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Composition and Diversity of Understory Plants in *Agathis labillardierei* Stands in the Sorong Nature Park Forest, West Papua

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ABSTRACT

This study aims to analyze the species composition, diversity, dominance, and evenness of deciduous understory plant species in *Agathis labillardierei* stands in the Sorong Nature Park Forest, West Papua. The survey method used was plot sampling in *Agathis labillardierei* stands of various ages. The results of the study showed that there were 37 species of understory plants distributed across 25 families, including *Araceae*, *Fabaceae*, *Poaceae*, *Piperaceae*, *Euphorbiaceae*, *Zingiberaceae*, *Acanthaceae*, *Urticaceae*, *Verbenaceae*, *Solanaceae*, *Bromeliaceae*, *Pteridaceae*, *Gleicheniaceae*, *Orchidaceae*, *Myrtaceae*, *Athyriaceae*, *Ophioglossaceae*, *Rubiaceae*, *Pandanaceae*, *Asteraceae*, *Marantaceae*, *Schizaeaceae*, *Dennstaedtiaceae*, *Thelypteridaceae*, and *Araucariaceae*. The diversity index of understory plants was classified as moderate, with a value of 1.497; the dominance index was low, at 0.037; and the evenness index was 0.954. These findings indicate that the understory plant community in *Agathis labillardierei* stands is in a relatively ecologically stable condition, with a high level of evenness that contributes to the stability of species diversity.

Keywords: *Agathis labillardierei,* composition, diversity, understory plants

INTRODUCTION

Understory plants are those that occupy the lower layer of the forest, excluding tree seedlings. These plants play a role in protecting the soil through their root systems, reducing erosion, and increasing organic matter in the soil[1][2][3]. Understory plants are one of the components of tropical forest vegetation that contribute to the complexity of forest structure and support habitat diversity for other biotic factors[4]. Plants within the forest ecosystem are closely related to their environment. In the forest, plants interact with one another as well as with their surrounding environment. They form a closely connected community, including the fauna that also inhabit the forest[5]. Where forests possess an extensive biodiversity, including both wildlife and plants. This condition makes forests a complex and diverse ecosystem[6]. The diversity of understory plants in forests has various ecological benefits that are highly important for maintaining the balance of the forest ecosystem. According to Nikmah[7]understory plants such as shrubs, small woody plants, and epiphytes can reduce soil degradation or erosion. These plants also contribute to maintaining soil stability and preventing the loss of nutrients that are essential for soil fertility. In addition, understory plants can create a more stable and humid microclimate on the forest floor. Differences in structure and composition at each stratum of understory vegetation are closely related to habitat conditions. The environmental factor that will affect their presence and growth is the altitude above sea level.

Understory plants are a type of vegetation that grows in the forest's lowest layer, specifically beneath the main tree stands. Their presence plays an important role in conserving soil and water, as their dense and spreading root systems are capable of forming compact clusters that effectively prevent erosion. In addition, understory plants also serve to protect the soil surface from the impact of raindrops and surface runoff, as well as contribute to increasing the organic matter content in the soil. According to Pebriyanty[8], understory plants function as a food source for various types of fauna living in the forest. They also contribute to soil fertility by adding nutrients to the soil. Several types of understory plants possess properties that can be utilized as medicinal plants. They have potential as natural sources of medicine for human health. Additionally, they function as rainwater buffers, which can minimize erosion and help maintain soil stability. This is highly important for preserving the balance of the forest ecosystem. Forests with a high diversity of understory plant species indicate a better-balanced ecosystem. This is because understory plants can adapt to various environmental conditions and fulfill diverse ecological functions. According to the study by [9], a high value of understory plant diversity tends to indicate a well-functioning ecosystem, affected by environmental factors such as light intensity, soil

moisture content, and soil organic matter. The conservation area of Sorong Nature Park is one of the vegetation habitats that holds several priorities based on species richness, endemism, habitat diversity, and its unique value, particularly various types of understory plants. Understory plants have an important role as part of biodiversity and in controlling the rate of erosion. However, information regarding the diversity of understory plant species in the forest, particularly quantitative data, remains very limited.

RESEARCH METHOD

The method used in this research was direct observation with a quadrat sampling technique, involving 25 plots in each *Agathis* stand of different ages. Each plot measured 2 m × 2 m and was consecutively placed on the right and left sides within each age group of the *Agathis* stands. The map of the Sorong Nature Park area below shows the location of the research site

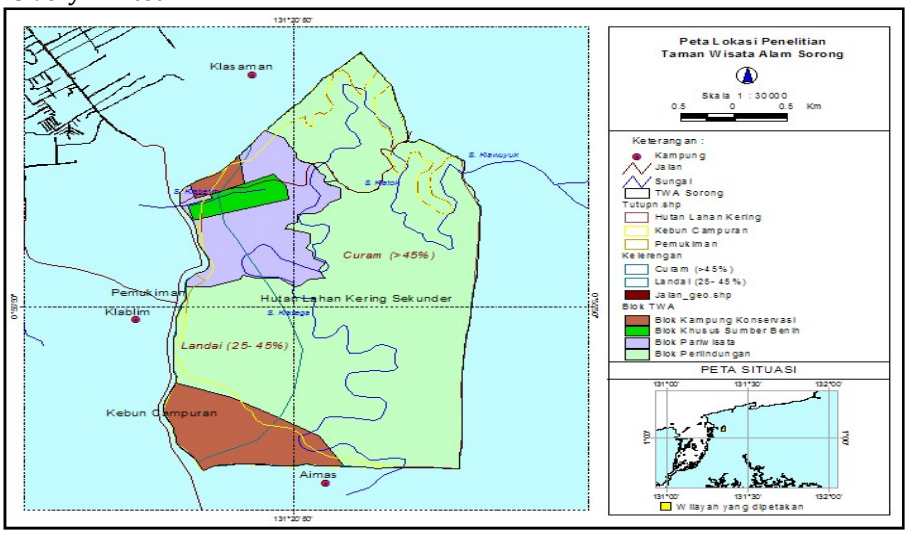

Figure 1. Research Site Map

The procedure used in this study used quadrat plots, with the determination of observation samples carried out by objectively considering the area.

1. Initial Preparation

   The implementation of the research began with preparations, which included coordination and collaboration with the Natural Resources Conservation Center (Indonesian: *Balai Besar Konservasi Sumber Daya Alam*; BBKSDA) to conduct a preliminary survey at Sorong Nature Park to support the research implementation.
2. Research Implementation Technique

   This research was conducted using a plotline technique based on the research site map of Sorong Nature Park. The implementation technique was carried out as follows:
   a. The research used quadrat plots to observe the types of understory plants, which were placed at 5 research site points.
   b. Observations were conducted, and the number of understory plant species in each plot was counted.
   c. The data obtained, both quantitative and qualitative, were recorded on data sheets/tally sheets.
3. Data Collection

   Data collection in this study consisted of primary data and secondary data. The primary data collected included:
   a. Types of understory plants, which referred to all types of understory vegetation found within the research plots.
   b. Distribution, referring to the spatial distribution of understory plants within the research plots.

   Meanwhile, the secondary data consisted of the research site map and the general condition of the research location
4. Data Analysis

   The observational data were analyzed according to each parameter and described both qualitatively and quantitatively, and presented in the form of tables and figures (charts, graphs, and photographs). Data analysis for the parameters used the formulas for diversity, dominance, and evenness of understory plant species according to Odum[10], as follows:
   a. Understory Plant Species Diversity

      To determine the diversity of understory plant species, the species diversity index (H') was used. The calculation was conducted using the Shannon and Wiener equation as follows:

$$H' = -\sum_{i-1}^{n} pi \ln pi$$

Description:
H' :Diversity index
pi : ni/N
ni :Number of individuals of the ith species
N :Total number of individuals of all species

A high species diversity indicates that a community has a high level of complexity due to the intense interactions among species within the community. A community is considered to have high species diversity when it consists of many species. Conversely, a community is considered to have low species diversity when it consists of

only a few species or when certain species dominate[11]

The criteria for the diversity index according to Fahrul[12]are as follows:

1) H' > 3 Value,High species diversity
2) H'= 1 ≤ H' ≤ 3 Value,Moderate species diversity
3) H' < 1 Value, Low species diversity

b. Dominance of Understory Plant Species

To determine the presence of understory plant species that indicate the dominance level of certain species within a community, the Species Dominance Index (D) was used, calculated using the equation by Simpson as follows:

$$D = \sum \left[\frac{ni}{N}\right]^2$$

Description:

D :Dominance index
ni : Number of individuals of the *i*th species
N :Total number of individuals of all species

The criteria for the Dominance Index were first proposed by Krebs[10]which categorizes the range of dominance index values as follows

1) 0.00 < D ≤ 0.30 indicates a low level of dominance,
2) 0.30 < D ≤ 0.60 indicates a moderate level of dominance
3) 0.60 < D ≤ 1.00 indicates a high level of dominance

c. Evenness of Understory Plant Species

To determine the evenness of understory plant species along the research transect, an analysis was conducted using the species evenness index (E) based on Pielou's equation as follows:

$$E = \frac{H'}{LogS}$$

Description:

E : Evenness index
H' : Species diversity index
S : Total number of species present

The criteria for the evenness index according to Fahrul[12]state that evenness is high if E > 0.6, moderate if 0.4 < E ≤ 0.6, and low if 0 < E ≤ 0.4.

RESULTS AND DISCUSSION

Based on field observations conducted in 25 observation plots with a total area of 100 m^2 (0.01 ha) in the forest of Sorong Nature Park, 37 species of understory plants were recorded, as presented in Table 1 below:

Table 1. Species Composition of Understory Plants in the Forest of Sorong Nature Park

Family	Local Name	Scientific Name
Urticaceae	Pohpohan	*Pilea trinervia*
Fabaceae	Daun kupu-kupu	*Bauhinia purpurea*
Verbenaceae	Pecut Kuda	*Stachytarpheta jamaicensis*
Solanaceae	Takokak	*Solanum torvum*
Bromeliaceae	Nanas	*Ananas comosus*
Pteridaceae	Paku	*Adiantum hispidulum*
Gleicheniaceae	Pakis Kawat	*Dicranopteris linearis*
Fabaceae	Putri Malu	*Mimosa pudica*
Poaceae	Alang-alang	*Imperata cylindrica*
Orchidaceae	Anggrek tanah	*Spathoglottis plicata*
Fabaceae	Sisik betook	*Desmodium triflorum*
Euphorbiaceae	Patik Mas	*Euphorbia heterophylla*
Euphorbiaceae	Patikan kebo	*Euphorbia hirta*
Myrtaceae	Pacing tawar	*Costus speciosus*
Araceae	Keladi tikus	*Typhonium* sp.
Athyriaceae	Paku	*Athyrium filix-femina*
Ophioglossaceae	Paku tunjuk langit	*Helminthostachys zeylanica*
Piperaceae	Sirih hutan	*Piper vilipedunculum*
Araceae	Keladi	*Schismatoglottis kotoensis*
Zingiberaceae	Jahe hutan	*Zingiber officinale*
Rubiaceae	Babadotan	*Ageratum conyzoides*
Pandanaceae	Pandan	*Pandanus amaryllifolius*
Asteraceae	Urang aring	*Eclipta prostrata*
Marantaceae	Bemban	*Donax cannaeformis*
Schizaeaceae	Paku Hata	*Lygodium flexuosum*
Dennstaedtiaceae	Paku	*Orthiopteris* sp.
Piperaceae	Sirih hutan	*Piper magnibacum*
Piperaceae	Sirih hutan	*Piper muricatum*
Acanthaceae	Gandarusa	*Justicia gendarussa*
Acanthaceae	Gandarusa	*Gandarussa vulgaris*
Araceae	Keladi tikus	*Typhonium* sp1

Family	Local Name	Scientific Name
Thelypteridaceae	Paku	*Cyclosorus dentatus*
Zingiberaceae	Lengkuas Melaka	*Alpinia malaccensis*
Araceae	Liana	*Syngonium podophyllum*
Poaceae	Rumput Napier	*Cenchrus purpureus*
Araucariaceae	Palem jari	*Rhapis excelsa*
Poaceae	Rumput	*Isachne* sp.

Based on the species composition table above shows that the 37 species of understory plants consist of 25 identified families. The family *Araceae* has the highest number of species, totaling 4 understory plant species. This is followed by *Fabaceae*, *Poaceae*, and *Piperaceae*, each with 3 understory plant species. The families *Euphorbiaceae*, *Zingiberaceae*, and *Acanthaceae* each have 2 plant species. Meanwhile, the families *Urticaceae*, *Verbenaceae*, *Solanaceae*, *Bromeliaceae*, *Pteridaceae*, *Gleicheniaceae*, *Orchidaceae*, *Myrtaceae*, *Athyriaceae*, *Ophioglossaceae*, *Rubiaceae*, *Pandanaceae*, *Asteraceae*, *Marantaceae*, *Schizaeaceae*, *Dennstaedtiaceae*, *Thelypteridaceae*, and *Araucariaceae* each have 1 understory plant species. The dominance of certain understory plant species in the composition reflects the characteristic floral formation in the area[13]. Understory plant families with high abundance in forest ecosystems provide important contributions to various ecological functions. Understory plants play a role in supporting nutrient cycling, accelerating litter decomposition, and increasing the availability of nutrients for other plants. They regulate the process of evapotranspiration, maintain soil moisture, and assist in water conservation and erosion prevention. They serve as habitat and food sources for various fauna, particularly arthropod insects, which subsequently play roles in biological control, pollination, and the population dynamics of other organisms[14]. The distribution of understory plant family diversity strengthens forest ecosystem functions through contributions to nutrient cycling, erosion control, and complex biotic interactions. Families such as *Poaceae*, *Asteraceae*, and *Fabaceae* play a key role in maintaining community stability, both due to species abundance and the specific ecological functions they possess, making their presence highly important even though their species count is not always the highest[15]. The distribution of understory plant growth, specifically the number of families and individuals under *Agathis* stands, is affected by environmental conditions and sunlight exposure. According to Nahdi [16] species distribution is indirectly affected by the interactions among vegetation, temperature, air humidity, and the physical-chemical properties of the soil, which together create specific environmental conditions. These conditions determine the presence or absence of a species and allow for its distribution based on varying levels of adaptability. Temperature affects the rate of metabolism and plant growth. Extremely high or low temperatures can inhibit the physiological processes of understory plants. Air and soil humidity play a crucial role in the processes of photosynthesis and transpiration. Humidity levels that are too low or too high can limit the growth and flowering of certain species. Soil pH determines the availability of nutrients and affect the activity of soil microorganisms[17]. Understory plants have varying pH tolerances, making soil pH an important ecological filter. Light intensity is a key factor, especially under dense forest canopies[18]. Many understory plants are adapted to low light conditions, but some require higher light levels to grow optimally[19][20].

For the levels of diversity, dominance, and evenness of species, an analysis was conducted using the approach of diversity index, species evenness, and dominance. The approach of diversity, evenness, and dominance is highly appropriate because it is simple, informative, and has been validated in numerous vegetation studies. The results of the analysis on the diversity index, dominance, and evenness of understory plant species in the forest of Sorong Nature Park are presented in Figure 2 below:

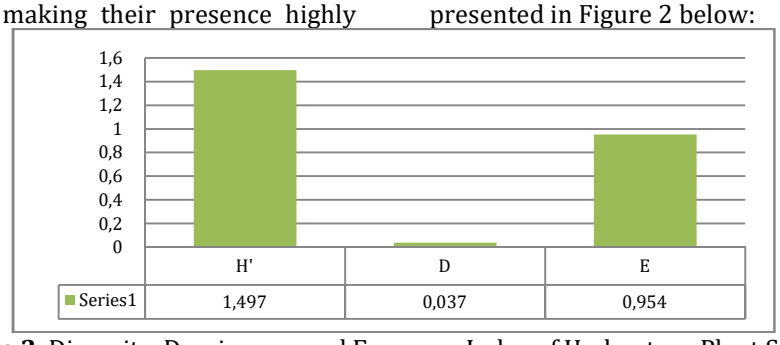

Figure 2. Diversity, Dominance, and Evenness Index of Understory Plant Species

The diversity index (H') is a vegetation parameter used to estimate the species diversity of understory plants[21].The results of the analysis of the diversity, dominance, and evenness indices of understory plant species, as shown in the figure above, indicate that the diversity index value of understory plants in Sorong Nature Park is 1.497, which falls into the moderate category. The dominance index is 0.037, which is categorized as low, and the evenness index is 0.954, which is categorized as high. The species diversity index in a given location is affected by various factors, including both internal and external factors. According to Andesmora [22], the species diversity of understory plants is affected by the intensity of light entering the

forest. The greater the amount of light reaching the ground, the higher the diversity of understory plant species. Environmental factors such as humidity, temperature, and wind speed also affect the diversity of understory plant species[23].According toWardhani[24],the presence of understory plants in teak forests can have positive impacts, specifically serving as a source of biodiversity, creating a microclimate on the forest floor, protecting the soil from the risk of erosion, and maintaining soil fertility.

In addition to habitat conditions, species diversity within a community is affected by disturbances, both natural and those caused by human activities. The diversity index of understory plants at the research site falls into the moderate category (1≤H'≤3), which indicates that, ecologically, the understory vegetation is in a relatively stable condition. The level of the diversity index value for a species is affected by the number of species and the number of individuals found[25].

The low dominance index of understory plant species in the Sorong Nature Park area indicates that no single species dominantly occupies the understory vegetation community. The presence of various understory plant species is relatively evenly distributed, with no species standing out significantly compared to others. This condition is caused by the *Agathis* stands having wider canopy openings, which allow more sunlight to reach the forest floor, thereby supporting the growth of diverse understory species without any single one becoming dominant. The low dominance index and the even distribution are closely related to the intensity of incoming light, which is approximately 55.6%[26].

A high species evenness index (0.954) indicates that in the ecosystem, individuals of all understory plant species are distributed evenly, without any species significantly dominating[27].However, a high evenness value does not necessarily reflect overall ecosystem stability. The evenness index only measures the distribution of relative abundance among species, without considering environmental factors that may limit the presence or growth of certain species. For example, changes in soil pH, nutrient deficiency, or other environmental stresses may limit the presence of certain species, allowing only tolerant species to survive[28].Thus, a high evenness index value may obscure the existence of underlying environmental pressures. This is supported by the opinion of Setiayu[29]stating that if species evenness is high, individuals of all understory plant species in the ecosystem are in an evenly distributed condition, so that no plant species becomes dominant. This is affected by environmental factors, where in the *Agathis* stands, there is a suitable combination of environmental conditions. In addition, variations in soil pH can affect the types of plants that are able to grow. Certain plant species can only thrive within specific pH ranges;thus, differing edaphic conditions may affect the distribution of understory plant species[30].

CONCLUSION

Based on field observations conducted in 25 observation plots in the forest of Sorong Nature Park, 37 species of understory plants were found, consisting of 25 families, namely *Araceae*, *Fabaceae*, *Poaceae*, *Piperaceae*, *Euphorbiaceae*, *Zingiberaceae*, *Acanthaceae*, *Urticaceae*, *Verbenaceae*, *Solanaceae*, *Bromeliaceae*, *Pteridaceae*, *Gleicheniaceae*, *Orchidaceae*, *Myrtaceae*, *Athyriaceae*, *Ophioglossaceae*, *Rubiaceae*, *Pandanaceae*, *Asteraceae*, *Marantaceae*, *Schizaeaceae*, *Dennstaedtiaceae*, *Thelypteridaceae*, and *Araucariaceae*. Understory plant species beneath *Agathis* stands in the Sorong Nature Park Forest showed a moderate diversity index value (1.497), a low dominance value (0.037), and a high evenness value (0.954). Thus, the higher the species evenness value, the more stable the species diversity. Ecologically, the understory vegetation is in a relatively stable condition.

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