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SHORT COMMUNICATION

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Peatlands restorer plant species in the protected forest area

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Abstract

Like other ecosystems, burnt peatlands will run into natural regeneration, characterized by pioneer plants' presence as a succession process guard. However, annual burnt peatlands can complicate vegetation growth, including the pioneer's presence. Besides that, it is unknown what kind of grow pioneers are, so the research aims to find out the pioneer plants' diversity on burnt peatlands is essential. The reasonably extensive distribution of peat ecosystems and high fire potential in Sumatra is Tanjung Jabung Regency of Jambi Province selected to study. The locations of plant species inventory are Orang Kayo Hitam Forest Park (burnt five times), village forest (HD) Sinar Wajo, and HD Koto Kandis Dendang (each burnt once) using the Nested Quadrat and Line Transect of vegetation survey method. Vegetation analysis showed that 22 pioneers were found in HD Sinar Wajo and 27 species in HD Koto Kandis Dendang. Some are identified as ferns (Pteridophyta), breed with spores, and pioneer plants reproduce by seeds (Spermatophyta). In Orang Kayo Hitam Forest Park found 26 species consisting of plants, trees, shrubs, and lianas. Among the three locations, we found the same type of pioneer. It is implied that patterns and regeneration processes can help each other in the same landscape.

Key words

forest fire, hutan desa, Koto Kandis Dendang, Orang Kayo Hitam Forest Park, peat rehabilitation, pioneer plants, Sinar Wajo

Introduction

Peat swamp forest is a growing place or habitat for various fauna species and rare plants (Wösten et al. 2006), has a very high conservation value and storing carbon stocks (Cole et al. 2015; Newbery et al. 2010; Yule 2010). Peat forests also hold the potential for medicinal plants beneficial to the community, such as other forest types (Nursanti et al. 2018). If the peat ecosystem -the soil with vulnerable groundwater (Mohammad et al. 2016) – is disturbed, natural disasters' intensity and frequency will occur more frequently.

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Forests fire is part of a natural and essential process for ecosystems. However, besides logging and encroachment (Cochrane et al. 2010; Miettinen et al. 2011; Yule 2010), fire disturbances have a worse impact (Taboada et al. 2018), mainly if they occur on peatland. The vegetation types' diversity level in peat forests that have experienced fires is lower than those in shared logging (Tata and Pradjadinata 2013). Fires cause vegetation death at various growth and development levels (Darwiati and Tuheteru 2010). For example, peatland-logged recovery in Estonia was arduous due to unfavorable water regime or slight remaining peat layer, so only heaths or grasslands that quickly grown (Orru et al. 2016).

In theory, disturbed areas have a self-healing mechanism through natural regeneration shown by vegetation changes on a large scale of space and time (Blackham et al. 2014; Chazdon and Guariguata 2016; Martínez-Ramos et al. 2016; Tata and Pradjadinata 2013). Post-disturbance natural forest regeneration can be characterized by pioneer plants' presence (Gałka et al. 2017); the adaptable plants to canopy opening have short-lived, bear fruit quickly, regularly, and are abundant. The growth of pioneer's diversity as a sign of natural regeneration origin illustrates the surrounding plant's diversity.

The pioneer plants and survivor diversity are allegedly different on once burnt peatlands and repeatedly burnt in the same landscape. The burnt peatlands occur periodically and spreadly have the potential to disrupt the peat ecosystem's resilience (Cole et al. 2015). Repeated fires have an impact on reducing the seedling recruitment and resprouter shrubs regrowth (Taboada et al. 2018). The once burnt peatland in 1997, then left for six years, have been known to run into natural vegetation succession. The first colonizers in burnt peatland are grasses, sedges, and ferns, but only ferns dominate, especially those facing brief and shallow flooding. Lemidi or Kelakai (*Stenochlaena palustris* Bedd) is the most common plant species on wet peat. Nephrolepis *bisserata* is followed in a relatively dry location (Van Eijk et al. 2009).

Unfortunately, no studies compare the diversity level of pioneer species and survivor trees in the same landscape with different levels of fire disturbance. There are similar allegations of pioneer plant species and survivor trees in these areas, especially if they are still in one landscape. More than 80% of peat swamp forest's plant species are commonly known for various habitats; the other is opportunistic pioneers or secondary forest species (Giesen et al. 2018). Thus, this study aims to explore the pioneer's diversity in regenerating peatlands at a burnt different level.

Material and methods

Study Site

This research was conducted in Jambi, a province with a relatively extensive distribution of peat ecosystems and high fire potential in Sumatra, Indonesia. Some areas in Jambi Province, especially in Tanjung Jabung Timur, the research sites, have experienced repeated fires almost every year starting in 1997, 2006, 2011, 2012, 2013, and 2014. The most significant fires occurred in 2015 and spent 9539.7 ha, including conservation areas, plantations, and community land. There are three selected research locations (Fig. 1), namely:

1. Orang Kayo Hitam Forest Park (Tahura OKH) (104° 0'21,741" E and 1°28' 9,931" S). OKH Forest Park is directly adjacent to Berbak-Sembilang National Park, also recognized as a buffer zone of Berbak-Sembilang National Park (Wulandari, Novriyanti, and Iswandaru 2021a; 2021b). In 2012 there were five classes of OKH Tahura land cover, namely secondary swamps (10,710.35 ha), primary wetlands (18.07 ha), shrubs (7,394 ha), and open land (1,53 ha), and swamp (109.92 ha). This Tahura was burnt five times every year.
2. Village forest (HD) Sinar Wajo located in the Peat Protection Forest (H.L.G.) Sungai Buluh (103° 34'4" E and 1° 9'24" S). This area caught fire in August 2015, covering an area of 265.90 ha from a total area of 5,089 ha. The burnt area has become an open land that pioneer species have overgrown, and some of it was also planted by the Sinar Wajo's community with plantation crops. The plant cultivated types are oil palm (*Elaeis guineensis* Jacq).
3. HD Koto Kandis Dendang is in H.L.G. Londerang (103° 53'17" E, and 1° 18'20" S). This area also was burnt in August (in the same year as HD Sinar Wajo), covering an area of 38.11% of the total area of 4,405 ha. Pioneer plants overgrow the open land. In some regions, these pioneers are allowed to grow together with the main plant species planted by the community, namely *Manihot utilissima* Pohl.

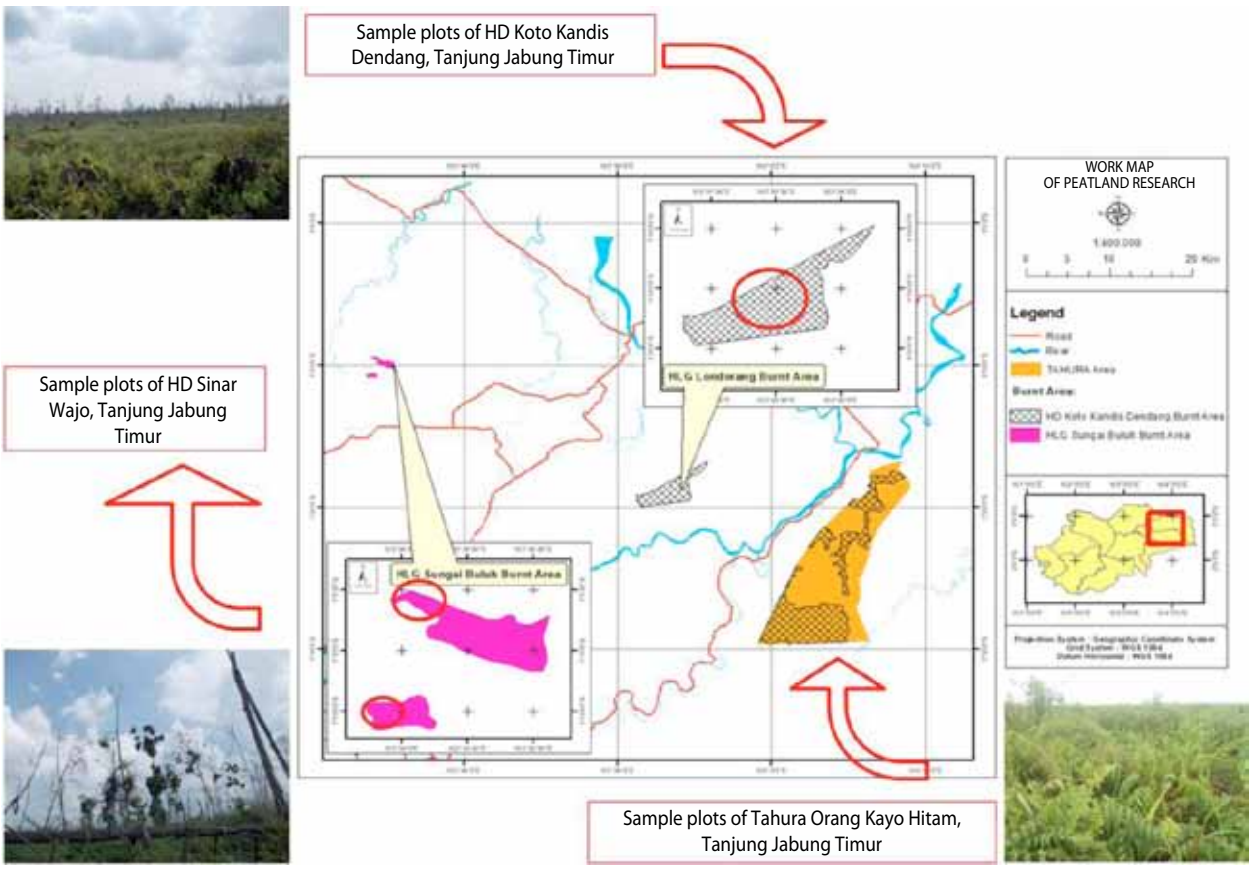

Figure 1. The peatland research location map in Tanjung Jabung Timur Regency

Transect and plot layout

Pioneer inventories in all three locations were carried out in 2016. Research requires work maps, cameras, GPS, measuring tapes, stakes, plastic bags, labels, raffia, newspapers, insulation, cutters, scissors, machetes, tally sheets, 70% alcohol, and specimen presses (*Sasak*) 50 cm × 35 cm. The plots surveyed at each location were determined based on the wide burned area and burnt intensity. Shrubs formed the burnt study area of the Tahura OKH. At this location, the researchers used the Double Plot method, which is commonly used in vegetation surveys, with the plot area observed for each 3 ha/plot of 469 plots measuring 8 m × 8 m. The sampling intensity used in this area was 0.02%.

Meanwhile, in the other two locations, large open areas were burnt once in 2015. Thus, we used methods and different plots than Tahura OKH, a single plot method placed zigzag, measuring 10 m x 10 m. At the Sinar Wajo HD location, the plots studied were 15 plots and 85 plots in HD Koto Kandis Dendang. This number adjusts to the burnt area in each village forest. So, the entire plots used for the area representation are 100 plots.

Data of plant species

All plants found in the plot were identified, including residual stands, lianas, and ferns. Field identification used the local name first. Then, all specimens are sent to Herbarium Bogoriense, Botany Division, Research Center for Biology, Cibinong Science Center, Indonesia, for identification to the scientific name. Before shipping, the specimens were collected, labeled, then dried.

Data analysis

There are two classifications of non-climbing wood species to be analyzed, namely trees (height> 3.1 m) and shrubs (size 0.5–3 m) (Blackham et al. 2014). Then we continue to calculate the abundance and the relative

abundance of each plant species (Wiryani et al. 2018). The formulas of each measure are:

$$\text{Abundance (A)} = \frac{\text{number of a species}}{\text{total area sampled}} \quad (1)$$

$$\text{Relative abundance (R.A.)} = \frac{\text{density of a species}}{\text{total density of all species}} \times 100 \quad (2)$$

Data on species richness (the number of species in a given area) and relative abundances were analyzed using The Shannon-Wiener diversity index (H') to measure the pioneer plant diversity.

Results and discussion

Recapitulation results showed that the number of pioneer plants found in three locations was 48 species (Fig. 2). Of these 48, 8 types of pioneers were found in three study locations (Fig. 3). Among these eight species, fishtail sword fern (*Nephrolepis falcata* (Cav.) C.Chr.) found the most, then *Stenochlaena palustris* (Burm.f.) Bedd, and satin tail (*Imperata cylindrica* (L.) Raeusch). *N. falcata* and *S.palustris* are ferns, while *I.cylindrica* is a grass group. Ferns and grasses are pioneering plants when forest fires occur. In natural succession theory, grass and ferns are in secondary succession events. In general, pioneer plants do not sprout; germination stimulated only after the fire occurred (Díaz Barradas et al. 1999).

In addition to finding the same kind of pioneer, all three locations also found 29 unique species. The species were only found in one area, either in Orang Kayo Hitam Tahura, in HD Sinar Wajo, or HD Koto Kandis Dendang. Based on the results analysis, a high-density unique species in a row is unidentified from Urticaceae, *Blechnum orientale* L., *Dicranopteris linearis* (Burm.f.) Undrew / Syn.*Gleichenia linearis* (Burm.f.) C.B. Claeke, *Physalis angulata* L., and *Ludwigia hyssopifolia* (G.Don) Exell. The others are unique species that generally has less than 3% of relative density (Fig. 4).

A total of 22524 individuals from 48 species were recorded during the study. Those plant species comprised saplings, shrubs, ferns, and herbs (non-woody plants). All of them were identified as pioneer species in secondary succession. However, the number of pioneer species found in each study location varies. In HD Koto Kandis Dendang found the highest number of pioneer species, while the fewest types of pioneers were found in HD Sinar Wajo (Tab. 1).

Table 1. Shannon Wiener Diversity Index (H') on each research locations

Burnt peatland research locations	Number of species	Shannon wiener diversity index (H')
Orang Kayo Hitam Forest Park	26	1.957170603
HD Sinar Wajo	22	2.392581806
HD Koto Kandis Dendang	27	2.262709845

The results analysis in Table 1 shows that the pioneer diversity index in the three study sites is no less than one and no more than 3. It is known that the pioneer's diversity found in the three study sites is classified as moderate with moderate community stability.

From Table 1, the value of H' obtained for the pioneer species diversity in burnt peatland of HD Koto Kandis Dendang is lower than HD Sinar Wajo. It can be found in the data that the highest diversity index is found in HD Sinar Wajo. It means that the number of species found at one location is quite large compared to other sites with a higher number of sample plots and does not always produce a high diversity index number.

Interestingly, from Table 2, we know that the pioneer species diversity index in the Orang Kayo Hitam Forest Park is the lowest (H' <2). It is due might occur the area experienced burnt repeatedly. Repeated fires

Table 2. Residual stand tree di HD Sinar Wajo dan HD Koto Kandis Dendang

Locations	Species	Amount
HD Sinar Wajo	*Payena lucida* A. DC.	2
	Litsea noronhae Blume.	1
	Dalbergia cf. *rostrata* Hassk.	1
	Diospyros racemosa Roxb.	2
	Korthalsia echinometra Becc.	1
	Piper cubeba Bojer.	1
HD Koto Kandis Dendang	*Livistona rotundifolia* (Lam.) Mart.	2

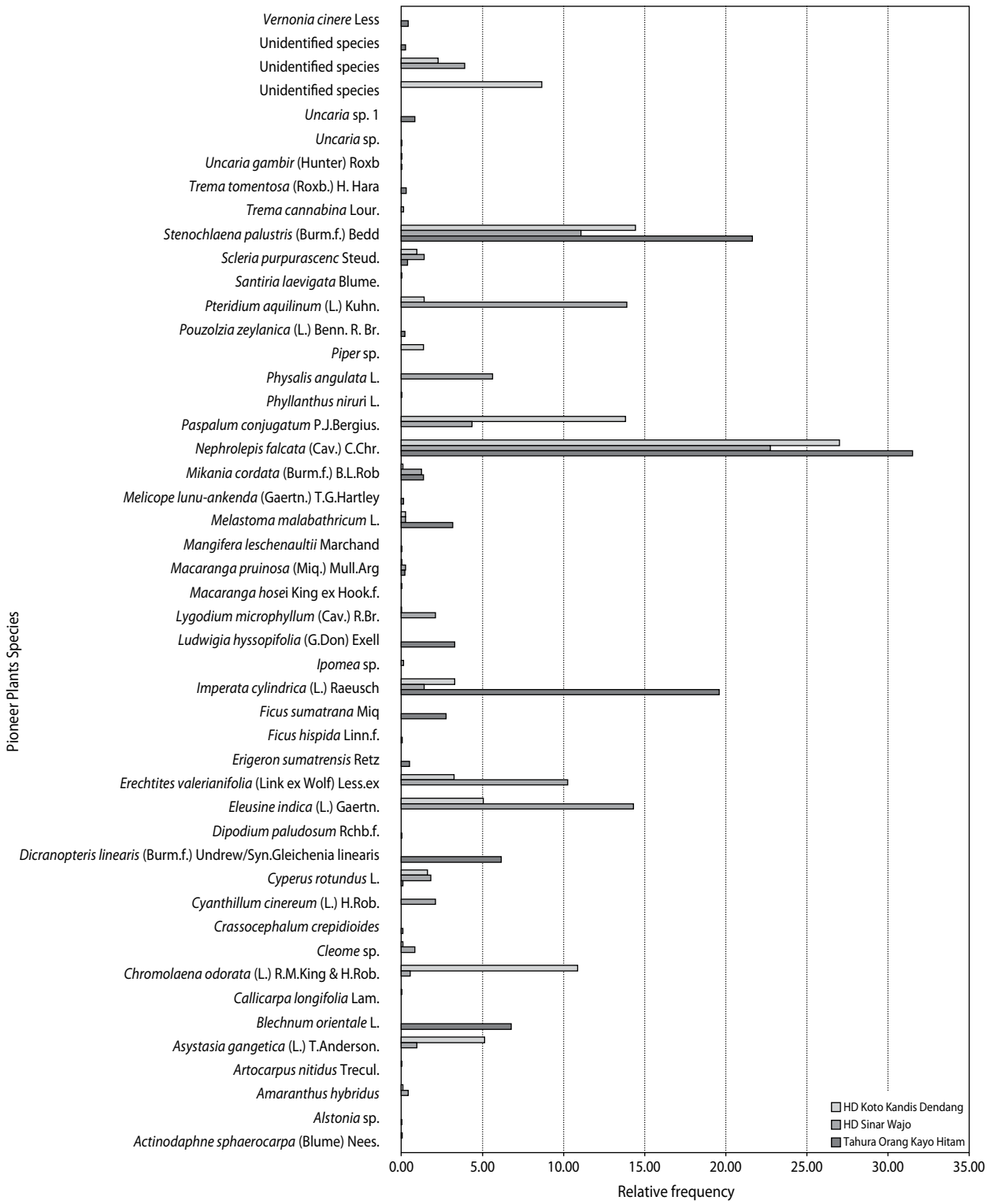

Figure 2. The relative frequency of pioneer plants species in burnt peatland

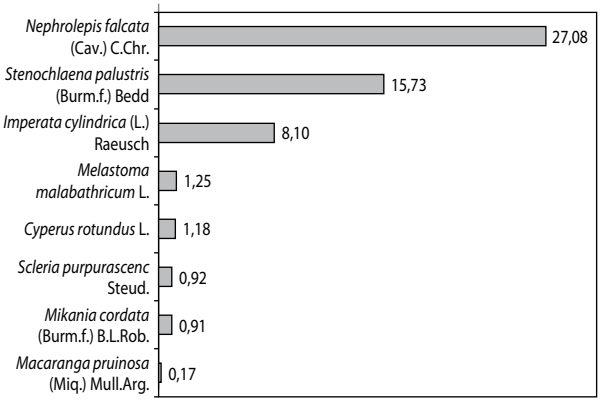

Figure 3. Kind of pioneers abundance found in all research locations

impact the plant community, which is an increase in shrubs and saplings (Trabaud and Galtié 1996). Data analysis on the three study sites also found that Tahura OKH, which had burnt repeatedly, had more shrubs and saplings than the other two locations that ignited once (Fig. 5). However, this cannot be called a regeneration setback (Slik et al. 2008).

Regeneration in some forest types shows that the shrubs dominate over other growth stages, especially in burnt areas. The pioneer shrubs have small canopies and no underground stems, hairy leaves, zoophilous pollination, and dry fruit types (Díaz Barradas et al. 1999). Meanwhile, burnt areas and open once or twice, such as in the southern Appalachian Mountains, found more herbs (Hagan et al. 2015). In mature peat forests, we will find more wood regrowth (Blackham et al. 2014).

If wood regeneration is not found, ferns will grow more, inhibiting wood plant species colonization (Blackham et al. 2014). Of the 48 species found in all three locations, the fern is the dominant species with a relatively high density. In HD Sinar Wajo and HD Koto Kandis Dendang, four types of ferns were found, two of them also found in Tahura OKH.

HD Sinar Wajo and Koto Kandis Dendang were ground burnt and left an open land expanse. The land was available for 11 months since the fire until the research was carried out; it has undergone gradual changes naturally. A noticeable difference was seen in the land cover. Some lands, there were planted intentionally by the surrounding community; other parts of peatland grow grasses, ferns, and other vegetation are allowed to grow by the community. The survival trees in both

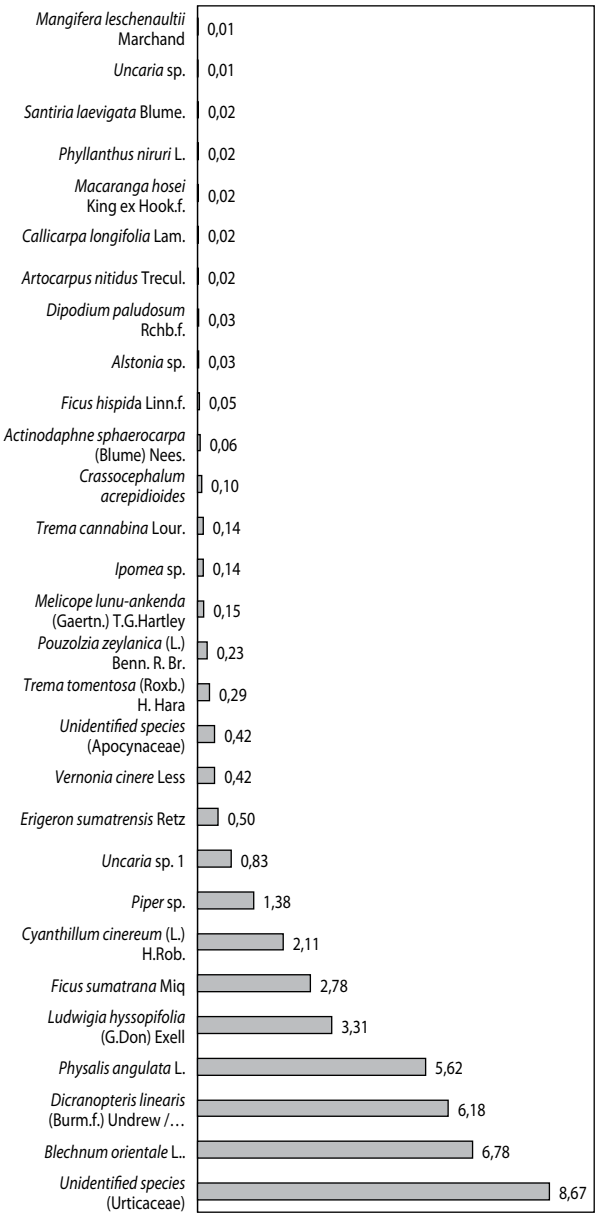

Figure 4. The relative abundance of a unique pioneer plant species found only in one research location

areas are only in small amounts so that the dominance of ferns is quite large (Fig. 5).

Some species found in all three locations can be classified as invasive species, such as *Imperata cylindrica*, *Paspalum conjugatum*, and *Eleusine indica*. In addition to ferns, the pioneer species density classified as intrusive is also relatively high. However, we are optimistic that the three locations will be

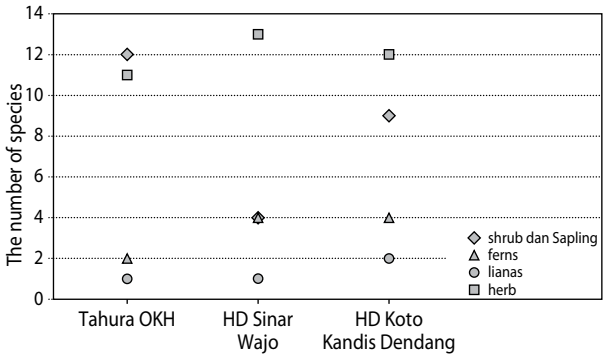

Figure 5. Pioneer category distribution in three research locations; OKH Forest Parkhas most shrubs and saplings

able to pass through the natural regeneration process and fulfill succession. In one landscape, other plant species in areas that have been burnt out can be increased with the help of birds and wind, although the availability of tree seeds from standing trees is limited. Bird communities are formed in each habitat and indicate the area's importance so that sustainable management is needed (Iswandaru et al. 2020). Seed bank's availability and species competition with an invasive one are not to be an obstacle to the forest restoration process (Cantab 2013). The high species diversity index in the burnt-out area of HD Sinar Wajo and Koto Kandis Dendang also indicates that there are better recovery opportunities. In tightly closed areas by ferns in Orang Kayo Hitam Forest Park (Fig. 6), it is felt necessary to carry out additional activities by planting typical species of peat, especially in areas that are not inundated.

Figure 6. (left) HD Koto Kandis Dendang peatland condition after burnt and (right) *Nephrolepisfalcata* (Cav.) C.Chr domination, and (below) Orang Kayo Hitam Forest Park peatland condition after burnt

Conclusion

This study found burnt peatlands do the natural regeneration with middle species diversity value. Repeatedly burnt peatland has lower diversity than once burnt peatland. The discovery of the same species at different research sites in one landscape raises the hope that if some of the burning peat begins recovery, it can help restore other peatland damaged parts.

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