

# Tropical peatland tree-species diversity altered by forest degradation

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**Abstract.** Astiani D. 2016. *Tropical peatland tree-species diversity altered by forest degradation. Biodiversitas 17: 102-109.* Indonesian experienced relatively high deforestation and degradation. The forests degradation could bring the forests into a temporary or might be permanent destruction not only in forest vegetation density and structure, but also in species composition. A study had been carried out to examine the impact of peatland forests degradation on their species diversity composition in Ketapang, West Kalimantan peatland forest. Stratified random sampling was used to distinguish forest degradation class (low, intermediate and high degradation levels) based on the differences in spectra image and confirmed with field checking by measuring forest canopy opening to measure the degradation levels. Six to twelve of a 20x100m plots were established to sample tree structure and composition distributed along peatland landscape. All trees species diameter >5cm was registered and species identified. Results indicated that tree diversity was significantly reduced due to forest degradation, in low, intermediate, and high degraded forest were 82, 72, and 48 consecutively. Forest degradation is not only resulted in more than 50% of important species loss in high degraded peatland forest but also reducing ~40% tree abundance. Ten species were found in high degraded forest, e.g., *Calophyllum inophyllum*, *Cyathocalyx biovulatus*, *Neoscortechinia kingii*, and *Eugenia cerina*, were not present in low degraded one. The species composition and abundance shifting due to forest degradation should be considered on peatland forest management to hinder permanent species loss.

**Keywords:** species abundance, species composition, tree species loss

## INTRODUCTION

Tropical forest is regarded as one of the largest biodiversity which has rich array of plants, animals, and microbial life form and plays an important role in ecological system due to its large area of coverage, which are important to maintain their function in biosphere (Dirzo and Raven 2003). It also provides habitat biodiversity, hydrology regulator, and carbon storage and the ecosystem recently deserve special attention because of continuing considerable destruction (Celine et al. 2013). While the tropical forests are facing the environmental problem, many aspects of the issue had been overlooked until recently. The tropical forest degradation was not only clearing large area of forests (i.e. with selective logging)-but the altering and replacing of old growth forest also happened spreadly (Foley et al. 2007).

Forest and non forest term are not adequate for describing forest in a landscape, yet until recently it is used to draw the condition of tropical forest. Recent forest ecosystem is further dynamic and a complex system because they experience logging, opening landscape, regrowth, mortality which result more complex mosaic of intact rain forest and recovering secondary forest (Nepstad et al. 1999; Cardille and Foley 2003).

Indonesian rainforest plays an important role in as home to third most extensive humid tropical rainforest and account for 2.3% of global forest cover (FAO 2010). It contains high floral and faunal biodiversity (Ministry of Forestry 2011), yet about 27% of Indonesian population depends directly on these forests for their livelihood.

Consequently, the forest experience relatively high deforestation and degradation. The deforestation rates of intact forest in Southeast Asian tropical peatlands-concentrated in Sumatra and Kalimantan Indonesia-has been reported as 3.4%  $y^{-1}$  from 1990-2010 (Miettinen et al. 2011; Achard et al. 2002). Similar to the global condition, tropical forests in Indonesia are in a lot of pressure mainly due to anthropogenic activities such as logging causing forest disturbances and degradation (Margono et al. 2012).

Land cover change pressures and rapid deforestation and degradation were also occurred in West Kalimantan peatland forests. The forest type extends about 1.58 million ha in this province however only around 45% of the forest is still remaining with variable forest conditions. The forests degradation may alter the forests into a temporary or might be permanent destruction in forest vegetation density and structure, species composition (Lambin 1999; Grainger 1993) and the condition could lead to reduce their productivities and ecological role in the landscape.

In addition, land use change will also impact effects and alter terrestrial ecosystem processes (Miettinen et al. 2011). Thus, land conversion has and will likely continue to alter the emissions of greenhouse gases (IPCC 2011; Carlson et al. 2012, 2013). However, the impacts of forest degradation on peatland forest in-situ condition such as micro climates and forest in state condition is not clearly stated and how this condition affect the process within the forest changes matrix is interesting to be investigated. The occurrence of various forms of peatland conversion and degradation is well known. Yet the impacts of forest degradation on forest dynamics is also not clear. To

investigate the impacts on the alteration of forest tree composition and their dynamics, a study had been carried out to examine the impact of peatland forests degradation on their species diversity composition in Ketapang, West Kalimantan peatland forest.

**MATERIALS AND METHODS**

**Study sites**

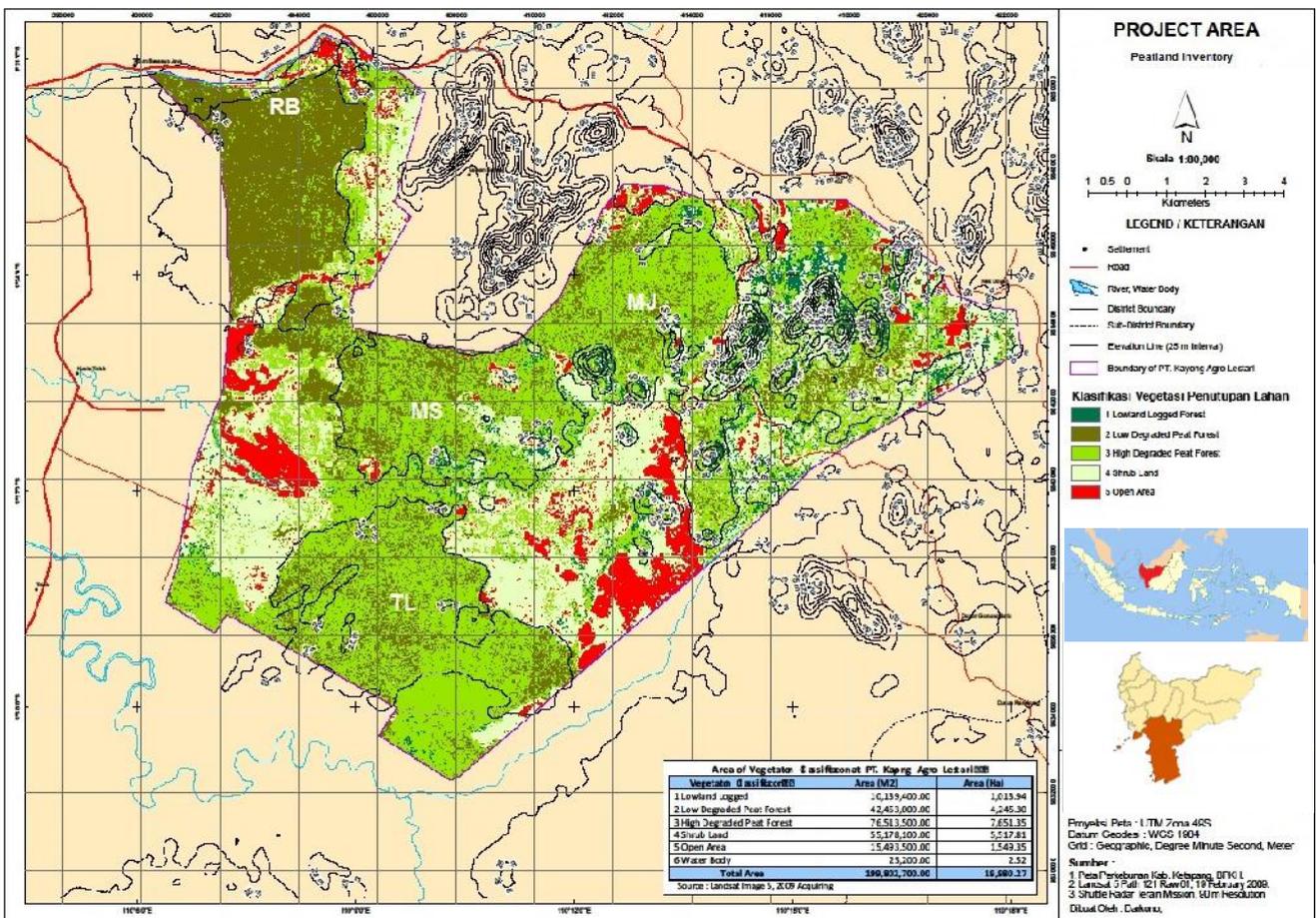
This study was conducted in an *ombrotrophic*, peatland in Riam Berasap and Tulak of Ketapang District, West Kalimantan, Indonesia (110° 6' 0" E to 110° 18' 0" E and 1° 21' 0" S to 1° 31' 0" S ~ 4 m asl.; Figure 1; in Astiani 2012). Peat depth range 2-7.5 m. Mean annual rainfall was 2892 mm ± 17 mm with 172 ± 8.2 rain days per year (compiled from Ketapang airport, Rahadi Usman weather station, West Kalimantan; in 200-2014). This area had been low-impacted logged 8-10 year ago and naturally regrowth. However, the forest coverage and condition was left in various conditions in term of their canopy coverage and tree density. The peatland forest in this area were distributed to four blocks: Riam Berasap (RB), Manjau

(MJ), Marsela (MS), and Tulak (TL) Peat Forest. These areas were chosen based on the indication of peat land area derived from satellite image interpretation and soil map.

From our peat surveys and studies in West Kalimantan (Astiani 2014), we determined that this study area was highly representative of West Kalimantan coastal-peatland areas as the overwhelming majority of coastal peat areas had been selectively-logged and transported with 'sepeda' or 'kuda-kuda' system along the skilled road (Figure 2.A and 2.B).

**Sampling approaches for collecting data**

Forest tree biodiversity was conducted following Astiani (2012) survey using stratified sampling based on the differences in spectra of Land Sat Image according to the land cover change or forest cover types. Based on overlaying of Landover Map 2009 and SRTM Spectra with 90 meter Resolution, this area is classified based on the canopy closures and land cover types in the area were grouped into: low, intermediate, and high degraded peatland forest. Field checkings were conducted to measure tree canopy opening using Densimeter measurement.



**Figure 1.** Study area map in Riam Berasap (RB) and Tulak (TL) of Ketapang, West Kalimantan, Indonesia



**Figure 2.** Low-impacted logging (A) and wood transportation using 'sepeda' (B) and 'gerobak' (C) on Ketapang, West Kalimantan peatland forest



**Figure 3.**A-B. Forest tree identification and measurement in peatland of Ketapang, West Kalimantan, Indonesia



**Figure 4.** Low (A), intermediate (B), and high (C) degraded peatland forest on Ketapang, West Kalimantan, Indonesia

Within each land cover stratification (low, intermediate, and high degraded forest), concurrently with carbon stock survey team works (Astiani et al. 2016, data not showed), we purposively measured 9-12 plots of a 20m x 100m size all tree species diameter >5cm. In each plot we measured: tree diameter >20cm within 20m x 100m area and tree diameter >5cm>20cm within 5m x 40m nested plot. Throughout each plot, we measured tree diameters, tree heights, and identified tree species local and scientific names. Some species found which not well identified in the field were made herbarium and brought to LIPI and other

labs to have species identified.

#### Data analysis

Throughout the estimation of species structure and composition, data are presented as mean and standard error (SE) in selected intervals unless otherwise noted. Analysis of variance ANOVA was used and then Pairwise comparisons (Tukey Procedures) was tested among peatland degradation levels (low, intermediate, high degraded forest) in term of basal area, tree density etc.

## RESULTS AND DISCUSSION

### Forest stratification description

In the entire forest area of peatland in Riam Berasap, 108 species from 39 families were found. The land cover stratification was Low, Intermediate, and Low Degraded Peat Forest. Each land cover and canopy opening of forest stratification could be described as follows and visualized in Figure 4, and the peatland forest structure is drawn in Figure 5 and 6.

**Low Degraded Peat Forest (LDPF).** This type of forest is covered by low impacted logged-over peat forest, mainly old secondary peat forest that had occurred at least more than 10 year ago. Peat forest is in good succession, indicated by sufficient level of young trees and they formed 'J-shaped' as an indicator of balance uneven structure of trees. There are 80 tree species listed that compose this forest type. In general, for the whole area forest cover are dominated by Jungkang (*Pouteria malaccensis*), Nyatoh daun lebar (*Palaquium coclearifoium*), Nyatoh punjok (*Palaquium pseudorostratum*), Ubah, Perepat (*Sonneratia alba*), and Nyatoh beras (*Palaquium ridleyii*). Low Degraded Peat Forest dominated by trees (diameter >20 cm) and poles (diameter 5-<20cm) with stem density  $258.9 \pm 30.6$  trees/ha and  $340.7 \pm 62.9$  tree/ha consecutively. Canopy gaps assessment resulted they ranged from close to medium opened canopy, and showed very good succession of younger and smaller trees growth. Mean tree basal area was  $22.6 \pm 2.0$  m<sup>2</sup>/ha (N=14)

**Intermediate Degraded Peat Forest (IDPF).** This forest mainly secondary peat forest, that recently (less than 5-6 year ago) disturbed by logging. Dominant tree species in intermediate was similar to low degraded one such as mentioned above, yet they had less stem density with opened to rather opened canopy. The stem densities for tree diameter >20 cm and 5-<20cm were  $199.5 \pm 23.1$  and  $358.0 \pm 21.3$  consecutively. The trees diameter >20 cm quantity is approximately four fifth of the LDPF, yet the stem density of smaller trees is not different, only a bit higher than LDPF. The basal area was also less than LDPF ( $19.6 \pm 2.3$  m<sup>2</sup>/ha (N = 11)). The species composition was altered their dominance which prominent species registered such as Jonger (*Ploiarium alternifolium*), Kelentit Nyamuk (*Mangifera swintonioides*), Kumpang perawas (*Gymnacranthera contracta*), Nyatoh Banir (*Palaquium ridleyii*), Unang-unang (*Polyalthia sumatrana*) and Leban Paya (*Porterandia anisophyllea*).

**High Degraded Peat Forest (HDPF).** These forests were mainly high degraded secondary peat forest that recently open or burned scatter and found interspaced among the other two canopy cover conditions. Vegetation was dominated by a few tree, pole, and saplings level tree growth and shrubs ferns, grasses were found scattered. The stem density was  $130.8 \pm 22.1$  and  $372.9 \pm 46.2$  for tree diameter >20 cm and 5-<20cm. Its mean basal area was  $13.2 \pm 2.0$  m<sup>2</sup>/ha (N = 7). Some prominent species found were Jungkang (*Pouteria malaccensis*), Leban Tikus (*Vitex secundiflora*), Mentepis (*Calophyllum inophyllum*), Keminting hutan (*Polyalthia glauca*), and Bintik (*Elaeocarpus graffithii*).

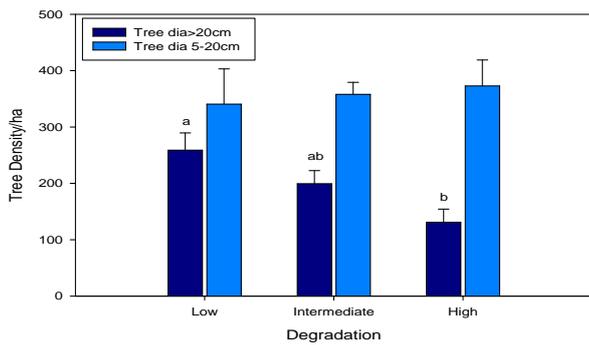
When we compared tree density among forest condition, it shown that tree diameter >20cm were significantly reduced their density in high degraded forest compared to low degraded one, while intermediate stage was a transition state between the low and high degraded forest. Smaller trees were relatively similar density (Figure 5). Difference in stand density affected their basal areas when compared amongst them. Reduction in basal area on high degradation forest reached 41,3% for tree diameter >20cm, yet increased ~33% for tree diameter 5-<20cm (Figure 6).

### Tree species diversity among forest degradation levels

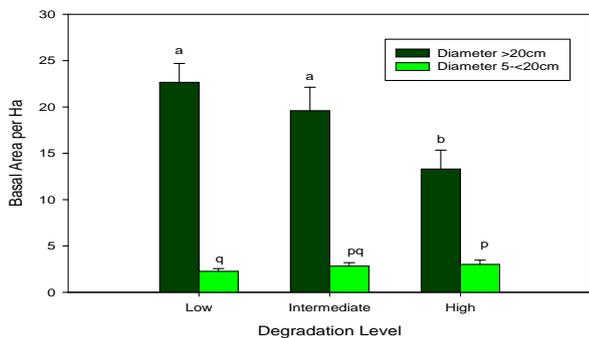
Resultsshowed that forest degradation had significant impacts on tree diversity in tropical peatland of Riam Berasap. Higher level of forest degradation reduced tree diversity variously and significantly influenced the existing peatland forest. For larger trees (diameter >20cm), there were found 82, 72, and 48 tree species in low, intermediate, and high forest degradation respectively, while in smaller trees, in similar order of degradation, there were 61, 53, and 28 tree species Figure 4. demonstrated that high degraded peatland forest decreased tree species diversity of 14% from low to intermediate and 43% from low to high degraded one.

Some species were lost in high degraded forest, and yet some other species emerged, while others survived among the tree degradation levels (Figure 5, Table 1). There were 45 species that found in low degraded forest that were not present in high degraded one. The most prominent species losses were some species of Nyatoh i.e. Nyatoh beras daun lebar (*Palaquium coclearifoium*), Nyatoh punyok (*P. pseudorostratum*), Nyatoh Babi (*P. xanthochynum*), Nyatoh Beras (*P. ridleyii*), Ubah (*Syzygium spicata*), Bintangur (*Calophyllum hosei* Ridley), Kayu Cin (*Nageia wallichiana* (Presl.) O.K.) and other important species where found abundant in low degraded peatland. On the other hand, 10 species were found in high degraded forest such as Mentepis (*Calophyllum inophyllum*), Mengkasai (*Cyathocalyx biovulatus*), Ilas (*Neoscortechinia kingii* King), Gelam tikus (*Eugenia cerina* Endl.) were not available in low degraded one.

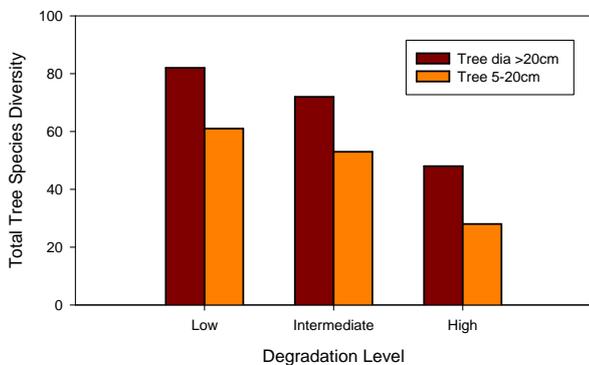
Viewing from forest ecology side, Shannon-Winner Index (Diversity Index) of trees among the three degradation levels were consider high (3.63, 3.32, and 3.21) consecutively for low, intermediate and high degraded peatland forest. It is indicated that among the three forest coverage levels they were all high in tree species diversity. Tree species in each forest condition has relatively diverse in tree abundance especially when low and high degraded forest compared, that shown from their Evenness Index which were 0.63 and 0.43. When analyzing their Similarity Index, their species composition were relatively shifted. The value were 41.5%, 34.3%, and 30.1% respectively when contrasting low vs intermediate, low vs high, and intermediate vs high degraded peatland forest. Those values described that between the 2 forest condition they have <50% tree species in common.



**Figure 5.** Peatland forest tree density among degradation levels



**Figure 6.** Tree basal area at various level of peatland forest degradation



**Figure 7.** Total tree species diversity found among degradation level in peatland forest of Riam Berasap, Ketapang, West Kalimantan, Indonesia

## Discussion

Simply, forest ecosystem classification is based on their type of habitat (i.e. tropical peatland forest is forest that is growing on peatland). However, forest ecosystem itself contribute to abundant and complicated roles in nature. There are variety of ecosystem function derived from tropical forest such as their roles in biogeochemical cycles, biological diversity, carbon sequester, improving welfare for people, opportunities on research, recreation and other ecosystem services (Putz and Redford 2010) and forest type description solely will mislead those ecosystem function.

Tropical peatland forest is one of vegetation ecosystem type which maintain enormous roles in their landscapes.

Recent condition and on going pressure on this ecosystem type could have devastating impacts on biodiversity of forest. The problems that are fundamental for maintaining and monitoring biodiversity is not yet appropriate at present even though several technique has been established to monitor forest such as land cover mapping and monitoring, either on local, regional, and continental scale (Eva et al 2010; Margono et al 2012). Our concerns on peatland forest conservation in West Kalimantan led us to study the impact of forest degradation and revealed the facts of peatland tree biodiversity influenced by the anthropological degradation. These results acknowledge and clarify exact impacts of forest degradation (even though this area was practiced by low impact logging before) to the future peatland forest structure and species composition.

Forest structure is related to physical arrangement, intermixing size and composition distribution and other components in the forest that are related to ecological function and processes that also encompasses species composition and basal area (McElhinney et al. 2005; Husch et al. 2002; Hansen et al. 2001). Results show that forest degradation altered forest tree density and forest basal area per hectare although this forest has been abandoned for about 10 years. The density of larger trees was decreased, while younger/smaller trees were increased when the degradation level rose. This result supported our previous finding in peatland forest of Kubu Raya West Kalimantan (Astiani 2014). Reducing larger trees in higher level of degradation, gave more opportunity to younger trees due to optimal gap size produced (Curran et al. 1999). Prescott et al. (2003) and Denslow et al. 1998 mentioned that large gap size enhance N mineralization and phosphorus availability that elevate their concentration available N and P for enhancing tree growth. Increasing canopy gap size has been shown to impart greater microclimate change on in the forest floor (Asbjornsen et al. 2004; Proe et al. 2001; Barton et al. 1989). These results imply that in tropical peatlands, forest degradation and land cover change-with corresponding alterations of soil microclimate (e.g., temperature, CO<sub>2</sub>, light, humidity)-will influence forest growth and dynamics.

The shifts also occurred on species composition. Species diversity was reduced when forest degradation increased. Moreover, some new species found their new sites in highly degraded forest. Although all those forest cover levels have relatively high in diversity, the species diversity shiftings are circumstances which need to be considered. The alteration of tree species composition could permanently cause the extinction of several important tree species along the peatland landscape. This post-logging dynamic in high degraded forest diminished more than one third species previously present in low degraded one. Most of species lost were high economic and conservation value timber/wood when logged, leaving less valuable tree species in high degraded forest. In term of tree species conservation, a lot of important tree species in tropical peatland (e.g., *Gonystylus bancanus*, *Shorea belangeran*, *Shorea teijsmanniana*, *Pouteria* spp., *Palaquium* spp. etc.) could be endangered when forest degradation continued.

**Table 1.** Species composition and tree density among forest degradation levels in peatland of Ketapang, West Kalimantan, Indonesia

Species	Local name	Tree density/Ha		
		Low	Intermediate	High
<i>Actinodaphne sphaerocarpa</i> (Bl.) Nees.	MedangAsam	0.6	1	0
<i>Adenantha pavonina</i> Lam.	Empahong	0	1	0
<i>Aglaia rubiginosa</i> Blume.	Parak	0.6	1	0
<i>Alangium longiflorum</i> Merr.	Mengkapas	11.1	0	1.7
<i>Alangium</i> sp.	Mengkapas	0.6	0	0.8
<i>Alseodaphne coreasea</i> Nees	Medang Pasir	0	0	0.8
<i>Alstonia spatulata</i> Blume	Pelaik Pipit	2.8	0	0
<i>Blumeodendron takbrai</i> (Blume) Kurz	Mengkajang	0.6	0	0
<i>Buchaniana arborescens</i> Blume	Mate udang	2.8	0	0
<i>Calophyllum hosei</i> Ridley	Bintangur	5.6	4.5	0
<i>Calophyllum inophyllum</i> Lam.	Mentepis	0	2.5	4.2
<i>Calophyllum schlerophyllum</i> Lam.	Bintangor	0.6	0	0
<i>Camnosperma squamatum</i> Ridl.	Terentang Putih	2.2	0	0
<i>Cantleya corniculata</i> (Becc) Howard.	Bedaru	8.3	4	0.8
<i>Choriophyllum malayanum</i> Bth..	Ubah Merah	0	0.5	0.8
<i>Cratoxylum glaucum</i> Korth.	Gerunggang	2.2	1	0.8
<i>Cyathocalyx biovulatus</i> Boerl	Mengkasai	0	0	2.5
<i>Dactylocladus stenotachys</i> Oliv.	Mentibu	8.3	0.5	0.8
<i>Dillenia pulchella</i> (Jack) Gilg.	Simpur Laki	1.1	1.5	0
<i>Diospyros bantamensis</i> Kds.et Val. ex Bakh.	Kayu Malam dl	0	3	0
<i>Diospyros maingayi</i> (Hiern.) Bakh.	Kayu Malam	1.1	1	0
<i>Dipterocarpus bornensis</i> Slooten.	Keruing Paya	0	0	0.8
<i>Durio carinatus</i> (Mast).	Durian Burung	0.6	0	1.7
<i>Dyera costulata</i> Hook.f.	Jelutung	3.9	1	0.8
<i>Elaeocarpus mastersii</i> King	Mentanang	0.6	0	0
<i>Elaeocarpus griffithii</i> A. Gray	Mempening	1.7	1.5	0.8
<i>Elaeocarpus petiolatus</i> (Jack) Wallich ex Steudel.	Pangal	2.2	2	0.8
<i>Elaeocarpus</i> sp.	Mencubok	0	1.5	0
<i>Eugenia cerina</i> Endl	Gelam Tikus	0	1.5	0.8
<i>Eugenia spicata</i> Lam.	Ubah	11.1	1	0
<i>Eugenia</i> sp.	Kelempit	0	0	0.8
<i>Ganua mottleyana</i> Pierre ex Dubard	Ketiau	1.7	0.5	0
<i>Garcinia cf. bancana</i> Miq.	Manggis Hutan	0	0.5	0.8
<i>Garcinia parvifolia</i> (Miq.) Miq.	Asam Kandis	1.7	2.5	0
<i>Gluta wallichii</i> (Hook.f.) Ding Hou	Meransing	0	1	0
<i>Gonystylus bancanus</i> (Miq.) Kurz	Ramin	3.9	0.5	0.8
<i>Gonystylus hankenbergii</i> Diels.	Ramin Buaya	0.6	0	0
<i>Gymnacranthera contracta</i> Warb.	Kumpang perawe	0	9	0
<i>Gymnacranthera</i> sp.	Kumpang	2.8	0.5	3.3
<i>Ilex cymosa</i> Blume	Mensire	0	1	0
<i>Ilex cf hypoglauca</i> (Mig.) Loes.	Rawe Aek	1.7	0	0
<i>Knema cinerea</i> Warb.	Mendarahan1	1.1	0	0
<i>Knema kunleri</i> Warb.	Mendarahan 2	1.1	0	0
<i>Koompasia malaccensis</i> (Maingay) Benth.	Kempas	4.4	0.5	3.3
<i>Litsea elliptica</i> Blume.	Medang sp.1	0.6	0	0
<i>Litsea gracilipes</i> Hook.f.	Medang Lendir	0.6	0	0
<i>Litsea grandis</i> 1 (Wall ex Nees) Hook.f.	Medang Kelincir	0.6	0	0
<i>Litsea nidularis</i> Gamble	Medang Keladi	2.2	0	0
<i>Litsea resinosa</i> Blume	Medang Perawas	0.6	0	0
<i>Litsea rufo-fusca</i> Kosterm.	Medang sp2	0	0	0.8
<i>Litsea</i> sp.	Medang kunyit	1.1	0	0
<i>Litsea turfosa</i> Kosterm.	Medang mali	0	0.5	0
<i>Macaranga caladiifolia</i> Beccari	Garung	0	1	0
<i>Macaranga pruinosa</i> (Miq.) Muell. Arg.	Mahang	0	1	0
<i>Madhuca mottleyana</i> (de Vr.) Baeh.	Nyatoh Ketiau	2.2	0	2.5
<i>Magnolia bintulensis</i> (A. Agostini) Noot.)	Medang limau	2.2	0.5	0
<i>Magnolia</i> sp.	Medang Kuning	0.6	0	0.8
<i>Mangifera longipetiolata</i> King.	Rerawe Babi	0	5	0
<i>Mangifera swintonioides</i> Kosterm.	Kelentit Nyamuk	3.3	9.5	0
<i>Mezzetia leptopada</i> Hk. f. & Th.	Keminting d kecil	1.1	0	0
<i>Mezzetia parviflora</i> Becc.	Mempisang	1.7	1	1.7
<i>Mezzetia umbelata</i> Becc.	Keminting d besar	1.1	0	0

<i>Nageia wallichiana</i> (Presl.) O.K.	Kayu Cin	4.4	0	0
<i>Neoscortechinia kingii</i> King	Ilas	0	0.5	1.7
<i>Nephelium maingayi</i> Hiern	Rambutan Hutan	2.2	0.5	0
<i>Notaphoebe umbeliflora</i> Blume	Medang Bulu	0	0.5	0
<i>Palaquium coclearifolium</i> Boerl.	Nyatoh dl	23.9	1.5	0
<i>Palaquium lanceolata</i> Blanco	Nyatoh dk	0	0.5	0
<i>Palaquium leicocarpum</i> Boerl.	Nyatoh Cermai	0.6	0	0
<i>Palaquium pseudorostratum</i> H.J.Lam	Nyatoh Punjok	22.8	1	0
<i>Palaquium ridleyi</i> King & Gamble	Nyatoh Beras /Banir	7.2	8.5	1.6
<i>Palaquium ridleyi</i> King & Gamble	Nyatoh Beras	14.4	1	0
<i>Palaquium xanthochynum</i> Pierre.	Nyatoh Babi	11.7	4.5	0
<i>Parkia singularis</i> Miq. subsp. <i>borneensis</i>	Petai Hutan	1.1	0.5	1.7
<i>Ploiarium alternatifolium</i> (Vahl) Melch.	Jonger	2.8	46	0
<i>Polyalthia glauca</i> (Hassk.) Boerl.	Keminting Hutan	6.1	3	3.3
<i>Polyalthia sumatrana</i> (Miq.) Kurz.	Unang-unang	1.7	7.5	0
<i>Pometia pinnata</i> J.R. & G. Forst.	Kasai	0.6	1.5	0
<i>Porterandiaanisophylla</i> (Jack ex Roxb.) Ridl	Leban Paya	5.6	6	2.5
<i>Pouteria malaccensis</i> (Clarke) Baehni	Nyatoh Jungkang	40.6	0.5	22.5
<i>Pouteria obovata</i> (R.Br.) Baehni	Nyatoh duduk	3.4	0.5	0
<i>Pternandra galeata</i> (Korth.) Ridl.	Meransik	2.8	0	0.8
<i>Santiria laevigata</i> Blume forma <i>glabrifolia</i> H.J.Lam	Asam Rawe	0	0	0.8
<i>Shorea belangeran</i> (Korth.) Burck.	Belangir	0.6	0	0
<i>Shorea parvifolia</i> Dyer.	Meranti	0	1.5	0
<i>Shorea parvistipulata</i> Heim.	Meranti Rawa	0.6	0	1.7
<i>Shorea teijsmanniana</i> Dyer ex Brandis	Meranti Batu	0	1	0
<i>Shorea uliginosa</i> Foxw	Meranti Bunga	0	3	0
<i>Sindora leiocarpa</i> Backer ex K. Heyne	Sindur	1.1	0	0
<i>Sonneratia alba</i> Seem.	Perepat	21.1	0.5	0.8
<i>Stemonurus scorpioides</i> Becc.	Mempasir dl	0.6	1	0.8
<i>Stemonurus secundiflorus</i> Blume	Mempasir dk	1.7	0.5	1.7
<i>Sterculia lychnophora</i> Hance	Semangkok	3.9	2	0
<i>Syzygium havilandii</i> (Merr.) Merr. & L.M.Perry	Ubah Bentan	3.9	0.5	0
<i>Syzygium lineatum</i> (DC.) Merr. & L.M. Perry	Ubah Jangkar	0.6	0	0
<i>Syzygium</i> sp.	Ubah Bunga	0	4	0
<i>Syzygium zollingerianum</i> (Miq.) Ams.	Ubah Jambu	0.6	0	0.8
<i>Tabernaemontana macrocarpa</i> Jack	Bintik	1.7	2	3.3
<i>Tetractomia tetrandra</i> Craib.	Ubah Putih	5	1.5	0.8
<i>Tetramerista glabra</i> Miq.	Punak	7.2	0.5	0.8
<i>Teysmaniadendron</i> sp.	Nyatoh sp.1	6.1	5.5	1.7
<i>Tristaniopsis cf merguensis</i> (Griff.) Peter G.Wilson & J.T.Waterh.	Pelawan	1.1	0	1.7
<i>Vatica mangapachoi</i> Blanco	Resak	0.6	0	0.8
<i>Vitex secundiflora</i> Hallier f.	Leban Tikus	5	0.5	8.3
<i>Xanthophyllum ellipticum</i> Korth. ex Miq.	Menjalin	1.1	0.5	0
<i>Xylopiya coryfolia</i> (Griseb.) King & Robins.	Angin-angin	0	0.5	0
<i>Xylopiya fusca</i> Maingay ex Hook. f. & Thomson	Bahang	0	1	0

Furthermore, there are numerous hydrological and ecological functions of tropical peatlands ranging from regulation of water flow to providing refuge for endangered animal species (Rieley and Page 2005). The increasing scarcity of available resources in mineral soils, advanced land conversion technology and continuously rising demand for forest and agricultural products have led to a rapid increase in peatland conversion and degradation. Escalating rates of logging, drainage, fires, conversion to plantations and expansion of small-holder dominated mosaic landscape have occurred since the 1980s and continued until recent time. These activities disturb ecosystem functions invariably, both directly because of altering forest dynamics, reduction of living biomass and acceleration in peat oxidation (Hooijer et al. 2006, 2010; Couwenberg et al. 2010) and indirectly by making the ecosystems more vulnerable to yearly fire activity (Siegert

et al. 2001; Page et al. 2002). The species composition and abundance shifting due to forest degradation should be considered on peatland forest management to hinder permanent species loss.

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