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Vegetation Composition of the Successed Habitat of Sumatran Orangutan (*Pongo abelii*) in Tropical Lowland Forest, Gunung Leuser National Park

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ABSTRACT

The Gunung Leuser National Park (GLNP) area, among others, consist of tropical lowland-forest ecosystems that becomes the habitat of Sumatran orangutans (*Pongo abelii*). The vegetation composition that renders the succession of Sumatran orangutans in the GLNP lowland-forest was obtained by conducting vegetation analysis on the restoration sites in the forest. The analysis method adopted on this research was the grid-path method. Two transect lines, 1,000 m each, were made for this purpose. Each line consisted of 10 plots with a distance of 100 m between plots. The measurements were made on the growth rate of seedling, sapling, pole, and tree. The data were then processed to determine the important value index (IVI), diversity index, richness index of vegetation, and dominance index of the research area. The results showed that the vegetation composition that rendered the succession of lowland-forests of GLNP consisted of 58 species and 26 families. Tree species of *Ficus fistulosa* had the highest IVI at the growth-stages of seedling and sapling. Subsequently, *Macaranga tanarius* had the highest IVI at pole and tree stages. The species diversity index of the vegetation on the site showed moderate values at seedling and pole stages, and high values at sapling and tree stages. The richness index showed moderate values at seedling and pole stages, as for at sapling and tree stages, it showed high values. The dominance index showed high values at all growth-stages

Keyword: Habitat, Lowland, Succession, Sumatran *Orangutan*, Vegetation Composition

1. Introduction

Indonesia is listed as one of the countries with the largest tropical forests in the world. Regrettably, Indonesian forest degradation has been highlighted as a significant factor. In 2017-2021, Indonesia lost 956,258 hectares of forests [1]. The island of Sumatra lost a total of 310,374 hectares, which made it the third-largest forest cover loss in Indonesia during the said period. The high rate of Sumatran forest degradation poses one of the serious threats to Sumatran orangutans (*Pongo abelii*) and Tapanuli orangutans (*Pongo tapanuliensis*), the two key species of both national and international conservation efforts, amidst the ongoing rescuing issue of one of the critically endangered great apes in the world [2, 3]

Lowland forest ecosystems in northern Sumatra are the habitat of Sumatran orangutans. The forest can be found almost throughout Indonesia, but the islands of Sumatra and Kalimantan have the most such ecosystems [4]. Lowland forest ecosystems, especially in Sumatra, have various types of edible trees that could be a food source for Sumatran orangutans. Apart from being the habitat of Sumatran orangutans, lowland forest ecosystems also play important roles in the lives of people living in the surrounding area, such as water system regulation, erosion prevention in steep and hilly areas, climate-pattern control, and carbon storage [5, 6].

One of those lowland-forest ecosystems that becomes the habitat of Sumatran orangutans is located in the Gunung Leuser National Park (GLNP) [7], which is under the administration of two different provinces, Aceh and North Sumatra, and lies on 830,268.95 hectares of land. Nowadays, the area is not free from the pressure of forest degradation, such as encroachment and land conversion to plantations. It is a perturbing condition, especially concerning the biodiversity in its ecosystem.

To restore the damaged ecosystem, the Indonesian government, through the Ministry of Environment and Forestry, has promulgated Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.48/Menhut-II/2014 concerning the Procedures for Implementing Ecosystem Restoration in Nature Reserves and Nature Conservation Areas, which states that one of the ecosystem restoration procedures is through natural mechanisms, or often referred to as natural succession [8]. It is carried out by protecting the continuity of natural processes. Natural succession is an essential component of ecosystem restoration activities. Maintaining natural succession could accelerate the process of forest formation, which results in saving the Sumatran orangutan habitat and other species.

2. Methodology

2.1. Research Location and Period

This research was conducted from August to September 2022. It is in a lowland forest at the Cinta Raja III restoration site, GLNP (Figure 1). This location has been an ecosystem recovery location in GLNP since 2017. The site is located in Batang Serangan Sub-district, Langkat Regency, North Sumatra Province.

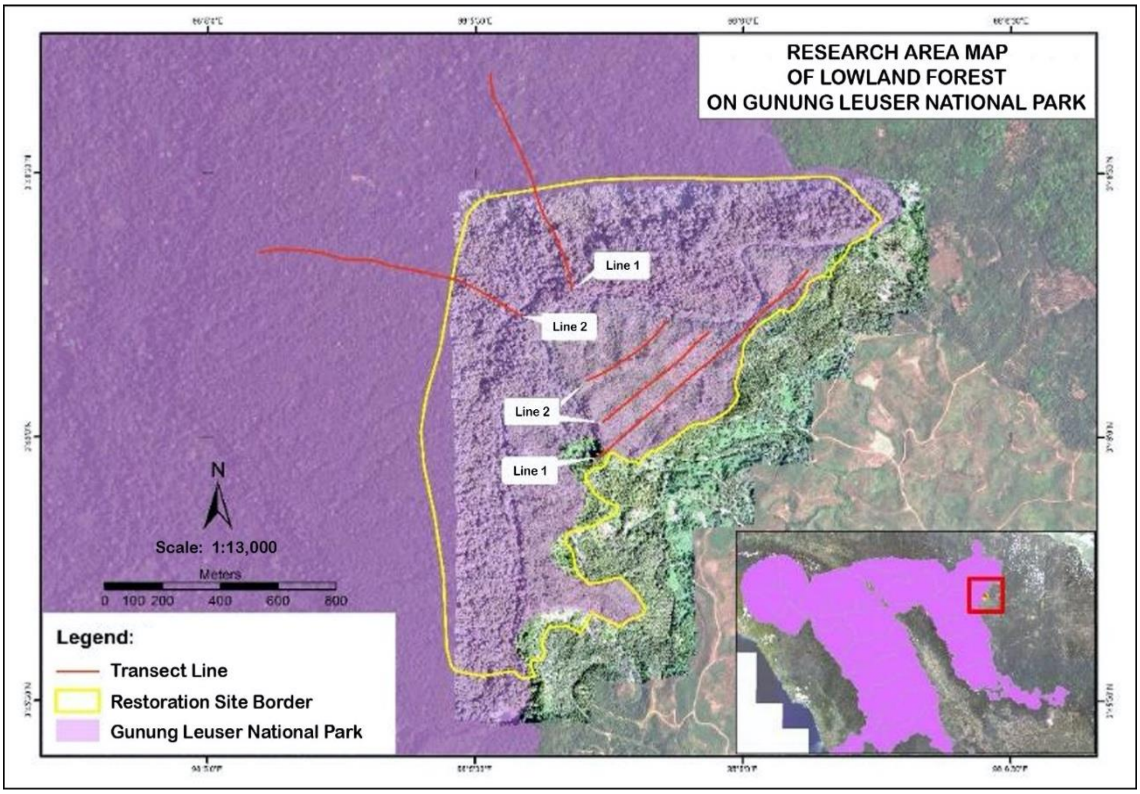

Figure 1. Research location map that showing the transect used at tropical lowland forest of Gunung Leuser National Park.

2.2. Data Collection

The equipment used during the survey was GPS Garmin 64 S, cameras Nikon P 1000, stationery, plastic ropes, tapes, measuring tapes, tally sheets, and personal computers (PCs) with relevant software. The vegetation analysis was conducted to determine the composition of forest vegetation in the research area using the grid path method. Two transect lines, measuring 1,000 meters in length each, with a distance of 300 meters between transects, were made for this purpose. Each line consisted of 10 plots with a distance of 100 meters between plots (Figure 2). Measurements were made at the growth rates of (A) seedling (2 x 2 m), (B) sapling (5 x 5 m), (C) pole (10 x 10 m), and (D) tree (20 x 20 m). The variables being observed included the species of vegetation, the number of individuals of each species, and the vegetation's diameter at breast height (dbh) and height. Measurements at the growth stage of the seedling were made at the height of ≤ 150 cm, measurements at the growth stage of the sapling were made at a diameter of ≤ 10 cm and at the height of > 150 cm, measurements at the growth stage of the pole were made at the diameter of 10 – 20 cm, and measurements at the growth-stage of tree were made at the diameter of ≥ 20 cms [9].

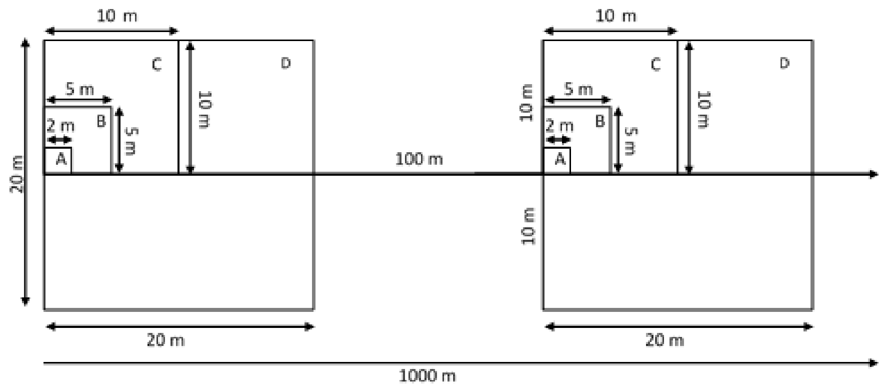

Figure 2. Transect for vegetation analysis in Orangutan habitat

2.3. *Data Analysis*

Species dominance can be represented by the importance value index (IVI), which is identified based on density, frequency, and cover dominance. A higher IVI value indicates that a species is dominant in the community [10]. The calculation of the quantitative value of vegetation parameters, especially in determining the IVI, is made using the following equations [11].

Density (D) = $\frac{\text{Number of individuals}}{\text{Total Area of Sample Plots}}$ (1)

Relative Density (RD) = $\frac{\text{Density of a Species}}{\text{Total Density of All Species}} \times 100\%$ (2)

Frequency (F) = $\frac{\text{Number of Plots in Which a Species Recorded}}{\text{Total Sample Plots}}$ (3)

Relative Frequency (RF) = $\frac{\text{Frequency of a Species}}{\text{Total Frequency of All Species}} \times 100\%$ (4)

Dominance (Do) = $\frac{\text{Basal Area of a Species}}{\text{Total Area of Sample Plots}}$ (5)

Relative Dominance (RDo) = $\frac{\text{Dominance of a Species}}{\text{Total Dominance of All Species}} \times 100\%$ (6)

Basal Area (BA) = $\frac{1}{4}\pi d^2$ (7)

Important Value Index (IVI) Equations:

The IVI at the stages of seedling and sapling = RD + RF (8)

The IVI at the stages of pole and tree = RD + RF + RDo (9)

Shannon-Weiner Index of Diversity Equation [12, 13] as follow:

$$H' = -\sum \boldsymbol{p_i} \ln \boldsymbol{p_i}, \ \textbf{with } \boldsymbol{p_i} = \frac{n_i}{N} \quad (10)$$

Where,

H' = Diversity Index of a Species

pi = Proportion of individuals of Species-i
ln = Natural log
n_i = Number of individuals of Spesies-i
N = Total Individuals of All Species.

Margalef's Species Richness Index Equation [14, 15] as follow:

$$d = \frac{S - 1}{ln\ N} \quad (11)$$

where,
d = Richness Index of a species
S = Number of Species
ln = Natural log
N = Total Number of Individuals of All Species.

Simpson's Dominance Index Equation [16] as follow:

$$C = \sum (pi)^2 \quad (12)$$

Where,
C = Dominance Index
pi = Proportion of Individuals of Species-i = ni/N
ni = Number of Individuals of a Species
N = Total Number of Individuals of All Species

3. Results and Discussion

3.1. Vegetation Composition

Field observation of the vegetation composition that rendered the succession of the restoration site in the lowland forests of GLNP was conducted on two transect lines consisting of 40 plots with a total plot area of 1.6 hectares. The vegetation analysis conducted on the restoration site discovered a total of 58 species from 26 families at all growth stages; there were 19 species at the stage of seedling, 30 species at the stage of sapling, 20 species at the stage of pole, and 33 species at the stage of tree (Table 1).

Table 1. The composition of species rendering the succession on the research location

No	Species Names	Families	Seedlings	Saplings	Poles	Trees	IUCN
1	*Actinodaphne glabra* Blume	Lauraceae				+	LC
2	*Aglaia argentea* (Reinw.) Blume	Meliaceae		+			LC
3	*Aglaia tomentosa* Teijsm. & Binn.	Meliaceae				+	LC
4	*Alstonia scholaris(L.)* R.Br.	Apocinaceae				+	LC
5	*Aporosa frutescens* Benth.	Phyllanthaceae		+		+	LC
6	*Aralia dasyphylla* Miq.	Araliaceae				+	LC
7	*Artocarpus elasticus* Reinw. ex Blume	Moraceae				+	LC
8	*Barringtonia macrostachya* (Jack) Kurz	Lecythidaceae				+	LC
9	*Bridelia tomentosa* Blume	Phyllanthaceae	+	+	+		LC
10	*Callerya atropurpurea* (Wall.) Schot	Fabaceae		+	+	+	LC
11	*Callicarpa pentandra* Roxb.	Lamiaceae		+	+		LC
12	*Cananga odorata* (Lam.) Hook.f. & Thomson	Annonaceae		+	+	+	LC
13	*Carallia brachiata* (Lour.) Merr.	Rhizophoraceae				+	LC
14	*Cleistanthus vestitus* Jabl.	Phyllanthaceae		+	+		NE
15	*Commersonia bartramia* (L.) Merr.	Malvaceae	+				LC
16	*Croton argyratus* Blume	Euphorbiaceae	+				LC

No	Species Names	Families	Seedlings	Saplings	Poles	Trees	IUCN
17	*Durio zibethinus* Murray	Malvaceae				+	DD
18	*Endospermum diadenum* (Miq.) Airy Shaw	Euphorbiaceae	+		+		LC
19	*Eurya acuminata* DC.	Pentaphylacaceae				+	LC
20	*Ficus fistulosa* Reinw. ex Blume	Moraceae	+	+	+	+	LC
21	Ficus hispida L.fil.	Moraceae			+		LC
22	*Garcinia atroviridis* Griff.ex T.Anderson	Clusiaceae				+	LC
23	*Glochidion littorale* Benth	Phyllanthaceae			+		LC
24	*Glochidion lutescens* Blume	Phyllanthaceae	+	+	+		LC
25	*Glochidion obscurum* (Roxb. ex Willd.) Blume	Phyllanthaceae	+	+	+	+	NE
26	*Talipariti macrophyllum* (Roxb. ex Hornem.) Fryxell	Malvaceae	+		+		NE
27	*Leea indica* (Burm.fil.) Merr.	Vitaceae	+	+			LC
28	*Litsea aurea* Kosterm.	Lauraceae				+	NE
29	*Litsea costalis* (Nees) Kosterm.	Lauraceae				+	LC
30	*Litsea elliptica* Blume	Lauraceae		+			LC
31	*Litsea firma* (Blume) Hook.fil.	Lauraceae		+			LC
32	*Macaranga bancana* (Miq.) Müll.Arg.	Euphorbiaceae	+	+			LC
33	*Macaranga gigantea* (Rchb.f. & Zoll.) Müll.Arg.	Euphorbiaceae	+	+	+	+	LC
34	*Macaranga hosei* King ex Hook.f.	Euphorbiaceae		+	+	+	LC
35	*Macaranga hypoleuca* (Rchb.f. & Zoll.) Müll.Arg.	Euphorbiaceae		+	+	+	LC
36	*Macaranga indica* Wight	Euphorbiaceae	+		+		LC
37	*Macaranga pruinosa (Miq.) Müll.Arg.*	Euphorbiaceae		+			LC
38	*Macaranga tanarius* (L.) Mull.Arg.	Euphorbiaceae	+	+	+	+	LC
39	*Macaranga trichocarpa* (Reichb.f. & Zoll.) Mull.Arg.	Euphorbiaceae				+	LC
40	*Mallotus paniculatus* (Lam.) Mull.Arg.	Euphorbiaceae	+	+	+	+	LC
41	*Melicope lunu-ankenda* (Gaertn.) T.G.Hartley	Rutaceae	+				LC
42	*Nauclea subdita* (Korth.) Steud.	Rubiaceae				+	LC
43	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae				+	NE
44	*Octomeles sumatrana* Miq.	Tetramelaceae				+	LC
45	*Oroxylum indicum* (L.) Kurz	Bignoniaceae		+	+	+	LC
46	*Piper aduncum* L	Piperaceae		+			LC
47	*Pometia pinnata* J.R.Forst & G.Forst.	Sapindaceae		+			LC
48	*Pterospermum javanicum* Jungh	Malvaceae	+	+		+	LC
49	*Saurauia cauliflora* Noronha ex Dc	Actinidiaceae		+			VU
50	*Sloetia elongata* (Miq.) Koord.	Moraceae				+	LC
51	*Spondias pinnata* (L.fil.) Kurz	Anacardiaceae				+	LC
52	*Syzygium kunstleri* (King) Bahadur & R.C.Gaur	Myrtaceae		+			LC
53	*Syzygium polyanthum* (Wight) Walp.	Myrtaceae	+	+	+	+	NE
54	*Tabernaemontana macrocarpa* Jack	Apocynaceae	+	+			LC
55	*Teijsmanniodendron bogoriense* Koord.	Lamiaceae				+	LC

No	Species Names	Families	Seedlings	Saplings	Poles	Trees	IUCN
56	*Terminalia catappa* L.	Combretaceae		+			LC
57	*Sterculia rubiginosa Vent.*	Malvaceae	+				LC
58	*Vitex pinnata* L.	Lamiaceae		+		+	LC

Conservation status based on the IUCN Red List shows that the species that rendered the succession in the study location are mostly types that are commonly found in secondary forests. Most of them have Least Concern status, consisting of 50 species and 1 species with Vulnerable status, i.e. *Saurauia cauliflora* Noronha ex Dc (Table 2).

Table 2. Conservation status of the species in the research location

IUCN Red List		Number of Species	Percentage (%)
CR	Critically Endangered	0	0.00
EN	Endangered	0	0.00
VU	Vulnerable	1	1.72
NT	Near Threatened	0	0.00
CD	Conservation Dependent	0	0.00
LC	Least Concern	50	86.21
DD	Data Deficient	1	1.72
NE	Not Evaluated	6	10.34
Total		58	100.00

3.2. Vegetation Diversity

The results of the vegetation analysis on the restoration site in lowland forests of GLNP showed that *Ficus fistulosa* had the highest IVI at the growth stages of seedlings and saplings. And *Macaranga tanarius* had the highest IVI at the growth stages of pole and tree. Apart from these two species, other species dominated the research area at all growth stages; they were *Bridelia tomentosa*, *Leea indica*, *Macaranga hypoleuca*, *Glochidion obscurum*, *Macaranga hoseii*, *Macaranga gigantea*, and *Barringtonia macrostachya*. The top five species with the highest IVI at each growth stage are presented in Figure 3.

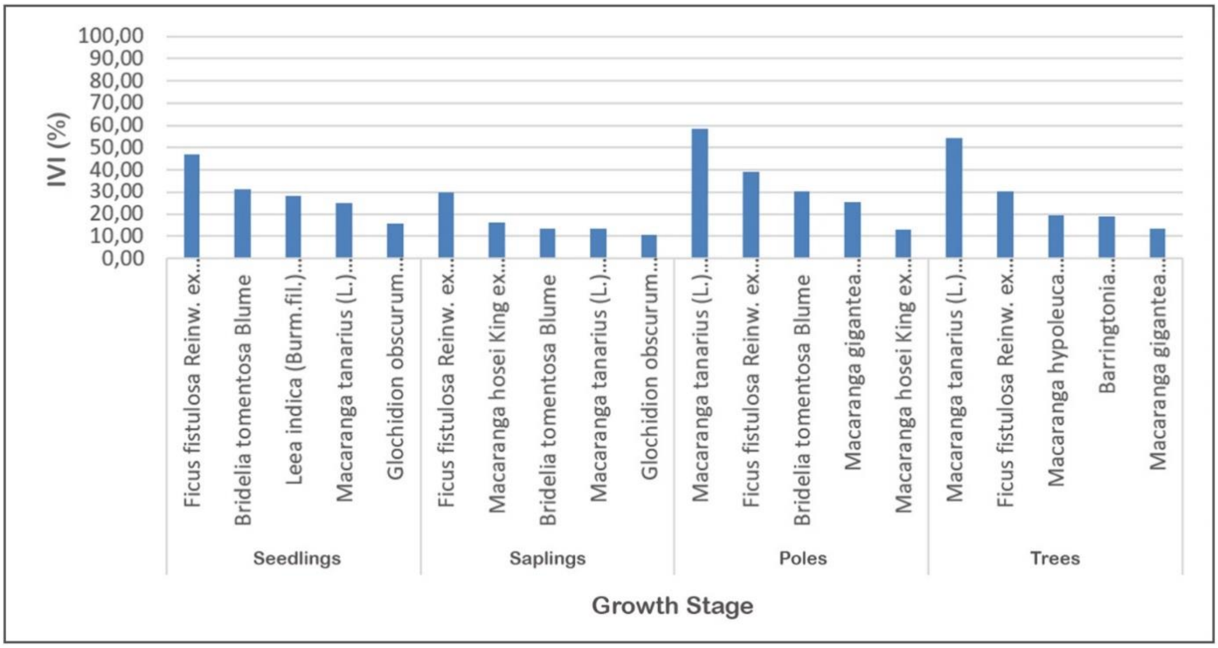

Figure 3. Species with the highest IVI at each growth-stage.

Ficus fistulosa and *Macaranga tanarius* (Figure 4) dominated the restoration site in the lowland forests of GLNP. Based on the analysis result, the two species were the most found species on the restoration site. *Ficus* spp. and *Macaranga* spp. were the dominant pioneer species at the first stage of forest growth [17-19].

Figure 4 (a). *Ficus fistulosa (left)* (b). *Macaranga tanarius (right)*

The growth response of *Ficus spp.* is very good on mineral soils that are deficient in nutrients. The research conducted by Wahyuningtias *et al.* [20] discovered that the growth response of *Ficus variegata* was very good on land where reeds (*Imperata clyndrica*) grew abundantly. Such a phenomenon was also found in this research area, in which *Ficus fistulosa* distinctly dominated the growth stages of seedlings and saplings.

Ficus fistulosa is one of Sumatran orangutans' food sources. It becomes their favorite feed because of its fragrant and watery fruits. Apart from the fruits, this type of *Ficus* is in fruit all year long. Not only are the fruits of *Ficus fistulosa* the favorite feed of orangutans, but also Sumatran elephants and various types of fruit-eating birds, which help its seeds disperse across the forest. Besides animal interventions, the vast spread of this species on the restoration site at the stages of seedling and sapling is also affected by the enormous number of seeds in each of its fruits. One fruit of *Ficus fistulosa* generally has more than 10,000 seeds in it.

Macaranga tanarius was the species with the highest IVI at the growth stages of the pole and tree (Figure 3). Not so different from *Ficus fistulosa*, *Macaranga tanarius* is also a pioneer species that can grow on low-nutrient soils. The species normally grows in groups in open areas, usually in logged-over forests [21]. The fruits of *Macaranga tanarius* are the favorite feed of various types of birds [20]. The field observation during this research discovered that birds and wind were the seed-dispersing agents of this species on the restoration site. The high dominance of *Macaranga tanarius* at the stages of pole and tree on the restoration site was due to its high survivability rate and tolerance to sunlight. The restoration site, which was exposed to the sun, then became a suitable habitat for this species [17, 21, 22]. The tree-growth measurement on the site discovered that *Macaranga tanarius* could grow up to 5-7 meters in one year.

Another factor that secured the dominance of *Ficus fistulosa* at the growth stages of seedling and sapling is that Sumatran elephants like it very much, especially at these stages of growth. When elephants roam and forage in the area, which usually takes place from March to May every year, they consume the seedlings and cambiums of *Ficus fistulosa* (Figure 5).

Figure 5. Cambiums eaten by elephants at the growth stage of saplings of *Ficus fistulosa*.

The incident repeatedly happens throughout the year and causes stagnation in the growth of *Ficus fistulosa* at the stages of seedling and sapling. *Macaranga tanarius*, on the other hand, grows well at the stages of seedling and sapling without any disturbances. It explains the dominance of *Macaranga tanarius* at the growth stages of the pole and tree compared to *Ficus fistulosa*.

To determine the quality and stability of ecosystems on the restoration site in lowland forests of GLNP, it is necessary to know the Diversity Index (H'), the Richness Index (R), and the Dominance Index (C) of the vegetation. The values of these indices are presented in Table 4.

Table 4. The indices of diversity, richness, and dominance of the restoration site in lowland forests of GLNP

Indeks		Seedling	Sapling	Pole	Tree
Shannon-Wiener Diversity Index	H'	2.40	3.11	2.33	3.03
Margalef Richness Index	R	4.33	6.74	4.16	6.45
Dominance Index	C	0.87	0.92	0.85	0.92

Diversity Index is one of the important parameters in vegetation analysis. Diversity can determine the complexity of the interaction between biotic and abiotic communities, as well as the stability of a vegetation community. The calculation of the Biodiversity Index at the stages of seedling and pole produced a moderate result ($1<H'<3$). This was due to the small number of species in the research area; there were 19 species at the stage of seedling and 20 species at the stage of pole. On the contrary, the Biodiversity Index at the stages of sapling and tree was high ($H' \geq 3$). This was due to the large number of species in the research area; there were 30 species at the stage of sapling and 33 species at the stage of tree. The high value of the Biodiversity Index at the stages of sapling and tree indicates that the species diversity on the restoration site is high.

The calculation of the Richness Index at the stages of seedling and pole produced a moderate result (RI = 3.5–5). This result was due to the large number of growth inhibitors, such as what happened to *Ficus fistulosa* that was eaten by elephants at the stage of seedling and to *Macaranga tanarius* that died of the weather influence and sunlight competition at the stage of pole. Quite different from that of seedling and pole growth stages, the Richness Index at the stages of sapling and tree was high ($RI \geq 5$).

The Dominance Index shows how much a species dominates over a habitat. The calculation of the Dominance Index in this research produced high results at all growth stages ($0.75 < C \leq 1.0$). The results imply that one species is dominating at each growth stage. Figure 3.1 shows that *Ficus fistulosa* dominates at the growth stages of seedlings and saplings, and *Macaranga tanarius* dominates at the growth stages of poles and trees.

The high value of the species diversity index at the sapling and tree stages indicates that the species diversity at the research location is relatively high. The species that dominate at the research location are species from the Euphorbiaceae family. Generally, species from the Euphorbiaceae family are pioneer species that have fast growth characteristics and can grow well in nutrient-deficient soil conditions. These Euphorbiaceae species include *Macaranga tanarius*, *Macaranga hosei*, *Macaranga hypoleuca*, and *Mallotus paniculatus*. Pioneer species can generally grow large and have broad leaves, so they can support the growth of tolerant species (requiring cover).

In addition to knowing the composition of species that grow in a degraded location, monitoring this succession is an effective way to restore forest ecosystems. In addition to being cheap, this method also provides an overview to area managers regarding the types that will be planted at that location. From the results of this study, information on the composition of species that make up succession is expected to be useful initial data for compiling a species selection framework in ecosystem restoration activities and other recovery activities, especially in the GNLP area and its surroundings.

4. Conclusions

The vegetation composition that rendered the succession of lowland forests of GLNP consists of 58 species out of 26 families. Ficus fistulosa was the species with the highest IVI at the growth stages of seedlings and saplings. *Macaranga tanarius* had the highest IVI at the stages of pole and tree. The Shannon-Wiener Diversity Index of the vegetation on the restoration site in lowland forests of GLNP was moderate at the stages of seedling and pole and high at the stages of sapling and tree. The richness index of species on the restoration site in lowland forests of GLNP was moderate at the stages of seedling and pole and high at the stages of sapling and tree. The Dominance Index of the restoration site in the lowland forests of GLNP was high at all growth stages.

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