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Vegetation Composition and Structure of Sapling Community in Girimanik Natural Forest Area, Setren Village, Slogohimo District, Wonogiri

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Abstract

Stake plants, commonly known as saplings, are needed to enhance soil structure, mitigate erosion, and bolster ecological stability. This research is essential as it provides a reference for knowledge pertinent to connected issues, which can be utilized to formulate policies that promote sustainability in natural forest ecosystems. This study seeks to ascertain the composition and structure of seedling vegetation in the Girimanik Natural Forest Area, Wonogiri. This research has not been conducted previously. The research methodology employs a quadratic sampling technique. Twenty-five plots, each measuring 5x5 m², were utilized by purposive sampling. This research identified 296 varieties of seedling plants across 30 species and 22 family. The sapling vegetation community in this region is predominantly composed of Pygeum parviflorum (nyampuh; English: Prunus), exhibiting an INP score of 59.24. The computed Shannon-Wiener diversity index in this study was 2.74, indicating a moderate amount of diversity, characterized by a balanced distribution of individual numbers without extreme diversity index values in the Girimanik forest area.

Keywords: *Forest; Quadrat Sampling; Sapling; Vegetation*

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INTRODUCTION

Vascular and non-vascular plants are essential constituents of vegetation that significantly influence the structure and function of forest ecosystems (Deng et al., 2023). Forests constitute a complex ecosystem that plays a crucial role in

sustaining ecological balance and biodiversity. The mix and structure of forest vegetation reflect the ecological conditions and disturbances present in the area. Environmental factors such as precipitation, temperature, and altitude significantly influence the floristic divergence of forest vegetation types (Kavgacı et al., 2021; Santhyami et al., 2021). Environmental factors significantly affect species diversity, particularly influencing expansion (Roziaty & Adnan, 2022). Community forests in Pasuruan exhibit a highly acidic soil pH, hindering nutrient absorption by plants (Ainiyah et al., 2017). The occurrence of several forms of sapling germplasm is exceedingly uncommon; also, some have become extinct due to land conversion, since development plans inadequately address sustainability in these areas. Consequently, the preservation of germplasm is essential to avert its extinction in regions susceptible to erosion (Wahyudin et al., 2023).

Natural forests provide superior carbon storage capabilities compared to agricultural land use systems, attributed to their high tree diversity, abundant understory vegetation, and substantial ground litter (Panggabean et al., 2013). Diversity dictates the presence of multiple varieties within a region (Putri & Santhyami, 2022). Natural forests possess various characteristics, including species composition, structure, and ecological functions that are almost identical or identical to the natural forests in that region. Natural woods often occur at elevations beyond 1,250 m above sea level and are predominant at elevations surpassing 1,375 m above sea level (Cahyanto et al., 2014).

The Girimanik Natural Forest, situated in Setren village, Slogohimo District, Wonogiri Regency, Central Java Province, Indonesia, is one of the natural forest regions on the island of Java (110 ̊41'-111 ̊18' East Longitude and 7 ̊32'-8 ̊15' South Latitude) (Mubarik et al., 2020). Girimanik Natural Forest is classified as a low mountain forest, situated at altitudes ranging from 1200 m to 2500 m above sea level (Roziaty & Utomo, 2020). The ecological functions of natural forest areas include mitigating soil erosion, regulating carbon dioxide and oxygen levels in the atmosphere, managing groundwater, enhancing the physical, chemical, and biological properties of soil, and lowering environmental temperatures.

Vegetation refers to the aggregate of plants that inhabit a particular area, or the assemblage of all plant species within a defined region (Roziaty & Pristiwi, 2020). The observations indicate that the vegetation in the Girimanik natural forest area (NFA) is highly diversified. Some of the vegetation in the Girimanik natural forest area (NFA) is in the form of trees, saplings, poles, bushes, shrubs, undergrowth, seedlings, lichens, and even epiphytic ferns (Roziaty & Utomo, 2020). According to Ndede et al., (2017), Saplings, also known as support plants, are utilized to enhance soil structure, mitigate erosion, and bolster ecological stability. These plants possess robust, deep roots that stabilize the soil and are capable of thriving in challenging situations. Sapling plants possess a stem diameter of under 10 cm and a height exceeding 1.5 m. Research on saplings conducted by Prastomo et al., (2017) in Nusapati Village, Mempawah Regency, indicates that mangrove forests exhibit a diversity of tree species according to the ecosystem/zoning sequence that requires inventorying.

Data on plant species, diameter, and height are required to ascertain the important value index of the forest community components for vegetation analysis. Vegetation analysis yields quantitative data regarding the structure and composition

of a plant community (Munawwaroh, 2016) .Vegetative analysis is essential for examining successional progress and development. Vegetative analysis is a methodical quantitative examination of the content and organization of plant communities in a designated area. Vegetation is affected by environmental elements including soil and air temperature, pH levels, and humidity. These elements are particularly significant for geologically dynamic regions. Vegetative structure refers to the vertical arrangement, distribution, and stratification of plants and other organisms. Attention is given to the species, diameter, and height of each plant to present a thorough overview of the community (Santhyami & Aryani, 2024).

This study will concentrate on determining the composition and structure of saplings in the Girimanik Natural Forest Area (KHA) located in Setren Village, Slogohimo District, Wonogiri Regency. This is due to the absence of prior studies on extant seedling plants. This allows for the determination of the Diversity Index Shannon Wiener (H') was calculated by using Shannon-Wiener Index (SWI) (Shannon & Wiener, 1963). Density (D), Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo) were then calculated based on Cox (1967) and Mueller-Dombois & Ellenberg (1974), Species dominance (CD) was calculated following the index by Simpson (1949), and Importance Value (IV) of seedling plants in the area.

METHOD

Research Location

Investigations of the composition and structure of saplings were conducted in the Girimanik Natural Forest Area on the slopes of Mount Lawu Selatan, situated in Setren Village, Slogohimo District, Wonogiri (110 °41'-111 °18' East Longitude and 7°32'-8°15' South Latitude). Girimanik Natural Forest is classified as a high mountain forest, situated at altitudes ranging from 1200 m to 2500 m above sea level (Roziaty & Utomo, 2020). The Girimanik Natural Forest has a temperature range of 22 - 26 °C, soil moisture levels between 20 – 40 %, light intensity of 900 – 1500 cd, and a soil pH of 7.5 - 8.0. The Girimanik Natural Forest Area (NFA) encompasses 10.6 hectares. The region possesses a tropical climate, with average annual precipitation between 1,557 and 2,476 mm (Gerhanawati, 2010). The designated site for data collection in the research is the Girimanik Natural Forest Area (KHA), as seen in Figure 1.

Research Methods

Sample Collection

This research uses a quantitative descriptive analysis method using Quadrat Sampling Techniques, which involves samples of sapling vegetation found in several Girimanik Natural Forest Areas. With a plot size of 5 x 5 m^2 for saplings there are 25 plots using purposive sampling to represent saplings in lowland forests from structural and composition parameters using the plot method. All plant samples were collected and identified at the Biology Education Laboratory, Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. The instruments and substances

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employed for plant collection include 70 % alcohol (which eliminates fungi and bacteria adhering to the plants), distilled water, adhesive, transparent plastic, solatip, and newspaper/HVS. Identify using the Gembong book reference from (Tjitrosoepono, 2007).

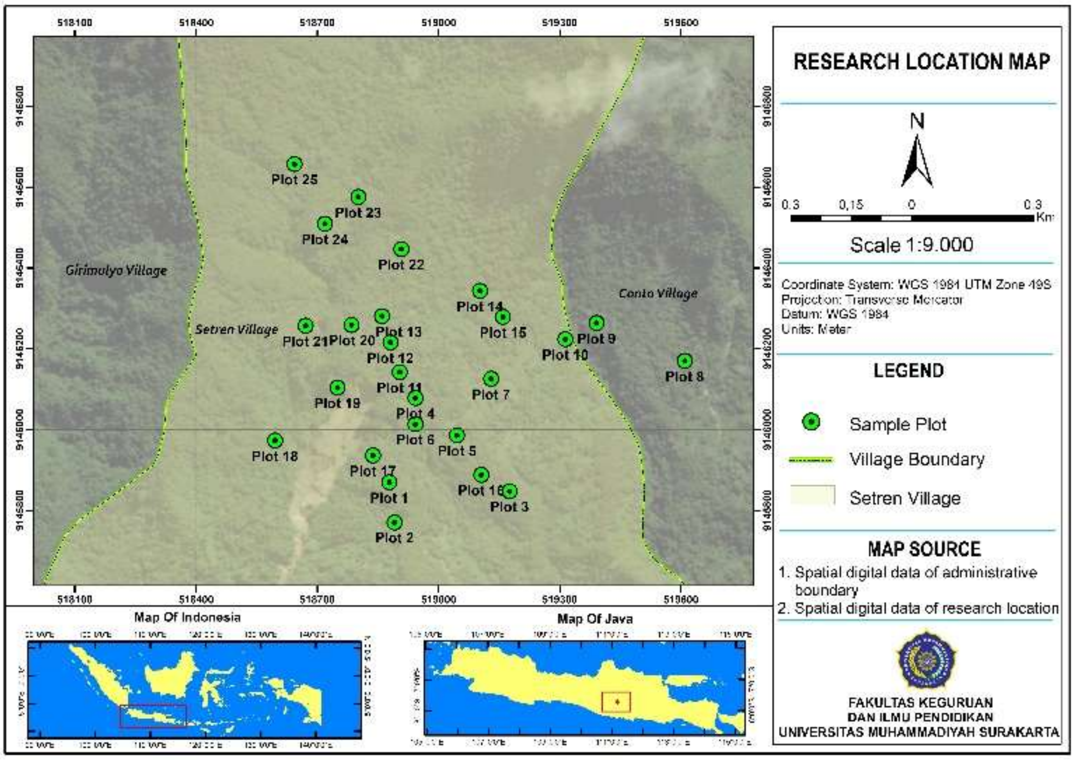

Figure 1. Map of research sites

Data Analysis

Important Value (IV)

Important Value (IV) is derived from the summation of relative density, relative frequency, and relative dominance. The significance of a kind varies from 0 % to 300 %. The important value runs from 0 to 300, indicating that a higher important value index for a species reflects the extent of environmental resources it utilizes for growth (Mueller-Dombois et al., 2016). The formula for important value (Mueller-Dombois et al., 2016) is as follows:

$$IV = RD + RF + Rdo \quad \ldots\ldots (1)$$

Note:

IV=Important Value;

RD= Relative Density;

RF= Relative Frequency;

Rdo=Relative Dominance.

Diversity Index (H')

To determine the diversity in vegetation, it can be calculated using the Shannon Wiener diversity formula. Species diversity can be calculated using the Shannon-Wienner diversity index with the following formula: (Shannon & Wiener, 1963).

$$H' = -\sum_{i=1}^{n} pi \ln pi \quad \text{.......} \quad (2)$$

Note:
H' = Diversity Index
Pi = ni/N
ni = Number of individuals of type i
N = Individual total

The scale calculated based on the Shannon-Wiener diversity index (Shannon & Wiener, 1963) is as follows:
H'≤1 = Low level of species diversity
1<H<3 = Medium level of species diversity
H'≥3 = High level of species diversity

Dominant Index

A high dominance index value indicates that control is concentrated in a single species. Conversely, a low dominance index value indicates that dominance is concentrated among multiple species. The conditions for the dominance index according to Simpson's are: 0 < C < 0.5, indicating no dominant type exists. 0.5 < C < 1 indicates the existence of a dominant type (Simpson, 1949). Dominance Index Formula (Simpson, 1949):

$$ID = \sum \left(\frac{ni}{N}\right)^2 \quad \text{.......} \quad (3)$$

Note :
ID = Dominance Index
ni = Important Value Index type-i
N = Number of Important Value Index

RESULT AND DISCUSSION

Sapling Community Composition

Research conducted in the Girimanik Natural Forest Area revealed the identification of 30 sapling plant species across 22 family. The frequently encountered species are *Pygeum parviflorum* from the Rosaceae family, totaling 64, followed by *Ficus* sp. from the Moraceae family with 41, and *Quercus sundaica* from the Fagaceae family with 30, among others (found on Table 1).

Table 1. Composition and structure of plant species at sapling level in KHA Girimanik

No	Species Name	Family	D	RD	RF (%)	RDo	IV	H'
1	*Abelmoschus moschatus* Medik.	Malvaceae	16	0.34	0.85	0.91	2.10	0.02
2	*Acer oblongum* Dinding. (DC)	Sapindaceae	320	6.76	6.84	0.00	13.59	0.18
3	*Aglaia odoratissima.* BI.	Maliaceae	64	1.35	1.71	1.19	4.25	0.06
4	*Chromolaena odorata* L.	Asteraceae	96	2.03	1.71	0.87	4.60	0.08
5	*Dendricnide stimulans (*L.fil)	Urticaceae	48	1.01	2.56	1.38	4.96	0.05
6	*Dichrocephata integeerifolia (*L.f) D.Don	Asteraceae	208	4.39	4.27	0.00	8.67	0.14
7	*Dryobalanops aromatica* Gaertn.f., nom kons.	Dipterocarpaceae	224	4.73	6.84	4.32	15.87	0.14
8	*Erythrina variegate* Lam.	Fabaceae	80	1.69	0.85	0.94	3.49	0.07
9	*Etlingera coccinea* Blume.	Zingiberaceae	16	0.34	0.85	0.74	1.93	0.02
10	*Ficus ribes* Blume.	Moraceae	80	1.69	3.42	2.10	7.21	0.07
11	*Ficus* spp.	Moraceae	656	13.58	6.84	24.11	44.80	0.27
12	*Ficus ribes* (Blume)	Moraceae	80	1.69	2.56	1.38	5.63	0.07
13	*Ficus variegate* (Blume)	Moraceae	48	1.01	2.56	1.43	5.01	0.5
14	*Marcopanax dispermus* (Blume) Kuntze LC.	Araliaceae	160	3.38	5.13	4.03	12.53	0.1
15	*Mitragyna speciose* Korth.	Rubiaceae	32	0.68	0.58	0.21	1.74	0.03
16	*Persicaria microcephala* (D.don) H.Gross	Polygonaceae	16	0.34	0.85	0.11	1.30	0.02
17	*Phyllanthus urinaria* Linnaeus.	Phyllanthaceae	32	0.68	0.85	0.55	2.08	0.03
18	*Pinanga corongata* Blume.	Arecaceae	144	3.04	0.85	2.67	0.56	0.11
19	*Piper retrofractum* Vahl.	Piperaceae	144	3.04	4.27	3.54	10.86	0.11
20	*Planchonia valida* Blume.	Lecythidaceae	48	1.01	1.71	0.62	3.34	0.05
21	*Pygeum parviflorum* (Wright).	Rosaceae	1024	21.62	15.38	22.24	59.24	0.33
22	*Quercus gamelliflora* Blume.	Fagaceae	16	0.34	0.85	0.08	1.27	0.02
23	*Quercus lineata* Blume.	Fagaceae	288	0.68	7.69	5.00	18.78	0.17

No	Species Name	Family	D	RD	RF (%)	RDo	IV	H'
24	*Quercus sundaica* Blume.	Fagaceae	480	10.14	10.26	13.79	34.18	0.23
25	*Saurauia bracteosa* DC.	Actinideaceae	32	0.68	1.71	1.02	3.40	0.03
26	*Schima wallichii* (DC.) Korth.	Theaceae	272	5.74	4.27	5.12	15.14	0.16
27	*Syzygium antisepticum* Blume.	Myrtaceae	16	0.34	0.85	0.04	1.23	0.02
28	*Tithonia diversifolla* (Hemsl.) A.Gray	Asteraceae	64	1.35	0.85	1.56	3.77	0.06
29	*Zanthoxylum caribaeum* Lam.	Rutaceae	16	0.34	0.85	0.04	1.23	0.02
30	*Zingiber zerumbet* (L.) Roscoe mantan Sm	Zingiberaceae	16	0.34	0.85	0.04	1.23	0.02
	Total		**4736**	**100.00**	**100**	**100.00**	**300.00**	**2.74**

Note: H'=Diversity Index; D=Density; RD=Relative Density; RF=Relative Frequency; RDo=Relative Dominance; and IV= Importance Value.

This research identified 296 varieties of sapling plants among 30 species and 22 family, as presented in Table 1. The sapling vegetation community in this region is predominantly composed of *Pygeum parviflorum* (Local name: nyampuh; English: Prunus), exhibiting an important value (IV) of 59.24. The elevated Importance Value (IV) signifies that this plant plays a crucial role in an ecosystem, such as offering habitat, food sources, mitigating erosion, and sequestering carbon (Ramadhan et al., 2024). The significant significance of this plant demonstrates its ability to adapt to the ecological circumstances of the Mount Lawu region, as corroborated by findings in a study Muhesi et al., (2024) *Pygeum africana* (or *Prunus africana*) is influenced by temperature, precipitation, soil composition, cloud cover, and is found at altitudes between 700 and 3000 meters above sea level, with an average temperature of 18°C to 26°C and annual precipitation of approximately 2000 mm. Nevertheless, to far, there has been no research providing additional information about the *Pygeum parviflorum* species itself.

The *Ficus* sp. plant (Local name: Jurang) had the greatest dominance in this investigation, attaining 24.11 %. The species exhibiting the highest INP significantly impacts a plant ecosystem (Irwansah et al., 2019). This high figure is supported by research Susilowati et al., (2022) which explains that *Ficus* sp. which is able to produce fruit throughout the year making it a "keystone species" very useful for preserving the forest ecosystem. Diverse species, including insects, birds, and mammals that consume this fruit, will facilitate the dispersal of seeds, resulting in widespread germination.

Quercus sundaica (Local name: Pasang kodok) possesses an important value (IV) of 34.18 and a density of 288 individuals per hectare, indicating robust reproduction. This finding surpasses previous research Istomo & Armila (2023) *Quercus sundaica* sapling growth was discovered on Mount Slamet along the Baturraden Botanical Garden path and the P7 route at sub-montane (KRB 0; P7 0) and montane (KRB 0; P7 11.26) elevations. The wood of this species is frequently utilized as a raw material for furniture, veneer, and carts due to its attractive and distinctive brownish-white to reddish hue. Permatasari et al., (2017) reported that *Syphalangus syndactylus* regularly use *Quercus sundaica* to rest and play, in line with the assertion Ramadhan et al., (2024) concerning the provision of habitat.

The computed Shannon-Wiener diversity index in this study was 2.74, indicating a moderate amount of diversity, characterized by a balanced distribution of individual numbers, with neither low nor high diversity index values present in the area. This figure exceeds the research conducted in the Qahabanga village forest in West Ternate District, which recorded just 0.35 (low) for the sapling level (Salatalohy et al., 2022). Comparable research was conducted at the Kuta Malaka Nature Tourism Park in West Aceh Regency, revealing a diversity index of merely 1.35 (medium) for sapling-level vegetation (Faradilla & Anhar, 2023). Alternative studies indicate superior results compared to the researchers' findings, including at the Sibolangit Nature Tourism Park in North Sumatra, which reported a Shannon-Wiener index value of 3.03, categorizing it as a high level of variety (Ulfa et al., 2022). The *Pygeum parviflorum* exhibited the highest dominance index in this study, attaining a value of 0.05, signifying an absence of species concentration within the community.

The overall species index recorded in this study was 0.10, categorized as low, further indicating a lack of species concentration in the community.

Regular vegetation analysis should be conducted to guarantee comprehensive documentation of alterations in composition, structure, and diversity of vegetation. This constitutes a fundamental action in the management of forest sustainability and conservation planning (Krisnawati et al., 2022). A higher diversity value in an environment signifies that the environment is in optimal shape (Nugroho et al., 2022).

Table 2. Comparison of sapling vegetation communities in various ecosystems

No	Location	H'	Dominant Species	Source
Protected Forest				
1.	Natural Forest Area (NFA) Girimanik	2.74	Nyampuh (*Pygeum parviflorum)*	This research
2.	Betania Village, Poso Regency	1.54	Eboni (*Diospyros celebica*)	(Hamka et al., 2022)
Mangrove				
1.	Tabulo Village, Gorontalo	0.62	Soga tingi *(Ceriops tagal*)	(Antu et al., 2015)
2.	Nusapati Village, Mempawah Regency	0.16	Api-api (*Avicennia lanatadengan*)	(Prastomo et al., 2017)
Urban Forest				
1.	Kibitay City, Sukabumi	4.71	Rambutan*(Nephelium lappaceum* L.)	(Suhendar et al., 2020)

Comparison of Dominant Species & Diversity Index Value

The results of table 2 show a comparison of sapling vegetation communities in various ecosystems. In the Girimanik protected forest ecosystem, the dominant species is *Pygeum parviflorum* (nyampuh), because this plant has a vital role in an ecosystem, for example providing habitat, food sources, preventing erosion, and even storing carbon (Ramadhan et al., 2024). This plant shows its capability in adapting to ecological conditions in the Lawu mountain area. Then in the protected forest ecosystem in Batania village, Poso Regency, the dominant species is *Diospyros celebica* (Local name: Eboni) because this plant has a vital role in an ecosystem, for example as a natural resource that can be harvested sustainably, and can be cultivated in community forests and social forests. This plant is spread in groups because it is

influenced by a non-uniform habitat. In the mangrove ecosystem in Tabulo village, Gorontalo, the dominant species is *Ceriops tagal* (Local name: soga tingi). This shows that the growth of this type of mangrove plant is better than other types (Antu et al., 2015). This plant has an important role in the coastal ecosystem because it can prevent erosion, this plant also provides habitat and shelter for animals in the mangrove area. In other mangrove ecosystems, namely in Nusapati Village, Mempawah Regency, the dominant species is the *Avicennia lanatadengan* (Local name: api-api) which is evenly distributed in the mangrove forest area of Nusapati Village, Mempawah Regency. This plant has benefits, namely its roots can protect the soil in coastal areas from seawater erosion, as a nutrient provider, as a waste absorber, and as a food ingredient. In the urban forest ecosystem in Kibitay, Sukabumi, the dominant sapling vegetation is *Nephelium lappaceum* L. (rambutan). Only a few sapling vegetation were found in a sample plot of 100 m^2. This states that this plant biologically has characteristics that are less suitable for planting in the City Forest with a limited area. *Nephelium lappaceum* is less tolerant of dense shade.

The diversity index value in the Girimanik forest research is 2.74, indicating a moderate level of diversity, characterized by a balanced distribution of individual numbers, with neither low nor high diversity index values present in the area. The seedling vegetation in the protected forest habitat of Betania Village, Poso Regency, exhibits a variety index value of 1.54, indicating a modest amount of diversity. This offers an assessment of the status of the protected forest in Betania Village and Girimanik woodland, which remain rather healthy and stable. The extensive species diversity is affected by individuals within their communities. The mangrove environment at Tabulo Village, Gorontalo, has an index value of 0.62, indicating minimal diversity. The diminished diversity index is attributable to the mangrove growth factor, which serves as a rehabilitation zone. In other mangrove habitats in Nusapati village, Mempawah, the diversity index value of 0.16 indicates a low level, since its value is H <1. The prevalence of mangrove vegetation types at the sapling stage in Tabulo village and Nusapati village is generally comparable and lacks diversity. The Shannon-Wiener species diversity index (H') for the urban forest ecosystem in Kibitay is calculated to be 4.71. This value is significantly elevated in comparison to that in Girimanik forest. The Kibitay forest possesses a stable ecosystem and harbors a diverse array of species. The diversity index indicates the correlation between species richness and individual abundance within a community.

CONCLUSION

The investigation conducted in the Girimanik Natural Forest Area revealed the identification of 30 seedling plant species across 22 family. The most often encountered species were *Pygeum parviflorum* (with Important Value-IV is 59.24) from the Rosaceae family, followed by the IV of *Ficus* sp. (44.80) from the Moraceae family,and the IV of *Quercus sundaica* (34.18) from the Fagaceae family, among others. The significant value signifies that this plant plays a crucial role in an ecosystem, such as offering habitat, food sources, preventing erosion, and sequestering carbon. The computed Shannon-Wiener diversity index value in this study was 2.74, indicating a moderate amount of

diversity, characterized by a balanced distribution of individual numbers without extreme diversity index values in the Girimanik forest area.

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