The Ecological Characteristics of Peatland Ecosystem
in Giam Siak Kecil–Bukit Batu Biosphere Reserve, in Riau Province, Sumatra, Indonesia.

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Location of field work: Riau Province, Sumatra, Indonesia
By Haris Gunawan (Graduate School of ASAFAS, Kyoto University, Japan)

Abstract

The Giam Siak Kecil-Bukit Batu landscape was officially declared as Riau's Biosphere Reserve in 2009, which totally area is 698.663 ha. This Biosphere representing tropical peat swamp forest, it will be used to conserve the peat swamp forest ecosystem and the other purposes as well. Fragile and very unique ecosystem, continuously converted natural sites, and lack of scientifically based information, are some of these factors that will influence efforts to conserve peat swamp forests and sustainability use its resources of this Biosphere in the future. This Study carried out in July to December 2009. The objective of study was (1) to elucidate distribution and the current condition of peat swamp forest, (2) to determine the ecological characteristics of peat swamp forest including natural forest recovery by assessing natural regeneration processes, and (3) to characterize the physical-chemical properties of peat at various of land uses. The reconnaissance survey, plot analysis, and observation methods were used to collect the data. Totally plot size is 1.93 ha. Whilst peat soil sample were taken at various of land uses within 0-20 cm, 20-40 cm, and 40-60 cm of peat depth. The preliminary results show that; Riau's Biosphere is divided into four forest conditions, namely (1) natural peat swamp forest (2) logged over peat swamp forest, (3) secondary peat swamp forest, and (4) artificial forest/pulp wood plantation. There are differences in forest structure and tree species composition throughout the peat swamp forests in this extensive river to inland of the peatland at Riau's Biosphere, indicated three types of peat swamp forest are: (1) Bintangur-Peat Swamp Forest, (2) Balam-Peat Swamp Forest and (3) Mixed Dipterocarp-Peat Swamp Forest (MDPSF). The natural recovery of the disturbed peat swamp forest, particularly at the river basin of Bukit Batu River show that natural regeneration is one of forest recovery methods which can be used to efforts conserving peat swamp forests in this Biosphere. However not at all of climax species were well regenerated (e.g. *Shorea* spp, *Gonystylus bancanus, Tetramerista glabra, Durio carinatus, and Callophyllum lowii*) are show limited or no regeneration. The chemical-physical quality and pattern of organic matter of peat soils depend on the various of land use and the peat depth. The information obtained from this study are valuable assets for formulating a more effective approach on conserving and sustainable use of peatland resources in Riau's Biosphere in the future.

Keywords: Ecological Characteristics, Peatland Ecosystem, Riau's Biosphere.

1. Research Background

Tropical peat swamp forest is an important natural resources of considerable environmental and economic value in Indonesia (Rieley et al. 1997). This ecosystem is one of the most fragile and very unique ecosystem in the world, but now the degradation and reduction has affected not only the production of timber but also the local and global environment.

In Sumatra island the largest area of peat land is located in Riau Province which is about 4.04 million hectare. Most of the peat thickness in this province is more than four meter depth. As a result, this area is one of the most important carbon pool in the world (Wahyunto and Heryanto, 2005).

According to WWF (2008), between 1982 and 2007, Riau's peat swamp forest lost 57% (1,831,193 ha). The remain of Riau's peatland distribute on five forest areas are (1) Senepis, (2) Giam Siak Kecil-Bukit Batu, (3) Libo, (4) Kampar Peninsular, and (5) Kerumutan. These forests remnants have variety of condition and quality. Parts of the forest area still keep in natural condition, while other areas have been degraded (Jarvie, *et al*., 2003).

In order to improve sustainability management of Riau's peatland, one of the larger peatland area in Riau Province has been officially declared as Biosphere Reserve in 2009, which totally area is about 698.663 ha.

The Riau's Biosphere Reserve is located in two districts are Bengkalis and Siak, and one city is Dumai, in Riau Province, Sumatra Indonesia. The uniqueness of this biosphere are a vast landscape having a unique hydrological network of small lakes and streams and remaining natural peat swamp forest. They are surrounded by different types of land use system, such as production forests, degraded/abandoned lands, industrial plantations (timber and oil palm), agricultural lands, and settlements as well.

Since 1990s the Giam Siak Kecil-Bukit Batu landscape has become the focus for rapid and widespread clearance and conversion. From analysis of LANDSAT satellite imagery indicating that forest cover has reduced from about 600,000 ha in 1985 to 350,000 ha in 2002 (Jarvie *et al*., 2003).

Due to the massive areas of degraded peatland in Riau's Biosphere Reserve, scientific attention is being given to manage the natural peatland resources. This may be to recapture the environmental services that the functioning ecosystem provided, or to recover lost biodiversity and the economic values from the peat swamp forest ecosystems.

2. Research Purpose and Aim

1. To elucidate distribution and the current condition of peat swamp forest.
2. To determine the ecological characteristics of peat swamp forest including natural forest recovery by assessing natural regeneration processes.
3. To characterize the physical-chemical properties of peat at various of land uses.

3. Methodology

The survey was carried out in Giam Siak Kecil and Bukit Batu Biosphere Reserves of Indonesia July-November, 2009. The permanent plots were be laid for degraded and natural peat swamp forests where will be carried out soil and vegetation survey. Totally size plot 1.93 ha. The plot size differs on each of forest conditions. For trees with DBH ≥ 3 cm, the stem diameter at breast height (d.b.h), numbering and location were recorded. Whilst peat soil sample were taken at forest and plantation area. We took soil sample in peat depth 0-20 cm, 20-40 cm, and 40-60 cm within two

points in each of land uses. For identification of plants, the voucher specimens will be set is for Ecology Laboratory of Riau University and to verify the specimen will be carried out at Herbarium Bogoriense in LIPI, Cibinong, Indonesia. Whereas the soil sample will be analyzed to The Soil Laboratory of Agriculture Department in Bogor and Laboratory of Ecology, Riau University. For the vegetation analysis we used Shannon-Wiener Index (H' = -∑ Pi ln Pi), Relative Density (number of plants by species in plot x100/total number of plants of all species), and Important Value Index (IVI: R.A + R.F + RD: R.A = relative abundance, R.F = relative frequency, RD = relative dominance) (Cox, 1996; Magguran, 1988).

4. Results and Achievements
4.1. Distribution and Current Conditions of Peat Swamp Forest

The Riau's Biosphere is divided into three types of peat swamp forest conditions as following are: (1) natural peat swamp forest (figure 1), (2) logged over peat swamp forest (figure 2), and (3) secondary peat swamp forest (figure 3).

Fig 1. Natural Peat Swamp Forest

Fig 2. Logged Over Peat Swamp Forest

Fig 3. Secondary Peat Swamp Forest

Natural peat swamp forest, located at up-stream of Bukit Batu River and near to Air Raja Sub Village in Tanjung Leban Village as well, characterized into three types: (1) much water on the surface of peatland, present *Pandanus* sp, and less tree density, (2) lack of water on surface of

peatland, present *Salacca sp, and* more dense of tree stand, (3) far from river and dominated by Bintangur (*Callophyllum* sp) tree species at the top of canopy layer. Whilst logged over peat swamp forest, located at river basin of Bukit Batu River, characterized into three types: (1) dense of reproductive trees, (2) less of reproductive trees, and (3) none of reproductive trees. Secondary peat swamp forest, located at the conservation area belonged SM forest company, and Bakti, Air Raja sub village in Tanjung Leban Village, characterized into two types of disturbance is as following; (1) wind disturbance, and (2) forest fire disturbance.

4.2. Ecological Characteristic of Peat Swamp Forest.
1. Tree Diversity and Forest Structure

A total of 122 trees species from 36 families of > 3 cm dbh were recorded and enumerated within the 1.93 ha plot. Dipterocarpaceae was the most diverse family with 10 trees species, and Lauraceae with 10 trees species, followed by Myrtaceae (9 trees species), Annonaceae (8 trees species), Sapotaceae (7 trees species), and Anacardiaceae (7 trees species). The most widespread species in the study was *Diospyros hermaphroditica* (Ebenaceae), which was recorded in 45 plots. Other widespread species included *Eugenia paludosa* (Myrtaceae, 34 plots), *Madhuca motleyana* (Sapotaceae, 27 plots), *Shorea hemsylena* (Dipterocarpaceae, 23 plots), *Shorea sp 1* (Dipterocarpaceae, 23 plots), *Ilex macrophylla* (Aquifoliaceae, 22 plots), *Callophylum lowii* (Clusiaceae, 17 plots), *Durio acitifolius* (Bombaceae, 17 plots), *Xylophia havilandii* (Annonaceae, 16 plots), and *Palaquium sumatranum* (Sapotaceae, 14 plots). The most widespread family was Myrtaceae, which was recorded in 103 plots. Other widespread families included Sapotaceae (69 plots), Dipterocarpaceae (68 plots), and Ebenaceae (61 plots).

The individual distribution pattern show almost similar represented mostly by small-sized trees ranging between diameter 3-20 cm and rarely exceeding Dbh (*Diameter at breast heigh)* 40 cm, this results indicating that severe environment of peat swamp ecosystem affect on development of peat swamp forest where only small number of species can reach exceed Dbh 40 cm (figure 4).
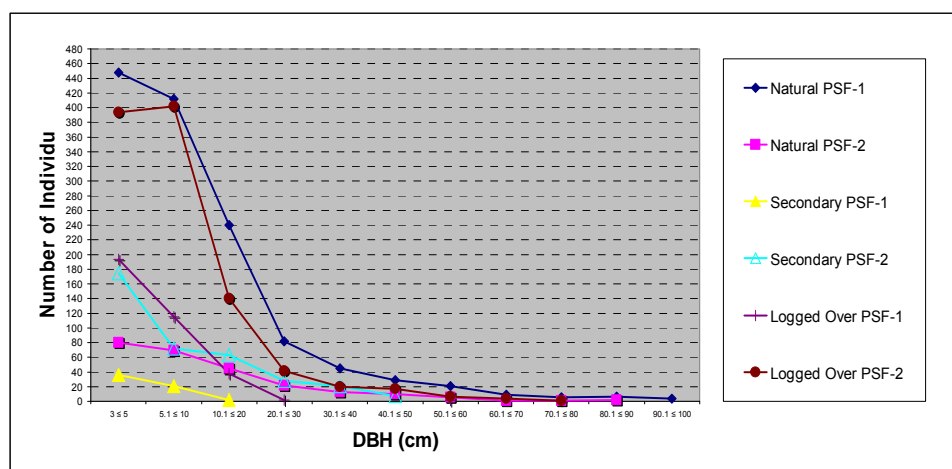

Fig 4. Diameter class distribution for Individu within total 1.93 ha study plot (Natural Peat Swamp Forest (PSF)-1 (10.000 m^2), Natural PSF-2 (1600 m^2), Secondary PSF-1 (125 m^2), Secondary PSF-2 (1800 m^2), Logged Over PSF-1 (800 m^2), and Logged Over PSF-2 (5000 m^2).

The diversity index (Shannon-Wiener Index: H^1) is moderate to high. Range interval: 2.6 to 3.6. Its almost similar tree species diversity is in natural peat swamp forest -1 (H^1 : 3.6) and natural peat swamp forest-2 (H^1 : 3.4) and logged over peat swamp forest-2 (H^1 : 3.5), its meant that tree species diversity can recovery naturally after selected logging, some typical peat swamp tree species still grow up at logged over peat swamp forest-2 i.e. families Sapotaceae, Annonaceae, and Myrtaceae.

Tree species with highest relative density in Natural Peat Swamp Forest-1 was *Eugenia paludosa* (12.87%), Natural Peat Swamp Forest-2 was *Palaquium sumatranum* (16.47%), Logged Over Peat Swamp Forest-1 was *Eugenia paludosa* and *Diospyros hermaphroditica* (9.25%), Logged Over Peat Swamp Forest-2 was *Eugenia paludosa* (11.87%), Secondary Peat Swamp Forest-1 was *Diospyros hermaphroditica* (25%), and Secondary Peat Swamp Forest-2 was *Callophylum lowii* (15.13%).

Most of peat swamp forest in Riau's Biosphere indicates moderate and vigorous their regeneration. However not at all species are show well regeneration, some of typical canopy species are show limited or no regeneration, particularly in Secondary Peat Swamp Forest-1 and Secondary Peat Swamp Forest 2, and Logged Over Peat Swamp Forest 1. Only in Logged Over Peat Swamp Forest-2, some of canopy species already regenerated such as tree species of *Palaquium sumatranum* and *Xylophia havilandii.*

2. Peat Swamp Forest Types

2.1. Balam Peat Swamp Forest

This forest has peat characteristics lack of water on the surface, present *Salacca sp, and* more dense of tree stand. It has a total of 55 species where *Palaquium sumatranum (Balam)* represents the most dominant species (IVI = 38.87%). *Palaquium sumatranum* also contributed 18.82% of the total basal area in this forest association. Followed species are *Diosphyros hermaproditica* (IVI =23.76%) within total basal area 9.37% %, *Tetractonia tetandra* (IVI =14.29%) within total basal area 5.10%, *Mangifera longipetiolata* (IVI =13.31%) within total basal area 6.19% and *Eugenia Setosa King* (IVI =10.53%) within total basal area 4.18%.

2.2. Bintangur Peat Swamp Forest

One of typical peat swamp forest that can be found in Riau's Biosphere is Bintangur Peat Swamp Forest. For the study indicated that this forest located far away from the river within peat depth more than 5 meter. The uniqueness of bintangur peat swamp forest is have quite same canopy height on the top layer. It means no emergent tree species.

Even though we established plot study in disturbed bintangur peat swamp forest, but the results show that it has a total of 43 species where *Callophylum lowii (Bintangur)* represents the most dominant species (IVI = 78.35%). *Callophylum lowii* also contributed 59.47% of the total basal area in this forest association. Followed by species are *Mangifera longipetiolata* (IVI =22.80%) within total basal area 2.30%, *Eugenia paludosa* (IVI =16.47%) within total basal area 4.07%, *Shorea teysmanniana* (IVI =15.29%) within total basal area 8.57% and *Eugenia setosa King* (IVI =14.09%) within total basal area 2.23%.

2.3. Mixed Dipterocarp Peat Swamp Forest (MDPSF)

Canopy tress species includes families dipterocarpaceae and Myrtaceae. It has peat characteristics much water on the surface, it will reach up 50-60 cm of water in rainy season, present *Pandanus* sp, less tree density, and with peat depth more than 5 m. It has a total of 84 species where *Eugenia paludosa* represents the most dominant species (IVI = 20.59%). *Eugenia paludosa* also contributed 4.49% of the total basal area in this forest association, followed by species are *Diospyros hermaprhoditica* (IVI =20.37%) within total basal area 9.47%, *Shorea teysmanniana (Dipterocarpaceae)* (IVI =16.72%) within total basal area 12.38%, *Durio acutifolius* (IVI =16.64%) within total basal area 11.7% and *Shorea sp1(Dipterocarpaceae)* (IVI =14.82%) within total basal area 9.65% .

4.3. Peatland Characteristics

The physical and chemical properties of peat land in various of land uses in Riau's Biosphere are as following as (1) carbon organic content is range 54.81 to 57.03% meaning that carbon content is normal in tropical peat soils. The highest carbon content at eucalyptus plantation (57.03%) and the lowest at oil palm plantation (54.81%). All of study plots show oligotrophic or poor nutrient with ash content is average < 5%, located in (1) natural peat swamp forest (3.78%), (2) oil palm plantation (4.28%), rubber plantation (3.4%), acacia plantation (3.23%), and eucalyptus plantation (2.44%). According to Yonebayashi et al (1997) it has been considered that the soils of tropical peat swamp forest ecosystems are quite oligotrophic.

From analysis bulk density we can determine degree of decomposition are grouped in to Hemic, it means that peat soil are moderate decomposition with bulk density > 0.1 to 0.2 gram/cm^3 (natural peat swamp forest was 0.12, oil palm was 0.19 and acacia plantation was 0.17); and Sapric, it means that peat soil has been decomposed with bulk density > 0.2 gram/cm^3 (secondary peat swamp forest was 0.32, rubber plantation was 0.23 and eucalyptus plantation was 0.21). Most of the plot study show strong acidity with pH 2.9 to 3.5. The general pattern of declining organic matter and chemical quality with increasing peat depth (Brady, 1997); Yonebayashi et al (1997). From these study show that some of organic matter and chemical quality with increasing peat depth but some of them also don't follow this general pattern. The pattern of organic matter and chemical quality depend on the various of land use and peat depth.

Implications and impact on future research

Bintangur forest is one of typical of tropical peat swamp forest existing in Riau's Biosphere, we need to clarify the ecological characteristic this forest in the natural site condition. Hence for the next field research we will establish a study plot in Bintangur Forest.

In addition to the study of forest regeneration, we are going to also make small quadrate plots in each of forest conditions. The regeneration capability of tree species can be determined in this study plots. The other topics of study is rehabilitation methods. Large degraded forests and lands need to recovery, some of rehabilitation methods will be applied in the next field study.

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