delonix regia (Bojer ex Hook.) Raf.	3.21	5.26	3.99	12.46
	Cassia glauca Lam.	17.67	20.18	7.35	45.19
	Parkia timoriana (DC.) Merr.	5.62	8.77	7.23	21.62
	Enterolobium cyclocarpum (Jacq.) Griseb.	2.41	4.39	6.71	13.50
	Butea monosperma (Lam.) Taubert	2.01	1.75	5.63	9.39
	Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	0.80	0.88	1.24	2.92
	Ceiba pentandra (L.) Gaertn.	2.41	3.51	8.64	14.55
	Swietenia macrophylla King.	44.98	25.44	41.71	112.13*
	Ficus racemosa L.	5.62	10.53	2.05	18.20
	Sapindus rarak Dc.	6.02	9.65	4.28	19.95
	Tectona grandis L.f.	6.43	5.26	6.44	18.13

Note: * : the highest value

One of the factors that caused the large number of *C. glauca* species found in the seedling phase was the characteristics of *C. glauca*, a plant with a good level of adaptation to the environmental conditions of MBNTP UB. The presence of seeds different types in the same individual of *C. glauca* has the potential to grow in colonies, thus requiring different germination requirements in various environmental conditions (Khurana & Singh, 2001). As an adaptive species, *C. glauca* can survive in relatively dry conditions, which can overcome drought by reducing water loss through stomata on its leaves or by developing strong roots to absorb water more efficiently (Putri & Dharmono, 2018).

The tree widely planted by managers and local communities for the conservation in MBNTP UB is *S. macrophylla*, so the plant is dominant in the pole, sapling, and tree phases. The presence of *S. macrophylla* can improve soil conditions, and has great potential for reforestation and greening. This plant is also used in agroforestry systems with corn, upland rice, and cassava (Krisnawati *et al*., 2011). Research shows that *S. macrophylla* was found to be the most dominant in the Dhaka South City Corporation Urban Area, Bangladesh, with an IVI of 193.22% (Jaman *et al*., 2017). Other researchers found *S. macrophylla* was also dominant in the seedling, sapling, pole, and tree phases in Nglanggeran Village of Batur Agung zone, Gunungkidul District, Yogyakarta (Tohirin *et al.*, 2021).

Forest managers have the most significant influence on the growth rate of *S. macrophylla* after harvest by implementing reforestation (Free *et al*., 2014). The main goal of reforestation is to restore ecosystem functions and increase species diversity (Derhé *et al*., 2016). Selecting tree species for reforestation programs in species-rich forest ecosystems requires much consideration to achieve landscape reforestation goals (Chechina & Hamann, 2015). The reforestation process needs to consider the types of trees planted. Choosing various tree types is more important than simply increasing the number of certain tree types (Jactel *et al*., 2017).

The existence of trees in MBNTP UB has excellent potential to be utilized. The high potential of the Natural Tourism Park area requires protection, preservation, and sustainable use to maintain its diversity (Kurey *et al*., 2019). Sustainable forest management has implemented various frameworks to maintain biodiversity (Mori *et al*., 2016). Trees have implications for planning structures, management institutions, and governance so that they can be used to improve sustainability, adaptation, and mitigation efforts (Ellison *et al*., 2017).

CONCLUSION

There are 14 species from 8 tree families found in MBNTP UB. The Fabaceae family is found to be abundant compared to other families. The highest number of individuals found in the seedling phase is *C. glauca*. Species has the highest individual numbers in the sapling, pole, and tree phases is *S. macrophylla*. The highest tree diversity is found in the tree phase (1.902), followed by the seedling phase (1.402), pole phase (1.219), and sapling phase (1.192). Diversity at the tree phase is classified as moderate, while at the seedling, pole, and sapling phase the diversity is low.

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