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Diversity of Seedling Species as an Indicator of Natural Regeneration in the Imbo Putui Customary Forest, Riau Province

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Abstract

Biodiversity is crucial for meeting the diverse needs of living organisms. As the human population grows, so do the demands on forests. Without proper management, large-scale exploitation of forest resources is risky. To ensure the sustainability of nature, it is essential to implement regeneration patterns in forest areas, such as natural regeneration. This study aimed to assess plant regeneration in the Imbo Putui Customary Forest area in Kampar Regency. The research utilized Systematic Sampling with Random Start to record seedlings in the study plot. Data analysis included the Important Value Index (INP), Species Diversity Index, Evenness Index, and Species Richness Index. The study identified 27 plant species, with Lalan (*Santiria laevigata*) being the dominant species. The diversity and species richness indices indicated moderate results, while the evenness index showed high evenness levels.

Keywords: Biodiversity, Imbo Putui Customary Forest, Importance Value Index (IVI), Natural Regeneration, Systematic Sampling

1. Introduction

Biodiversity plays a crucial role in meeting the diverse needs of all living organisms, including humans, encompassing economic, clothing, food, oxygen (Dendang & Handayani, 2015), carbon absorption (Pebriandi et al., 2024), recreation, and aesthetic beauty (Pajri et al., 2023). Indonesia ranks among the top countries globally regarding biodiversity, following Brazil and Congo (Seprido & Hadi, 2024). Plants in forest ecosystems are a vital component of this diversity, serving various functions for different organisms (Puspitasari et al., 2022). With the growing human population, the demands on forest resources are escalating, potentially leading to large-scale exploitation if not managed sustainably. Therefore, proactive measures are necessary to prevent this scenario. Managing and assessing the plant composition in forest areas is crucial to determine the appropriate management strategies for maintaining the ecosystem. Studying the natural regeneration of seedlings in forest areas is a key activity as it ensures the establishment of a healthy ecosystem and helps control invasive species (Rachmanady & Yuwati, 2023). The success of seedling growth depends heavily on the quality of regeneration and seedlings (Mardhiansyah et al., 2024).

The Imbo Putui Customary Forest was selected for this study due to its preservation of authenticity in Riau Province. Managed by the local indigenous community, this forest area retains its natural beauty and authenticity in line with its traditions (Safitri et al., 2019). Previous research in the exact location focused on identifying the tree stands within the area (Safitri et al., 2019), but there has been no investigation into the natural regeneration processes. Hence, this study aims to provide updated insights and understand the dynamics of the Imbo Putui Customary Forest plant regeneration.

2. Material and Methods

2.1. Place and Time

The present study was conducted in the Imbo Putui Customary Forest area in Petapahan Village, Kampar Regency, Riau Province (see Figure 1), which is located at coordinates 0°32'33.2"N 101°03'54.2"E. The study was conducted during June and July of 2024. The specific location is delineated in Figure 1.

2.2. Tools and Materials

The tools used in this study include tallysheets, plant

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identification manuals, thermometers, hygrometers, global positioning systems (GPS), meters, stationery, and laptops. The materials used in this study are maps of research locations and seedling-level vegetation found in observation plots.

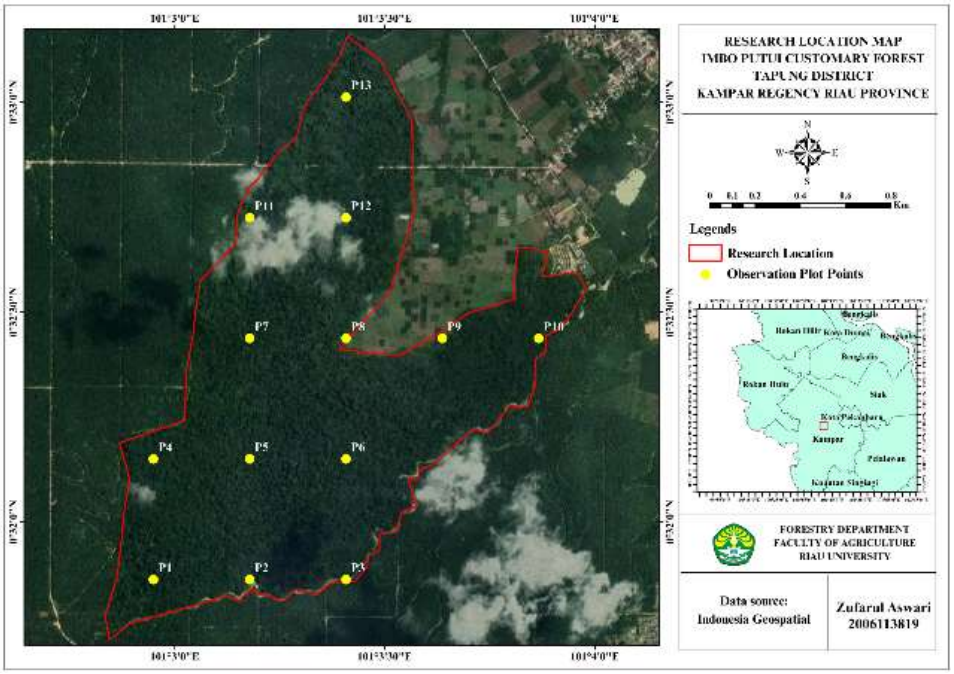

Figure 1. Research Location Map

2.3. Research Methods

The present study utilizes the Systematic Sampling with a Random Start method, employing a sampling intensity of 1% of the total area, encompassing a research area of 2.5 ha. The research area will be subdivided into 13 observation plots, each measuring 20 x 100 m, with a distance of 500 m between plots.

The sequence of research activities is illustrated in Figure 2 below.

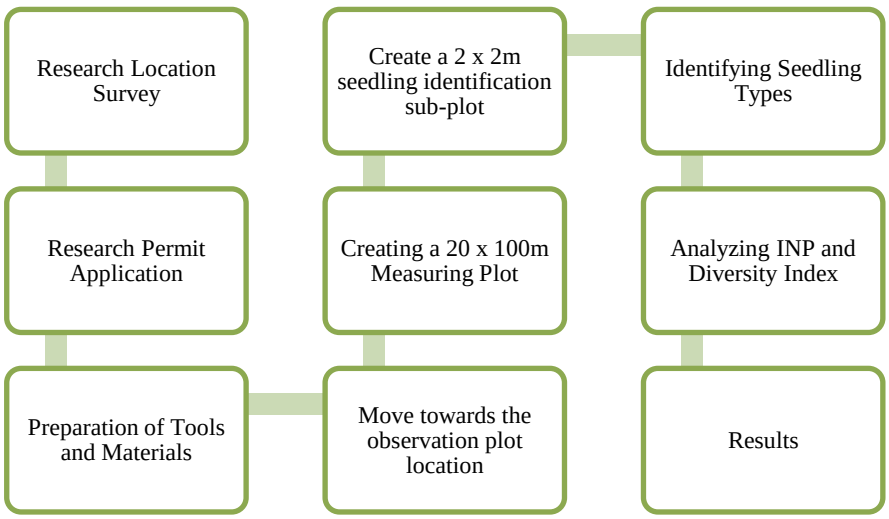

Figure 2. Research Flow Diagram

2.4. Data Analysis

The data analysis employed in this study is the Important Value Index (INP) analysis, which is derived using the following formula:

$$\textbf{Density (K)} = \frac{\sum \textbf{Individuals of a species (N)}}{\textbf{Sample plot area (ha)}}$$

$$\text{Relative Density (KR)} = \frac{\text{Density of a species}}{\sum \text{Densityof entire species}} x\ 100\%$$

$$\text{Frequency (F)} = \frac{\sum \text{Plot found a type}}{\sum \text{entire plot}}$$

$$\text{Relative Frequency (FR)} = \frac{\text{Frequency of a species}}{\sum \text{Frequency of entire species}} x\ 100\%$$

$$\text{Importance Value Index (IVI)} = \sum KR + \sum FR$$

Following the implementation of the INP analysis, the subsequent analyses—namely, the Shannon-Wiener Species Diversity (H'), Evenness Index (E), and Species Richness (R) analyses—were conducted to ascertain the level of biodiversity and uniformity in addition to quantifying the species present within a given area. The following formula was employed to calculate these metrics:

$$H' = -\sum Pi \ln (Pi)$$

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

$$R = \frac{(S-1)}{\ln(N)}$$

Information:
H' = Species Diversity Index
E = Equity Index
R = Species Richness Index
Pi $= \frac{ni}{N}$
ni = density value of type i
N = Total Density
S = Number of Species found
ln = Natural Logarithm

The level of species diversity can be determined based on the results obtained in the analysis. In the context of Shannon and Weaver's (1964) taxonomy, the level of diversity is categorized as follows: if H' is less than 1, the level of diversity is designated as low; if H' is greater than 3, the level of diversity is classified as high; and if the analysis results show a number between 1 and 3, the level of diversity is designated as moderate.

The level of evenness can be determined using the results of the analysis. A level of evenness is classified as low if $E < 0.3$, high if $E > 0.6$, and moderate if $0.3 < E < 0.6$ (Ludwig & Reynolds, 1988).

The level of species richness can be determined through the analysis results. If $R < 3.5$, then the species richness is classified as low; if $R > 5.0$, then the species richness is classified as high; but if the results of the analysis show a number between 3.5 - 5.0, then the level of species richness is classified as moderate (Magurran, 2004). The results obtained will be analyzed using the *Microsoft Excel 2013 software*.

3. Results and Discussion

3.1. General Conditions of the Research Location

Petapahan Village is one of 25 villages in Tapung District, Kampar Regency. Geographically, the village is situated along the Tapung Hilir River, with the Petapahan River forming a tributary. The village's terrain exhibits a diverse array of land cover types. Plantations and agricultural areas, collectively encompassing an area of 5,900 hectares, predominate in the village. This result is followed by rice fields, which occupy an area of 50 hectares; swamp areas, which extend over 85 hectares; and forests, which cover 251 hectares.

The Imbo Putui Customary Forest is the sole remnant of a natural forest within the Petapahan Village area. The Imbo Putui Forbidden Forest, spanning approximately 251 hectares, is a notable feature of the landscape. The topography of this forest area is characterized by a general incline of 20-40°, with an altitude range of 500-1000 meters above sea level (Badriansyah, 2014).

This customary forest is the original habitat of various living creatures, including both flora and fauna. The forest is home to approximately 60 species of trees, including kelat, meranti, fig, and endemic species such as kulim. Among the fauna, Sumatran tigers, honey bears, and tapirs have been documented (Firmanda, 2017).

3.2. Diversity of Vegetation Types

The Imbo Putui Customary Forest area exhibits a high diversity of vegetation types, influenced by factors such as rainfall, soil type, and altitude (Khairi et al., 2023; Rizkiyah et al., 2013). Soil type and organic matter content are crucial in promoting plant growth (Darlis et al., 2024). The

predominant soil type in the research location is mineral soil. Situated in Riau Province, the area receives an average annual rainfall of 3,255 mm in 2022 (Badan Pusat Statistik Provinsi Riau, 2023), significantly impacting the forest's flora diversity.

Table 1. Overview of the species diversity observed in the forest area.

No	Local Name	Latin Name	Family	IUCN Conservation Status
1	Balam	*Palaquium* sp.	Sapotaceae	NT
2	Ubar	*Syzygium* sp.	Myrtaceae	
3	Kempas	*Koompassia malaccensis*	Leguminosae	LC
4	Kelat	*Syzygium claviflorum*	Myrtaceae	LC
5	Medang	*Litsea* sp.	Lauraceae	LC
6	Nasi-Nasi	*Syzygium zeylanicum*	Myrtaceae	V
7	Lalan	*Santiria laevigata*	Burseraceae	LC
8	Tampui	*Baccaurea kunstleri*	Euphorbiaceae	LC
9	Bintangur	*Calophyllum* sp.	Guttiferae	LC
10	Rengas	*Gluta renghas*	Anacardiaceae	NT
11	Marapuyan	*Rhodamnia cinerea*	Myrtaceae	LC
12	Tapah	*Diospyros* sp.	Ebenaceae	
13	Pudu	*Artocarpus lanceifolius*	Moraceae	LC
14	Pagar-Pagar	*Ixonanthes reticulata*	Ixonanthaceae	LC
15	Rotan	*Calamus* sp.	Arecaceae	LC
16	Senduduk	*Clidemia hirta*	Melastomataceae	LC
17	Pasak Bumi	*Eurycoma longifolia*	Simaroubaceae	LC
18	Jambu-Jambu	*Syzygium borneensis*	Myrtaceae	
19	Mendarahan	*Myristica* sp.	Myristicaceae	LC
20	Pisang-Pisang	*Anaxagorea javanica*	Annonaceae	LC
21	Petatal	*Ochanostachys amentacea*.	Olacaceae	LC
22	Ribu-Ribu	*Retrophyllum rospigliosii*	Podocarpaceae	LC
23	Kulim	*Scorodocarpus borneensis*	Olacaceae	LC
24	Asam	*Garcinia microcarpa*	Guttiferae	
25	Mempening	*Quercus* sp.	Fagaceae	LC
26	Meranti	*Shorea* sp.	Dipterocarpaceae	EN
27	Pelajau	*Pentaspadon motleyi*	Anacardiaceae	LC

Source: Field Processing Data (2024)
Information:
LC = Least Concern (Low Risk)
NT = Near threatened
V = Vulnerable
EN = Endangered

Based on field observations, the Imbo Putui Customary Forest area contains 27 plant species classified as seedlings. These seedlings belong to 21 different families, with one plant species known locally as maghoubi. A Shannon-Wiener diversity index analysis was conducted to assess the species diversity at this growth stage. This analysis helps determine the diversity level of species within a specific community. The results of the Shannon-Wiener diversity analysis are presented in Table 2.

Table 2. Diversity Index (H')

Diversity Index (H')	Level of Diversity
2,235	Currently

Source: Field Processing Data (2024)

The analysis results demonstrate that the diversity index of seedling species is classified as moderate. The growth rate of seedlings was obtained from a total of 27 different species, with a total of 608 individuals. The substantial diversity observed can be attributed to a diverse array of species and individuals, as Mokodompit et al. (2022) asserted.

3.3. Analysis of Importance Value Index

Data processing involves analyzing the Important Value Index (INP) based on the number of individuals found to determine the dominance level of a type or species in a community (Parmadi et al., 2016). The INP analysis includes calculating density (K), frequency (F), dominance (D), relative density (KR), relative frequency (FR), relative dominance (DR), and Important Value Index (INP). The results of the INP calculation are presented in Table 3.

The analysis of the initial development stage (INP) at the seedling level, as presented in Table 3, indicates the predominance of the lalan species. This species was documented as having the highest value compared to other species, a phenomenon reflected in its substantial presence within the sample plot. A total of 207 lalan individuals

were documented across the observation plot, underscoring its prevalence in the study area.

Table 3. Analysis of Importance Value Index

No	Name		Family	KR	FR	INP
	Local	Scientific				
1	Lalan	*Santiria laevigata*	Burseraceae	34.05	13.45	47.59
2	Bintangur	*Calophyllum* sp.	Guttiferae	18.59	10.42	29.00
3	Kelat	*Syzygium claviflorum*	Myrtaceae	14.14	8.33	22.48
4	Medang	*Litsea* sp.	Lauraceae	4.44	9.38	13.82
5	Kempas	*Koompassia malaccensis*	Leguminosae	4.44	7.29	11.73
6	Ubar	*Syzygium* sp.	Myrtaceae	4.28	7.29	11.57
7	Ribu-Ribu	*Retrophyllum rospigliosii*	Podocarpaceae	1.97	6.25	8.22
8	Balam	*Palaquium* sp.	Sapotaceae	3.13	3.13	6.25
9	Jambu-Jambu	*Syzygium borneensis*	Myrtaceae	1.64	4.17	5.81
10	Marapuyan	*Rhodamnia cinerea*	Myrtaceae	1.48	4.17	5.65
No	**Name**		**Family**	**KR**	**FR**	**INP**
	Local	**Scientific**				
1	Lalan	*Santiria laevigata*	Burseraceae	34.05	13.45	47.59
2	The Star	*Calophyllum* sp.	Guttiferae	18.59	10.42	29.00
3	Chelat	*Syzygium claviflorum*	Myrtaceae	14.14	8.33	22.48
4	Field	*Litsea* spp.	Lauraceae	4.44	9.38	13.82
5	Candle	*Koompassia malaccensis*	Leguminosae	4.44	7.29	11.73
6	Ubar	*Syzygium* spp.	Myrtaceae	4.28	7.29	11.57
7	Thousands	*Retrophyllum rospigliosii*	Podocarpaceae	1.97	6.25	8.22
8	Balam	*Palaquium* sp.	Sapotaceae	3.13	3.13	6.25
9	Guava	*Syzygium borneensis*	Myrtaceae	1.64	4.17	5.81
10	Maghrib	*Rhodamnia cinerea*	Myrtaceae	1.48	4.17	5.65

Source: Field Processing Data (2024)

Figure 3. Lalan seedlings (*Santiria laevigata*)

The dominance of lalan species at the seedling level indicates a high regeneration ability and good adaptation to local environmental conditions. The successful regeneration of lalan species can be attributed to the characteristics of its seeds, which have high resistance and good germination ability. Fitri et al. (2014) stated that the Burseraceae family, including lalan species, has a high regeneration rate.

The spread of lalan can also be influenced by edaphic and microclimate factors that support its growth. Research by Slik et al. (2018) shows that local species, such as those from the genus Santiria in the Indo-Pacific tropical rainforest area, thrive in soil with good drainage and high humidity, conditions commonly found in lowland tropical rainforests.

The results of this Importance Value Index (INP) analysis highlight the role of a species in its community. Ismail et al. (2017) discuss how the level of dominance of a species reflects its ability to survive and adapt in its community. Based on this, it can be concluded that lalan species is highly adaptable and resilient, as its dominance is evenly distributed throughout the seedling observation plots.

3.4. Species Richness Index Analysis

The Margalef species richness index is a metric employed to ascertain species richness. The assessment of species richness necessitates measuring the number and diversity of species (Komul & Hitipeuw, 2021). The value

of this species richness index ranges from 3.5 to 5. The ensuing discussion will expound upon the salient findings of the Margalef species richness index analysis, as elucidated in Table 4.

Table 4. Analysis of Species Richness Index (R) and Species Evenness Index (E)

Index	Mark	Species Richness Level
Species Richness (R)	4,056	Currently
Evenness of Type (E)	0.678	Tall

Source: Field Processing Data (2024)

The analysis of the level of richness in the seedling type yielded a figure of 4.056%. This finding indicates that the richness level is categorized as moderate at the seedling development level. This outcome is contingent upon the number of species present within a community. This phenomenon can occur because there are not many species found. This observation aligns with the assertion by Baderan et al. (2021) that the Margalef species richness index is contingent on the number or quantity of species present within a community. The index values are inversely proportional to the number of species, with lower values indicating a smaller number of species and higher values denoting a greater number of species.

3.5. Evenness Index of Species

The species evenness index is a metric employed in vegetation analysis. This index assesses the uniformity of an individual's presence within a community. This index assesses the uniformity of an individual's distribution within a community.

The analysis of the evenness index, grounded in field data, yielded findings concerning the overall growth rate. The findings of this analysis are presented in Table 4.

The analysis revealed that the seedling level exhibits a significant degree of evenness, as evidenced by results surpassing the threshold of 0.6. According to Selfiany (2020), this level of evenness is influenced by the diversity of species present and the total number of species identified. The evenness value reflects the distribution of species within a community. An evenness index approaching one indicates a more uniform distribution across the observation area. Conversely, if one species is particularly dominant while others are scarce, the evenness index will decrease, moving further from one (Setiarno et al., 2022). Therefore, it can be concluded that the individuals of various species are well-distributed within each observation plot, resulting in a high level of evenness at the seedling stage.

4. Conclusion

The Imbo Putui Customary Forest area exhibits 27 species, classified into 21 distinct families. The lalan species predominates at the seedling level, exhibiting an INP of 47.59%. The seedlings exhibited a moderate diversity and species richness level, yet the evenness of species at the seedling level was relatively high.

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