VEGETATION AND TREE DIVERSITY REPORT IN RESTORASI EKOSISTEM RIAU

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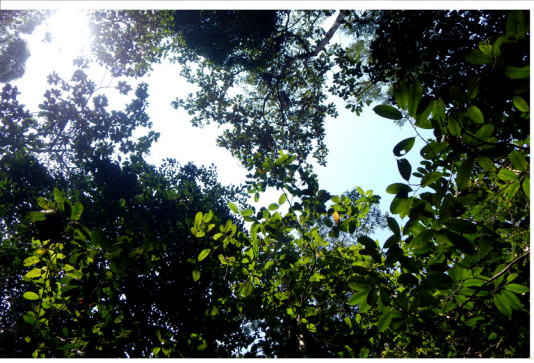
REPORT



FAUNA & FLORA INTERNATIONAL

RESTORASI EKOSISTEM RIAU

APRIL

VEGETATION AND TREE DIVERSITY REPORT IN RESTORASI EKOSISTEM RIAU

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APRIL **2016**

FAUNA & FLORA INTERNATIONAL

Fauna & Flora International (FFI) is the first international organization which engaged in the field of conservation. Since its establishment in 1903, FFI had contributed to many important conservation areas for biodiversity. In the early year of its establishment, FFI has helped and supported the determination of the various conservation areas in Africa, including Kruger National Park and the Serengeti. Currently, FFI has contributed substantially to the protection of threatened biodiversity and ecosystems in more than 40 countries spread over 5 continents with a total of more than 13.50 million acres of important conservation area, either on land or sea.

FFI with its vision believed that biodiversity could effectively being conserved by having communities living side by side in any protected landscape. To achieve its goal, FFI has implemented various scientific approach as a basis for creating conservation solutions that are sustainable and still take into account of human needs. FFI-IP helps communities to map the indigenous forests and get the its recognition officially to manage the forest in a sustainable way. In addition, FFI participate for guarding the survival of endangered species through sustainable funding mechanisms based on the program of REDD and PES.

FFI-IP has a broader its approach in the conservation efforts, mainly focused in the landscape level. Currently, FFI-is doing several conservation efforts at various locations in Indonesia like Sumatra, Kalimantan, Papua (Waigeo), Java (Nusakambangan) and Lombok. Through the assessment of High Conservation Value (HCV), FFI-IP has helped community to protect forests with a high potential for carbon reserves as well as the important habitats of the various endangered species (Sumatran Elephant, Sumatran Tiger, Orangutan) since 2007.

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OVERVIEW

Kampar Peninsula Peat Swamp Forest is one of the remaining peat swamp forests in Riau province and plays an important role in our life, such as hydrological functions and serving as a carbon reserve. This area is managed with a comprehensive ecosystem management which includes its vegetation. This study aimed to understand the vegetation structure and species composition in peat swamp forest of the Kampar Peninsula under the Riau Ecosystem Restoration area. The vegetation data being collected using a combination between transect and adaptive plot method with a total plot coverage of 39.75 ha. Results showed that the vegetation in Kampar Peninsula Peat Swamp Forest is comprised of 112 plant species belonging to 43 families. The average DBH of a big tree was 40.11 ± 10.3 cm, medium tree 19.6 ± 3.7 cm, and pole 8.6 ± 3.1 cm with densities of each class respectively 50.9 stands per hectare, 317 stands per hectare and 1174 stands per hectare. According to the importance value index (IVI), *Shorea teysmanniana* (27.84), *Pandanus* sp.'mengkuang' (19.54), and *Campnosperma coriaceum* (15.57) were the most common species with a relatively high IVI in each growth stage.

I. PREFACE

1.1 Background

Peat swamp forest is a unique and fragile ecosystem which under threat by human disturbances. Sumatra had the largest peat swamp forest with 7,151,887 ha. However, due to illegal logging, habitat changes into agriculture, plantation and also due to forest fire caused loss of peatland of Sumatra. Sumatra lost about 78% from its previous initial area (Purba et al., 2014). Riau province has the largest peatland area which had 4,004,434 ha in Sumatra and about 671,125 ha existed in Kampar Peninsula (Tropenbos International Indonesia Program, 2010).

The Kampar Peninsula is part of the largest peatland forest for Riau, plays an important area for biodiversity conservation. This area also an important habitat for Sumatran Tiger and other endangered species. Birdlife International also declared that this landscape as one of Important Bird Area (IBA). Kampar Peninsula also provide important ecosystem services such as the storage of carbon stocks which potentially ranged from 2.14 to 2.68 billion tonnes, preservation of water resources and flood reducer (Tropenbos International Indonesia Program, 2010).

In an organizational perspective, Riau Ecosystem Restoration (RER) is a non-profit organization formed by APRIL in 2013 with an area of about 150,000 ha. RER has the purpose of restoration and conservation of peat swamp forest ecosystem in the area of Kampar Peninsula as a response to the program from the Ministry of Environment and Forestry-Republic of Indonesia to protect 2.6 million hectares of forest through ecosystem restoration forest system (IUPHHK-RE).

Three of the four concessions under support of the RER in the Kampar Peninsula had obtained a license of IUUPHHK-RE which are PT. Gemilang Cipta Nusantara (20.265 ha), PT. Sinar Mutiara Nusantara (32.830 ha) dan PT. The Best One Unitimber (39.412 ha). RER's restoration and conservation efforts are very important as RER concession occupied about 29% of coverage of the Tasik Besar Serkap-Forest Management Unit. RER had been collaborated with Fauna and Flora International-Indonesia Programme (FFI-IP) for designing the framework, policies and management plans which relate to the Community, Climate and Biodiversity (CCB) assessment in the landscape profile. The management plan resulted from this assessment will restore its ecological for the Kampar Peninsula landscape. This initiative will ensure the ecosystem services from the peat swamp forest to many people, especially the communities that coexist with this landscape (Restorasi Ekosistem Riau, 2015). If successful, the restoration and conservation program can be a model to be replicated in other areas in the broader landscape level (Kristi, 2014).

Biodiversity is part of an important aspect as a constituent biotic component of peat swamp forest ecosystem in Kampar Peninsula. However, the availability and an update of biological diversity data at a study site is very limited or difficult to obtain. Unfortunately, the data is needed as a reference for making a consideration on the preparation of programs related to the management of restoration and conservation efforts. In order to fulfill those needs several studies of the diversity of fauna and flora in the region is an important part for

managing the landscape properly.

Restoration and conservation program generally requires a variety of basic data as consideration for further program development, especially related to the management plan. Basic data on vegetation and floristic diversity of the community in the area of peat forests of the Kampar peninsula is still lacking. In order to do that, study on floristic diversity and vegetation analysis might be needed in the future.

1.2 Aim

To meet the needs of basic data about the analysis of the floristic diversity of vegetation and goal of this botanical survey of the studies is to:

1. Describe the current condition of the structure and composition of peat forest vegetation in the area of the RER,
2. Determine the type of peat forest area ecosystem RER,
3. Determining the diversity and wealth of floristic peat forests as well as the RER constituent record those types of important and threatened with extinction.

II. METHOD

2.1 Study Site

The area of Riau Ecosystem Restoration (RER) consists of PT. Gemilang Citra Nusantara (GCN). PT. Sinar Mutiara Nusantara (SMN) and PT. The Best One UniTimber (TBOT(in the stretch of the Kampar Peninsula which its topography ranges from 2-16 m. This area classified as a wet tropical climate with relative humidity ranging from 81-84 % with an annual average of around 82 %. Annual rainfall ranges between 1.949-2.951mm/year. Monthly average for air temperature ranged from 26.1-27.5^{o}C with annual average 26.7^{o}C (PT. GCN, 2012).

In general, there are three main type of ecosystems in Kampar Peninsula which are mangrove forest, peat swamp forest and riparian forest. For RER area, main ecosystem can be classified based on the type of vegetation: (1) Mix peat swamp forests with uneven canopy heights (mixed peat swamp forest), (2) Peat swamp forests with relatively flat-high tree canopy and has a uniform diameter trees (tall pole forest), (3) Peat swamp forests with low canopy (low pole forest), and (4) Riparian forest. Riparian forests in the RER are along the three rivers that flow in the area of the Turip River, and Serkap River which flow into PT. TBOT, Serkap River in PT. SMN and Sangar River inside PT. GCN. During the highest tide, wide puddle of these rivers may reach 1-1.5km. The peat depth on RER reaches 15m with the level of acidity (pH) ranged from 3.1 to 3.9 (Tropenbos International Indonesia Program, 2010; PT. GCN, 2012).

Peat swamp forest ecosystem in Kampar Peninsula is an important habitat for endangered fauna and flora. Several endangered flora species had a high economic value such as ramin (*Gonystilus* sp.), other Dipterocarp species (*Shorea* spp.), durian (*Durio* sp.), kempas (*Kompassia malaccensis*) and punak (*Tetramerista glabra*). Couple critically endangered and threatened mammals such as sumatran tiger (*Panthera tigris sumatrae*), pangolin (*Manis javanica*), and sun bear (*Helarsctos malayanus*). Some species of hornbills and raptors such as hawks and falcons, and also some reptiles like false gharial (*Tomistoma schlegelii*) and painted terrapin (*Batagur borneoensis*) (Tropenbos International Indonesia Program, 2010).

a.Survey in PT. Gemilang Cipta Nusantara

In PT. Gemilang Cipta Nusantara (GCN), eight transects were conducted within concession area and one additional transect in Tasik Besar Serkap Forest Management Unit which is located at the outside of PT. GCN. Survey was conducted from May to June 2015 with approximately effective time of data collection are 18 days. In the concession area lies Sangar River with 5-7 m width which is the only major river that flows from the northeast to the southwest. In general, PT. GCN represent a secondary peat swamp forest which dominated by mengkuang (*Pandanus* sp.) and meranti (*Shorea* spp.).

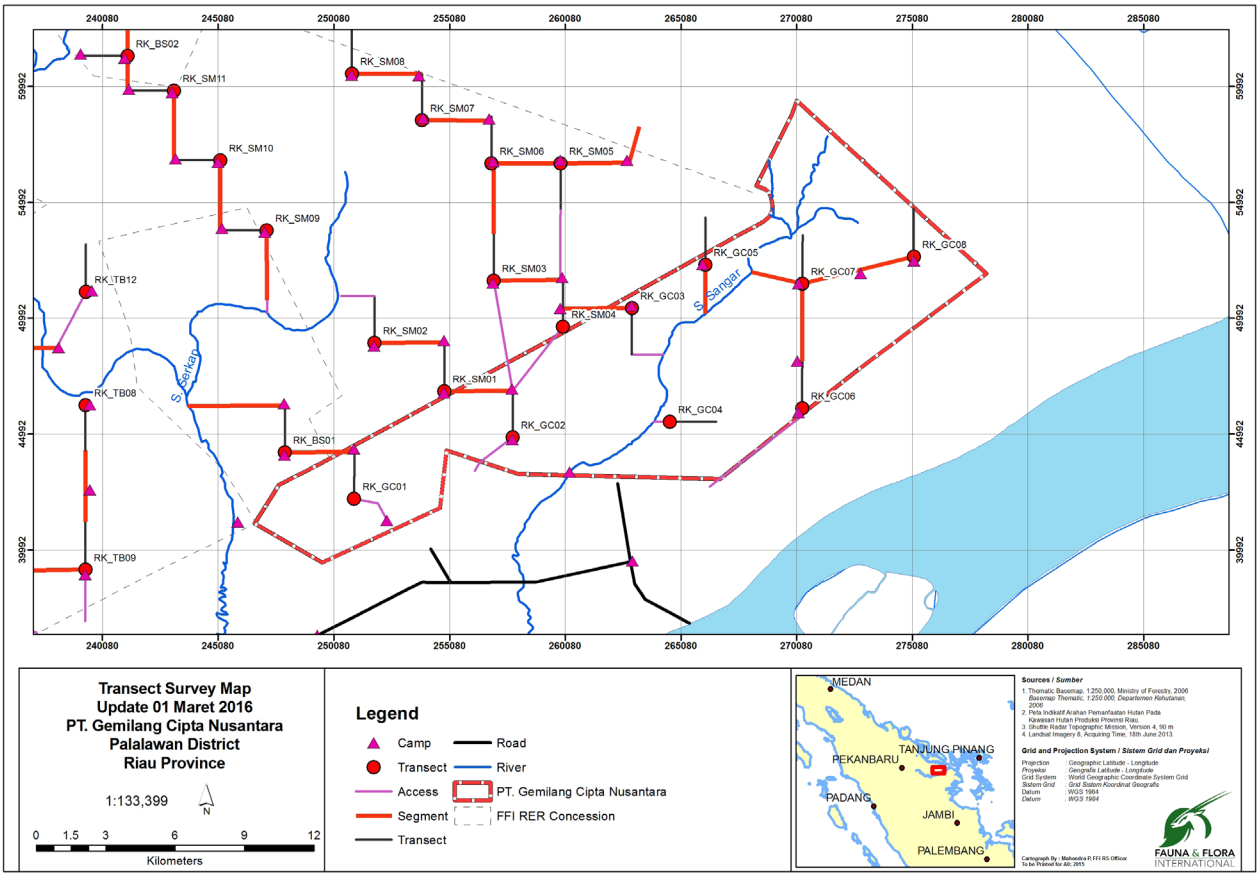

Figure 1 Distribution of nine transects in PT . GCN.

Five of the nine transect is relatively close to the Sangar River which about 4 km apart signed as RK_GC03, RK_GC04, RK_GC07 and GC_04. The condition of the forest floor is largely inundated to a depth at least 30-40 cm in transects RK_GC03 and GC_04, while other transect remained dry.

In the transect with the relatively high light intensity or low canopy cover due to the openings, mostly found mengkuang (*Pandanus*) in the form of live shrubs or trees. Pandan dominance conditions and shrubs was found in transect RK_GC02, RK_GC04, RK_GC06, RK_GC07 and RK_GC08. In opening area, we found several *Nepenthes* spp.

In transect of RK_GC01 and RK_BS01, have relatively different vegetation conditions with other transects with mengkuang dominance compared to other transects. Transect of RK_GC06 located in the periphery of the southern part of the concession area. The forest area in transects connected to acacia plantation paralled with a 5 m width canal as the demarcation. In RK_GC06 transect also found a wide access track (approx. 5 m), which might be used for illegal logging.

Figure 2 Mengkuang domination on some points in transecks RK_GC06, RK_GC07 and RK_GC08.

b. Survey in PT. Sinar Mutiara Nusantara

The survey was conducted on ten transects in the concession area and one transect (RK_BS02) located outside the concession area about 1km to the south of Tasik Besar Lake. The survey was conducted during August-October 2015 by the effective time for 29 days.

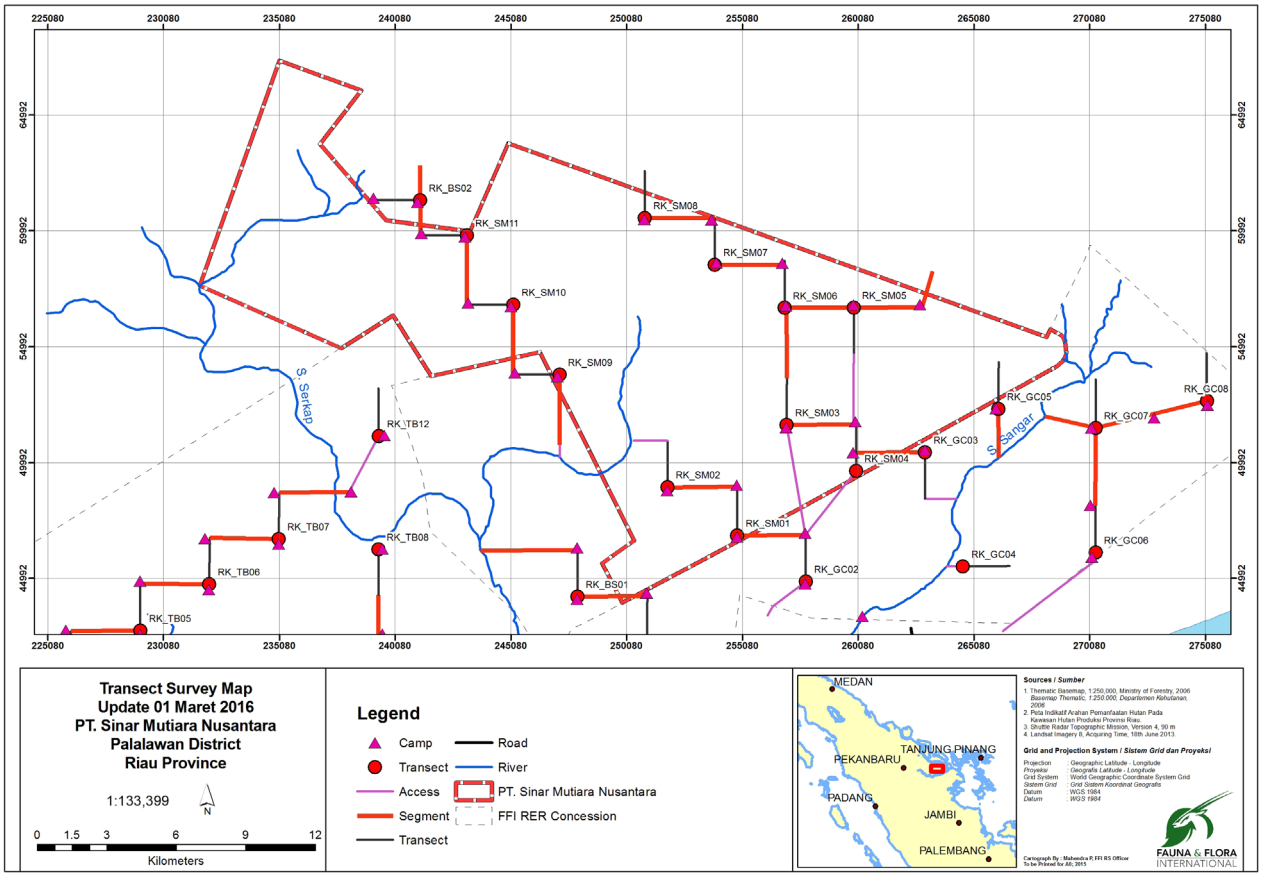

Figure 3 Distribution of transects in the area of PT. SMN. RK_BS02 transect was outside the concession boundaries of PT.SMN and approaching Tasik Besar Serkap.

In general, the location of data collection was a secondary peat swamp ecosystem. The habitat is a terrestrial patches with dry conditions. Although in some locations of sampling, a water source such as a stream; inundation due to fallen trees; puddle; water in tree holes and water from Pitcher *(Nepenthes sp.)* can be found in RK_SM04. The dominant tree vegetation that can be found throughout the concession such as meranti (*Shorea teysmanniana*), punak (*Tetramerista glabra*), and bintangur (*Calophyllum ferrugineum*) with such *Pandanus* spp. The dominant vegetation of *Pandanus* sp. in PT. SMN can be found in transects of RK_SM04, RK_SM06, RK_SM07. Transect of RK_SM05 was dominated with Rasau (*Pandanus helicopus*) while others like in RK_SM11 and RK_BS02 had vegetation ranging from shrubs, Pandan, Linau (*Cyrtostachys renda*) and Salak (*Eleiodoxa conferta*). *Nepenthes* sp. also found in significant amounts in almost all transects.

Figure 4 Condition of a transect with several small stands of trees with its diameters between 5 to 10 cm and water puddle as a habitat for fauna.

c. PT. The Best One Unitimber

The survey was conducted on 12 transects during November to December 2015 with effective survey time by 30 days in mostly rainy season conditions. Most transects in the concession are moist peat swamp forest with inundation depth of about 15-50 cm in most of the transects, except for transects of RK_TB08, RK_TB09, RK_TB10, RK_TB11 dan RK_TB12.

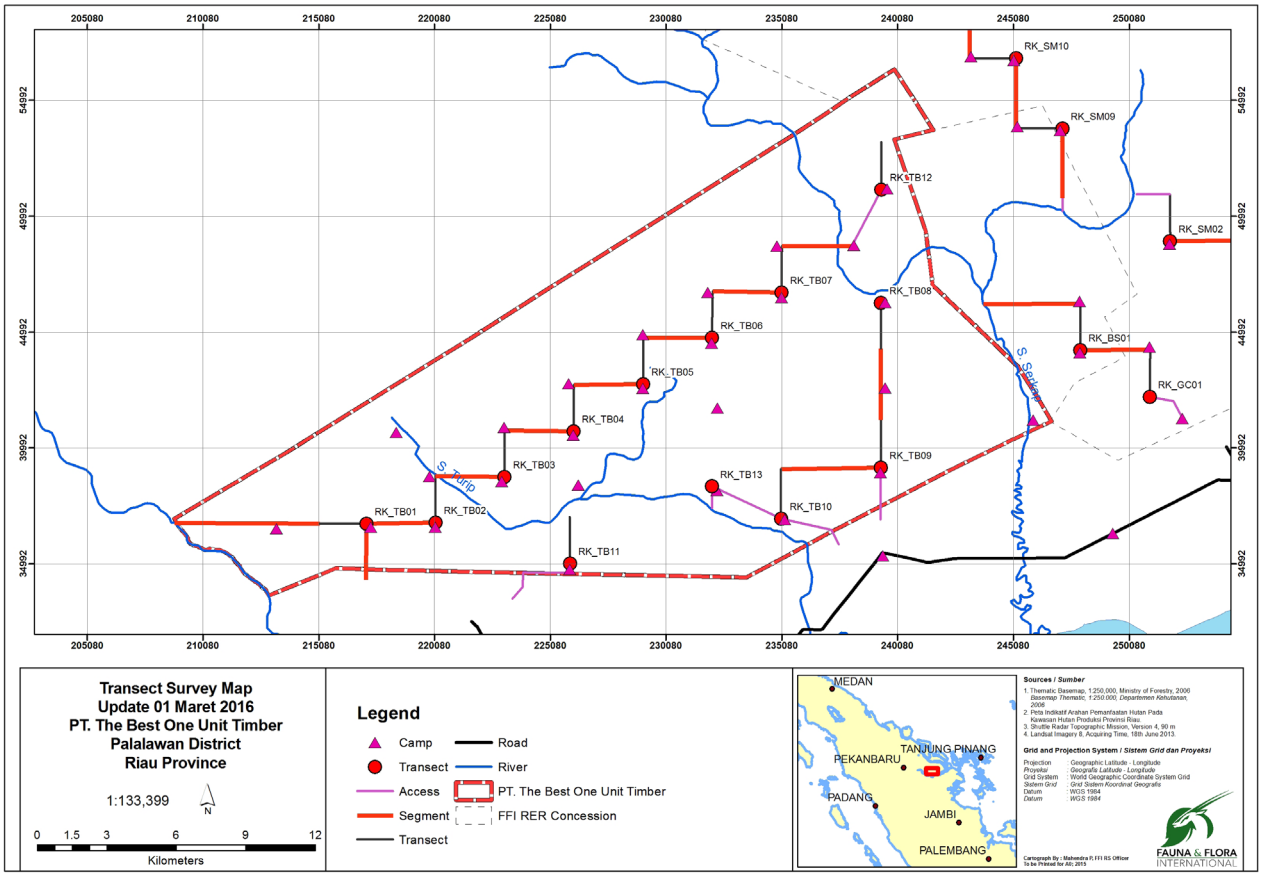

Figure 5 Distribution of transects in the area of PT. TBOT.

Transects at RK_TB01, RK_TB08, RK_TB09, RK_TB11 tend to have a lot of stands of large trees from meranti, punak, suntai and kelat with a diameter of more than 30 cm when compared with other transects. Mengkuang (*Pandanus* sp.) in the form of the tree was rarely found in each transect except in transect of RK_TB11, but in the form shrubs which dominated the whole of the beginning of 100-300 m transects of RK_TB05, RK_TB06, RK_TB10, RK_TB11, dan RK_TB12. *Nepenthes* sp. was rarely being found in this area.

Figure 6 Domination of large trees such as Punak, Suntai, Kelat and Meranti are relativly prevalent in some transects in the area of PT. TBOT form a dense canopy cover.

2.2 Data Sampling

General Research Design

Data collection for fauna and flora refers to the line transect method. A total of 32 transects with 2 km length was chosen by stratified random sampling. The number of transects in each concession was amended by the proportion of its range and orientation representing the four cardinal directions. Nine transect were in PT. GCN, 11 transects were in PT. SMN and 12 transects were in PT. TBOT.

Floristic Data Collection

Data collection was conducted within transect, along a 2 km straight line. In each transect, we put five adaptive plot located in each 0,5km (point 0km, 0,5km, 1km,1.5km, and 2 km). In each plot, there were three sub-plots of different sizes based on group size chest-high diameter (Diameter at Breast Height - DBH). The placement point of the plot and sub-plot based on the class of the tree can be seen in Figure 7 and table 1. Observation and measurement of the data will be conducted in each sub-plots.

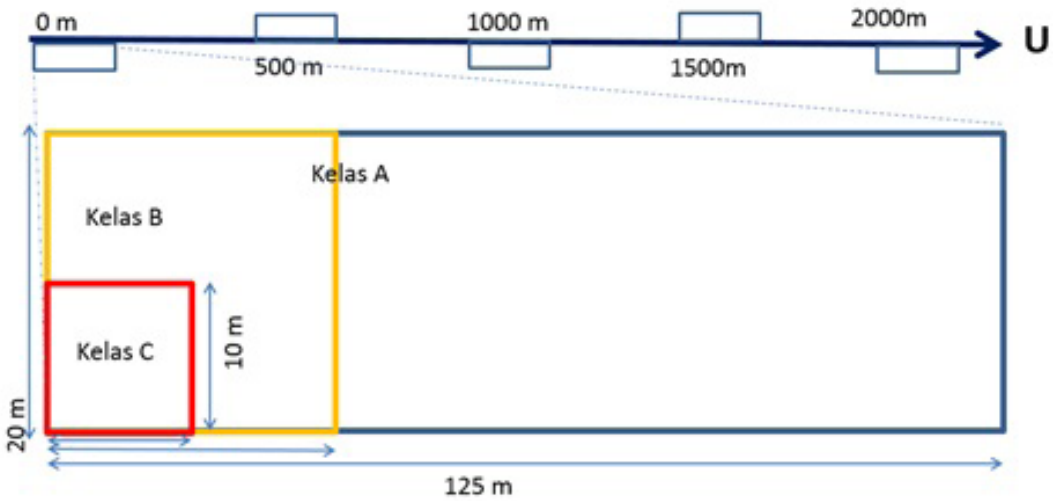

Figure 7. The shape and placement of the sub plots at transect.

Table 1. The size of each sub-plots and tree class category.

Sub Plot	DBH (cm)	Category	Class
10m x 10m	5 - <15	pole	C
20m x 20m	15 - <30	small tree	B
20m x 125m	> 30	big tree	A

In each sub-plots, the parameters being collected are tree species, Diameter at Breast Height (DBH), total height, branchless height of each individual stands appropriate to its class of DBH. The coordinates of each of the adaptive plot were recorded using GPS Garmin ™ type 62sc, right at the initial point (0.0) of plot. Leaves, twigs, fruit, and flowers of every type of tree was collected for herbaria. Each herbarium photographed for identification purposes. Early identification of plants is done in the field. To verify the species name, results from collected herbarium vouchers and photos are then compared with a database of photos of plants at the FFI-IP office, and herbaria specimens in Herbarium. The remaining unidentified and some confusing specimen finally being sent to *Herbarium Bogoriensis* to have a verified identification. For completing the list of the vegetation type and having the descriptions of habitat, observations are also carried out around the plots and transect area.

2.3 Data Analysis

Analysis of vegetation is observed based on the structure of vegetation, the composition of the floristic diversity and floristic similarity between forest communities examined. The structure of the vegetation will be overviewed from horizontal and vertical structure. Horizontal structure seen from the density of the forest on each class, dbh (max., min. average), while the vertical structure would be visible from the layer of strata high in the canopy. In general, a layer of vegetation is divided into layers of the forest floor (understorey) and the top layer (upper-storey). The top layer of peat forest is again based on the height of the forest: the upper canopy with a range of 25 – 37 m, the middle canopy with a range of 15 – 25 m, and the lower canopy (sub canopy) with a range of 5 – 15 m. Sometimes found layers of emergent canopy, that the trees have exceeded the upper canopy so that the trees looks emerge out above the vegetation.

Analysis of the floristic communities is done using the Important Value Index (IVI), while for the analysis of diversity and community indices used Shanon-wienner diversity index (H‘), Simpson’s dominance index (D) and Evenness (E) to find out the level of diversity and community a description of the area. Bray-Curtis similarity index is used to see the level of similarity between community (transect) and in the end also used to see a cluster of similar communities. The index value is calculated with the help of important software Microsoft ® Excel ™ 2010, whereas the index-index of diversity and community is done with the help of Past software © ver. 3.08 (Hammer *et al*., 2001). Formulation and explanation regarding each of the above indexes are as follow:

a. Floristic Diversity Shannon-Wiener

Floristic diversity in each transect was measured using the Shannon - Wiener diversity index (H’) and Pielou evenness index (J), which is calculated by using the formula (Shannon, 1948):

$$H' = -\sum_{i} \frac{n_i}{N} ln \frac{n_i}{N}$$

H’ : diversity index Shannon- Wiener
ni : number of individuals-i
N : the total number of individuals

Shannon - Wiener diversity index calculates the relative abundance and species richness. The index value will increase along with the addition of species richness and species evenness (Brower *et al*., 1998).
For comparing the diversity of vegetation between transects, t-test on the value of the index Shannon-Wiener will be conducted (Hutcheson, 1970 in Hammer, 2015) with hypothetical state as follows:

H0: there is no difference in the value of Shannon - Wiener diversity index between the two transects were compared.
H1: here are differences in the value of the Shannon - Wiener diversity index between the two transects were compared.

H’ variance will be calculated using this formula

$$Var\ H' = \frac{\Sigma pi\ (\ln pi)^2 - [\Sigma(pi \ln pi)]^2}{N} + \frac{S-1}{2N^2}$$

S is the total number of species

b. Pielou Evenness Index

To measure the level of species evenness, Pielou Evenness Index will be used by this formula (Pielou, 1966):

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

E : Pielou Evenness Index
H' : Shannon diversity index
S : Number of total species

E value ranges from 0 to 1. The closer the value of E to 1 means that a community has a number of individuals per species that is relatively the same.

c. Simpson's Dominance Index

The index are used to inform about the presence of domination by one or several species among community. To measure the dominance level are use the following formula (Simpson, 1949):

$$D = \sum_{s-1}^{s} (Pi^2)$$

where,
D : Simpson's dominance index
S : Species number in community
Pi : Proportion of individual number or sample size to species

D value ranged between 0 to 1. The closer to 1, means the presence of domination is higher among community, in opposite, the community is construct by co-domination among species if the D is close to 0. (Harper, 2000).

d. Cluster analysis

This analysis was conducted to see the similarities of plant community within surveyed transects. Transect with similar communities will tend to be clustered in one group. On the other hand, transect that has different plant communities will be separated into another group. The cluster analysis was conducted using PAST 3 software (Hammer, 2015). Bray - Curtis index will be used to create a similarity community tree (dendogram) using relative abundance data, the index value ranging from 0 to 1. The closer to 1, means the two communities have a high similarity in species composition.

III. RESULT AND DISCUSSION

3.1 OBSERVATION RESULTS

a. RER Diversity

The grouping of vegetation and community structure resulted in at least 3 main types of peat ecosystem in the RER area, which are: 1) Mixed Peat Forest (MPF) ecosystem, 2) Low Pole Forest (LPF) and 3) Mengkuang (screw palm) field or degraded forest. MPF were mostly found in the GCN and TBOT concession area while the SMN concession area was dominated by the LPF. On the other hand, Mengkuang field ecosystem could be found in former logging areas such as in RK_GC06, RK_TB05, and RK_GC08.

Results of the study showed that the species composition of tree in the Kampar Peninsula under the RER area is comprised of 112 tree species from 43 families. Of the 43 identified families, 5 families dominated, which are *Myrtaceae*, *Dipterocarpaceae*, *Sapotaceae*, *Anacardiaceae*, and *Pandanaceae*. Of the 112 plant species, a majority (45.5%) are reported as peat swamp forest indigenous species. A number of peat swamp forest indigenous species such as *Shorea uliginosa*, *Agalaia rubiginosa* and *Shoraea teysmanniana* could be found in large numbers. Other species such as *Camnosperma coreaceum*, *Calophyllum ferrugineum*, *Mangifera parvifolia*, and *Myristia lowii* could thrive in peat swamp habitat. With A class tree density of 50.9 stands per hectare, B class 317 stands per hectare and C class 1174 stands per hectare. The average DBH of each class were: big tree = 40.1 ± 10.3 cm, small tree = 19.6 ± 3.7 cm, and pole = 8.6 ± 3.1 cm. The canopy layer of this forest is still complete with 3 main layers; upper canopy, middle canopy and lower canopy, with a proportion of 15.2%, 39,8% and 44,6% respectively.

Results of the observation will be presented and explained per concession, which will eventually address the RER peat swamp forest landscape comprehensively in the discussion section. The sub-section parts will provide results and reports on vegetation structure, floristic composition, floristic diversity and important species. In the discussion section, the topic is further broadened with ecosystem type grouping, peat swamp forest important species and even threatened species.

b. PT. Gemilang Cipta Nusantara

Vegetation Structure

Vegetation structure can be identified by the quantity or density of stands correlated with the DBH of stands per area. Data of the stands density and DBH measurements in the 9 transects in PT. Gemilang Cipta Nusantara (PT. GCN) is shown in table 2. Based on the vegetation measurements in 8 transects in PT. GCN's concession and 1 transect outside but adjacent to PT. GCN area. The density of tree stands per hectare in PT. GCN's concession forest for A class was 57 trees per hectare or 2 trees per 20x20m, B class 356 trees per hectare, and C class 1,424 poles per hectare. GCN forest also had a big tree DBH of 41.5cm

with a maximum DBH of 86.3cm. The highest DBH average was found in transect RK_GC04; while the tree with the longest diameter was located in transect RK_GC05. With the high density of big trees, this area tend to be darker/dimmer since sunshine is mostly absorbed by the bigger trees leaving little for the trees in the lower levels

Table 2 Quantity and density of stands per class in each transect

Parameter	Class	RK_ BS01	RK_ GC01	RK_ GC02	RK_ GC03	RK_ GC04	RK_ GC05	RK_ GC06	RK_ GC07	RK_ GC08
Number of Stand (∑) and Density (∑/Ha)	∑A	71	118*	70	69	24**	81	34	77	98
	∑A/Ha	56,8	94,4	56	55,2	19,2	64,8	27,2	61,6	78,4
	∑B	73	65	54**	65	67	80	56	111*	61
	∑B/Ha	365	325	270	325	335	400	280	555	305
	∑C	85*	74	53	46	25	35	29	14**	48
	∑C/Ha	1700	1480	1060	920	500	700	580	280	960
Average DBH (cm)	A	36,8**	35,7	39,9	41,6	49,2*	44,4	37,9	44,2	42,9
	B	19,9	21,8	19,4	19.6	18,1	18,9	18,3	18,4	21,1
	C	8,2	8,6	9,5	9,9	8,7	9,5	9,1	10,5	8,2
DBH Maximum (cm)	A	67,9	59,7**	72,2	75,1	80	86,3*	60,7	79,5	74,5
	B	28	29,5	28	29,5	29,1	29,2	28,3	27	29,8
	C	13,8	14,8	14,9	14,9	14,8	14	14,8	14,7	14,7

Note: per class A (dbh >30 cm), B (dbh 15 - 29,9 cm) and C (dbh 5 - 14,9 cm); '' show bigger data, '**' show smallets data*

Based on the table above, the vegetation in RK_GC01 had the largest number of big trees and was the most dense transect out of all the transects. However, it had the smallest average DBH. This means that this area has a fair number of big trees but with relatively shorter diameters (around 35.7cm) in comparison to other areas of the GCN forest. This also occurred in RK_GC07 but for the small tree class and in RK_BS01 for the pole stage. This phenomenon, especially for RK_GC01, shows a tendency that the tree stands within the forest are still in a competition process towards final succession stage. In RK_GC07 and RK_BS01, competition occurred in each small tree class and pole to grow into a higher tree stage.

In comparison, the vegetation in RK_GC04 and RK_GC06 had the lowest density (dispersed). In addition, the lower class trees also tend to be more dispersed. This condition indicates that this area is more open on each level, especially in RK-GC06. Seeing that both areas are inside a mixed peat forest with enough resources for maximal vegetation growth, it could be assumed that the level of disturbance in both areas is quite high. Historically, both RK_GC04 and RK_GC06 have had significant degradations, which was the large-scale forest fire in 2014 in RK_GC04 and massive illegal logging in RK_GC06. These incidents reduced the presence of its upper stands, especially in the RK_GC06 area. In RK_GC04, despite having dispersed density, the average DBH was large, which shows that big trees survived.

Other than from its horizontal structure, vegetation structure can also be identified from its vertical structure, which is seen from the height composition of stands that form the vegetation canopy layer. The measurement of tree height data of each vegetation canopy layer in PT. GCN concession peat swamp forest is shown in Table 3. Based on that data, PT. GCN peat swamp forest still has a complete structure with a dominant middle canopy. The upper and lower canopies were formed from few stands (each 240 and 310 trees), in comparison to 1.132 trees in the mid canopy. A more detailed canopy layer comparison can be seen in Figure 8 which shows the proportion of each canopy layer role in covering the forest.

Table 3 number of stands construct canopy layer per class in each transect.

		RK_ BS01	RK_ GC01	RK_ GC02	RK- GC03	RK_ GC04	RK_ GC05	RK_ GC06	RK- GC07	RK_ GC08	PT. GCN
upper canopy	∑	9**	26	17	23	9**	30	7	53	66	240
middle canopy	∑	168	183	137	116	76**	145	60**	137	110	1132
lower canopy	∑	52	48	23	40	31	21	52	12**	31	310

*Noted: '**' show smallets data.*

Domination of middle canopy from other canopy layers indicates that this canopy layer is the main forest layer cover instead of the upper canopy (closed canopy). This data also shows that the upper canopy is rather dispersed, resulting in more sunshine reaching the layers below. At the same time, the mid canopy retains sunshine even lower, which in result causes the lower canopy to become more dispersed

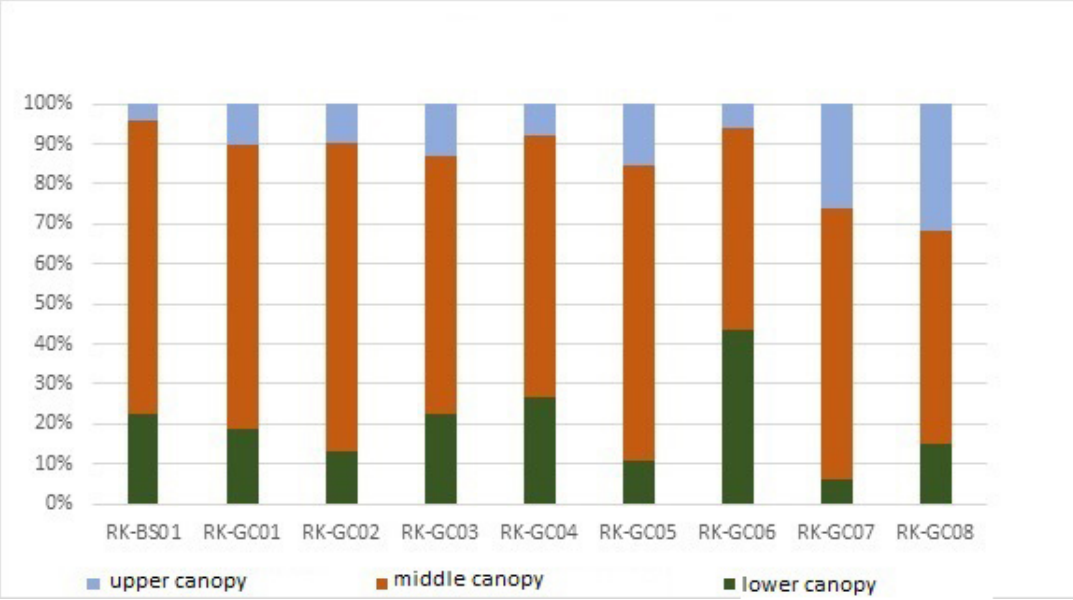

FIGURE 8 Proportion of each canopy layer per transect

Based on the distribution of canopy layers in each transect, RK_GC04 and RK_GC06 can be viewed as an open forest from its scant amount of upper and middle canopy layer compared to other transects. In RK_ GC06, we could even see that the forest was equally covered by the lower and mid canopies. Both canopy layers (middle and lower) were composed of mostly small tree class. This condition (a more open forest) was likely caused by the absence of big tree class as the main upper canopy. The sparse upper canopy was not counter-balanced by a dense coverage by the middle canopy; hence the lower canopy received abundant amount of sunshine.

Based on its horizontal and vertical structures, the vegetation of GCN peat swamp forest can mainly be categorized as Mixed Peat Swamp Forest (MPF). MPF has a few characteristics, including: the forest is dominated by trees with a height reaching 30 – 35m with canopy coverage of the mid layer consisting of trees with a DBH of >20cm (Anderson, 1963; Page *et al*., 1999).

Tree Community

Tree community indicates the species composition that made up the peat swamp forest in PT. GCN. The tree community in an area can be determined by the importance value of each forest area. Species with a high importance value indicates that it dominates most of the space in that community. Below are the

species with the highest importance value in each class:

A- *Shorea teysmanniana* (50,5), *Shorea uliginosa* (39,7), *Palaquium sumatranum* (26,9), *Tetramerista glabra* (23), *Campnosperma coriacea* (17,7);

B- *Pandanus* sp.'mengkuang' (78,3), *Mangifera parvifolia* (22,2), *Syzygium* sp1 (18,7), *Stemonurus secundiforus* (15,2), *Shorea uliginosa* (12,8);

C- *Mangifera parvifolia* (23,1), *Ilex cymosa* (22,2), *Stemonurus secundiflorus* (21,8), *Syzygium* sp1(17), *Syzygium chloranthum* (15,2), *Pandanus* sp. (14), *Horsfieldia crassifolia* (13,1).

A completed data on the importance value of each species per transect can be seen in Appendix 1. According to the importance value, the forest of PT. GCN was dominated by meranti bunga (*Shorea teysmanniana*) and meranti sarang punai (*Shorea uliginosa*) for the big tree class. For the small tree class, the forest was dominated by mengkuang while the pole class was dominated by salakeo (*Mangifera parvifolia*), *Ilex cymosa*, sembasah (*Stemonurus secundiflorus*) as well as species from the Myrtle family *(Syzygium spp.).* Some other species with high abundance in the forest of PT. GCN were Bintangur *(Calophyllum ferrugineum)*, ramin *(Gonystylus bancanus)*, kelat malas *(Parastemon urophyllus)*, tempurung bintang *(Blumeodendron kurzii)*, kelat pisang *(Austrobuxus nitidus)*, mangosteens *(Garcinia* spp.*)*, and parak *(Aglaia rubiginosa)*.

For the small tree class, mengkuang (*Pandanus* sp.'mengkuang') was very dominant with the highest importance value (78.3 or 26.1% of the small tree population). This value was significantly higher than the second highest importance value of 22.2 or exceeded 7.4%. This gap in numbers made the mengkuang very dominant, almost without a co-dominant. In some forest areas such as in RK_GC04, RK_GC06, RK_GC05 and RK_GC07, it was clear that mengkuang dominated the land and as a result played a big role in creating the forest structure and function.

Diversity of important species

The peat swamp forest in PT. GCN's concession harbors at least 93 wood species from 28 families. Out of the 28 families, the families with has the most species member are (see Figure 9): *Myrtaceae* (7), *Dipterocarpaceae* (6), *Lauraceae* (5), *Myristicaceae* (4), and *Sapotaceae* (4). The score of diversity index for forest in PT. GCN was 3.47, which illustrates a high level of diversity (see H' value categories in methodology section). Even so, the diversity in each transect varied depending on the dominance and evenness of each species as well as the number of species and stands in the area. Distribution of dominance, evenness, number of species and stands in each transect is shown in Table 4.

Table 4 Floristic diversity indices.

Indeks	RK_ BS01	RK_ GC01	RK_ GC02	RK_ GC03	RK_ GC04	RK_ GC05	RK_ GC06	RK_ GC07	RK_ GC08
Diversity H'	3,34*	3,18	3,05	3,18	2,16**	2,84	3,20	2,64	2,85
Species richness	40*	36	37	36	22**	34	35	35	29
Number of Stands	229*	261	177	183	117*	198	119	202	207
Dominant_D	0,04**	0,05	0,06	0,06	0,22*	0,10	0,06	0,17	0,08
Evenness_e	0,70*	0,67	0,57	0,67	0,39**	0,50	0,70	0,40	0,59

Note: '' show biggest data, '**' show smallest data*

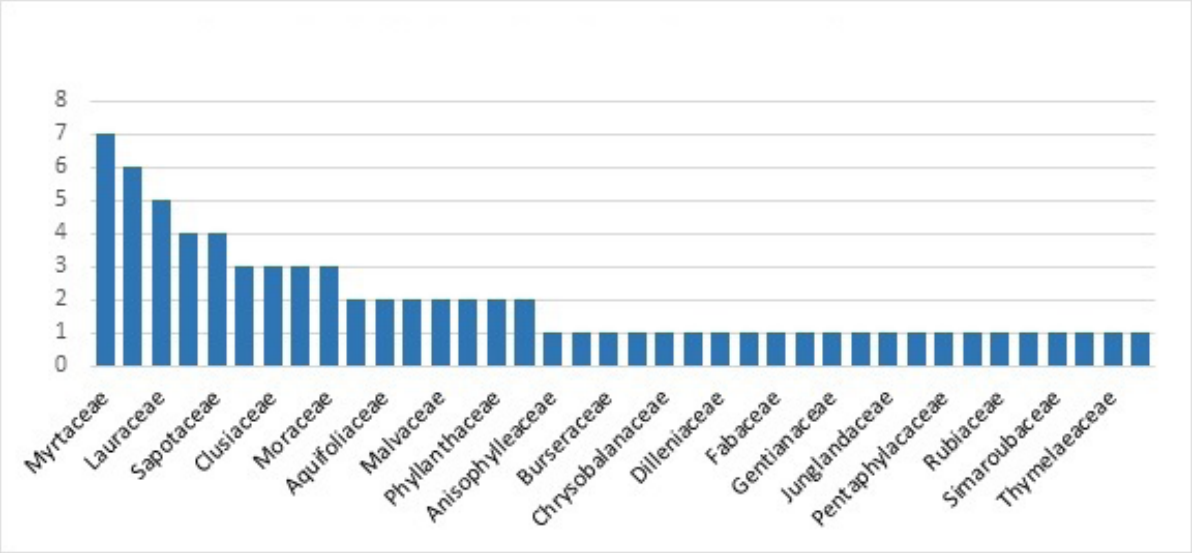

Figure 9 The size of each woody plant families in PT. GCN peat swamp forest.

The low species diversity in RK_GC04 area was caused by the high dominance of mengkuang in comparison to other areas. In addition, the area also had a low species count. According to local information and direct field observation, this area was affected by the 2014 fire making its land covered mostly with mengkuang, thus limiting room for other species to grow. In contrast, the area of transect RK_BS01 and RK_GC01 had the highest diversity. These neighboring transects had a similar forest condition. Both transects had a relatively even species abundance (high E) with a low dominance score. The even species abundance displayes coexistence between growing plants; they shared space in a relatively balanced composition. In other words, no single species dominated

c. PT. Sinar Mutiara Nusantara

The peat swamp forest of PT. Sinar Mutiara Nusantara (PT. SMN) concession is located in the heart of Kampar peninsula, bordering with PT. GCN concession in the east and PT. TBOT in the west. Vegetation and floristic diversity survey in this concession area was done using 11 systematically installed transects.

Vegetation structure

Based on the measurement of the horizontal structure (see table 5), the peat swamp forest in SMN concession area had an average tree density of 43 stands for A class (big tree) per hectare, 281 stands for B class (small tree) per hectare and 1,520 stands for C class (pole) per hectare. From the distribution of stands density per hectare in each transect, RK_SM01 had the most big tree stands, while the highest number of small tree was found in RK_SM04 and pole stands in RK_SM09. Average DBH of big tree in SMN peat swamp forest was around 38.9cm, small tree 19.3cm and pole 8,4cm with the widest diameter of 83cm. From its trunk diameter distribution in each transect, RK_SM04 had the largest average diameter for the big tree class as well as having the tree with the widest diameter. The transect with relatively small trunk diameter was RK_SM08 with an average of 36.5cm and maximum diameter of only 48cm.

Table 5 Density and dbh per tree class in each transect

Parameter	Class	RK_ SM01	RK_ SM02	RK_ SM03	RK_ SM04	RK_ SM05	RK_ SM06	RK_ SM07	RK_ SM08	RK_ SM09	RK_ SM10	RK_ SM11
Total number (∑)		211	144	209	224	196	194	162	139	190	184	201
number of stands(∑) and density (∑/Ha)	∑ A	**96***	48	70	75	49	37	29**	26**	49	62	58
	∑/Ha	**76,8**	38,4	56	60	39,2	29,6	23,2	20,8	39,2	49,6	46,4
	∑ B	61	42	55	**96***	55	77	49	42	37	55	50
	∑/Ha	305	210	275	**480***	275	385	245	210	185**	275	250
	∑ C	54**	54**	84	53**	92	80	84	71	**104***	67	93
	∑/Ha	1080	1080	1680	1060	1840	1600	1680	1420	**2080**	1340	1860
Maximum dbh	A	67,7	60,2	73,8	**83***	53	59,5	61,8	48**	67,5	59,1	58,5
	B	29,8	29,7	29,8	27,9	28	27,6	29	29,5	25,5	28,3	29,7
	C	14,8	23,8	18,1	14,5	14,8	14,8	14,2	14,2	14,9	14,5	14,9
Average dbh	A	38,4	39,9	38,4	**42,6***	37,2	39,6	37,4	36,5**	40,3	39,6	38,2
	B	20,3	19,1	20,1	18,3	19,8	19	18,6	19,3	18,5	19,4	19,7
	C	9	8,8	9,3	7,9	8,2	8,6	7,4	8,3	8,1	8,6	8,5

Noted: '' showed biggest data and '**' showed smallest data.*

From its vertical structure (see table 6), the peat forest in PT. SMN had a complete canopy layer (upper, middle and lower), and even had emerging tree stands. The average height of a big tree was 24.4m (middle canopy layer) with maximum tree height of 37.8m. The main covering canopy layer (closed canopy) of SMN peat forest was the lower canopy with a large contribution towards overall canopy of 64.3%, followed by middle canopy (25.6%) and upper canopy (9.8%). The lower canopy was mainly formed by the pole class with a contribution of (61.7%) followed by small trees (30.4%). The middle canopy was evenly composed of big trees (55.4%) and small trees (40.2%), while the majority of the upper canopy was made up of big trees (97.5%).

Table 6 Number of stands forming the canopy layer of SMN peat forest.

Parameter	Class	RK_ SM01	RK_ SM02	RK_ SM03	RK_ SM04	RK_ SM05	RK_ SM06	RK_ SM07	RK_ SM08	RK_ SM09	RK_ SM10	RK_ SM11	SMN (%)
Emergent	total	-	-	-	-	-	-	-	-	1	1	1	**0,15%**
	A	-	-	-	-	-	-	-	-	1	1	1	**3**
	B	-	-	-	-	-	-	-	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-	-
Upper canopy	total	47	15	2	6	14	4	3	2	28	45	37	**9,8%**
	A	43	15	2	6	14	4	3	2	27	45	37	97,5%
	B	4	-	-	-	-	-	-	-	1	-	-	2,5%
	C	-	-	-	-	-	-	-	-	-	-	-	-
Middle canopy	total	92	66	41	38	59	33	23	22	42	58	53	**25,6%**
	A	52	30	35	35	29	25	19	13	21	15	20	55,8%
	B	37	32	6	3	29	8	4	9	20	38	26	40,2%
	C	3	4	-	-	1	-	-	-	1	5	7	4%
Lower canopy	total	72	63	166	180	123	157	136	115	119	80	110	**64,3%**
	A	1	3	33	34	6	8	7	11	-	1	-	7,9%
	B	20	10	49	93	26	69	45	33	16	17	24	30,4%
	C	51	50	84	53	91	80	84	71	103	62	86	61,7%

Since the forest was mainly covered by the lower canopy, this means that the peat forest of SMN concession had relatively short trees. This structure tend to be even in every transect (see figure 10) with the exception of RK_SM01 and RK_SM02 where the cover was evenly shared by the lower as well as the middle canopy

layers. This lower canopy forest cover could be distinctly seen in transects RK_SM03, RK_SM04, RK_SM06, RK_SM07 and RK_SM08 where more than 75% of the canopy was composed of the lower canopy.

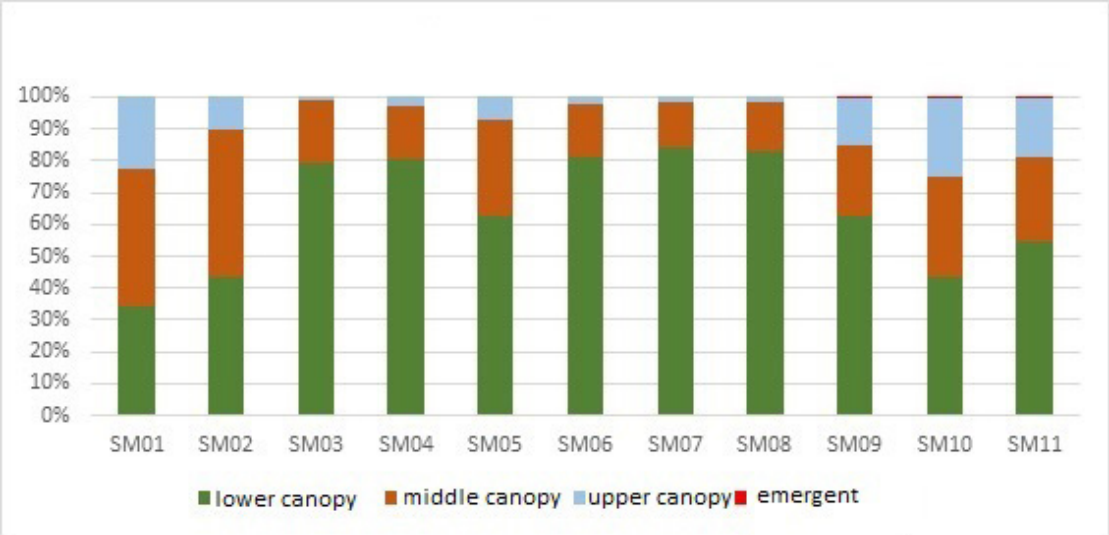

Figure 10 Proportion of each canopy layer.

Based on its horizontal and vertical structures, SMN peat forest is generally classified as Low Pole Forest (LPF) according to the classification of Anderson (1964) and Page *et al*. (1999). LPF is characterized by having trees with relatively small diameter and low average of canopy height. The LPF is clearly visible in transects with lower canopy layer of more than 75%. It is usually located in inner peat area or peat dome area. In addition to LPF, SMN peat forest also contains mixed peat swamp forest (MPF) characterized by the high dominance of large trees, canopy covering made up of the middle and upper canopy, and tree height that can reach up to 35 m (Page *et al*., 1999). Based on those characteristics, MPF in this study was found in transect RK_SM01, RK_SM02 and RK_SM10. Discussions on the ecosystem type zones are presented in this document in the zonation of ecosystem type section.12.

Tree Community

Tree community in the peat forest of SMN concession was generally dominated by meranti bunga *(Shorea teysmanniana)*, terentang manuk *(Campnosperma coriaceum)* and mengkuang *(Pandanus* sp.'mengkuang'*)*. This dominance was determined by Important Value Index (IVI) of those plant species. Dominance of each species in each class in SMN peat forest could thoroughly be seen in appendix 2. Overall, plant species dominating the concession forests based on the IVI in each class were as followed:

Large tree (class A) – *Shorea teysmanniana* (78,5),*Campnosperma coriaceum* (41,1), *Shorea uliginosa* (36,5), *Tetramerista glabra* (35,8), *Calophyllum ferrugineum* (27,6)

Small tree (class B) – *Pandanus* sp.'mengkuang' (60.4), *Campnosperma coriaceum* (31.02), *Austrobuxus nitidus* (28), *Mangifera parvifolia* (20.7), *Blumeodendron kurzii* (20.4)

Pole (class C) – *Ilex cymosa* (48.2), *Syzygium chloranthum* (18.9), *Tetractomia tetrandra* (18.28), *Ilex hypoglauca* (16.86), *Campnosperma coriaceum* (16.63), *Stemonurus secundiflorus* (15.51), *Mangifera parvifolia* (14.89), *Austrobuxus nitidus* (13.21)

Based on IVI species, the vegetation type of SMN peat forest could be determined as meranti bunga-terentang forest because of the high dominance of these two species. The dominance of meranti bunga, which was a Dipterocarp species, indicates that SMN forest is an old forest on the late succession stage (Anderson, 1964; Ashton *et al*., 2001). In the small tree class, however, mengkuang seemed to dominate the land with IVI score of 60.42, which was twice as high as the second greatest IVI. The abundance of mengkuang in SMN forest area gives a contradictive image of the forest. According on the upper canopy,

the forest seemed to be in good condition since it is dominated by meranti bunga and terentang. However, the lower canopy which has excessive number of mengkuang indicated poor forest condition. This kind of forest was found in transect RK_SM04, RK_SM06, and RK_SM07. Mengkuang was also found as the dominant canopy cover in these transects.

In the pole class, dominance of Ilex cymosa was significant, with IIV value of almost three times higher than the second greatest IIV (Kelat Jambu). The difference of IVI among other species was likely to be small or almost similar, which indicates that the dominance by other species tends to be even. The plant species in this pole class were mostly the species that will become large tree class in the future. The IVI of Terentang Manuk (*Campnosperma coriacea*) for each class tend to be high. This tendency indicates that terentang has high survival rate. It was dominant in the tree classes (large tree and small tree) along with meranti bunga and mengkuang. It was also abundant in the pole class. With this condition, the abundance of this species in the future is secured.

Floristic diversity

Based on the floristic survey result, there were at least 34 non-woody plant families composing the SMN peat forest (figure 11). Among them, six families had the highest number of species, i.e. Myrtaceae (7), Lauraceae (4), Myristicaceae (4), Sapotaceae (4), Dipterocarpaceae (4) dan Clusiaceae (3). Six species among the Myrtaceae were *Syzygium* spp or the Guava group which produce edible fruits attractive to seed dispersing animals such as birds and monkeys. These features could be the reasons why *Syzygium* could grow massively together in this peat forest and led Myrtaceae to become the largest woody plant family. However, the highest abundance was still held by Dipterocarpaceae family, represented by meranti bunga and meranti sarang punai. Both of them were the main components of this SMN peat forest (see IVI in appendix 3)

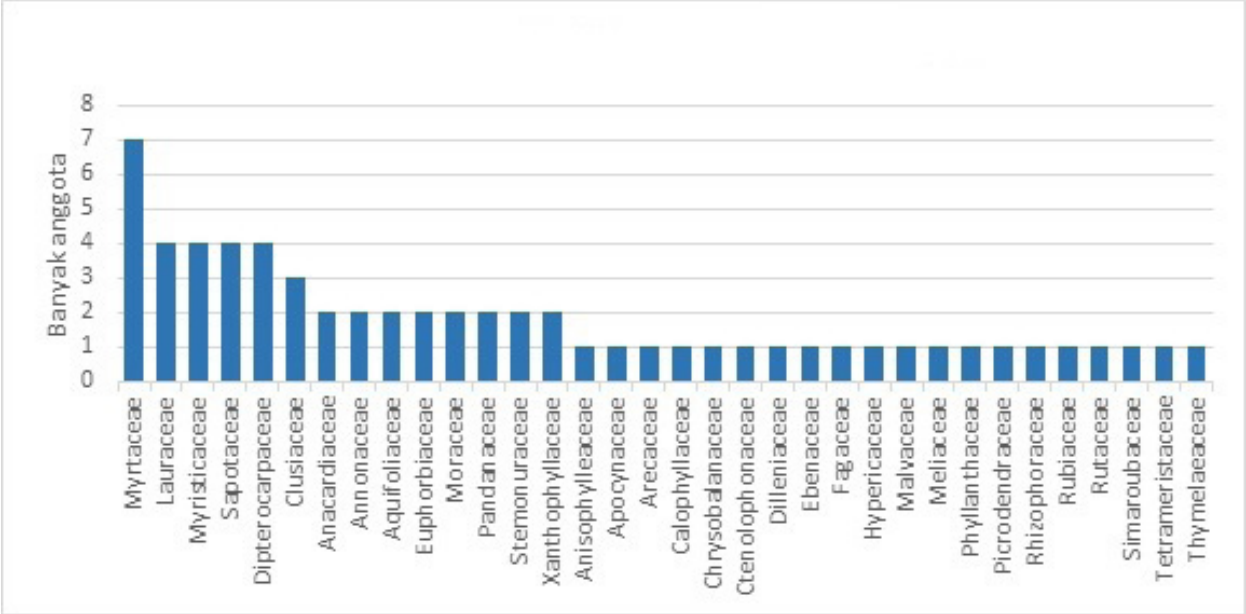

Figure 11. Species richness chart per tree family in SMN peat forest

Woody plant diversity of SMN peat forest was generally categorized as medium to high (see category of H' value in methodology section). Diversity index value of this forest ranged from 2.4 to 3.07 with the distribution in each transect as seen in table 7. The forest area in RK_SM02, RK_SM03, RK_SM09, and RK_SM10 showed the highest diversity with the value of H' > 3. In these transects, the dominance index was low, which means that there is no strong dominance of any of the species as a result of even abundance. This could also be seen from the relatively higher evenness index scores

Table 7 Woody plant diversity indices for SMN forest.

Indeks	RK_ SM01	RK_ SM02	RK_ SM03	RK_ SM04	RK_ SM05	RK_ SM06	RK_ SM07	RK_ SM08	RK_ SM09	RK_ SM10	RK_ SM11
Diversity (H')	2,89	**3,02***	**3,02***	2,64	2,71	2,48**	2,42**	2,42**	**3,07**	**3,05**	2,95
Species Richness	30	29	33	33	25	22	21	19	35	33	30
Dominansi (D)	0,09	0,06	0,06	**0,15***	0,09	0,11	**0,13***	0,12	0,06	0,06	0,06
Kemerataan (e)	0,56	**0,71***	0,62	0,43	0,60	0,54	0,53	0,59	0,62	0,64	0,64

Noted: '' showed biggest data and '**' showed smallest data; .*

A different situation was shown in transect RK_SM06, RK_SM07, and RK_SM08 which had the lowest diversity compared to other transects. However, ther diversity scores were categorized as 'medium'. It was also obvious that this low diversity value was caused by the dominance of certain species (dominance index value was relatively higher than that of the other transects) as well as the low number of species (19 – 22 species). In these areas, lower diversity values do not mean poor forest quality. Meranti Bunga and Terentang which are old forest species had high dominance in these areas. Ashton *et al*. (2001) described the main member of vegetation in a climax stage forest are species from old forest group, generally Dipterocarpa.

In contrast, SM04 area also has low diversity. This forest area had the highest dominance score compared to other transects. The observation revealed that forest SM04 was more dominated by mengkuang with IVI of 176.8 or 58.9% compared to meranti bunga (IVI of 78.9%). With such high percentage, Mengkuang was covering the forest land. This condition implies that this forest was subjected to fairly severe degradation as the presence of Mengkuang indicates that a forest has been degraded (Wibisono *et al*., 2005).

From the woody species found, seven of them are listed as threatened species based on the status of IUCN, CITES, and the Indonesian Government (see table 13). Among them, meranti bakau and resak paya are considered to be the most threatened species as their status are 'Critically Endangered' (CR) and have limited suitable habitat. Meranti Bakau was found specifically in the peat forest close to the peat river, whereas resak paya has limited distribution; could only be found in the peat forest of Sumatra. This condition makes them even more vulnerable to extinction if disturbances to their habitats are allowed to continue.

d. PT. The Best One Unitimber

Peat forest area in PT. the best one of unitimber (TBOT) concession is located in the center of Kampar peninsula, adjacent to the peat forest of PT. SMN concession at the East and the peat forest of PT. GAN at the East and North. Survey for vegetation and floristic studies had been conducted in this area on 12 transects that were distributed systematically in all concession areas.

Vegetation structure

Vegetation structure of TBOT peat forest could be determined from its horizontal structure based on the number of individuals, density, and average stand diameter (dbh) on each vegetation strata i.e. class A (large tree), class B (small trees), and class C (pole). The composition of these three vegetation classes was almost even. The density of large tree was 52.7 (~53) trees per hectare, whereas small tree class was 285.4 (~285) trees and pole class was 1042 trees per hectare.

Trunk diameter (dbh) of large tree was 42.4 cm in average (see table 8). This normal average range tends to be small if compared to the maximum possible size of the wood growing in peat forest. From the data obtained, the dbh of large trees in RK_TB10 and RK_TB11 was relatively higher than the normal average, whereas RK_TB05 and RK_TB06 contained large trees which were relatively small in diameter (average dbh was lower than the normal average). Maximum tree diameter in RK_TB10 and RK_TB11 was likely to

be as big as 88.8 cm, whereas trees in RK_TB05 and RK_TB06 could only reach 60.64 cm. The largest tree diameter in TBOT peat forest of 92.3 cm was found in RK_TB08

Table 8 Density and trunk diameter of stands per transect

	RK_ TB01	RK_ TB02	RK_ TB03	RK_ TB04	RK_ TB05	RK_ TB06	RK_ TB07	RK_ TB08	RK_ TB09	RK_ TB10	RK_ TB11	RK_ TB12	TBOT
Stands (number of stands on each transect)													
A	69	**90***	**89***	61	41**	67	58	61	66	69	58	**52**	**781**
B	41	57	60	45	**85***	61	57	39	73	58	49	60	**685**
C	60	60	57	64	37**	43	51	57	51	44	67*	34	**625**
Density (number of stands per hectare)													
A	55,2	**72***	**71,2***	48,8	32,8**	53,6	46,4	48,8	52,8	55,2	46,4	41,6	**52,7**
B	205	285	300	225	**425***	305	285	195	365	290	245	300	**285,4**
C	1200	1200	1140	1280	740**	860	1020	1140	1020	880	1340	680	**1042**
Mean of DBH - cm													
A	42,5	42,7	41,4	41,3	39,2	43,5	38**	42,9	39,9	**45,7***	**45,6***	44,9	**42,4**
B	20,4	19,6	20,5	20	19,53	19,5	19,7	20,6	19,6	20,5	20,7	19,5	**19,9**
C	8,1	7,6	7,9	8,9	9,77	8,9	8,9	8,4	9	9,1	8,4	8,1	**8,5**
DBH maximum (highest DBH of class on each transect) - cm													
A	80	90	84	61	64.5	79,1	60**	**92,3***	71,4	88,9	87,5	72,1	**92,3**
B	28	30	29	29	29,9	28	29	28,3	29,2	29,8	29,5	28,9	**30**
C	14,2	14	14	14,5	14,9	14,5	14	14	14,9	14,8	14,5	13,9	**26**

Noted: '' showed biggest data and '**' showed smallest data.*

In addition to horizontal structure, vegetation structure can also be determined from the vertical structure i.e. stand height composition that makes up the forest canopy. Data on stand height of all three tree classes had been measured and categorized into 3 canopy layers i.e. lower canopy, middle canopy, and upper canopy. Tree with a height higher than the upper canopy is classified as emergent tree because this kind of tree does not form any layer as other canopies do. According to the data (see table 9), approximately 0.14% of TBOT peat forest stands were emergent upon 15ha measure area. The percentage of upper, middle, and lower canopy layers were 16.8%, 45.4% and 37.9% respectively. Therefore, the middle canopy dominated the canopy cover. This dominance was followed closely by the lower canopy. The main components of this middle canopy were species from the small trees wih a contribution of 52.7%, and it was complemented by 45.8% of the large trees. The pole only contributed as much as 1.5% on the composition of this middle canopy.

The proportion of canopy layer in each transect was shown in figure 12. This figure showed that dominance of the middle canopy was not found in all transects. Out of 12 transects, 4 of them were dominated by lower canopy (RK_TB08, RK_TB10, RK_TB11, and RK_TB12). It is obvious that in transect RK_TB01, RK_TB04, and RK_TB09 the dominance of forest cover by the middle canopy tend to be even with the lower canopy. The dominance of both middle and lower canopies might be caused by opened upper canopy which make it easier for sun light to penetrate into the lower layer. Open upper canopy indicates less number of large trees (the main components of upper layer). Thus, it could be concluded that large trees in that area has been decreasing.

Table 9. Canopy layer per class in each transect

	RK_ TB01	RK_ TB02	RK_ TB03	RK_ TB04	RK_ TB05	RK_ TB06	RK_ TB07	RK_ TB08	RK_ TB09	RK_ TB10	RK_ TB11	RK_ TB12	TBOT
Emergent	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**-**	**0,14%**
A	-	-	-	-	-	-	-	-	-	3	-	-	3
Upper canopy	**45**	**41**	**15**	**22**	**6**	**26**	**9**	**42**	**31**	**54**	**21**	**35**	**16,6%**
A	43	40	15	22	6	26	9	41	28	53	21	32	96,8%
B	2	1	-	-	-	-	-	1	3	1	-	3	3,2%
Mid canopy	**65**	**98**	**120**	**79**	**104**	**88**	**96**	**45**	**87**	**51**	**68**	**48**	**45,4%**
A	26	50	72	39	35	41	49	19	34	13	37	20	45,8%
B	37	48	48	38	69	47	47	26	47	36	29	28	52,7%
C	2	-	-	2	-	-	-	-	6	2	2	-	1,5%
Lower canopy	**60**	**68**	**71**	**69**	**53**	**57**	**61**	**70**	**72**	**63**	**85**	**63**	**37,9%**
A	-	-	2	-	-	-	-	1	4	-	-	-	0.90%
B	2	8	12	7	16	14	10	12	23	21	20	29	22%
C	58	60	57	62	37	43	51	57	45	42	65	34	77,1%

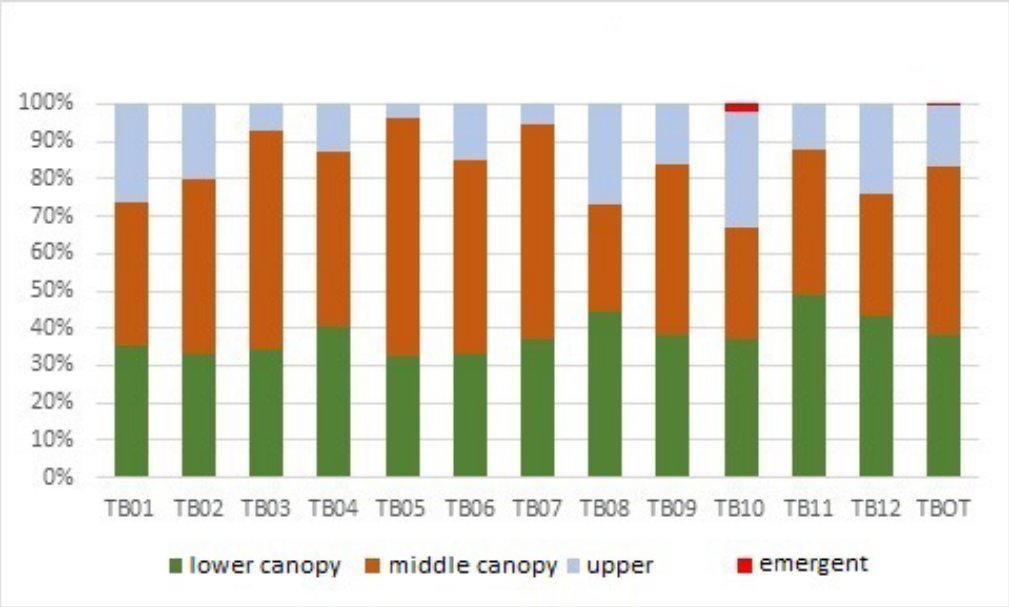

Figure 12. Layer proportion of each canopy layer per transect

Tree community

Tree community in peat forest of TBOT concession was determined from the IVI of each species which was present. Dominance of each species in each class in TBOT peat forest could thoroughly be viewed in appendix 4. Overall, based on the IVI scores, the dominating species in each class were as followed:

A – *Palaquium sumatranum* (38.51), *Tetramerista glabra* (30.03), *Shorea teysmanniana* (28.65), *Syzygium chloranthum* (23.82), *Gonystylus bancanus* (12.60)

B – *Pandanus* sp.'mengkuang' (39.22), *Mangifera parvifolia* (29.52), *Madhuca* sp.1 (26.07), *Syzygium chloranthum* (19.59), *Shorea teysmanniana* (18.65), *Madhuca motleyana* (16.52),

C – *Syzygium chloranthum* (20.78), *Madhuca motleyana* (19.37), *Stemonurus secundiflorus* (19.16), *Madhuca* sp.1 (19.05), *Timonius flavescens* (17.99), *Shorea teysmanniana* (15.97), *Diospyros siamang* (15.72), *Mangifera parvifolia* (14.21), *Ilex cymosa* (11.52)

Referring to the species dominance described above, the vegetation type of TBOT peat forest coud be determined as Suntai – Punak forest due to the high dominance of those species. In the small tree class, Mengkuang and Salakeo were codominant. The high abundance of Mengkuang in TBOT forest area indicates the presence of abandoned degraded area. This finding is supported by Wibisono et al. (2005) who stated that Mengkuang is an indicator of degraded forest condition. However, the result of this study showed that this condition did not apply to all transects. A transect which strongly described this condition was TB05 which tend to be an open forest. Mengkuang in this transect made up most of the forest canopy. Similarly, transect RK_TB06, RK_TB07, RK_TB10, and RK_TB12 were occupied by Mengkuang, but their abundance were less than that in RK_TB05.

For the pole class, the IVI scores of each species tend to be even. All five species with the highest IVI were codominant. Kelat Putih, berengku, and meranti bunga were codominant speies in the pole class as well as in the small tree class. Meranti bunga and kelat putih were even abundant in large tree class. This condition indicates that these species have high survival rate, thus assuring their abundance in the future.

Floristic diversity

From the results of this survey, there were at least 55 plant species from 31 families found in the observation transects. According to the data, the five most dominant families (see figure 13) were Sapotaceae, Myrtaceae, Dipterocarpaceae, Tetrameristaceae, and Lauraceae. Suntai (Sapotaceae) as the most dominant species in TBOT forest contributed to the high dominance of Sapotaceae as also meranti to Dipterocarpaceae and kelat putih to Myrtaceae. Even though Meranti had higher IVI than Kelat Putih, Myrtaceae became the second most dominant family in the forest because it has higher species number (7). In contrast, although Lauraceae (Medang group) had quite high number of species (4), its dominance was still weaker compared to punak (Tetramerista glabra – Tetrameristaceae). Thus, Tetrameristaceae was considered to be more superior to Lauraceae.

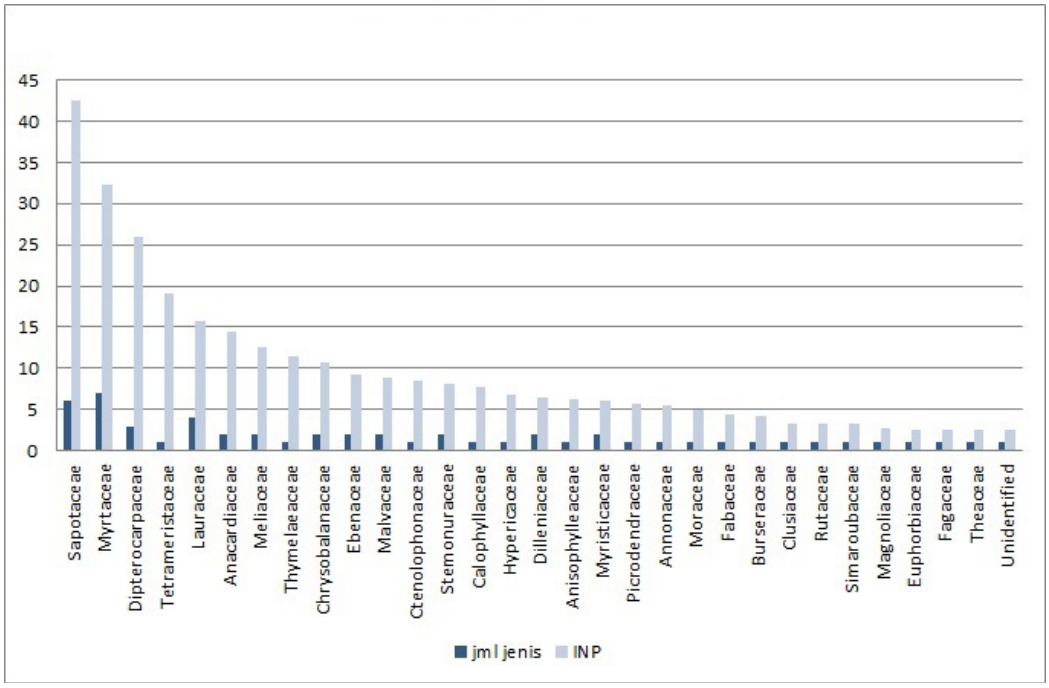

FIGURE 13 Size and abundance of each family of PT. TBOT peat forest

Floristic diversity of woody plants in TBOT peat forest was accounted to be high with the diversity index (H') of 3.66. Distribution of this diversity index in each transect is presented in table 11 below. Transects with the highest species diversity were transect RK_TB10, RK_TB08 and RK_TB06, whereas the one with the lowest species diversity were RK_TB12 and RK_TB05. Low diversity in RK_TB12 dan RK_TB05 was due to the occurance of a greater dominance in other transects. In addition, the number of species composing the forest in these transects was less than that of other transects. Major dominance by a certain species

causes limited growing space for other species. There was a high dominance of one species in RK_TB05 i.e. Mengkuang. In RK_TB12, major dominance was found not only for mengkuang in small tree class, but also for Suntai and Punak in large tree class

TABLE 10 Floristic diversity indices of TBOT peat forest.

Indeks	RK_ TB01	RK_ TB02	RK_ TB03	RK_ TB04	RK_ TB05	RK_ TB06	RK_ TB07	RK_ TB08	RK_ TB09	RK_ TB10	RK_ TB11	RK_ TB12
Diversity	3,17	3,08	3,15	3,01	2,81	3,33	3,19	3,35*	3,00	3,29	2,95	2,65**
Species Richness	41	35	35	31	30	38	35	43*	31	42	35	24**
Stands	170	207*	206*	170	163	171	166	157	190	171	174	146**
Dominancy (D)	0,07	0,06	0,06	0,07	0,10	0,04	0,05	0,05	0,06	0,05	0,09	0,10
Evenness (e)	0,58	0,62	0,67	0,65	0,55	0,73	0,70	0,66	0,65	0,64	0,55	0,59

Noted: '' showed biggest data and '**' showed smallest data.*

From the woody species found, seven of them were categorized as threatened species based on the status of IUCN, CITES, and the Indonesian Government (see Table 13). Among of them, meranti bakau and resak paya are considered to be the most threatened species as their status are 'critically endangered' (CR) and have limited suitable habitat. Meranti bakau was found specifically in the peat forest close to the peat river, whereas resak paya had limited distribution; could only be found in the peat forest of Sumatra. This condition makes them even more vulnerable to extinction if disturbances to their habitats are allowed to continue.

In addition to the two species above, Ramin is also considered to be a highly threatened species. Because it has vulnerable status (VU) and illegal trading of this species is flaring, it has been included in the appendix II of the IUCN lists. Besides, the Indonesian Government has listed it into a group of species protected by Law (PP RI No. 7 year 1999). As it is harder to find this species in the wild, the preservation of Ramin needs to receive more attention. Other species, along with meranti Bakau, Resak Paya and Ramin, are ascociated specifically with peat ecosystem. It means that these species cannot grow in an ecosystem other than peat. With less peat forest ecosystem, these species are more at risk to extinction.

e. Threats

From the total of 112 species present in Riau Ecosystem Restoration (RER) area, some of them are either locally or globally threatened species as a result of human activities including illegal logging and land conversion into plantation and agriculture land (complete lists of vegetations are presented in table 13 in discussion section). The presence of those species makes the area of Semenanjung Kampar RER peat forest vital for conservation. Besides, most of the species in this forest are also unique species of the peat forest, which means that these species could only be found in peat ecosystem. These species include: *Shorea uliginosa*, *Shorea teysmanniana*, *Shorea platycarpa*, *Horsfieldia crassifolia*, *Combretocarpus rotudatus*, and *Vatica teysmanniana*. Some non-woody plants (*Cyrtostachys renda*, *Eleiodoxa conferta*, *Nepenthes rafflessiana* and *Nepenthes ampullaria*) are peat specialist plants as well.

3.2 Discussions: Vegetation structure and floristic community of RER peat forest

a. Structure and Floristic Composition

The dbh of 5.828 stands from 112 woody plant species had been measured. The result divided them into three classes i.e. class A (large tree, dbh >30cm), class B (small tree, dbh 15 – 30cm), and class C (pole, dbh 5 – 15cm). The average dbh of each class was 40.1 ±10.3cm for large trees, 19.6 ±3.7cm for saplings, and 8.6 ±3.1cm for poles. The density of stands per hectare in each class in RER peat forest is shown in table 11, along with the comparison between their densities with other peat ecosystems. From this table, it is clear that stand density in RER peat forest was still in the normal range.

Table 11 Comparison of stand density and the number of species between the areas of peat forest.

Location	Density (∑/Ha)	Species Richness	Unit*	Refrences
RER, Kampar, Riau	50,9 (dbh≥30cm) 317 (dbh 15 - 30cm) 1174 (dbh 5 - 15cm)	112	39,75 Ha	This study
SM Kerumutan	6932 (dbh ≥1cm)	31-59/plot	0,28 Ha	(Kuniyasu & Tetsuya, 2002)
Giam siak kecil, Riau	578 (dbh>10cm)	64	1 Ha	Partomihardjo et al. (2011) dalam (Rosalina et al., 2013)
Giam Siak kecil - Bukit Batu, Riau	662 - 2,492 (dbh≥3cm)	135	3 Ha	(Gunawan et al., 2012)
Merang Kepayang, Jambi	232 - 600(dbh≥10cm)	>100	11,25 Ha	(Solichin et al., 2010)
Sebangau, Kalteng	2689 (dbh≥15cm)	133	2 Ha	(Mirmanto, 2010)
Selat Panjang, Riau	550 (dbh≥10cm)	50	1 Ha	(Rosalina et al., 2013)
Sanggau, Kalbar	513 (dbh≥10cm)	60	1 Ha	Sambas (1994) after (Rosalina et al., 2013)

**Unit area = total area of measurement unit timber (eg there are 25 spacious units of measurement (plot) , respectively - each plot measuring 20 x 20 m , the width measuring area is (20 x 20) x 25 = 2.000m2 = 2HA)*

Based on the structure of the canopy layers, RER peat forest still own complete canopy strata i.e. upper canopy, middle canopy, lower canopy as well as understorey layer which covers the forest floor. Most of the canopy cover was the lower canopy, followed by the middle canopy (44.9% and 39.8% from the total stands respectively), wheras the upper canopy made up only 15,2% from the total stands. However, if the proportion of plant height per 5 m was taken into account (figure 15), it would be obvious that the abundant species were trees with the height of 10 – 15m and 15-20m. These height classes are a mixed between the middle and upper canopy layer class. It show that the forest cover layer was a mixture of middle and lower canopy or with ranged of 10 – 20m (46,35%).

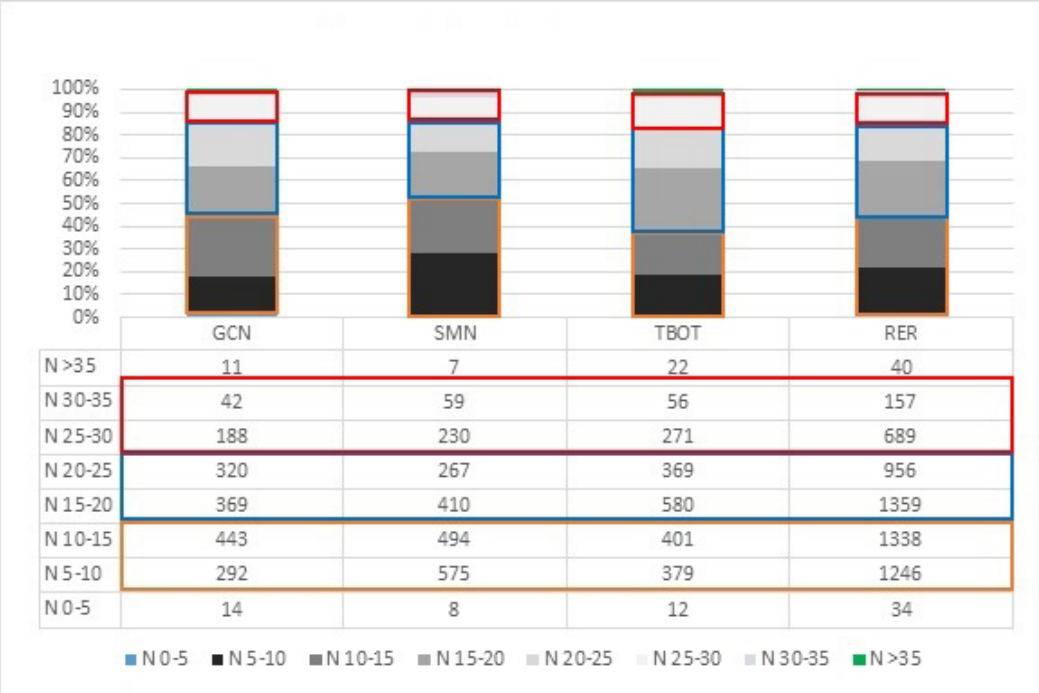

Figure 14 The proportion and number of stands per height range of 5m.

The family compositions of the forest tend to vary as seen in appendix 1. The most abundant families were Myrtaceae and Dipterocarpaceae, followed by Sapotaceae, Anacardiaceae, and Pandanaceae. Myrtaceae was abundant due to the number of species members (9 *Syzygium* and 1 *Tristaniopsis*) and the high abundance of several of their members such as kelat putih and kelat jambu. Dipterocarpaceae was represented by 5 species (3 *Shorea*, 2 *Vatica*), but the high abundance of two *Shorea* species (*S. teysmanniana* and *S.uliginosa*) determine the dominancy of this family. Similar for Sapotaceae, it was represented by a fairly high number of species (7 species~ 3 *Palaquium*, 2 *Madhuca*, 2 *Pouteria*). In addition, Suntai in several locations was the main component of the forest as well as Berengku was dominant in the small tree class causing Sapotaceae to become dominant as well. Anacardiaceae and Pandanaceae comprised of 2 species members each (1 *Campnosperma* and 1 *Mangifera*; 2 *Pandanus*). High abundance of Terentang and Mengkuang caused this family to become dominant.

The condition above was in accordance with the IVI results of each species which showed that the 15 most abundant species in RER forest mostly came from dominant family groups, i.e.: *Shorea teysmanniana* (27.84), *Pandanus* sp.'mengkuang' (19.54), *Campnosperma coriaceum* (15.57), *Shora uliginosa* (15.51), *Tetramerista glabra* (14.43), *Palaquium sumatranum* (13.91), *Mangifera parvifolia* (13.55), *Syzygium chloranthum* (12.69), *Calophyllum ferrugineum* (9.25), *Stemonurus secundiflorus* (9.02), *Ilex cymosa* (8.82), *Austrobuxus nitidus* (8.02), *Blumeodendrin kurzii* (7.73), *Parastemon urophyllus* (7.73), and *Madhuca motleyana* (7.04).

Based on the description above, the species construct the upper canopy was dominated by Meranti group (*Shorea* spp. – Dipterocarpaceae), Suntai (*Palaquium* – Sapotaceae), Terentang (*Campnosperma* – Anacardiaceae), Bintangur (*Calophyllum* – Calophyllaceae) and some Kelat species (*Syzygium* spp. – Myrtaceae). The middle and lower canopies, however, were dominated by Mengkuang (Pandanaceae), followed by forest species such as Berengku and Nyato (*Madhuca* and *Palaquium* – Sapotaceae), Salakeo and Terentang (*Mangifera* and *Campnosperma* – Anacardiaceae), Kelat Species (*Syzygium* spp. – Myrtaceae), *Ilex* spp. (Aqufoliaceae), *Blumeodendron* (Euphorbiaceae) and *Austrobuxus* (Picrodendraceae).

b. Classification of RER Peat Forest

The structure and canopy component mentioned above shows that RER peat forest was at the late secondary succession stage. This stage is characterized by upper canopy that is dominated by late successional species such as Dipterocarpaceae, Sapotaceae, Myrtaceae, and Anacardiaceae (Anderson, 1964; Ashton et al., 2001). This stratum is basically similar to primary forest, but the abundance of Mengkuang indicates that disturbance has occurred in the past (areal opening present) which fairly affects the vegetation structure. This condition, however, was not found in all transects.

Various studies have been conducted by many peat forest researchers to classify peat forest ecosystem including *Six Phasic Community* Anderson, Page classification, and Furukawa zonation (Anderson, 1963; Page et al., 1999; Kuniyasu & Tetsuya, 2002). This classification was based on the composition and structure of forest vegetation systematically from along the river towards the peat dome. To find out the zonation of RER peat forest ecosystem, forest area group has to be analyzed based on the structure and composition of its vegetation.

Based on the main plant species composition of the forest community, RER forest ecosystem could be classified as seen in figure 15. This figure shows the ordination of transect grouping based on its main composition using *Principal Component Analysis* (PCA). This analysis was used to collect transect population based on the species abundance that make up its vegetation. To reduce variations without reducing the representation of population, the most dominant species in RER peat forest were used.

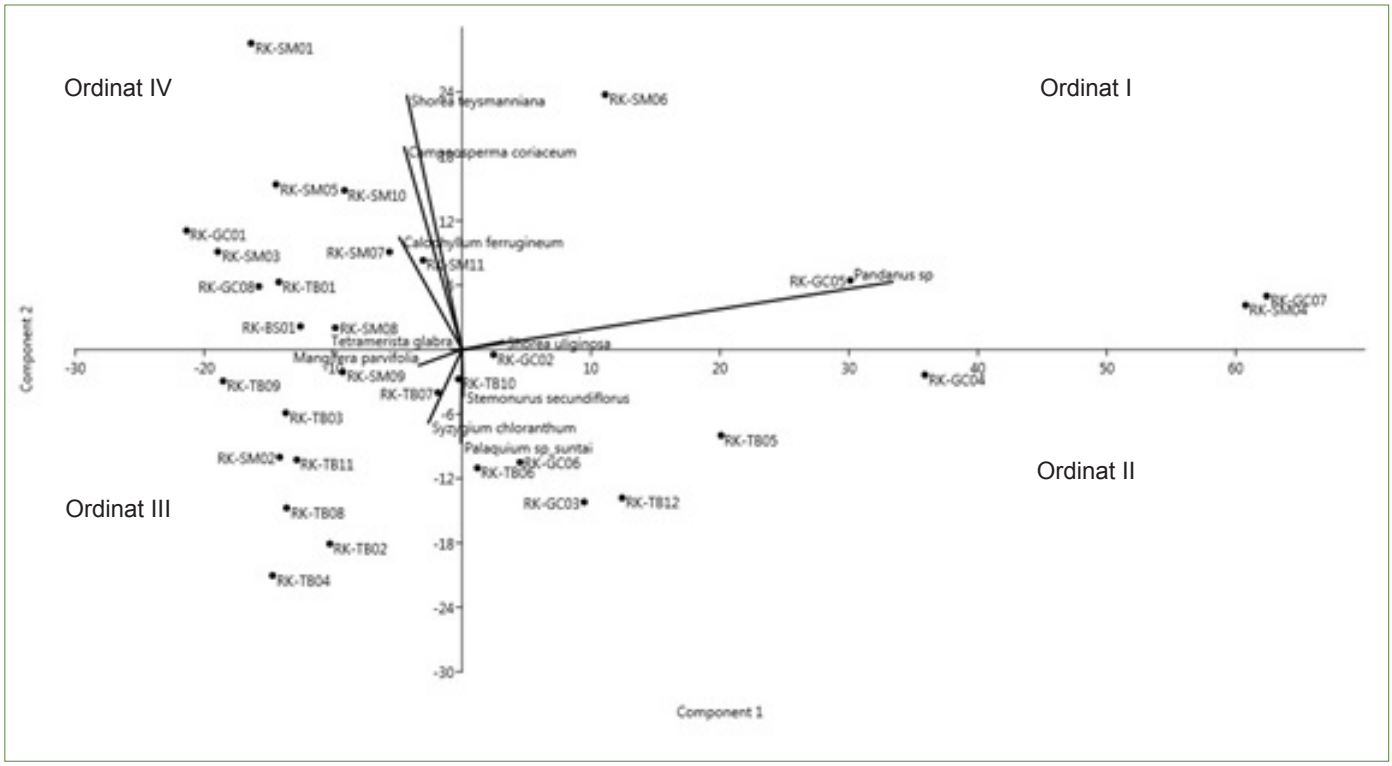

Figure15 Transect ordination based on the most abundant species

The PCA classifies transects based on the abundance of Mengkuang (*Pandanus* sp.; eigenvalue 0.96 in *component* 1) and Meranti Bunga - Terentang (*Shorea teysmanniana* eigenvalue 0.68 and *Campnosperma coriaceum* eigenvalue 0.54, in component 2). Component 1 and 2 were accounted as much as 46.7% and 19.1% from the total variance. It means that both components could represent the whole population. From this ordination, transects were divided into 4 ordinates based on their composition, i.e.:

- Ordinate I, *Mengkuang field*: transects with Mengkuang as the main composition including RK_GC05, RK_GC04, RK_GC07, RK_SM04 and RK_SM06. Along with Mengkuang, natural species composition included Meranti Sarang Punai (*Shorea uliginosa*), Suntai (*Palaquium sumatranum*) and *Stemonurus* spp are also common.

- Ordinate II, *Suntai-Sembasah mixed forest*: a mixed forest with Suntai as the main components in large tree class and Sembasah (*Stemonurus secundiflorus*) in lower stratum. This included transect RK_GC06, RK_GC03, RK_TB06 and RK_TB10,

- Ordinate III, *mixed-species forest*: several species such as Suntai, Meranti, Salakeo, and Kelat Putih were abundant in this area. Large tree dominance represented by Suntai and Kelat Putih was stronger than that of Meranti Bunga. Mengkuang in this forest transect was scarce, thus it was considered as a pristine forest.

- Ordinate IV, *Meranti-Terentang field*: both species strongly affected the formation of forest vegetation along with other species such as Bintangur and Punak. Mengkuang was still abundant in this group, but it did not give much effect on the forest structure (competition of old forest species was high).

The grouping mentioned above is only based on the forest species composition, so that the structure is not described. Grouping which includes structure can be performed using similarity index among transects to find the similarity among them. Transects which were similar in structure and composition would make a group. Structure components used for grouping include the number of stands in each tree class, average of dbh and canopy layers, whereas composition component used was the 15 most abundant species (the 15-highest IVI). The result of grouping was presented in figure 16 in the form of similarity tree using Bray-

Curtis index. According to the tree, it is obvious that the similarity in each transect tend to be high (> 0.5). However, it is found in general that transects were divided into three unique vegetation groups (SI >0,65).

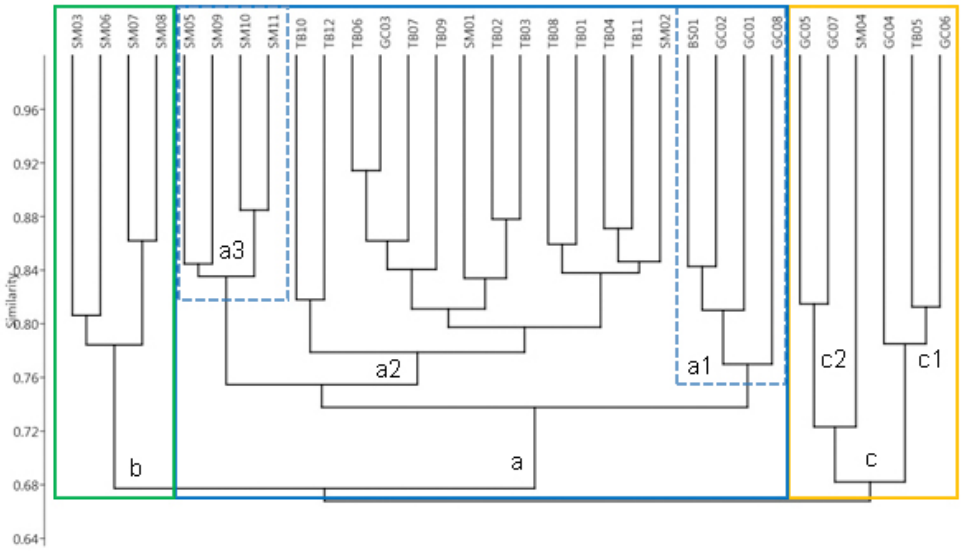

Figure 16 Dendogram of transect grouping based on community structure similarity

The grouping was then compared to the classification of peat ecosystem (Anderson, 1963 and Page et al, 1999) in RER forest. The result was described as follow:

a. *Mixed Peat Forest* (MPF): shown by vegetation group of *a*, characterized by: abundant large tree and sapling speciest, middle canopy layer (15 – 25m) as the forest cover, a relatively dense upper canopy cover and relatively sparse lower canopy (5 – 15m). Trees with the class B and A diameter were easily found (the average>±10 stands). It is mainly composed of species from ordinate III and IV, with twin Meranti (*Shorea teysmanniana* and *Shorea uliginosa*) as the main components. Other species with similar proportion included Suntai, Bintangur, Punak, Salakeo and mengkuang, was sometimes present. The species compostion of the lower canopy were not only from both pole and large tree classes but also from the small tree class including *Ilex hypoglauca, Ilex cymosa, Diospyros siamang, Stemonurus secundiflorus,* and *Horsfieldia crassifolia*. This MPF was divided into three sub-categories based on structure, the number of stands, and height of large tree, i.e.:

- *a1*--> MPF with high abundance of big trees, but 'medium' diameter (average dbh ~ 35 – 42cm), ordinate composition IV of Meranti field, followed by Terentang and Bintangurr.
- *a2* --> MPF with big trees abundance roughly similar to that of small trees, diameter of large trees tend to be bigger (average ~ 40 – 45cm), ordinate composition II and III of suntai field followed by Meranti, Kelat Putih, Punak and Terentang. High Mengkuang abundance was still found in transects of ordinate II.
- *a3*--> transition forest: big trees were rare, pole and small trees were abundant, and the structure of forest height tend to be short. This forest was the transition from MPF to LPF, so that its structure was similar to MPF but with shorter canopy and rarer big and tall trees. In addition, small trees and poles were starting to flourish and make up the forest cover canopy. Species was mainly composed of plants from ordinate IV (but also from ordinate III), including Meranti and Terentang field as well as Bintangur, Salakeo, Kelat Putih, *Stemonurus, Ilex,* and *Austrobuxus*.

b. *Low pole forest* (LPF): charactereized by abundant pole composition and low abundance of large trees making the main canopy to be made up of the lower canopy (~ 10 – 20m). Most of the trees found were relatively short. This category was found in group *c* according to the dendrogram above.

The composition was similar to the transition forest previously mentioned which was in ordinate IV including Meranti-Terentang field, and also small tree species such as Kelat Putih, *Stemonurus, Ilex*, and *Austrobuxus*. Plants in transect RK_SM06 mostly belonged in ordinate I due to the high abundance of Mengkuang though Meranti-Terentang field from the remaining natural forest were still a part of the composition

c. *Mengkuang field*: The main characteristics of this vegetation were the very high abundance of Mengkuang resulting from the absence/low presence of large trees as the main canopy. The absence of large tree caused opening of forest canopy, so the land was occupied massively by Mengkuang which is one of pioneer species. This condition was supported by various research showing that Mengkuang is a pioneer species which respond to opened forest very immediately by rapid and invasive growth (Wibisono et al., 2005; Gunawan *et al*., 2012; Erik T, 2013). According to the dendrogram above, this type of forest is displayed in group *c* with ordinate 1 as the main composition. Group *c1* and *c2* were separated by differences in the structure of the remaining natural forest. Those differences wera as followed,

- *c1*, *Logged - over forest* or degraded forest. The abundance of large and small trees remains 'low', so the forest are opened and thus filled with Mengkuang. The absence of large trees are caused more by logging extraction than natural process. The forest tend to highly degraded by massively large trees extraction, particularly in RK_GC06 and RK_TB05. In RK_GC04, though the large trees are rare but the dbh of remaining large trees are high (mean dbh = 48,7cm). This area are located next to the wide after burnt 2014 area, and have a high possibility to had impacted where trees are also burnt or fall due to burned substrate. For this certain area, The fire are suggested as the main cause of this tree loss than logging extraction.
- *c2*, big trees and small trees abundance remain high with relatively big dbh. Mengkuang are abundant as a result of logging activity. In addition, the location of RK_GC05 and RK_GC07 which are near the river contributed significantly to the high abundance of this plant (Mengkuang is naturally distributed along river banks). In addition to Mengkuang, Meranti field still could be found along with Terentang, Suntai, Punak and Ramin within these two transects. They were also indicated as riparian forest (see part *d* below). Transect RK_SM04 is quite interesting as this area have less big trees, a fair abundance of small trees and are mostly dominated by pole. This transect is located within the transition forest area from MPF to LPF, so that the structure of the remaining forest was similar to this area i.e. forests occupied by pole and lower canopy species.

d. In addition to the three forest zones above, there is also a *river forest ecosystem*. This type of forest is located on riverbanks (of rivers with a width of 3 - 20m), spreading out from the river edge to as far as where river tide extends. An example of this type of forest can be seen along Sangar River, Serkap River, as well as Turip River, expanding as far as approximately 500m into the forest. The main characteristic of this forest is its submerged substrate -both periodically and permanently- as well as having the lower canopy as its dominant canopy with a few spots dominated by the middle canopy. The main vegetation in this forest include *Syzygium glaucum, Syzygium antisepticum, Shorea platycarpa, Campnosperma coriaceum, Parastemon urophyllus, Pandanus* sp.'mengkuang' and *Pandanus helicopus. Pandanus* spp. is often spotted as dominant cover at multiple spots of the riverbank. Description of this forest in the classification (Page et al. 1999) is labeled as *riverine forest and transition riverine to MPF*.

Based on the classification above, it is apparent that the MPF ecosystem is the most extensive ecosystem in RER peat forest. This ecosystem type is vastly spread in PT. GCN and PT. TBOT concession areas, where the majority of its forest land is covered by big trees. On the other hand, the forest of PT. SMN inclines toward a MPF-LPF transition type, and that the LPF ecosystem was observed from the forest's composition structure. The extent of the LPF area shows that this forest is located in the inner peat area, or even around the peat dome. This is in line with Anderson (1964) and Page et al. (1999) who claimed vegetation in the inner peat area are relatively lower and smaller, observed as dense and short pole forests. Some of the remaining area is a Mengkuang field. Mengkuang fields are spread in a number of locations and are generally found in former logging areas. .

c. Species Diversity and Richness

The biodiversity in Semenanjung Kampar peat forest in general and RER peat forest in particular is still high. This is shown by the species diversity of woody plants which was categorized as 'high' (see H' value category in methodology section). Woody plant species in RER forest had diversity index score (Shannon-Wiever-H') of 3.66 for the whole RER areas. Whereas, H' value representing each transect ranged from 2.16 to 3.35 (H'GCN = 2.16 – 3.34; H'SMN = 2.42 – 3.07; H'TBOT = 2.65 – 3.35). The value of H' for the whole area and for each transect are still within the normal range for peat forest ecosystem (see table 12).

Table 12 Comparison of diversity between peat forets in Indonesia.

Location	∑Species	Diameter[a]	Range H'	Unit Size[b]	Refrence
RER, Kampar, Riau	112	Dbh ≥ 5 cm	3,66	40Ha	This study
			2,16 – 3,35	1,25Ha (x32)	
			2,12 – 3,35	0,25Ha (x179)	
Giam Siak kecil-Bukit Batu, Riau	135	Dbh ≥ 3 cm	2,7 – 3,6	0,5Ha (x6)	(Gunawan *et al*., 2012)
Sebangau, Kalteng	133	Dbh ≥ 15 cm	1,47 – 1,90	0,25Ha (x8)	(Mirmanto, 2010)
Selat Panjang, Riau	50	Dbh > 10 cm	3,05	1Ha	(Rosalina *et al*., 2013)
Sebangau, Kalteng	146	Dbh > 6 cm	2,45 (edge forest)	0,14Ha	(Erik T, 2013)
			3,3 (50m from edge)	0,13Ha	
			3,83 (100m from edge)	0,14Ha	
			4,17 (forest interior)	1,79Ha	
SM Kerumutan, Riau	40-59	Dbh ≥1 cm	2,98 – 3,67	0,04Ha (x7)	(Kuniyasu & Tetsuya, 2002)
	31-48	BA≥10 cm	2,4 – 3,2	0,24Ha (x7)	

notes: dbh= diameter at breast height, BA=diameter at basal kawasan; b shows wide unit that can be represented by H ' certain value, numbers in parentheses indicate the number of plots / unit area measuring region which have H ' ; Ha = hectares (equivalent to 10,000m^2)

From the comparison table, the species diversity value in RER peat forest is similar to the other peat forests, mainly Sumatra peat such as Giam Siak kecil-Bukit batu, Selat Panjang, and Kerumutan. Those three peat forests are located in a landscape close to the Semenanjung Kampar forest. The highest diversity of peat forest was found in Kalimantan peat forest area (Sebangau) which reached an H' value of 4.17 representing forest interior area as wide as 1.79 Ha. In that area, species richness was higher than that of RER peat forest. Borneo peat forest in many literatures was found to have the greatest species richness (>380 species) if compared to other Southeast peat areas (Page *et al*., 2006; Posa *et al*., 2011)

When looking closer at the species richness in RER peat forest, the correlation (*Pearson correlation*) between parameters showed that diversity index H' had the highest correlation with dominance index of (R = -0.9), compared to species richness, number of trees, and evenness index/E (each correlation value was 0.86, 0.22, and 0.77 respectively). The negative sign indicates negative correlation; the higher the D the lower the H'. This correlation could be seen from the distribution of H' and D score in all transects (in figure 17).

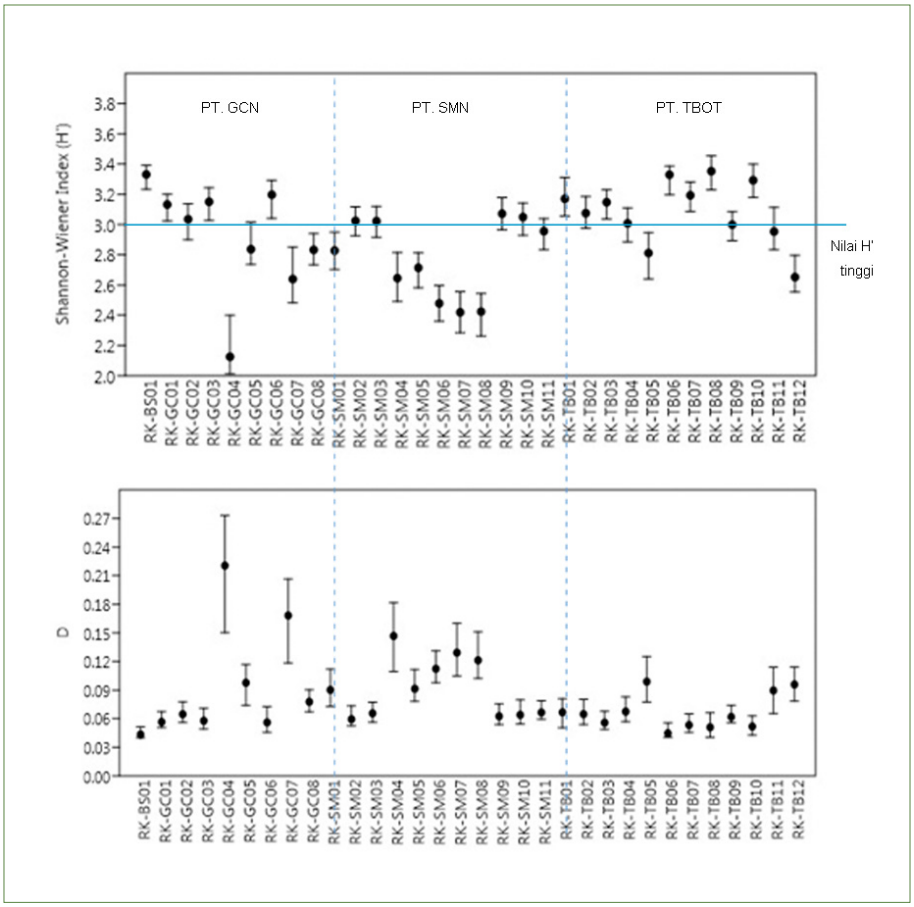

FIGURE 17 Shannon-wiener diversity index value (H') and dominance (D) in each transect.

Negative correlation between H' and D was obvious in RK_GC04 which has the lowest diversity score but the highest dominance score. In transect RK_GC04, one species, mengkuang (*Pandanus* sp.'mengkuang'), dominated causing limited space for other species and thus low species number. In areas such as in RK_BS01 and RK_TB08, H' scores were high but D scores were low. The species there had equal proportion so no single species dominated the vegetation. About 53% of RER peat forest area had high diversity (H'>3) and are distributed mostly in PT. GCN and PT. TBOT. Forest area with medium diversity (H' = 2 -3) was found in SMN area with LPF ecosystem type. In this area, high dominance in the big tree class was shown not only by Mengkuang but also Meranti Bunga and Terentang. Both species can survival well in inner peat area (Anderson, 1964; Gunawan et al., 2012)

d. Important and Threatened Species

The high diversity of woody plant species in RER forest is a result of species competition to occupy land and resources which may facilitate coexistence (Finegan, 1984). This phenomenon is related to the ability of each species to adapt to the highly stressfull peat ecosystem. Plants growing in peat forest are exposed to higher level of stress such as low soil fertility level, high substrate acidity (pH 2-4), waterlogged soil, low nutrition due to slow litter decomposition and low soil strength to support vegetation (Melling et. al., 2007). These conditions limit the number of plant species living there as well as their growth. The plants that could grow tend to be have inhibited growth and thus shorter, especially in the inner peat area.

Species which could survive are the species which have stilt-root, tall buttress root, pneumathophore, and strong root tissue system to improve stand stability and gas exchange in the water-logged soil (Melling et al., 2007; Yule, 2010; Posa *et al*., 2011; Campbell, 2013). Root system becomes more extensive we get closer to the inner peat, especially peat dome area (Anderson, 1963; Melling et al., 2007). Some of the dominant

species in RER peat forest such as Meranti, Suntai, Terentang, and Kelat displayed these characteristics. Having features that fit a certain type of ecosystem will lead a species to be more competitive and eventually have high abundance (Finegan, 1984).

Species that survive better in extreme condition of a peat ecosystem might not be able to get optimally habituated to mineral-rich ecosystem condition. This causes some plant species to grow only in peat (peat specialist). Approximately 11% of plants found in the peat of Southeast Asia are peat specialist species (Posa et al., 2011). Some of peat specialist species found in RER peat forest included *Shorea teysmanniana, S. uliginosa, S. platycarpa, Vatica teysmanniana, Myristica lowiiana, Horsfieldia crassifolia, Diospyros siamang,* and *Combretocarpus rotundatus.*

There are over 130 plant species found in the RER peat forest; a number of them are threatened species based on the IUCN as well as CITES categories, and are listed as plants protected by law. The list of the threatened species can be seen in table 13 and a more detailed description of each species in appendix 5. All Dipterocarps in RER peat forest are classified as threatened, including the two dominant meranti, meranti bunga and meranti sarang punai. A large number of these species are peat specialists (asterisked in the list). Habitat loss due to illegal logging activities and forest conversion (IUCN) are the main threats for the species living in RER peat forest).

Among the threatened plant species, Meranti Bakau and Resak Paya requires more attention since these two species are critically endangered (CR). This means that the global populations of these species are near extinction. Other than the fact that they are peat specialists, they both have extremely limited habitat to live. Meranti bakau can only grow in peat areas close to streams and are almost never found away from streams within a peatland. Meanwhile, resak paya has a confined distribution; only found in peat forests of Sumatra. Its range covers the peat forests of Riau, Jambi, and all the way to Bangka.

Table 13 List of threatened species.

Local Name	Species	Family	IUCN	CITES	RI	Location
Garam-garam/perepat	*Combretocarpus rotundatus**	Anis.	VU			G,S,T
Meranti sarang punai	*Shorea uliginosa**	Dipt.	VU			G,S,T
Ramin	*Gonystylus bancanus**	Thym.	VU	App. II	PP7a	G,S,T
Mersawa[a)]	*Anisoptera marginata*	Dipt.	EN			G
Meranti bunga	*Shorea teysmanniana**	Dipt.	EN			G,S,T
Resak	*Vatica pauciflora**	Dipt.	EN			G
Meranti bakau	*Shorea platycarpa**	Dipt.	CR			G,S,T
Resak paya	*Vatica teysmanniana*,[e]*	Dipt.	CR			G,S,T
Pinang merah	*Cyrtostachys renda**	Arec.			PP7a	G,S,T
Suntai putih	*Palaquium cf. walsurifolium*	Sapot.			PP7a	G, T
Periuk kera	*Nepenthes ampullaria**	Nepen.		App. II	PP7a	G,S,T
Periuk kera	*Nepenthes rafflessiana**	Nepen.		App. II	PP7a	G,S,T

*Notes: * = peat specialist; [a)] found outside transect; e = endemic Sumatra; VU = Vulnerable, EN = Endangered, CR = Critically Endangered; App.II = appendix II on CITES; RI = Republic of Indonesia, PP 7a = Peraturan Pemerintah Indonesia No. 7 tahun 1999 about flora and fauna protected by law; Location: G = GCN, S= SMN, T = TBOUT.*

In addition to the two species above, Ramin is also considered to be a highly threatened species. Because it has vulnerable status (VU) and illegal trading of this species is flaring, it has been included in the appendix II of the IUCN lists. Besides, the Indonesian Government has placed it into a group of species protected by Law (PP RI No. 7 year 1999). As it is harder to find this species in the wild, the preservation of ramin needs to receive more attention. Other species, along with meranti bakau, resak paya and ramin, are peat specialist species. It means that these species cannot grow in an ecosystem other than peat. With less peat forest ecosystem, these species are more at risk to extinction.

e. Non-woody Species

At least 40 species of non woody plants grow in RER peat forest. This number excludes an estimated total of more than 20 species of orchids (Orchidaceae). Non woody-plants includes the rattans, palms, understory herbs, ferns, erect shrubs and lianas (see list in appendix 5). Some of these plans are also peat specialist such as two species of Pitcher plants (Nepenthaceae, *Nephenthes ampullaria* and *N. rafflessiana*), three species of palms (Arecaceae, Linau-*Cyrtostachys renda*, Palas-*Licuala spinosa* and Asam Paya/Kelubi-*Eleiodoxa conferta*). These three species of palms are often found in abundantly as forest floor cover (understory) in several locations, mainly areas close to streams.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

1. Vegetation structure of RER peat forest presently has an average big tree dbh of 40.1 + 10.3 cm, small tree class of 19.6 ±3.7cm, and pole class of 8.6 ±3.1cm with the density of each class respectively 50.9 stands per hectare, 317 stands per hectare, and 1174 stands per hectare. Canopy layer stratum in this forest was still complete with 3 main layers i.e. upper canopy, middle canopy, and lower canopy, with the proportion for each layer 15.2%, 39.8% and 44.6% respectively. This condition in each concession tend to be vary especially in SMN concession where the lower canopy proportion was very dominant i.e. 52% compared to other canopies. In GCN and TBOT, the proportion of middle and lower canopy tend to be even, and both of them became main covers of the canopy layers.
2. Ten dominant species determining the RER peat forest composition included *Shorea teysmanniana, Pandanus* sp.'mengkuang', *Campnosperma coriaceum, Shora uliginosa, Tetramerista glabra, Palaquium sumatranum, Mangifera parvifolia, Syzygium chloranthum, Calophyllum ferrugineum,* and *Stemonurus secundiflorus*. Based on the presence of those species, the plant community was classified into 4 ordination i.e. ordinate 1= Mengkuang field, ordinate 2 = mixed forest of Suntai-Sembasah, ordinate 3 = mixed forest of peat species, ordinate 4 = Meranti – Terentang field. GCN tend to be occupied by community of ordinate 1 and 2 although some of them also contained the community of ordinate 4. In SMN, the main community was generally community of ordinate 4, and TBOT contained community of ordinate 3.
3. The vegetation structure and community in RER area could be grouped into at least 3 types of main peat ecosystem, i.e.: 1) ecosystem type of mixed peat forest (MPF), 2) pole forest with short vegetation (*Low Pole Forest* – LPF), and 3) mengkuang field or degraded forest. MPF was mostly found in GCN and TBOT concession areas, whereas SMN dominant ecosystem type was LPF. The ecosystem of mengkuang field was found in former logging areas such as RK_GC06, RK_TB05 and RK_GC08.
4. It was recorded that at least 112 woody plant species belonging in 43 families were found in the observation transects as well as 40 non-woody species. Diversity of woody species in this area was quite high with a diversity index of 3.66. Among these species, important species composing the peat forest are mostly characterized by having strong roots such as pneumatophore, stilt-root, buttress-root as well as leaves with oil dots. These characteristics are adaptive response to the extreme environment of peat ecosystem. These species were found abundantly in RER peat area such as Meranti (*Shorea* spp), Suntai (*Palaquium sumatranum*), Terentang (*Camnosperma coreaceum*), Darah-darah (*Myristica lowii*) and Guava group (*Syzygium* spp).
5. There are at least 13 endangered species according to the red lists of IUCN, CITES, and Indonesian law. Among these 13 species, Meranti Bakau (*Shorea platycarpa*) and Resak Paya (*Vatica teysmanniana*) are the species which need more attention due to its CR status and restricted distribution.
6. It was found that the peat swamp forest of Semenanjung Kampar are composed of species with quite

high diversity level if compared to several other places in Sumatra such as (SM Kerumutan), (Merang - Kepayang, Jambi) and (Giam siak kecil, Riau). However its diversity was lower than the peat swamp forest in (Giam Siak kecil-Bukit Batu, Riau) and (Sebangau, Kalteng)

4.2 Reccommendations

Based on the recent study of vegetation structure and floristic diversity in RER peat forest area, several reccommendations on planning and management action are given:

1. RER should restore the degraded area such as mengkuang field area within their concession and monitor the concession especially for mitigating the illegal logging, forest fire and other possible threat to the peat swamp forest.
2. RER should do a socialization of important species to their staffs and the general public via counceling, information board, book or poster. RER could release a management plan which exposed its conservation purpose and having regular biodiversity inventorization (once every two years).
3. RER could conduct population studies of threatened species, especialy for Meranti Bakau (*Shorea platycarpa*) and Resak Paya (*Vatica teysmanniana*). With healthy population size, it is expected that ecological process supporting environmental service improvement would run appropriately. Terentang species (*Camnosperma coreaceum*), Gerunggang (*Cratoxylon arborescens*), *Combretocarpus rotundatus* and *Macaranga* spp, are indigenous species which are potential to be developed as forest restoration.

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