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COMPOSITION AND DIVERSITY OF VEGETATION TYPES IN BURNED PEATLANDS AT HABARING HURUNG RESORT IN SEBANGAU NATIONAL PARK, CENTRAL KALIMANTAN

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ABSTRACT
Forest and land fires can alter the habitat characteristics, leading to a significant decrease in the number of microorganisms due to direct impacts on population and soil organisms' mortality. Vegetation composition refers to the arrangement and collection of plants, including trees and shrubs that coexist and interact with each other to form an ecosystem. This research aims to investigate plant species diversity in both burnt and unburnt areas of Hubaring Hurung Sebangau National Park in 2015. The findings reveal that the highest species diversity (H') was recorded in unburnt peat depths of 50-<100 cm at the sapling level, with a value of 2.50. The highest Species Richness Index (R) was observed at the tree level, with a value of 2.89 in unburnt locations with peat depths of 100-<200 cm. The highest Evenness Index (E) was found at the pole level, with a value of 0.93 in unburnt locations with peat depths of 50-<100 cm.

KEY WORDS
Forest fire, diversity index, national park, Indonesia.

Peat, a naturally occurring organic material, is produced by the incomplete decomposition of plant matter and can be found in swamps, typically with a thickness of at least 50 centimeters, as stated in Regulation of the Government of the Republic of Indonesia number 57 of 2016. According to Listiyani (2019) and Khotimah et al. (2020), peatlands offer a promising opportunity for agricultural and forestry development in Indonesia. However, managing peatlands is a complex task as it involves various challenges related to physics, chemistry, biology, and hydrology, as noted by Armaini et al. (2008) and Triadi (2020).

The peat swamplands play a vital role in maintaining environmental balance, serving as water reservoirs, sinks for carbon, and supporting biodiversity, but their existence is increasingly at risk (Daryono, 2009; Anton, 2016; Yuningsih et al., 2019). However, these areas are currently under threat due to logging and forest fires, which lead to a reduction in vegetation diversity and a shift in species composition. Peat swamp forests are home to many endemic species, and the distribution of species diversity can span large areas (Yulianti et al., 2009; Tanjung et al., 2012; Haryadi, 2017; Nurfatma et al., 2017; Barus et al., 2018; Yuniati et al., 2018; Selfiany, 2020). Historical records indicate that forest fires, particularly in Indonesia's wet tropical rainforests, have been occurring since the 18th century, and these fires have caused extensive damage, burning up to 95% of some plant species from 1998-2015. The peat swamp forest ecosystem, in particular, has undergone significant changes following the 1997 and 2002 fires (LIPI research center, 2019).

Forest fires have been a recurring phenomenon in Indonesian wet tropical rainforests since the 18th century. These fires can cause explosive damage over a large area in a relatively short period of time. Between 1998 and 2015, forest fires resulted in the burning and drying of up to 95% of several plant species. As a result, the forest ecosystem in peat swamp forests that experienced fires in 1997 and 2002 underwent significant changes (LIPI research center, 2019).

Forest fires in Indonesia are often caused by land clearing and forest conservation activities, which involve burning litter, leaves, and plant residues. This method of burning is the cheapest, easiest, and most efficient way to clear land, but if not controlled, it can quickly spread and start fires (Nugroho, 2000; Reyhan et al., 2021; Marlina & Rahmaniati, 2022).

Weather factors such as wind, temperature, rainfall, groundwater conditions, and relative humidity are also important factors that contribute to forest fires. The time of year also plays a role, as weather conditions vary depending on the season. The topography of the land, including the slope, slope direction, and terrain, also greatly influences the behavior of forest and land fires (Hatta, 2008; Rahayu, 2011; Murtinah et al., 2017; Rinaldo et al., 2017; Widodo et al., 2017; Rahmawati & Sumunar, 2018; Wulansari et al., 2020; Asbi & Siregar, 2021; Marlina & Rahmaniati, 2022). Forest fires have become a serious annual problem in Indonesia, especially during the dry season, and not only affect the local area but also neighboring countries (Pasaribu & Friyatno, 2008; Tuhulele, 2014; Harahap, 2016; Suhendri & Purnomo, 2017; Hafnizal, 2018; Septianingrum et al., 2018; Marlina & Rahmaniati, 2022).

Measuring the stability of a community can be done through species diversity, which refers to the variety of species within a community. A community that consists of numerous species is considered to have high species diversity, while a community with only a few species is considered to have low species diversity (Indriyanto, 2006; Erwin et al., 2017; Indriyani et al., 2017; Astuti et al., 2017; Marfi, 2018; Septria et al., 2018; Amin et al., 2021). Species diversity is composed of various components, with one of the primary components being species richness, which refers to the number of species within a community. The two approaches used to calculate species diversity are species richness and species evenness. Species richness is determined by the species index, which calculates the number of species within a specific unit area (Maimunah et al., 2022). The abundance of species within a community varies, with some being common and others being rare (Puri et al., 2004; Indriyanto, 2010).

METHODS OF RESEARCH

The study was conducted in Sebangau Resort Habaring Hurung National Park, Bukit Batu District, Palangka Raya City, Central Kalimantan, and lasted for 7 months from August 2021 to February 2022. The research activities involved collecting library materials, preparing research proposals, presenting proposal seminars, surveying the research site, collecting and analyzing field data, and preparing research results. The study focused on vegetation growth rates, including seedlings, saplings, poles, and trees, in both burnt and non-burnt areas. The equipment used for data collection included a compass, meter tape, phi band, plastic rope, machete, camera, GPS Garmin GPSMAP 78S Marine Handheld, tally sheet, writing tool, peat drill, plant species identification book, computer, and calculator.

The study collected both primary and secondary data. Primary data collection involved direct vegetation observation in a predetermined area using a combination method of plot and checkered line methods. The variables observed depended on the growth rate of the vegetation. Secondary data collection included temperature, climate, topography, soil, and hydrology, which were obtained from the Sabangau National Park Office. The research observation plots were determined using a purposive sampling method to represent the actual condition of the vegetation. The sample plots were located at a depth of 50-100 cm for shallow peat and 100-200 cm for medium peat. A total of 100 plots were used, with a size of 20 m x 20 m, and sub-plots of various sizes were used to measure the growth rate of the vegetation.

In this study, a tree was defined as a woody plant with a diameter at breast height (dbh) equal to or greater than 20 cm (Ø ≥ 20 cm), poles were defined as woody plants with a diameter (dbh) between 10 cm and less than 20 cm (10 ≤ Ø < 20 cm), saplings were defined as woody plants with a stem diameter <10 cm and a height above 1.5 m (Ø<10 and T > 1.5 m), and seedlings were defined as woody plants up to 1.5 m high (T ≤ 1.5 m), based on Indriyanto's (2006) definition. The data collected were adjusted to the sample plots to represent each level of vegetation growth.

The size and shape of the observation plots are the most fundamental things in conducting a biodiversity inventory. Different plot shapes with the same size have different circumferences which is called the edge effect. Research conducted by Kusuma (2007) in Ali et al. (2016) who found that rectangular plots can include higher diversity than square plots.

Analysis of the data to determine the composition and structure of the vegetation which is the object of research is calculated on parameters which include important value index, species diversity index, species richness index, evenness index, similarity index.

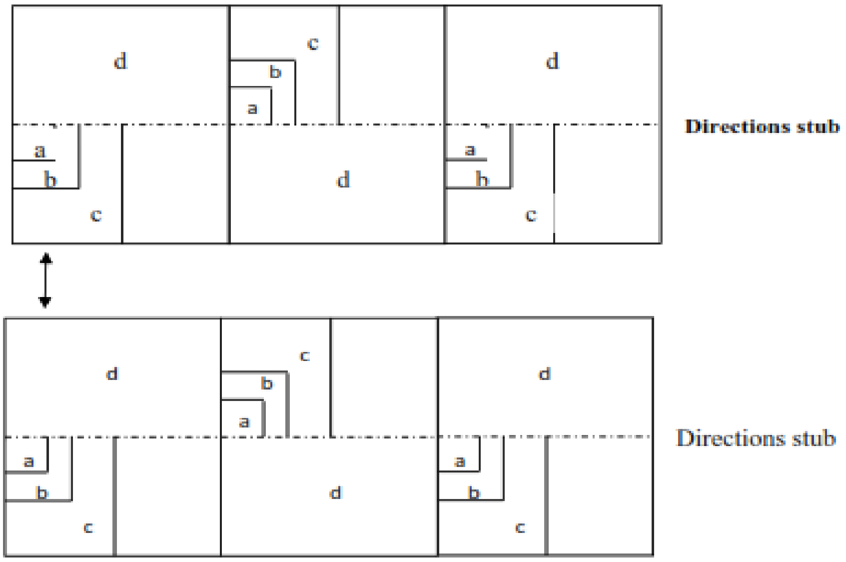

Figure 1 – Sample Plot Design of Observations with the Path Combination and Checked Line Methods

Description:
—— : Directions stub;
a: Observation plot of seedling rejuvenation level;
b: Stake youth level observation plot;
c: Pole level stand observation plot;
d: Tree level stand observation plots.

Important Value Index (INP) is a quantitative parameter that can be used to express the level of dominance (level of mastery) of species in a plant community. The data obtained is then analyzed to calculate the density, frequency, and dominance factors using the formula (Soerianegara and Indrawan, 1998).

$$\text{Density (K)} = \frac{\text{The number of individuals of a kind}}{\text{Sample Plot Area (ha)}}$$

$$\text{Relative Density (KR)} = \frac{\text{Density of a kind}}{\text{Density of all Types}} \text{x100}$$

$$\text{Frequency (F)} = \frac{Number\ of\ Plots\ of\ a\ type\ found}{total\ number\ of\ plots}$$

$$\text{Relative Frequency (FR)} = \frac{Frequency\ of\ a\ type}{Frequency\ of\ all\ Types} \text{x 100}$$

$$\text{Domination} = \frac{Base\ area\ of\ a\ Type}{Sample\ Plot\ Area\ (ha)}$$

$$\text{Relative Domination (DR)} = \frac{Domination\ of\ a\ kind}{Domination\ of\ All\ Kinds} \text{x 100}$$

INP Pole and Tree Level = KR + FR + DR = INP

INP Seedling and Sapling Levels = KR + FR = INP

Diversity Type index which states the structure of the community and the stability of the ecosystem. Commodities studied in the field can be identified by calculating the value of species diversity using the Shannon-Wienner formula (Mazawin and Subiakto, 2013) as follows:

$$H^i = \sum_{i=1}^{s} (p \text{ In } p)$$

Description:

- H' = Diversity index;
- N = Number of individuals of all kinds;
- ni = The number of individuals of a kind;
- In = Natural logarithm.

The criteria put forward by the IPB Study Team (1997) in Hidayat (2001) for the species diversity parameter fall into several criteria weights and classifications. Where if the H' value ≥ 3 the species diversity is high, if the H' value = 2-3 then it shows medium species diversity, and if the H' value < 2 the species diversity is low.

Evenness of species is the distribution of individuals between species in a balanced community. Species are considered maximum if all species in the community have the same number of individuals. Species evenness index € shows the level of evenness of individuals per species. The closer the E value is to 1, the higher the evenness value. Ludwig and Reynolds (1988), the value of E is calculated using the following mathematical formula.

$$E = \frac{\mathrm{H'}}{\mathrm{Ln\ (S)}}$$

Where:

- E = Species Evenness Index;
- H' = Indeks Shannon;
- S = Number of Types found;
- Ln = Natural logarithm.

The species richness index is calculated using the Margallef formula (Ludwig and Reynolds, 1988), which is as follows:

$$R = \frac{\mathrm{H} - 1}{\mathrm{In\ (N)}}$$

Where:

- R = Species richness index;
- S = Number of Types;
- N = Total Number of Individuals;
- Ln = Natural logarithm.

According to Odum (1993) to calculate the Similarity Index (IS) between two samples, the following formula can be used:

$$\mathrm{IS} = \frac{\mathrm{2C}}{\mathrm{A+B)}} \text{x } 100\%$$

Description:

- IS = Similarity index;
- A = The number of species in the sample A;
- B = The number of samples in the sample B;
- 2C = The number of species is the same in both samples.

RESULTS AND DISCUSSION

Composition Type. The analysis of the plants found in the study plots on shallow and medium depth peat with unburned conditions and traces of fire (seedlings, saplings, poles, trees) identified 30 species from 22 families (appendix 2), including the balangeran species (Shorea balangeran), mandaraan (Myristica longipes), meranti (Myristica longipes), and meranti (Myristica longipes) (Shore sp.). There were 27 varieties of plants in the unburned region, including bangaris (Koompassia malaccensis), bintangur (Calophyllum inophyllum), galam rat (Syzygium inophyllum), and gerunggang (Cratoxylum arborescens). There were 22 species of vegetation with 14 families identified at peat depth (50-100 cm), and 17 types of vegetation with 12 families found at shallow peat depth (100-200 cm). There are 12 varieties of plants with 11 families in the burned area, including mangkinang (Palamnamicus elaeocarpus) and tumih (Combretocarpus rotundatus). There were 11 varieties of vegetation with 11 families discovered at peat depths of 50 to 100 cm. Ten species of flora with ten families were discovered at peat depth (100-200 cm). Figure 2 shows the vegetation data for each growth rate for shallow and medium peat depths.

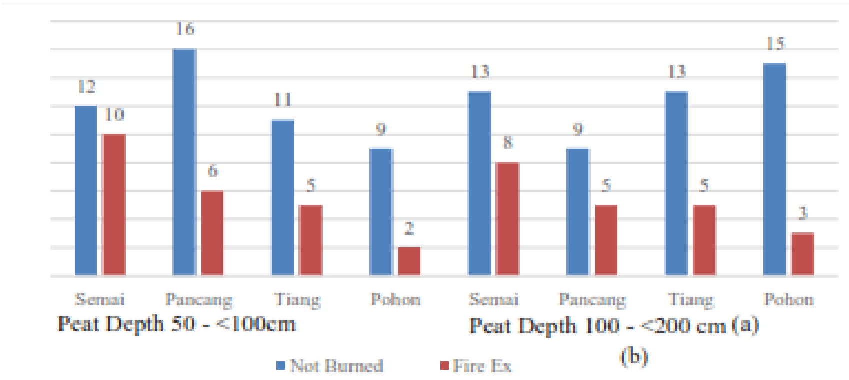

Figure 2 – Histogram of the number of species in each class of peat depth a and b at the study location

Based on Figure 2, it can be seen that in a non-burned area, the number of plant species detected varies at different depths of peat. At a depth of 50-100 cm, there were 12 plant species found at the seedling level, 16 at the sapling level, 11 at the pole level, and 9 at the tree plant level. Meanwhile, at a depth of 100-200 cm, 13 plant species were discovered at the seedling level, 9 at the sapling level, 13 at the pole level, and 15 at the tree plant level.

In the 2015 fire-affected forest, the number of plant species found was lower compared to the non-burned area. At a peat depth of 50-100 cm, only 10 plant species were found at the seedling level, 6 at the sapling level, 5 at the pole level, and 2 at the tree plant level. At a depth of 100-200 cm, only 8 plant species were discovered at the seedling level, 5 at the sapling level, 5 at the pole level, and 2 at the tree plant level.

Diversity of Types. The results of calculating the diversity of plant species at the study site for all stages of growth (seedlings, saplings, poles and trees). Recapitulation of H' in the condition of non-burnt forests and burnt areas with shallow peat depths of 50 - <100 cm can be seen in Figure 3.

Based on Figure 3, it can be observed that in both unburned and 2015 fire-affected forests with shallow peat depth (50-<100 cm), the diversity values (H') vary among the different stages of plant growth, including seedlings, saplings, poles, and trees. The differences in plant diversity can be influenced by the diversity and composition of individual groups in each stage. The unburned forest had a low diversity value at the seedling level (1.8) and tree level (1.62), while the sapling level had a medium diversity value (2.5 and 2.23). In the 2015 fire-affected forest, the highest H' value was observed at the seedling level (2.02) with a medium category, while the sapling, pole, and tree levels had low diversity values of 1.32, 1.28, and 0.5, respectively. The low and medium diversity categories observed in both burned and unburned areas are thought to be influenced by the soil fertility, high organic matter, and high rainfall in the location. Poor habitat conditions and lack of nutrients can also affect the number of species that grow in peat swamp areas. (Yulianti et al., 2009; Wibowo, 2009; Daryono, 2009; Nugroho, 2011; Tata & Pradjadinata, 2013; Khairil et al., 2015; Birawa & Sukarna, 2016; Zuhud & Hikmat, 2016; Maysarah et al., 2016; Rachmanadi et al., 2017; Prayogo et al., 2019; Welandika et al., 2019; Sunardi & Mansur, 2021; Sunariyati et al., 2022). The diversity values (H') for unburned and 2015 fire-affected forests with medium peat depth (100-<200 cm) are shown in Figure 4.

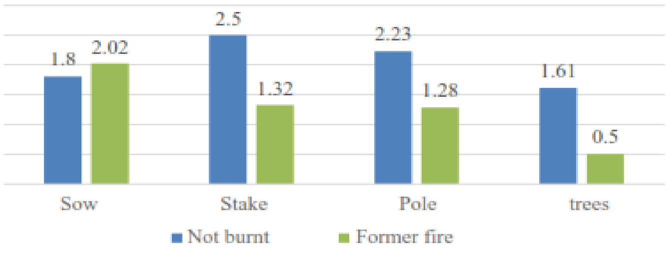

Figure 3 – Species Diversity Index (H') Diagram of Peat Depth 50<100 cm Non-burnt and Burnt Areas in 2015

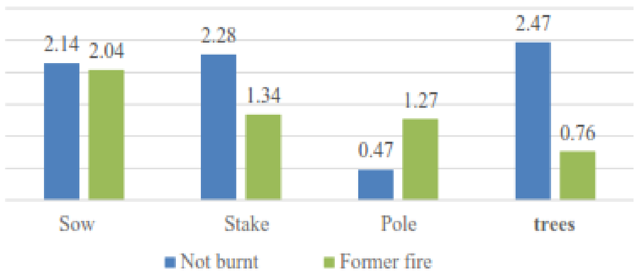

Figure 4 – Species Diversity Index (H') diagram of burned and burned areas in 2015 at peat depths of 100-<200 cm

Figure 4 shows that in medium peat depths of 100-<200 cm with non-burnt forest conditions, the diversity (H') values were in the medium category at the sapling level (2.14), and in the low category at the pole level (0.47) and at the tree level (2.47). For the fire-affected forest in 2015, the diversity value was in the medium category for the seedling level (2.04), and in the low category for the sapling level (1.3), poles (1.27), and trees (0.76). The seedling level at the research location showed that the phase of high seedling value had passed, but it still dominated compared to other levels. The forest fire caused the land to be directly exposed to sunlight, which reduced its function as a provider of nutrients for the plants to regenerate the forest. The loss of seed sources due to the high rate of fires also led to the appearance of ferns and other pioneer plants in several locations of the plant forest fires, such as tumih and gerunggang.

Despite the low diversity value, the fires that occurred in 2015 still left vegetation levels, poles, and trees in both peat depth classes at both locations. The remaining species may be resistant to fires or may have survived the fires because the outer bark of the tree was burned, but not the cambium, or because the vegetation was able to recover quickly. Acacia species are among the plants that can grow in open areas and dominate the area quickly because of their ability to adapt to local environmental conditions, as confirmed by research (Firdaus et al., 2018).

Species Richness Index (R). The Species Richness Index (R) shows the species richness in a community. This index is calculated based on the number of species and individuals in a community. The recapitulation results for calculating the Species Richness Index (R) in unburned and burnt forest conditions with shallow peat depths of 50-<100 cm can be seen in Figure 5.

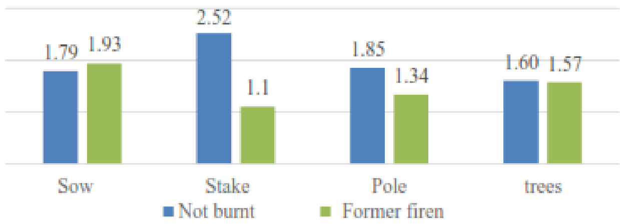

Figure 5 – Species richness index (R) diagram for non-burnt and burnt areas in 2015 Peat depth 50-<100 cm

According to Figure 5, the Species Richness Index (R) for the unburned forest conditions is classified as low with an R value of 1.79 for the seedling level, 2.52 for saplings, 1.85 for poles, and 1.60 for trees, since the R value is <3.5. Meanwhile, in the former fire area in 2015, the R value for the seedling level was 1.93, 1.1 for saplings, 1.34 for poles, and 1.57 for trees. Magurran (2004), Rachman and Hani (2017), Hidayat and Bambang (2020), Safe'I et al. (2021), and Gaol et al. (2022) have stated that an R value <3.5 indicates low species richness, an R value between 3.5-5.0 indicates moderate species richness, and an R value >5.0 indicates high species richness. The Species Richness Index value for medium peat depth (100-<200 cm) under unburned and former fire conditions in 2015 is shown in Figure 6.

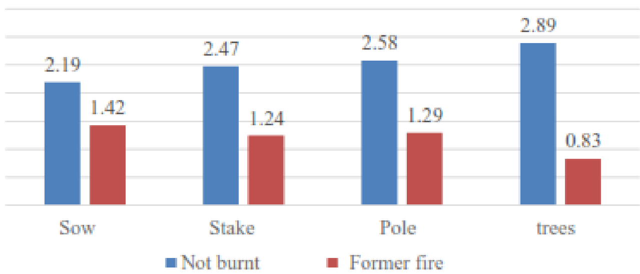

Figure 6 – Species richness index (R) diagram of non-burnt and burnt areas in 2015 at a peat depth of 100-<200 cm

According to Figure 6, the Species Richness Index in the location affected by the 2015 forest fire is low, with values of 1.42 for seedlings, 1.24 for saplings, 1.29 for poles, and 0.83 for trees. This indicates that forest fires have a strong impact on the species richness in the area, as very few species were found in the observation plots. The remaining trees in the area after the fire may be resistant to fire or able to quickly recover and adapt to the environmental conditions. The 7-year period after the 2015 fire in the observation plot at the research location may have allowed the identification of trees that are fire-resistant or able to survive forest fires.

Species Evenness Index (E). The value of the Species Evenness Index (E) provides insight into the stability of a community in an ecosystem. It indicates the evenness of the distribution of individuals among different species in a community (Santosa in Sipahutar, 2017). A higher E value suggests that the species are more evenly distributed and not dominated by any particular species. The summary of the evenness index (E) for both unburnt and burnt forest conditions in the study area is presented in Figure 7.

Based on Figure 8, the Evenness Index values for the unburned forest at the depth of 100-<200 cm are 0.73 for the seedling level, 0.89 for the sapling level, 0.94 for the pole level, and 0.73 for the tree level. On the other hand, in the burnt forest, the evenness index values are 0.85 for the seedling level, 0.72 for the sapling level, 0.80 for the pole level, and 0.72 for the tree level. The evenness index values for both conditions are classified as high evenness, based on the E value classification criteria, which states that an E value greater than 0.6 indicates high evenness of species. These results indicate that the burnt forest still has a high evenness index, although it has been affected by fire.

Figure 7 – Evenness index diagram for 2015 types of non-burnt and burnt areas at peat depths of 50-<100 cm

Figure 8 – Evenness index diagram of types of non-burnt and burnt areas in 2015 at peat depths of 100-<200 cm

Figure 8, it is presented that the Evenness Index value for a moderate peat depth of 100-<200 cm in unburned conditions is 0.83 for the seedling level, 0.86 for the sapling level, 0.89 for the pole level, and 0.91 for the tree level. Meanwhile, for the 2015 fire-affected forest, the value was 0.93 for the seedling level, 0.83 for the sapling level, 0.79 for the pole level, and 0.69 for the tree level. The calculation of the evenness value for each condition of unburned and burnt forest showed a high categorization. This suggests that the vegetation in both unburned and burnt forests with shallow and moderate peat depth has a high variety of species, and the individuals are more evenly distributed. According to Odum (1996), the evenness index reflects the pattern of vegetation distribution in an area, and the greater the evenness index value, the more evenly distributed the species composition.

CONCLUSION

The results of the research plot at Sebangau Resort Habaring Hurung National Park can be concluded as follows:

1. At the study site, a total of 30 plant species from 22 families were identified in both the 2015 fire-affected area and the non-burnt area, with the dominant species being Hangkang, Guava, and Meranti. In the non-burnt area, there were 27 plant species from 21 families, with the dominant species being Bintangur, Nyatoh, and Kapur naga. In contrast, the 2015 fire-affected area only had 14 plant species from 11 families, including Gerunggang, Mangkinang, and Tumih;
2. Rewritten: In the non-burnt area with shallow peat depth (50-<100 cm), the Species Diversity Index (H') is categorized as low to medium, the Species Richness Index (R) is categorized as low, and the Evenness Index (E) is categorized as high. At medium peat depth (100-<200 cm), the Species Diversity Index (H') is categorized as medium to low, the Species Richness Index (R) is categorized as low, and the Evenness Index (E) is categorized as high. In the burnt area with shallow peat depth (50-<100 cm), the Species Diversity Index (H') based on growth rate is classified as low to medium, the Species Richness Index (R) is classified as low, and the Evenness Index (E) is classified as high. At medium peat depth (100-<200 cm), the Species Diversity Index (H') based on growth rate is classified as low to medium, the Species Richness Index (R) is classified as low, and the Evenness Index (E) is classified as high.

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