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Tree diversity and forest composition of a Bornean heath forest, Indonesia

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Abstract Heath Forest on Borneo is a forest type mostly found between the transitions from the peat-swamp forests in lowlands to the Dipterocarp Forest in hillier areas. Heath forest soil structure is characterized by a dominant sand layer with a thin organic horizon on top. Tropical Heath Forest has been understudied and undervalued for many years, considered as a low-diversity habitat due to a nutrient-poor sandy soil, unable to aggregate and bind nutrients, resulting in stunted, low canopy forest. Despite its reputation, our research in the KHDTK Mungku Baru (it is a Forest Area with Special Purpose (KHDTK)) in southern Central Kalimantan is revealing heath forest of remarkably high quality, with large trees, high canopy and high biodiversity, including important endemic and emblematic flora and fauna species. Fourteen 30 m x 30 m nested plots were established, where all the trees ≥ 10 cm diameter breast height (DBH) were identified and measured. Additional 5 x 5 m and 2 x 2 m nested plots were used to define the micro-habitat and soil composition, determining the pH, organic layer depth, water moisture, and canopy cover. A total of 1,007 trees were recorded, representing 87 species in 58 genus and 40 families. Soil layers exhibited visual differences and analysis of soil composition was used to define 2 sub-habitat types of Heath Forest, named as Black sand Heath Forest (BHF) and White sand heath forest (WHF). Significant differences were found on peat/organic layer depth (BHF 26.4 cm; WHF 6.1 cm) and soil moisture (BHF 18.3 %; WHF 11.1 %). Independent analysis for the tree community compositions was done for each sub-habitat type. Few differences were found between sub-habitat types on DBH (BHF 18.9 ± 11.7 cm; WHF 18.6 ± 9.7 cm) and tree height (BHF 18.9 ± 5.5 m; WHF 17.9 ± 5.4 m). Tree species composition analysis reveals in both cases a high species richness, with no differences in distribution (Simpson's Diversity Index BHF=0.96; WHF=0.95) but significant differences in species abundance (Fisher's alpha index BHF=23.74; WHF=18.01). BHF is a more homogeneous sub-habitat type, dominated by species belonging to Dipterocarpaceae (19.5 %), Myrtaceae (19.2 %) and Sapotaceae (13 %) families, whereas WHF is largely dominated by Dipterocarpaceae species (43.4 %) including *Dipterocarpus borneensis* and *Shorea teysmanniana*. The preliminary results of this study indicate that the Central Kalimantan's Heath Forest presents high tree species diversity with high conservation value, with potentially 2 different sub-habitat types characterized by their soil and tree composition. This highlights the importance of protecting this rare and understudied habitat in the context of Borneo biodiversity conservation.



1. Introduction

Biodiversity is a value that shows the level of species diversity both animals and plants in an area. Assessing and monitoring forest biodiversity to the extent that biodiversity is a major challenge, especially in tropical regions such as Indonesia, which has very high biodiversity.

From the type of forest itself, the tropical landscape has a very diverse forest type. In one forest area, it may consist of several types of forest based on inundation conditions, types of soil types, topography to rock conditions and climate. This was explained by a study conducted by the Borneo Nature Foundation and the Muhammadiyah University of Palangkaraya in 2016 that forests in Mungku Baru are divided into 3 major types, namely lowland forests, heath forests, and peat swamp forests.

Heath forests are forests that have extreme land and are vulnerable or very sensitive to disturbances such as fires. [1,2] stated that heath forests are special and easily recognizable ecosystems in all lowland rainforest formations. Kalimantan has the most extensive area of heath forest in Indonesia. The word Heath (in Indonesia is Kerangas) comes from the Iban Dayak language which means land that cannot be planted with rice. The name is given because the soil content that forms heath forests is very poor in nutrients. Heath forest is named heath forest [3,4] which is special vegetation in Sarawak. Forests are one of Indonesia's important forests that grow on Podolski, nesting quartz sand soil, poor in nutrients and low pH. This causes, heath forests are susceptible to disturbance [5] referenced in [6]. Sandy, dry and arid physical conditions give the impression of being unproductive in heath forests. Agricultural activities cannot take place on heath forest lands. The ecosystem is easily damaged and difficult to return if it has been disturbed. The openness of heath forests will result in the emergence of arid savannahs [1,2].

Heath forest is a type of forest that is located between lowland forests and swamp forests with the dominance of sandy and thin peat layers. The specialty of this area is the presence of flora and fauna with high diversity. Heath forest is a nutrient-poor forest that is dominated by sand as the main constituent of the soil which is very difficult to bind nutrients and tends to be washed away by water flow. In its natural conditions, the formation of heath forests has more diverse biodiversity than lowland forests and swamp forests even in the surrounding peat swamp forests.

Usually, the soil in the heath forest comes from inseparable silica mineral material with a rough texture. The soil bound in the heath forest or under brownish black shrubs; this is due to the decomposition of organic matter. Whereas in open fields, generally white with a thickness of about 0.5-5 cm around the darker layer. Land in the Heath forest is known as white-sand soils. White-sand soils are formed due to coastal erosion and the removal of the seabed to the surface. This ongoing state will build a hard layer (Podsol). In general, heath forests grow in low-lying areas. Heath forests are spread in Sumatra, Singkep, Belitung, Kalimantan, Sarawak, Sabah, and Brunei. Usually, many are found in hilly areas [7,6]. In Central Kalimantan, heath forests are not evenly distributed; there are only a few regions that have heath forests, such as Palangka Raya, Katingan, Sampit, Pangkalan Bun, and several other areas. This study aims to determine the diversity of tree species that grow in Heath forest as basic data for forest plant research in KHDTK Mungku Baru.

2. Materials and Methods

This research was carried out in the KHDTK Mungku Baru area precisely in Rakumpit Subdistrict, Mungku Baru Village. The time needed in this study is approximately 1 month, namely in July 2017. Includes preparatory activities, carrying out data analysis until the research report.

The collection of vegetation data was carried out using a combination method between lane and plot lines. There are 14 plots in the size of 30x30m to observe their diversity including data on tree diameter, tree height, species whereas habitat data such as canopy density, understorey, soil, slope, inundation, lianas, medicinal plants, and peat depth were observed in 4 10x10m plots in a 30x30m plot. The natural regeneration state data was observed in a 2x2 m plot and pegged on a 5x5 m plot size, both of which were on a 10x10m plot.

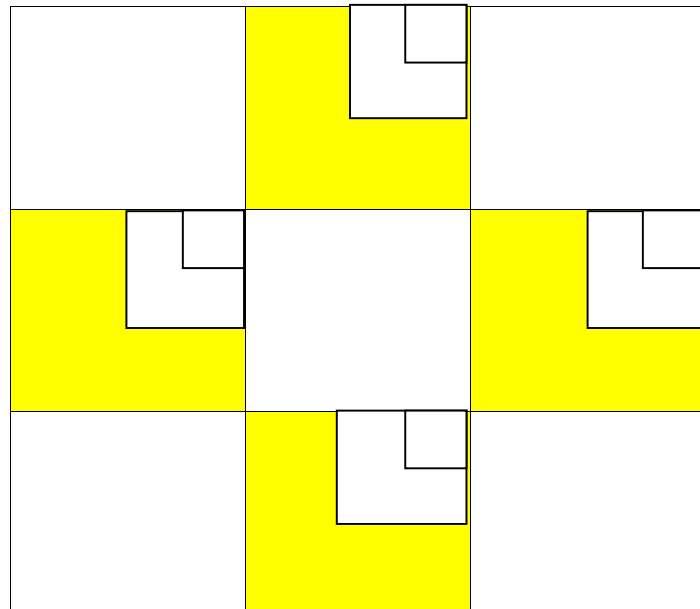


Figure 1. Plot layout used for collecting flora and soil characteristic data in the KHDTK

3. Result and Discussions

KHDTK UM Palangkaraya based on Forestry Minister's legal status by number 611 / Menhut-II / 2014 dated July 8, 2014 concerning the Determination of Forest Areas with Special Purpose as Educational Forest in Permanent Production Forest Areas in Palangka Raya City, Central Kalimantan Province covering $\pm$ 4,910 Ha, where the management was delegated to Muhammadiyah University of Palangkaraya at an altitude of about 60 meters above sea level with hill topography and has several small rivers (Sub-watersheds) so that it has a variety of forest types including health forest area.

Heath forest in KHDTK Mungku Baru is divided into 2 types, namely white sand heath forest and black sand heath forest which has different types and characteristics ranging from sand color to growing plant species. Black sand heath forests are usually located on low slopes and are near sub-watersheds. While white sand heath forests tend to be in higher soil conditions. The difference in the color of the sand also affects the type of vegetation that grows on it. In a study conducted by Borneo Nature Foundation (BNF) at KHDTK MungkuBaru found several species found in black sand heath forests but not found in white sand heath forests, such as *Neoscortechinia kingii*, *Elaeocarpus mastersii*, and *Nephellium maingayi*. Likewise, there are several species found in white sand heath forests, but not found in black sand, such as *Pararthocarpus venenosus*, and *Ilex cymosa*. From the observations found 6 types of meranti included in meranti balau goals, red meranti groups, and white meranti.

900m² plot area with 14 plots in different locations, 9 plots for black sand shells and 5 plots for white sand shells. Black sand shells have a greater density of species with the number of trees found in 664 in 32 families while in white and only 343 trees from 35 families. Black sand shells have a higher number of trees even though the family is less than white sand shells. The availability of natural regeneration and density is higher in black sand scales up to 465 tillers, while white sand scales are only 245 tillers and the number of trees for each growth phase (seedlings, saplings, poles, and trees) is balanced. The existence of poles in both health types has the highest percentage of life in all plots, both black sand, and white sand. The area of black

sand and white sand shells in the field compared to 9: 5. Table 1 below shows the comparison of tree populations between black sand and white sand scales in terms of a number of species, tree population, and growth both in diameter and height of trees and their density.

Table 1. The comparison of tree populations between black and white sand

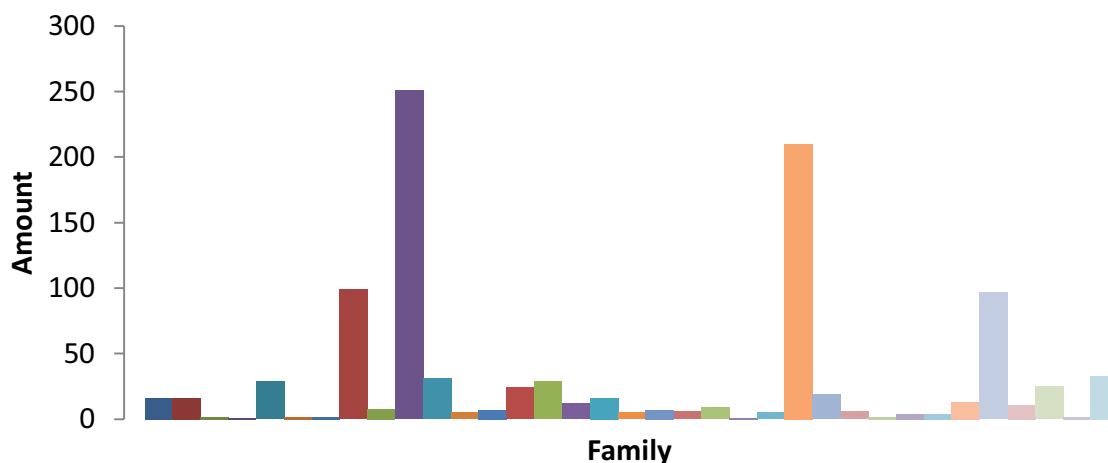
Values	Black and type	White sand type
Tree count	664	343
Average DBH	18,96	18,65
Standard deviation of DBH	± 11,77	± 9,78
Average tree height	18,99	17,96
The standard deviation of tree height	± 5,56	± 5,47
Number of species	80	54
% represented species	74%	50%
No. Plots (900m ²)	9	5
No. Sub plots (100m ²)	81	45
Total area plots (m ²)	8.100	4.500
Total area plots (ha)	0,81	0,45
Tree density (trees/m ²)	0,082	0,076
N species per 100 stems	12,05	15,74
Stand basal area (m ² /ha)	0,00	0,00
Aprox. volume (m ³ /ha)	0,03	0,03
DBH class:		
9,86 - 20 cm	465	245
20 - 30 cm	116	57
30 -40 cm	50	24
40 -50 cm	20	12
> 50 cm	13	5
	664	343
% DBH class:		
10 - 20	0,00%	0,00%
20 - 30	58,29%	58,16%
30 -40	25,13%	24,49%
40 -50	10,05%	12,24%
> 50	6,53%	5,10%
	100%	100%

Table 2 shows some similarities between dominant families on black and white sand scales in terms of differences in number and percentage of growth. The 4 dominant families in both types of health are the Dipterocarpaceae family as the dominant family, the more abundant colony species in the Myrtaceae growing place, the Sapotaceae family more as a food source for wildlife such as the orang utans that are spreading in the type of heath forest including Guttiferae. In black sand scales, the percentage of its presence is balanced for the 4 families, whereas in white sand scales it is more dominated by Dipterocarpaceae family up to 34.4%.

Table 2. Percentage of the dominant family in heath forest

Family	Black sand type		White sand type	
	Number	Percentage	Number	Percentage
Dipterocarpaceae	130	19,52	118	34,40
Myrtaceae	128	19,22	52	15,16
Sapotaceae	87	13,06	38	11,08
Clusiaceae (Guttiferae)	69	10,36	30	8,75

Graph 1 generally shows the distribution of families with a general dominance in heath forests which are known to have 4 dominant families also presented in Table 2 above. Dipterocarpaceae family is predominantly followed by Myrtaceae and is balanced between Sapotaceae and Guttiferae which is dominated by a feed from forest people and wildlife.

**Figure 2.** Total family in Bornean heath forest

Graph information is showing in Table 3. Table 3. show the number of family in the heath forest with the number of species in each family.

Table 3. The number family in heath forest

No	Families	Number	No	Families	Number
1.	Anacardiaceae	16	19.	Lauraceae	7
2.	Annonaceae	16	20.	Melastomaceae	6
3.	Apocynaceae	2	21.	Meliaceae	9
4.	Aquifoliaceae	1	22.	Moraceae	1
5.	Araucariaceae	29	23.	Myristicaceae	5
6.	Bignoniaceae	2	24.	Myrtaceae	210
7.	Casuarinaceae	2	25.	Pentaphylacaceae	19
8.	Clusiaceae (Guttiferae)	99	26.	Pittosporaceae	6
9.	Crypteroniaceae	8	27.	Podocarpaceae	2
10.	Dipterocarpaceae	251	28.	Rosaceae	4
11.	Ebenaceae	31	29.	Rutaceae /Oleocarpaceae	4
12.	Elaeocarpaceae	5	30.	Sapindaceae	13
13.	Euphorbiaceae	7	31.	Sapotaceae	97

14. Fabaceae (Leguminosae)	24	32. Sterculiaceae	11
15. Fagaceae	29	33. Thymelaeaceae	25
16. Gentianaceae	12	34. Theaceae	2
17. Icacinaceae/ Stemonuraceae	16	35. No name	33
18. Hypericaceae	5		
Total			1009

The following Graph 2 illustrates the number of trees from each family that grows in a hydrocarbon and white heath forest with 4 dominating families above. A number of families found in 32 black sand shells and 35 white sand.

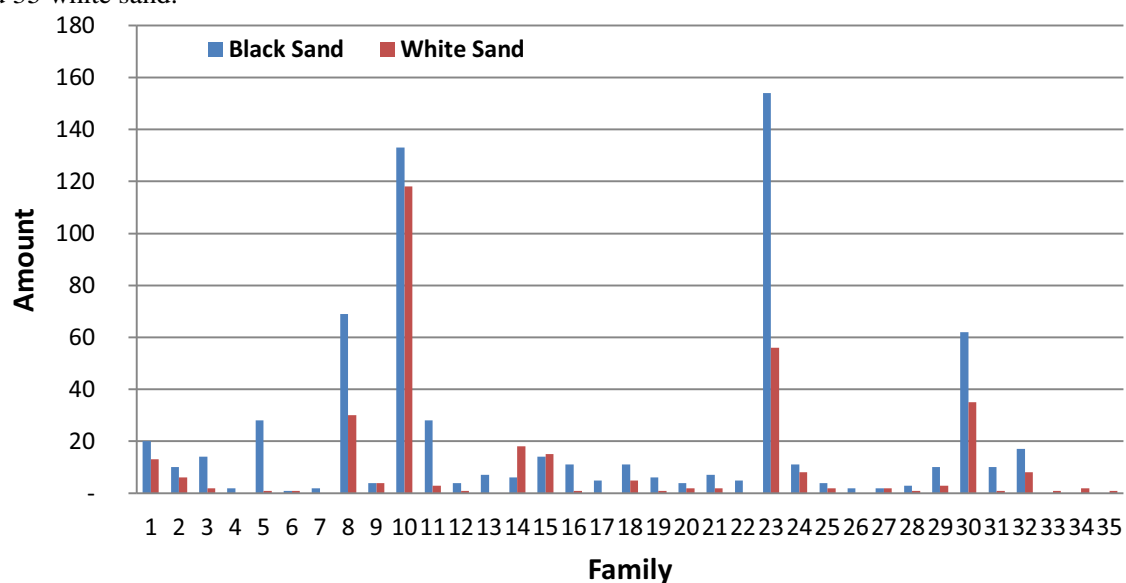


Figure 3. Plant family in Bornean heath forest

Graph information showing in Table 4. Likewise, Figures 3 and 4 show the existence of the number of trees in each family that grow both in black sand and white sand heath forests. The highest dominance black sand shells were the families Myrtaceae, Dipterocarpaceae, Guttiferae, and Sapotaceae, while the dominance of white sand scallops was sorted from the most dominant were Dipterocarpaceae, Myrtaceae, Sapotaceae and Guttiferae.

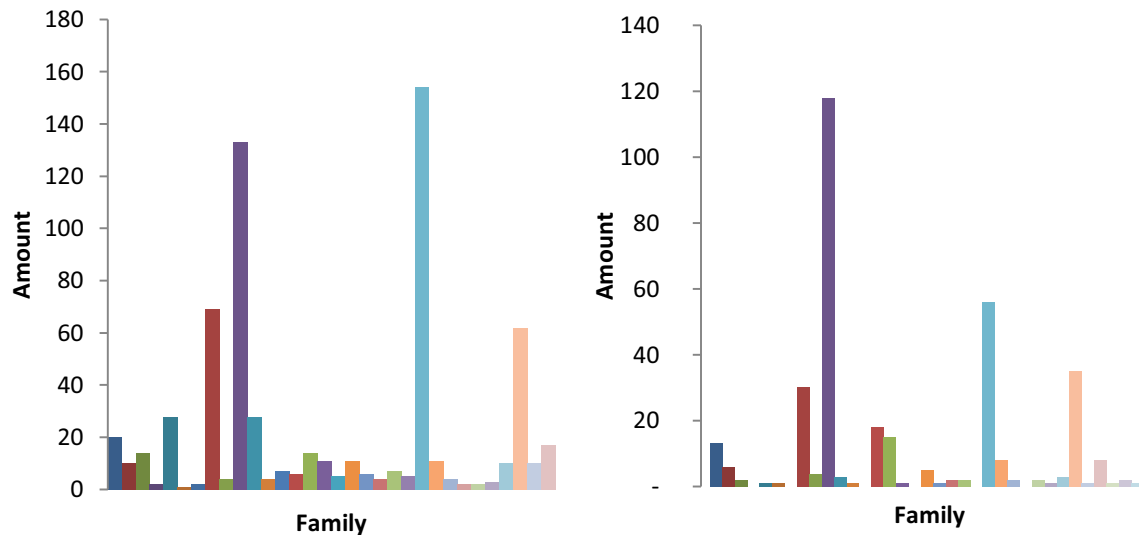


Figure 4 The comparison of family number based on sand types in the heath forest: black sand type (left) and white sand type (right)

Graph information showing in Table 4. Table 4 shows the number of family in the heath forest between black and white sand type to information about the difference of the family in black and white sand composition.

Table 4. The number of family in black and white sand type in heath forest

No	Family	Black Sand	White Sand
1.	No name	20	13
2.	Anacardiaceae	10	6
3.	Annonaceae	14	2
4.	Apocynaceae	2	-
5.	Araucariaceae	28	1
6.	Bignoniaceae	1	1
7.	Casuarinaceae	2	-
8.	Clusiaceae (Guttiferae)	69	30
9.	Crypteroniaceae	4	4
10.	Dipterocarpaceae	133	118
11.	Ebenaceae	28	3
12.	Elaeocarpaceae	4	1
13.	Euphorbiaceae	7	-
14.	Fabaceae (Leguminosae)	6	18
15.	Fagaceae	14	15
16.	Gentianaceae	11	1
17.	Hypericaceae	5	-
18.	Icacinaceae/Stemonuraceae	11	5
19.	Lauraceae	6	1
20.	Melastomaceae	4	2
21.	Meliaceae	7	2

22.	Myristicaceae	5	-
23.	Myrtaceae	154	56
24.	Pentaphylacaceae	11	8
25.	Pittosporaceae	4	2
26.	Podocarpaceae	2	-
27.	Rosaceae	2	2
28.	Rutaceae / Oleocarpaceae	3	1
29.	Sapindaceae	10	3
30.	Sapotaceae	62	35
31.	Sterculiaceae	10	1
32.	Thymelaeaceae	17	8
33.	Aquifoliaceae	-	1
34.	Theaceae	-	2
35.	Moraceae	-	1
		666	343

Table 5 shows the condition of the surrounding environment in the black and white sand shells from the presence of natural regeneration encountered, saplings, the presence of lianas including rattan, *Nephentes sp.*, orchids, ferns, large and small pandanus, traditional medicinal plants such as *pasak Bumi*, ant nests, root of banner, pneumatophore and root of the knee. The presence of puddles, water basins, waterways, peat, peat depth, soil pH. This type of rattan is found in black sand shells. Other existence is balanced between black and white sand. Ecosystem biodiversity, population, and genetics are very important to know so that biodiversity can be conserved [8].

Table 5. Comparison of the environmental condition in the black and white sand

Values	Black sand type	White sand type
Average of number seedlings	60,9	72,6
Average of number saplings	64,3	50,7
Average of number pitcher plants	0,6	0,2
Average of number lianas	4,8	5,3
Average of number vines	7,1	5,0
Average of number big pandan	0,4	0,2
Average of small number pandan	1,9	1,3
Average of number large rattan	6,3	1,2
Average of number stilted roots	4,8	3,4
Average of number ant plants	0,1	0,1
Average of number orchids	1,6	1,8
Average of % hummock/hollow	17,3	11,4
Average of % stand water	0,0	0,0

4. Conclusion

This study shows that there are several special types that grow in heath forests, both shellfish with black sand and white sand, which are dominated by the families of Dipterocarpaceae, Myrtaceae, Sapotaceae and Guttiferae with a comparison of growth in different percentages between black and white sand. There are 32 families of trees that grow on black sand shells and 35 families on white sand shells with the similarities between the two types of families in the family Sterculiaceae, Thimeliaceae and Theaceae on white sand shells.

Special environmental conditions for the growing environment between black sand and white sand shells have similarities only in black sand has a higher density of growing semar bags and rattan is often found in black sand shells. White sand shellfish has abundant natural regeneration.

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