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Tree Vegetation Diversity In The Natural Reserve Of Jagat Mountain Sumedang

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Abstract: Mount Jagat is a 133.64-hectare nature reserve area that is directly adjacent to the village and community agricultural land. The designation and management of nature reserves aim to conserve biodiversity, prevent species extinction, protect the forest as a life-support system, and sustainably utilize biodiversity. The threats posed by anthropogenic activities in the Mount Jagat area indicate the need for an inventory and analysis of species diversity, especially tree vegetation, as a first step for conservation. Data collection was carried out using nested quadrats which were placed systematically based on the Land Mapping Unit (LMU). The quadrats were 20 m x 20 m for trees, 10 m x 10 m for poles, 5 m x 5 m for saplings, and 2 m x 2 m for seedlings. The data were then analyzed using Family Importance Value (FIV), Importance Value Index (IVI), Shannon's Diversity Index (H'), and global conservation status by the International Union for Conservation of Nature (IUCN). There are 78 species from 32 families found in the study area. The results showed that the highest FIV for trees was the Moraceae family, 15.43%. The highest FIV for polishes and saplings were in the family Euphorbiaceae with 20.65% and 23.60% respectively. The highest FIV at the seedlings level was the Lauraceae family at 28.47%. Two species were found that had IVI above 10% in almost every growth stage, namely *Machilus rimosa* (Blume) Blume. and *Orophea hexandra* Blume. *Machilus rimosa* (Blume) Blume. found at the tree, pole, sapling, and seedling levels. *Orophea hexandra* Blume. found at the pole, sapling, and seedling levels. The H' values for the stages of tree growth, polishing, sapling, and seedling were 1.71, 1.63, 1.47, and 1.39, respectively, included in the moderate diversity category. Globally, there are 2 species categorized as vulnerable (VU) and 1 species near threatened (NT) based on IUCN data.

Keywords: Diversity, Nature Reserve, Trees

INTRODUCTION

Threats posed by anthropogenic activities in natural forest areas indicate the need for identification, inventory, and analysis of species diversity, especially tree vegetation. Identification and inventory are the beginning of conservation efforts to restore or protect the

naturalness of forest areas. Research in Romania showed that there was a large decrease in the area of primary forest that has turned into secondary forest due to anthropogenic activities over the last 50 years, Grindean, et al. (2019). This research predicts that if anthropogenic activities continue and are not accompanied by efficient conservation implementation, the loss of primary forest area will be much faster. In India, anthropogenic disturbance to species diversity and vegetation structure of tropical forests has had a significant impact on decreasing tree species richness, density, area of cover, and diversity index. On the other hand, an increase in anthropogenic disturbance causes a significant increase in bush density, bush cover area, and herb density (Gogoi & Sahoo, 2018).

The diversity of tree species increases the stability of forest growth dynamics. This is mainly due to the different responses of each species to environmental fluctuations (Aussenac et al., 2019). These differences in response then shape the composition, population structure, and level of dominance of species in forest areas. Species composition is the diversity of existing stands. Species composition data is needed to understand the function of the area's ecosystem as a whole (Borogayary, et al., 2018). The population structure is the density ratio in each stand phase which shows the potential for regeneration (Pradhan, et al., 2019). There are 4 patterns of population structure of woody species, namely the inverted J shape, J shape, bell shape, and irregular shape. Patterns of J shapes, bell shapes, and irregular shapes indicate that the population is experiencing disturbance from the environment (Mewded, et al., 2020). An increase in dominance by one or several species will reduce the contribution of other species to ecosystem function (Genung, et al., 2020).

Rahman, et al. (2020) assessed the status of natural regeneration in Bangladesh forest areas using the Family Importance Value (FIV) formula, Importance Value Index (IVI), Shannon's Diversity Index (H'), and global conservation status by the International Union for Conservation of Nature (IUCN). The ability of natural tree regeneration is very important for the conservation and maintenance of tree species diversity in natural forests. Natural regeneration is a biological process that will affect the structure of the forest in the future. The small regeneration ability of a population causes an increased threat of extinction for the population in question.

The highest FIV indicates the dominating tree family in an area based on the number of individuals and the number of species in the family. The highest IVI indicates a tree species that dominates an area based on the number of individuals, distribution of individuals within the area, and individual body size. H' is a description of the magnitude of the comparison between the number of individuals of each species with the number of individuals of all species. The higher the H' value the higher the level of tree diversity. The IUCN determines the level of threat of extinction for a species with global conservation status based on research results.

Mount Jagat is a Nature Reserve area with an area of 133.64 ha which is directly adjacent to the village and community agricultural land. Community pressure on the Mount Jagat Nature Reserve area is quite high, because most of the people's needs for life still depend on this area. The designation and management of nature reserves aim to conserve biodiversity, prevent species extinction, protect life support systems, and utilize biodiversity in a sustainable manner. Inventory and analysis of tree vegetation is the right step to start conservation efforts to restore or protect forest areas.

RESEARCH METHODS

This research was conducted in the Gunung Jagat nature reserve area, Sumedang district, West Java, Indonesia. Observations in the field were carried out for 2 (two) months. The research location is divided into 6 Land Mapping Units (LMU) based on the classification of altitude, rainfall, and soil type. The map of research locations is shown in Figure 1.

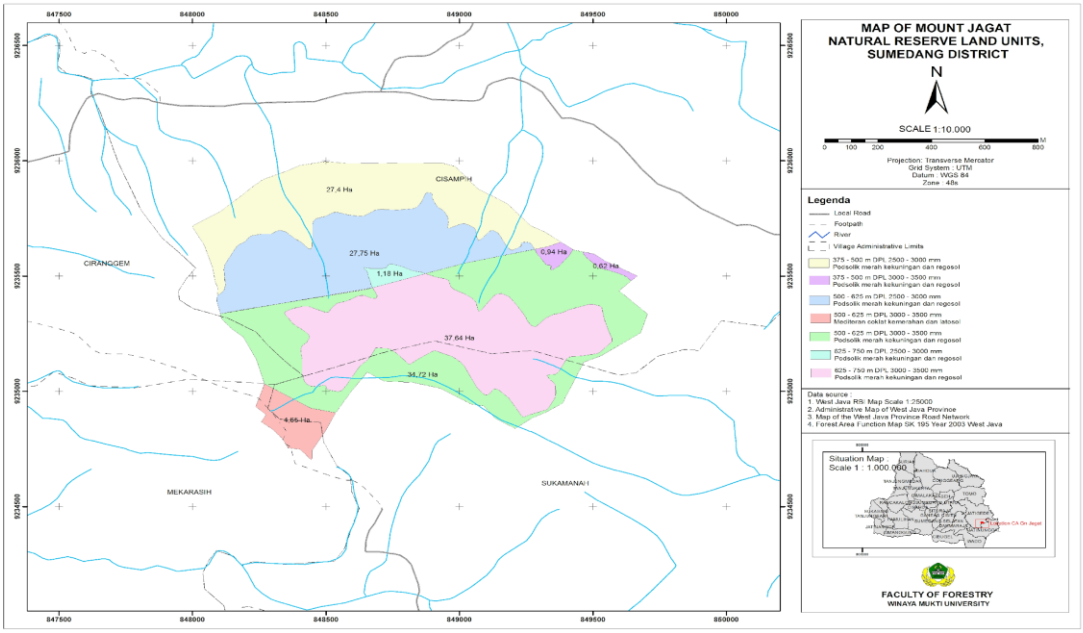

Figure 1. Map of research locations divided into 6 LMUs

The tools used in this study were a measuring tape, Global Positioning System (GPS), Compass, and Phiban. The object of observation is tree vegetation at the seedling, sapling, pole, and tree levels. The sampling technique was carried out by setting nested quadrats of 20 m x 20 m for the tree level, 10 m x 10 m for the pole level, 5 m x 5 m for the sapling level, and 2 m x 2 m for the seedling level. Quadrats are placed systematically, in as many as 37 plots. The number of sampling quadrats is determined based on the proportion of the area of each LMU. Growth stages for trees with a trunk diameter of >19 cm, pole stage with a stem diameter of ≥ 10 – 19 cm, sapling stage with a height of > 1.5 m, diameter < 10 cm, and seedling stage with a height of ≤ 1.5 m.

Data analysis was carried out using FIV, IVI, and H' for each level of seedlings, saplings, poles, and trees. The equations used in data analysis are shown in Table 1.

Table 1. The equation for data analysis

Attributes	Formula
Family Relative Density (Fd)	$Fd = \frac{Nf}{Ti} X\ 100$
Family Relative Diversity (Fr)	$Fr = \frac{Ns}{Ts} X\ 100$
Family Importance Value (FIV)	$FIV = Fr + Fd$
Density (D)	$D = \frac{a}{b}$
Relative Density (RD)	$RD = \frac{n}{N} X\ 100$
Frequency (F)	$F = \frac{c}{b}$
Relative Frequency (RF)	$RF = \frac{Fi}{\Sigma Fi}$
Abundance (A)	$A = \frac{n}{c}$
Relative Abundance (RA)	$RA = \frac{Ai}{\Sigma Ai}$
Importance Value Index (IVI)	$IVI = RD + RF + RA$
Diversity Index (H')	$H' = -\sum(\frac{n}{N}) log\ (\frac{n}{N})$

Note: Nf: number of individuals in a family; Ti: total number of individuals; Ns: number of species in a family; Ts: total number of species, a: total number of individuals of a species in all the quadrats; b: total number of quadrats studied; n: total number of individuals of the species; N: total number of individuals of all the species; c: total number of quadrats in which the species occurs; b: total number of quadrats studied; Fi: frequency of one species; Ai: abundance of one species.

The Shannon's Diversity Index was calculated for each of the four growth stages (seedling, sapling, pole, and tree). Vegetation has a high level of diversity if the Diversity Index H' > 3. Categorized as moderate if the value of H' = 1 – 3, and said to be low if the value of H' < 1.

The conservation status of existing species is determined by category globally by the IUCN. The categories used are global IUCN categories. CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near threatened; LC: Least Concern, DD: Data Deficient.

RESULTS AND DISCUSSION

The topography of the Gunung Jagat nature reserve area varies, ranging from moderately undulating, hilly to mountainous at an altitude of 454 – 742 meters above sea level. Shrubs are abundant at an altitude of 454 – 500 meters above sea level, while trees with dense crown cover are found at an altitude of > 500 – 742 meters above sea level. This area has 3 series of mountains namely Mount Jagat, Mount Puseur, and Mount Kencana. The Gunung Jagat nature reserve is bordered by Cisampih village and Sukamanah village. According to the Schmidt-Ferguson climate system and classification, this area is included in the C climate type with rainfall ranging from 2.500 – 3.200 mm per year. Inside the Gunung Jagat nature reserve area, there are sacred ancestral graves. This place is often visited by the community for pilgrimage activities. This sacred place is one of the reasons for access to the nature reserve area.

From observation and data processing for all levels of stands found 32 families with 78 species in it. There are 3 families with the highest FIV at each growth stage and 8 families with the lowest FIV at each growth stage. There are 2 species that have the highest IVI at each growth stage and 5 species with the lowest IVI at each growth stage. A graph of FIV numbers for each growth stage with the highest FIV is shown in Figure 2.

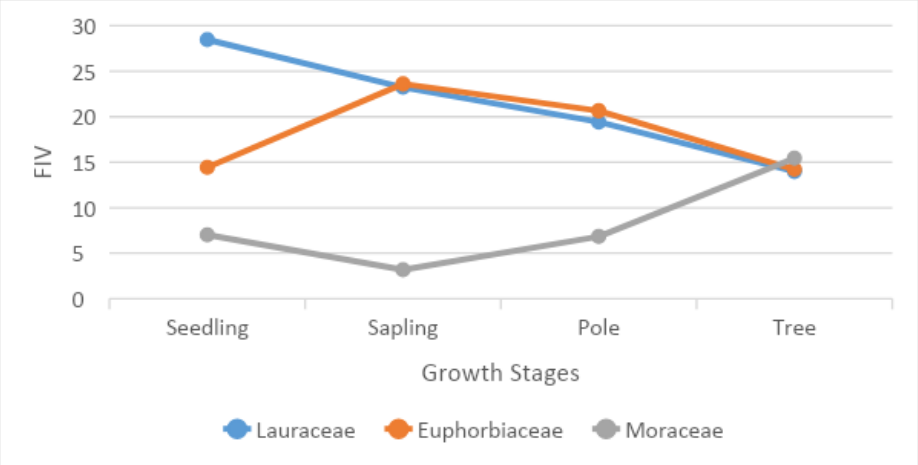

Figure 2. Family graph at each growth stage with the highest FIV

At the seedling level, 25 families were found, 27 families at the sampling level, 29 families at the pole level, and 32 families at the tree level. The increase or decrease in the FIV number which can be explained by the graph in Figure 2 is the existing condition. The decrease in FIV in Lauraceae and Euphorbiaceae at each growth stage was caused by a decrease in the

number of individuals with relatively the same number of species. In Moraceae, the increase in FIV at the tree level was caused by the presence of individuals from the species *Ficus septica* Burm. and *Ficus virens* Aiton. which were not present at the seedling, sapling, and pole levels.

The highest FVI figures at the seedling level were found in Lauraceae (28.47%) and Moraceae (15.43%) at the tree level. The results of Dodo & Hidayat's research (2020), show that the most species found in the Kinarum Protected Forest South Kalimantan area are the Lauraceae (13 species), Moraceae (11 species), and Rubiaceae (10 species) families. The Lauraceae and Moraceae families are families that dominate tropical and subtropical ecosystems.

At the sapling and pole levels, the highest FIV numbers were occupied by the Euphorbiacea family, namely 23.60% and 20.65%. Munawaroh, et al. (2020) stated that several Euphorbiaceae genera have a wide tolerance for environmental factors, have a wide geographical distribution, and can even grow and develop in degraded areas. The existence of Euphorbiaceae with the highest FIV at the sapling and pole levels in the Gunung Jagat nature reserve area shows this in accordance with the statement.

The highest IVI rate (> 10%) was found in 6 species of trees, 5 species of poles, 4 species of saplings, and 3 species of seedlings. The lowest IVI numbers were 1 species of tree (0.52%), 1 species of pole (0.83%), 2 species of saplings (0.70%), and 2 species of seedlings (0.81%). The highest IVI numbers at each stage of growth are shown in Tables 2, 3, 4, and 5.

Table 2. Species with the highest IVI number at the tree level

Species	Family	RD (%)	RF (%)	RA (%)	IVI (%)
Ficus altissima Blume.	Moraceae	4.33	3.43	12.11	19.87
Nauclea subdita (Koth.) Steud.	Rubiaceae	5.03	4.86	8.35	18.24
Taraktogenos heterophylla (BI.) Shloot.	Flacourtiaceae	4.51	4.57	3.97	13.05
Machilus rimosa (Blume) Blume.	Lauraceae	4.51	5.14	2.47	12.12
Crypteronia paniculata Blume.	Crypteroniaceae	4.16	3.43	4.37	11.96
Dracontomelon dao (Blanco) Merr. & Rolfe	Anacardiaceae	3.81	4.29	2.85	10.95

Table 3. Species with the highest IVI number at the pole level

Species	Family	RD (%)	RF (%)	RA (%)	IVI (%)
Machilus rimosa (Blume) Blume.	Lauraceae	9.47	8.30	7.95	25.72
Bridelia glauca Blume.	Euphorbiaceae	4.86	4.15	4.83	13.84
Orophea hexandra Blume.	Annonaceae	4.61	4.57	3.94	13.12
Taraktogenos heterophylla (BI.) Shloot.	Flacourtiaceae	3.58	4.15	3.84	11.57
Antidesma tetrandum BI.	Phyllanthaceae	3.84	2.91	3.71	10.46

Table 4. Species with the highest IVI number at the sapling level

Species	Family	RD (%)	RF (%)	IVI (%)
Machilus rimosa (Blume) Blume.	Lauraceae	11.41	7.86	19.27
Antidesma tetrandum BI.	Phyllanthaceae	10.00	5.76	15.76
Orophea hexandra Blume.	Annonaceae	9.13	6.29	15.42
Dracontomelon dao (Blanco) Merr. & Rolfe	Anacardiaceae	6.67	6.81	13.48

Table 5. Species with the highest IVI number at the seedling level

Species	Family	RD (%)	RF(%)	IVI (%)
Machilus rimosa (Blume) Blume.	Lauraceae	16.60	10.49	27.09
Orophea hexandra Blume**.**	Annonaceae	9.48	7.40	16.88
Antidesma tetrandum BI.	Phyllanthaceae	9.88	6.79	16.67
Sterculia oblongata R. Br	Sterculiaceae	5.53	6.17	11.70

There are 2 species that have IVI above 10% in almost every growth stage, namely *Machilus rimosa* (Blume) Blume. and *Orophea hexandra* Blume. *Machilus rimosa* (Blume) Blume. found at the tree, pole, sapling, and seedling levels. *Orophea hexandra* Blume. found at the pole, sapling, and seedling levels. According to Dodo & Hidayat (2020), the presence of a species in a habitat is caused by the species having tolerance for habitat factors such as slope, altitude, soil type, and climate.

Machilus rimosa (Blume) Blume. belongs to the family Lauraceae. Hops, et al. (2020), stated that the Lauraceae family is widespread in Southeast Asia and tropical America. These areas have an environment capable of meeting the requirements of Lauraceae vegetation, including the genus Machilus. The genus Machilus lives in forests with medium forest status with a biomass volume of 101 – 200 m3/ha and in rich forests with a biomass volume of 201 - <250 m3/ha.

The research results of Febriana et al. (2019) on the Semenanjung Ujung Kulon show that *Orophea hexandra* Blume. has a high density of 752 individuals per ha with an IVI reaching 66.19%. There are several similarities in habitat factors between the Semenanjung Ujung Kulon and the Gunung Jagat nature reserve area including climate factors and altitude. This is the reason for the existence and dominance of *Orophea hexandra* Blume. in the Gunung Jagat nature reserve.

The Diversity Index (H') is a description of the level of diversity of species in a community which expresses the ratio of the abundance of individual species in the community (Dodo & Hidayat, 2020). The results of the analysis of H's data are shown in Table 6.

Table 6. Diversity Index at tree, pole, sapling, and seedling levels

Growth Stages	Number of Species	Number of Individuals	Diversity Index (H')
Tree	69	574	1.71
Pole	62	401	1.63
Sapling	47	570	1.47
Seedling	47	507	1.39

Table 6 shows that the H' obtained was 1.71 at the tree level, 1.63 at the pole level, 1.47 at the sapling level, and 1.39 at the seedling level. The Shannon's Diversity Index stipulates that H' which is in the range of 1 – 3 is included in the moderate diversity category. In the Pananjung Pangandaran nature reserve, West Java, H' reached 3.55, indicating a high level of diversity. The succession of the Pananjung Pangandaran nature reserve forest has reached its climax. An ecosystem that has reached a climax is an indicator of the high complexity of interactions that will create ecosystem stability (Salwanafi et al., 2023).

According to the IUCN list, of the 78 species found, there are 2 species that fall into the category of the vulnerable (VU), 1 species near threatened (NT), 34 species of least concern (LC), and 1 species deficient (DD). Table 7 shows the conservation status of VU and NT species according to the IUCN.

Table 7. Conservation status of VU and NT species according to IUCN

Species	Family	IUCN category	IVI (%)			
			Tree	Pole	Sapling	Seedling
Dalbergia latifolia Roxb.	Fabaceae	VU	4.08	7.12	2.10	3.04
Swietenia macrophylla King	Meliaceae	VU	2.19	3.77	2.28	3.43
Gluta renghas L.	Anacardiaceae	NT	5.61	4.55	4.55	4.64

Note: The categories used are global IUCN categories. CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near threatened; LC: Least Concern, DD: Data Deficient.

IUCN data (2023) on the species *Dalbergia latifolia* Roxb. shows there has been a decline in population. Population decline is caused by a continuous decline in mature individuals and a decrease in habitat area. This happened because of timber harvesting, illegal logging, expansion of seasonal crop farming, and expansion of settlements. The research results of Arunkumar, et al. (2022), in India *Dalbergia latifolia* Roxb. is a tree species with high economic value, resulting in excessive timber harvesting and illegal trade which results in population decline. In the Gunung Jagat nature reserve, the presence of the species *Dalbergia latifolia* Roxb also showed a low IVI (3.04), although not the lowest IVI.

There is no specific population trend data for the species *Swietenia macrophylla* King. in IUCN (2023), due to the latest data obtained in 1998. It is known that *Swietenia macrophylla* King. wood has a high economic value in the international market, resulting in over-exploitation and a reduction of its population. In addition, this species has slow growth and is sensitive to climate change (Herrera-Feijoo et al., 2023). In the Gunung Jagat nature reserve, the presence of the species *Swietenia macrophylla* King. also showed a low IVI (3.43).

Gluta renghas L. population is declining due to over-logging. Logged wood is used as a substitute raw material for species Hongmu in the manufacture of traditional furniture in China. It is assumed that population decline will continue, especially in Southeast Asia (IUCN, 2023). The results of Atmoko & Mukhlisi's research (2021) show that the *Gluta renghas* L. tree is still one of the 4 main habitats for the endangered species *Nasalis larvatus* Wurmb. in East Kalimantan. In contrast, in the Gunung Jagat nature reserve, the presence of the species *Gluta renghas* L. showed a low IVI (3.43).

CONCLUSION

There are 78 species from 32 families found in the Gunung Jagat nature reserve. The highest number of FIV trees was the Moraceae family 15.43%. The highest FIV polishes and saplings were the family Euphorbiaceae 20.65% and 23.60%. The highest FIV at the seedlings level was the Lauraceae family at 28.47%. Two species were found that had IVI above 10% in almost every growth stage, namely *Machilus rimosa* (Blume) Blume. and *Orophea hexandra* Blume. *Machilus rimosa* (Blume) Blume. found at the tree, pole, sapling, and seedling levels. *Orophea hexandra* Blume. found at the pole, sapling, and seedling levels. The H' values for the stages of tree growth, polishing, sapling, and seedling were 1.71, 1.63, 1.47, and 1.39, respectively, included in the moderate diversity category. Globally, there are 2 species categorized as vulnerable (VU) and 1 species near threatened (NT) based on IUCN data.

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