Chapter 11
Floristic Diversity in the Peatland Ecosystems of Central Kalimantan

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Abstract Tropical peatlands have accumulated huge amounts of carbon. However, the carbon pool is presently disturbed by land utilization practices, and consequently it is becoming vulnerable to the effects of the changes. Tropical peatlands present a threat if they switch from being carbon sinks to carbon sources for the atmosphere. In the present state they provide a number of ecosystem services, such as biodiversity, habitat maintenance, water cycling, and commodities for exploitation. Tree diversity in the peatland forests of various study sites in Central Kalimantan are described here. In the Sebangau, Bawan, and Hampangen villages, the trees species were only 42.5 % of the total number of tree species found in the peatland forest. The estimates of above-ground biomass was about 331 t ha^{-1}, and the litterfall around 6.5–9.1 t ha^{-1} $year^{-1}$. The litterfall varied among locations, different in the degraded and intact peatland forests, and the nitrogen and carbon input of litterfall in these peatland forest types were 39.1 and 2,724 kg ha^{-1} $year^{-1}$, respectively.

Keywords Above ground biomass • Central Kalimantan • Litterfall • Peatland forest

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11.1 Introduction

About 83 % of the South East Asian tropical peat lands are found in Indonesia (wetland http://www.wetlands.org/TabId=2739&AlbumID=11455-88). Indonesia has the largest area of peatland forests in the tropics, covering an estimated 20.7 Mha (range 16–27 Mha) (Radjaguguk 1992; Rieley et al. 1996) and distributed mainly across Sumatra (4.7–9.7 Mha), Kalimantan (3.1–6.3 Mha), and Papua (8.9 Mha) (Silvius 1989; Rieley et al. 1996). Peatland forests occur in waterlogged soils, which prevent dead leaves and wood from full decomposition, and which over time creates thick layers of acidic peat. The water of peatland forests is dark brown due to the large amounts of tannins that leach from the fallen leaves. Peat is mainly fibrous with low ash and mineral contents, and nutrient content commonly decreases from top to base of the acidic peat and the pH is below 4.0 (Haraguchi et al. 2000). Peatland forests are a unique and important wetland ecosystem, but they are also fragile and sensitive to large changes when developed.

About 258,650 higher plants have been recorded worldwide, and an estimated 13–15 % of these are found in Indonesia (35,000–40,000 species). At least 5,575 higher plant species have been found in Kalimantan, including 71 lichens, 376 mosses, 235 fungi, and other families (Anonim 2011). In Borneo there are around 927 species of flowering plants and ferns, while in Peninsular Malesia there are 260 (http://en.wikipedia.org/wiki/Borneo_peat_swamp_forests). In Sebangau (Central Kalimantan), 808 plants species were reported by the WWF (personal communication, 2006). Sebangau peatland forests are mainly composed of Dipterocarpaceae, Clusiaceae, Myrtaceae, and Sapotaceae (Mirmanto 2010).

Peatland forests in Borneo have been studied for the tree species found there, DOC (Dissolved Organic Carbon), biomass, and carbon content (Saribi and Riswan 1997; Page et al. 1999; Siregar and Sambas 2000; Nishimura et al. 2007; Miyamoto et al. 2007; Ludang and Jaya 2007; Rahajoe 2003). However, the biodiversity of the peatland forests needs to be explored due to the fast rate of degradation.

Forest fires is one factor in forest degradation in Kalimantan. At the end of the extremely dry season in 1997 (caused by an ENSO event), the historically largest fires broke out in almost all forest types in Kalimantan and Sumatra Islands. Forest fires have a very large impact on tropical forest ecosystems and biodiversity (Barber and Schweithelm 2000). The estimated extent of fires during 1997–1998 in Kalimantan were 75,000 ha of peatland forest, 2,375,000 ha of lowland forest, 2,829,000 ha of agricultural land, 116,000 ha of timber plantations, 55,000 ha of estate crops, and 375,000 ha of dry scrub, and grasslands for a total of 6,500,000 ha (Bappenas 1999). Frequent forest fires occurred during the past 10 years, and repeated cycles of burning have transformed forests completely into grass or scrubland. In a study of the effect of forest fires on biodiversity, about 90 % of 240 trees died in a 1.6-ha permanent plot (Whitmore 1984).

Land-use changes may be among the most important factors which significantly affect ecosystem processes and services, since land use change potentially alters, either positively or negatively, the available net primary production area. However,

monitoring and projecting the impacts of such land-use changes are difficult because of the large volume of data and the interpretation required as well as the lack of information about the contribution of alternative landscapes to these effects. It has been predicted that in the future, land use change is likely to occur predominantly in the tropics, associated with decreases in net primary productivity and increases in surface temperatures (DeFries and Bounoua 2004). In addition, land-use changes are mainly driven by agricultural expansion and deforestation (DeFries et al. 1999).

Kalimantan is the biggest island in Indonesia, and peatland forests mainly occur in Central Kalimantan. Palangkaraya is the capital of Central Kalimantan province, covering 153,800 km^2, with more then 80 % of the area covered with dense jungle, while swamps, rivers, and lakes take up approximately 2 % and agricultural land about 3 % of the area (http://www.borneotourgigant.com/Central_Kalimantan_Introduction.html).

Two habitat types found in Central Kalimantan are heath forests and peat-swamp forests, and these each cover over 10 % of the lowlands of Kalimantan. Heath forests develop on white sandy soils and are called "Kerangas", very similar to forests growing on white sand in Neotropical areas (areas south of the equator). Because of low water retention, sandy soils periodically cause severe desiccation of heath forests where the saplings have deep root systems enabling them to endure the dry season however. Peat-swamp forests develop over waterlogged low areas along rivers, where the high water table in the rainy season prevents dead trees from decomposition. In high latitude regions, peat is mainly composed of undecomposed herbaceous plants, and develop due to high water contents and low temperatures.

Almost four-fifths of Central Kalimantan is made up of tropical forests, producing valuable commodities such as rattan, resin, and wood of many kinds. Palangkaraya is located on the upstream regions of the Kahayan River, and covers an area of about 2,400 km^2. Plantations cover 3,139,000 ha growing palm-oil, rubber, rattan, coffee, cocoa, and coconuts. Food crops cover an area of 5,980,750 ha of paddy, cassava, pineapples, corn, bananas, rambutan, and cempedak (a locally growing fruit tree). The annual mean temperature varies between 26.8 and 28.1 °C. The lowest annual rainfall was recorded in 1996, 2001, and 2004, while the highest annual temperature was recorded in 1998, a year after the biggest forest fires ever broke out in Central Kalimantan.

11.2 Tree Species in the Peatland Forests of Central Kalimantan

The natural vegetation of an area is dictated by a combination of several factors: topography, altitude, geology, soils, climate, and water supply. Kalimantan lies on the equator in a region experiencing high temperatures throughout the year and is within the wettest parts of Indonesia. These conditions and its geological history have resulted in high species diversity. Kalimantan supports of the largest areas of

tropical rainforests in Southeast Asia, providing the most species-rich habitat of this region. Long monitoring and field surveys of tree diversity in peatland forests have mainly focused on Central Kalimantan.

A total of 927 species of flowering plants and ferns have been recorded in the peatland forests (Yule 2010). A decade of research in the peatland forest, recorded 103, 73, and 187 species in the Bawan, Hampangen, and Sebangau Villages, respectively (Rahajoe 2003; Anonim 2010). Tree species numbers were lower than the number of species that were recorded in the Sebangau peatland. The total of plant species that were recorded in Sebangau, Bawan, and Hampangen were about 426 (Annex 1). This number is only 42.5 % of the total number of plant species in the peatland forests of Kalimantan. The data from our study site reported 61 species found in the heath forests of Lahei Village, and 22 species in the heath and peatland forests.

Locations were selected for monitoring the biodiversity, biomass estimates, and carbon stock and these included the Sebangau, Bawan, Hampangen, Lahei, and Klampangan peatland forests. The forest that was monitored was described as comprising intact and degraded peatland forests, based on the tree species dominance and from the history of the location based the information of the villagers in surrounding areas.

The density of trees with GBH (Girth at Breast Height) ≥15 cm were between 1,475 and 3,809 ha^{-1}, the basal area ranging from 25.1 to 45.5 m^2 ha^{-1}, and the number of tree species 69–134 in the Peatland forests (Suzuki et al. 1998; Simbolon and Mirmanto 2000; Miyamoto et al. 2007; Mirmanto 2010) and our study site in Central Kalimantan (Table 11.1). The species dominance varied among the locations and were *Combretocarpus rotundatus* and *Cratoxylum glaucum* in the peatland forests after forest fires or in degraded peatland forests such as in the Klampangan and Hampangen villages, while in the intact peatland forests the dominant species were *Palaquium leiocarpum* and *Vatica oblongifolia* in the Sebangau and Lahei Villages, respectively. Suzuki et al. (1998) and Nishimura and Suzuki (2001), reported that the forest community (for trees ≥15 cm trunk girth) consisted of 69 species and was dominated by *Vatica oblongivolia* Hook f. ssp. *oblongifolia* Ashton, *Buchanania sessilifolia* Blume, and *Gluta rugulosa* Ding Hou in the Lahei peatland forest. This peatland forest consisted of some large trees where trunk diameters reached 100.2 cm with the tallest trees 30 m high. The density of trees with GBH ≥15 cm in the forest community was 1,475 ha^{-1}, and the basal area was 45.5 m^2 ha^{-1}.

The Klampangan peatland forest was dominated by: *Combretocarpus rotundatus, Palaquium cochlorifolium, Cratoxylum glaucum*, *Callophyllum canum,* and *Ctenolophon parvifolius* and this forest was degraded due to establishment of a man made canal and wildfires in 1997 and 2002 (Table 11.1). After the forest fires of 2002, the dominant species were: *C. rotundatus, C. arborescens, Palaquium gutta, Shorea teysmaniana* and *Syzygium ochneocarpum*. Of 1,158 individuals; 1,102 individuals had grown after the wildfires, while the remaining 56 individuals were pre-fire trees that had survived the wildfires of December 1997, they mostly belong to: *C. canum, C. rotundatus, Dyera lowii, and P. gutta* (Simbolon 2004). In September 2002, wildfires burnt all trees for the second time, only two individuals,

Table 11.1 Data of field studies in the peatland and heath forests of Central Kalimantan

Locations	GBH ≥15 cm ($ha^{-1)}$	Basal area (m^2 ha^{-1})	Number of species	Dominant species
Heath forest[d]	1982	27.6	122	1. *Calophyllum pulcherrimum*
				2. *Tristaniopsis obovata*
				3. *Palaquium leiocarpum*
Heath forest (Bawan Village)[d]	2207	30.32	49	1. *Calophyllum elegans* Ridley
				2. *Hopea ferruginea* Parijs
				3. *Ternstroemia aneura* Miq.
Peatland forest (Lahei)[a]	1475	45.5	69	1. *Vatica oblongifolia* ssp. *oblongifolia*
				2. *Buchanania sessilifolia*
				3. *Gluta rugulosa*
Peatland forest (Klampangan)[b]	3014	33.2	88	1. *Combretocarpus rotundatus*
				2. *Calophyllum canum*
				3. *Cratoxylum glaucum*
Peatland forest Sebangau[c]	2689	31.5	103	1. *Palaquium leiocarpum*
				2. *Combretocarpus rotundatus*
				3. *Eugenia catnaneum*
Peatland forest (Hampangen)[d]	3809	25.1	134	1. *Cratoxylum glaucum* Korth
				2. *Garcinia rigida* Miq.
				3. *Nephelium ramboutan-ake* Leenh

Note: [a]Suzuki (1998); [b]Simbolon (2004); [c]Mirmanto (2010). [d]field study (unpublished data) in note

Table 11.2 Tree inventories (GBH ≥15 cm) in the sampling of peat and heath forests, Central Kalimantan, Indonesia

Variable	Hampangen (peat forest)	Bawan (heath forest)
Species richness	14.9	40.1
Diversity indices		
(a) Shannon-Wiener (H)	1.4	1.6
(b) Simpson (D)	16.4	16.5
(c) Evenness (E)	0.8	0.7
Stem density	3,809 tree ha^{-1}	2,207 tree ha^{-1}
Stand basal area	25.18 m^2 ha^{-1}	30.32 m^2 ha^{-1}

both *D. Lowii,* were still standing and producing new leaves in August 2004, and both these individuals had also survived the first wildfires. In August 2004 or about 2 years after the second round of wildfires the floor of the peatland after the second year of wildfires was covered by 12 species of herbs and seedlings, which were mainly the ferns *Stenochlaena palustris* (Burm.f.) Bedd. and *Blechnum indicum*. Species richness and diversity indices of peat forest in Hampangen and heath forest in Bawan area was found in Table 11.2.

In Hampangen, the altitude is 50 m above sea level (asl) in the secondary peatland forest. Forest fires have burned through this forest, and the area will be developed into an oil palm plantation. The rate of plant population growth and species composition establishment is rapid in the early phase of a succession, and then decline. The rate of plant population growth and change in species composition in the next stage are affected by environmental factors and are not suitable to support the survival of certain species in the regeneration (Marsono and Sastrosumarto 1981 in Irwanto 2006).

11.2.1 Species Composition

The waterlogged condition, the high level of acidity and organic materials, the low input of nutrients, and the lack of soil or firm ground in peatland forests have resulted in different forest structures. In one of our permanent plots in Bawan village, the trees were dominated by 53 pioneer species, with small diameters and high tree density per hectare. The sampling plot was dominated by species of *Cratoxylum glaucum* and *Garcinia rigida*. Both species had higher relative densities (RD) than other species (>10) and *C. glaucum* is often found to be dominant in the peat of burned forests. Other species are also widely encountered including *Syzygium garcinifolium*, *S. moultonii*, and *Nephelium ramboutan-ake*, as shown in the Table 11.3.

The high density also directly affects the high basal area of a species, to result in high relative coverage (RC). The Importance value (IV) of both types showed that all three variables, basal area, presence in a subplot, and density were high for both dominant species. This also indicates that those species are able to compete well in utilizing water resources, nutrients, and growing space. A dominant species is a species that can utilize the environmental factors more efficiently than other species in the same place (Smith 1977), giving it higher productivity (Odum 1971). Some species typical of peatland forests was found in the sampling plot, *Palaquium rostratum*, *P. ridleyii*, *P. leiocarpum*, *Tetramerista glabra*, *Camnosperma auriculatum,* and *Dyera costulata*.

In Bawan village, there are around 135 species with trees generally shorter and smaller than those of lowland mixed dipterocarp forests, and the characteristics of the type of forest detailed by Whitmore (1984) and Kartawinata (1980). This forest also had a low, uniform and single layer canopy formed by the crowns of large saplings and thin stems Although only a low number of individual trees was observed, the basal area and species composition in the area was slightly larger than in peat areas (Table 11.4), indicating that some trees had large gbh values (girth at breast height), >110 cm, these included *Dipterocarpus borneensis*, *Shorea teysmaniana*, *S. rugosa*, *S. brunnescens,* and *Hopea ferruginea*. The in heath forests the genera of *Shorea*, *Hopea,* and *Tristaniopsis* were also found (Whitmore 1984).

Table 11.3 List of the 30 most common species in the tree inventories (GBH ≥15 cm) in the sampling plot of peat forest in Hampangen, Central Kalimantan, Indonesia

No	Species name	RC	RF	RD	IV
1	*Cratoxylum glaucum* Korth	18.4	6.2	14.3	38.9
2	*Garcinia rigida* Miq.	15.1	6.6	11.2	33.0
3	*Nephelium ramboutan-ake* Leenh.	5.0	5.5	5.9	16.3
4	*Syzygium garcinifolium* (King.) Merr. & Perry	3.6	5.6	6.9	16.1
5	*Horsfieldia crassifolia* (HK.f.etsh) Warb.	4.9	5.7	5.1	15.8
6	*Lhitocarpus leptogyne* (Korth.) Hatusima	4.9	5.1	5.3	15.4
7	*Palaqium rostratum* Burck.	6.8	3.3	4.9	15.0
8	*Syzygium moultonii* Merr.n.sp	3.2	5.3	6.1	14.5
9	*Combretocarpus rotundatus* (Miq) Danser	6.4	2.6	3.1	12.1
10	*Shorea teysmaniana* Dyer.	3.5	3.5	3.1	10.0
11	*Acronychia porteri* Hook.f.	2.1	4.0	3.9	10.0
12	*Tetramerista glabra* Miq.	3.4	3.4	2.2	8.9
13	*Palaquium ridleyii* K.& G.	2.6	3.5	2.8	8.9
14	*Tristaniopsis merguensis* (Griff.) P G.Willson	1.6	2.9	3.1	7.5
15	*Bouea oppositifolia* (Roxb.) Meisn	1.9	2.9	2.6	7.4
16	*Syzygium creaghii* (Ridl.) Merr & Perry	1.1	2.9	2.3	6.3
17	*Xylopia fusca* Maing.	1.5	2.4	1.4	5.3
18	*Camnosperma auriculatum* (Bl) Hook.f.	1.6	1.9	1.4	5.0
19	*Palaquium leiocarpum* Boerl.	1.7	1.9	1.2	4.8
20	*Syzygium valdevenosa* Duhie	1.4	2.2	1.1	4.7
21	*Ilex* cf *hypoglauca* (Mig.) Loes.	0.9	2.0	1.7	4.7
22	*Calophyllum canuum*	0.9	1.9	1.3	4.1
23	*Garcinia* sp.	0.5	2.2	1.1	3.8
24	*Disepalum coronatum* Beccarii	1.1	1.8	0.9	3.7
25	*Sterculia coccinea* Jack.	0.5	1.9	1.0	3.3
26	*Dalbergia ferruginea*	1.1	1.3	0.7	3.1
27	*Neonauclea calycina* (Korth) Merr.	0.3	1.3	0.7	2.3
28	*Diospyros polyalthoides* Korth.ex Hieron	0.3	1.2	0.6	2.1
29	*Tristaniopsis whitiana* (Griff.) P G.Willson	0.3	1.2	0.6	2.1
30	*Dyera costulata* Hook.f	0.6	0.9	0.5	2.0

Note: RC, RF, RD, and IV are respectively, relative coverage, relative frequency, relative density, and importance value

The sampling plot was dominated by the species *Calophyllum elegans* followed by *H. ferruginea*, *Ternstroemia aneura,* and *Calophyllum calcicola*. The dominant tree species had high IV, larger than 15, indicating that those species are crucial in an ecosystem (Heriyanto 2004).

The basic study of ecosystem services and the biodiversity survey recorded that 12 species of timbers and 14 medicinal plants were commonly used by the local inhabitants before 1960s in the Bawan Village. The survey among Bawan villagers

Table 11.4 List of the 30 most common species in tree inventories (GBH ≥15 cm) in the sampling plot of a heath forest in Bawan, Central Kalimantan, Indonesia

No	Species name	RC	RF	RD	IV
1	*Calophyllum elegans* Ridley	9.6	7.1	18.5	35.2
2	*Hopea ferruginea* Parijs	6.1	5.7	9.5	21.3
3	*Ternstroemia aneura* Miq.	5.2	5.5	6.9	17.6
4	*Calophyllum calcicola* P.F. Stevens	7.3	3.1	5.8	16.2
5	*Shorea rugosa* Heim.	8.9	3.6	2.6	15.0
6	*Baccaurea javanica* (BL) Muell Arg.	2.2	5.3	3.9	11.5
7	*Mangifera swintonioides* Kosterm.	2.9	3.5	3.5	9.9
8	*Neoscortechinia kingii* (Hook.f.) Pax.	3.9	3.1	2.6	9.6
9	*Dipterocarpus elongatus* Korth.	6.3	1.7	1.1	9.0
10	*Tristaniopsis obovata* (Benn.)	3.4	2.1	1.9	7.4
11	*Shorea brunnescens* Ashton.	5.1	1.3	0.9	7.3
12	*Stemonurus secundiflorus* Bl.	2.3	2.5	2.4	7.2
13	*Kayea borneensis* P.F. Stevens	3.2	1.8	1.6	6.7
14	*Gluta wallichii* (Hook. f) Ding Hou.	2.5	2.3	1.5	6.4
15	*Shorea* cf. *faquetiana* Heim.	2.7	1.5	1.5	5.7
16	*Syzygium ochneocarpa* Merr.	0.7	2.4	2.4	5.6
17	*Shorea atrinervosa* Sym.	1.0	1.9	2.2	5.1
18	*Ilex cymosa* Bl.	1.1	1.8	1.7	4.6
19	*Garcinia nitida* Pierre	0.9	2.0	1.6	4.5
20	*Parastemon urophyllus* A. DC.	1.2	1.6	1.6	4.4
21	*Lithocarpus dasystachyus* Miq.) Rehd.	1.0	1.8	1.2	4.1
22	*Syzygium cerinum* (M.R.Hend.)	0.4	1.8	1.5	3.7
23	*Croton oblongus* Burm.f.	1.1	1.3	1.0	3.5
24	*Diospyros curaniopsis* Bakh.	0.4	1.8	1.4	3.5
25	*Elaeocarpus petiolosus*	1.5	0.9	0.7	3.1
26	*Plectronia glabra* Kurz.	0.3	1.4	0.9	2.6
27	*Ilex macrophylla* wall. Ex hook. f.	0.7	1.1	0.8	2.6
28	*Calophyllum venulosum* Zoll.	0.3	1.1	0.9	2.3
29	*Syzygium* sp.	0.8	0.8	0.6	2.2
30	*Santiria laevigata* Bl.	0.4	1.0	0.8	2.2

Note: RC, RF, RD and IV are respectively, relative coverage, relative frequency, relative density, and importance value

showed that since 2006 only six kinds of timber trees and four medicinal plants were commonly found in the forest. The population of major timber species Benuas and Meranti of the *Shorea* timber group) declined after the 1960s. This tendency was also found for medicinal plants.

11.3 Nutrients in the Peatland Forest

Ecosystem services are the conditions and processes through which natural ecosystems and the species sustain and assist in human life. They represent the multiple benefits human beings can obtain, either directly or indirectly, from the available ecosystem functions (Daily 1997). Many of these are very crucial to human survival (food and fiber, watershed protection, climate modulation, nutrient cycling, and habitats for plants and animals). Economic evaluations of ecosystem services are becoming increasingly important to understand the multiple benefits provided by ecosystems (Guo et al. 2001).

Nutrient cycling in forests involves a complex set of direct and indirect feedback mechanisms between soil and vegetation. Tropical forest ecosystems are characterized by high primary production and rapid decomposition rates of organic matter (Jordan 1985). The nutrient input and output of the ecosystem of the peatland discussed here are shown in Table 11.5, with a total biomass of about 351.9 t ha^{-1} from the accumulation of the aboveground biomass, litterfall, and the litter on the forest floor. This value is higher than in the heath forest.

The liter fall in the tropical forest varied among the ecosystems. The litterfall ranges from 3.1 to 15.3 t ha^{-1} $year^{-1}$ (Vitousek 1984). The litterfall in temperate forest is 3.1–3.8 t ha^{-1} $year^{-1}$ (Vogt et al. 1986). In Borneo it was reported to range from 5.7 to 12.0 t ha^{-1} $year^{-1}$ and the lowest litterfall was reported for heath forests (Moran et al. 2000). While in the degraded and intact peatland forests in Lahei and Klampangan Villages, the litterfall were recorded as around 6.5 and 9.1 t ha^{-1} $year^{-1}$ respectively (Rahajoe 2003). This was reflected by the high contribution of the leaf litter of the dominant species, such as *Combretocarpus rotundatus* and *Cratoxylum glaucum*, their leaves were accumulated during the rainy season.

Litter biomass on the forest floor was high in peatland forests, here the higher canopy mass of peatland forests resulted in a greater accumulation of litter on the forest floor, due to the low rate of decomposition in peatland forests (Table 11.5). This suggests that the nutrient cycling is slower in peatland forests.

Table 11.5 Biomass inputs and outputs in heath and peatland forests

Components	Heath forest	Peatland forest
Biomass (t ha^{-1})	232[b]	336[b]
Canopy leaf mass (t ha^{-1})	5.9[a]	12.0[a]
Annual litterfall (t ha^{-1} $year^{-1}$)	6.2[a]	9.1[a]
Annual leaf litterfall (t ha^{-1} $year^{-1}$)	3.4[a]	5.9[a]
Litter in the forest floor (t ha^{-1})	7.5[a]	6.8[a]
Leaf turnover rate ($year^{-1}$)	0.5[a]	0.8[a]
Total biomass	245.7[a]	351.9[a]

Note: [a]Rahajoe (2003)
[b]Based on allometric equation for both forest types (Biomass = x $Diameter^{y}$; x and y represented as constant values)

Table 11.6 Estimated nitrogen and carbon supply from leaf litterfall (mean ± SE; n = 4)

	Heath forest		Peat forest[a]	
	N	C	N	C
Components	(kg ha^{-1} year^{-1})		(kg ha^{-1} year^{-1})	
Leaves >1 cm	20.6 ± 1.9	1537.0 ± 60.2	20.1 ± 0.9	1164.0 ± 41.8
Leaves <1 cm	0.8 ± 0.1	59.2 ± 6.5	0.4 ± 0.001	23.6 ± 3.0
Stem <2 cm	10.1 ± 2.4	853.2 ± 176.1	11.2 ± 1.5	788.4 ± 152.7
Reproductive parts	2.4 ± 0.7	128.1 ± 29.8	3.7 ± 0.6	139.2 ± 32.3
Others	3.4 ± 0.8	146.4 ± 23.7	2.8 ± 0.5	111.2 ± 25.9
Total	37.4 ± 5.2	2,724 ± 268	39.1 ± 1.3	2,227 ± 123

[a]The estimation of N and C in peatland forest based on the 10-month data excluding rainy season. Rahajoe (2003)

The decomposition and nutrient cycling occur rapidly in some tropical rain forests, but as the present study shows there are slow cycling environments in particular forest types. This is both due to the high concentration of lignin in the leaf litter of the dominant species and water logging of the humus layer as well as to the low amount of standing biomass of heath and peatland forests (Rahajoe 2003).

The total nitrogen supply from leaf litterfall was higher in peatland forests than in heath forests (39.1 ± 1.3 and 37.4 ± 5.2 kg ha^{-1} year^{-1} respectively) (Table 11.6). while the opposite was the case for carbon ($P < 0.01$) (2,227 ± 123 and 2,724 ± 268 kg ha^{-1} year^{-1} respectively). The nitrogen content of fallen litter was higher in peatland forests than in heath forests. The idea that heath forests are N-limited compared to peatland forests is consistent with the findings in other tropical forest types on white sand substrates (Cuevas and Medina 1986). The high level of nitrogen supply in peatland forests was due to the high rate of leaf litterfall, and also due to a high nitrogen concentration in the peatland forests (0.8–1.2 %). Although the nitrogen supply was high in peatland forests. the slow decomposition rate was a cause of the slow turnover of the nutrients. Therefore, even though a peatland forest is known as an ecosystem, this nutrient component (N) is not available for plant uptake. The carbon supply in forests was higher than in peatland forests, even though the litterfall was higher in the peatland forests, which is possibly because the carbon concentration of all litter components was higher in the heath forests than in the peatland forests (Rahajoe 2003). In the heath forest, the combination of low litter production and high decomposition may lead to a high rate of nutrient cycling.

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Annex 1

Plant species in the peatland forests in various locations in Central Kalimantan

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
1	*Acronychia pedunculata* (L.) Miq.	Rutaceae					√
2	*Acronychia porteri* Hook.f.	Rutaceae			√		
3	*Adenanthera malayana* Kosterm.	Fabaceae					√
4	*Adenanthera pavonina* L.	Fabaceae				√	
5	*Agathis borneensis* Warb.	Araucariaceae			√		
6	*Aglaia rubiginosa* (Hiern) Pannell	Meliaceae				√	
7	*Aglaia silvestris* (M.Roem) Merr.	Meliaceae		√			
8	*Aglaonema nitidum* (Jack) Kunth.	Araceae				√	
9	*Alseodaphne coriacea* Kosterm.	Lauraceae				√	√
10	*Alseodaphne glomerata*	Lauraceae				√	
11	*Alseodaphne* sp.2	Lauraceae					√
12	*Alyxia reinwardtii* Blume	Apocynaceae				√	
13	*Antidesma coriaceum* Tul.	Euphorbiaceae	√			√	
14	*Antidesma montanum* Blume	Euphorbiaceae				√	
15	*Appendicula* sp.4	Orchidaceae				√	
16	*Archidendron borneense* (Benth.) I.C.Nielsen	Fabaceae			√	√	
17	*Archidendron* sp.	Fabaceae					
18	***Ardisia oxyphylla* Wall. ex A.DC.**	Myrsinaceae	√				
19	***Ardisia sanguinolenta* Blume**	Myrsinaceae	√				
20	*Aromadendron nutans* Dandy	Magnoliaceae	√			√	
21	***Austrobuxus nitidus* Miq.**	Euphorbiaceae	√				

(continued)

(continued)

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
22	*Baccaurea bracteata* Müll.Arg.	Euphorbiaceae		√		√	√
23	*Baccaurea javanica* (Blume) Müll.Arg.	Euphorbiaceae	√	√			
24	*Baccaurea stipulata* J.J.Sm.	Euphorbiaceae				√	
25	***Baccaurea sumatrana* (Miq.) Müll.Arg.**	Euphorbiaceae	√				
26	*Blechnum indicum* Burm f.	Blechnaceae				√	
27	*Blumedendron tokbrai* (Blume) Kurz	Euphorbiaceae		√		√	
28	*Blumeodendron elateriospermum* J.J.Sm.	Euphorbiaceae				√	
29	*Bouea macrophylla* Griff.	Anacardiaceae				√	
30	*Bouea oppositifolia* (Roxb.) Adelb.	Anacardiaceae			√		
31	*Buchanania* sp.	Anacardiaceae					√
32	*Calophyllum elegans*	Clusiaceae	√				
33	*Calophyllum longiforum*	Clusiaceae	√				
34	*Calophyllum biflorum* M.R.Hend. & Wyatt-Sm.	Clusiaceae				√	
35	*Calophyllum calcicola* P.F. Stevens	Clusiaceae	√	√			
36	*Calophyllum canum* Hk.f.	Clusiaceae		√	√	√	
37	*Calophyllum confertum* P.F. Stevens	Clusiaceae	√				
38	*Calophyllum elegans* Ridl.	Clusiaceae		√			
39	*Calophyllum fragrans* Ridl.	Cluciaceae				√	
40	***Calophyllum gracilipes* Merr.**	Clusiaceae	√				
41	*Calophyllum hosei* Ridl.	Clusiaceae				√	
42	*Calophyllum inophyllum* L.	Clusiaceae				√	
43	***Calophyllum lanigerum* Miq.**	Clusiaceae	√				
44	*Calophyllum lowii* Hook.F	Clusiaceae		√			
45	*Calophyllum nodusum*	Clusiaceae					√
46	***Calophyllum pseudomolle* P.F. Stevens**	Clusiaceae	√				

47	*Calophyllum sclerophyllum* Vesque	Clusiaceae				√	
48	*Calophyllum soualattri* Burm.f.	Clusiaceae		√			
49	*Calophyllum* sp.	Clusiaceae				√	
50	*Calophyllum teysmannii* Miq.	Clusiaceae				√	
51	*Calophyllum venulosum* Zoll.	Clusiaceae		√			
52	*Camnosperma auriculatum* (Bl) Hook.f.	Anacardiaceae			√	√	
53	*Campnosperma coriaceum* (Jack) Hallier f.	Anacardiaceae				√	√
54	*Campnosperma squamatum* Ridl.	Anacardiaceae				√	
55	***Canarium caudatum* King**	Burseraceae	√				
56	*Canarium* sp.1	Burseraceae				√	
57	*Canthium confertum* Korth.	Rubiaceae				√	
58	*Canthium didymum* C.F.Gaertn.	Rubiaceae				√	
59	***Carallia brachiata* (Lour.) Merr.**	Rhizophoraceae	√				
60	***Carallia calophylloidea* Ding Hou**	Rhizophoraceae	√				
61	*Carallia* sp.1	Rhizophoraceae					√
62	*Castanopsis foxworthyi* Schottky	Fagaceae				√	√
63	***Castanopsis tungurrut* (Blume) A.DC.**	Fagaceae	√				
64	*Cephalomappa* sp. 1	Euphorbiaceae				√	
65	cf. *Anisoptera* sp. 1	Dipterocarpaceae				√	
66	cf. *Cubilia cubili*	Sapindaceae				√	
67	cf. *Rapanea borneensis*	Primulaceae				√	
68	***Chaetocarpus castanocarpus* (Roxb.) Thwaites**	Euphorbiaceae	√				
69	*Cinnamomum iners* Reinw. ex Blume	Lauraceae		√			
70	***Cinnamomum javanicum* Blume**	Lauraceae	√				
71	***Cleistanthus brideliifolius* C.B.Rob.**	Euphorbiaceae	√				
72	*Combretocarpus rotundatus* (Miq.) Danser	Rhizophoraceae		√	√	√	
73	*Combretum tetralophum* C.B.Clarke	Combretaceae				√	

(continued)

(continued)

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
74	*Connarus cf. semidecandrus* Jack.	Connaraceae				√	
75	*Cotylelobium burckii* (Heim) Heim	Dipterocarpaceae	√				
76	*Cotylelobium lanceolatum* Craib	Dipterocarpaceae		√		√	
77	*Cotylelobium melanoxylon* (Hook.f.) Pierre	Dipterocarpaceae				√	√
78	*Cratoxylon arborescens*	Hypericaceae				√	
79	*Cratoxylum glaucum* Korth.	Hyperiaceae	√	√	√	√	
80	*Croton oblongus* Burm.f.	Euphorbiaceae	√	√			
81	*Cryptoaria* sp.1	Lauraceae					√
82	*Cryptocarya mentek* Blume ex Nees	Lauraceae			√		
83	*Ctenolophon parvifolius* Oliv.	Linaceae		√		√	
84	*Cyathocalyx biovulatus* Boerl.	Annonaceae		√			
85	*Cyperus sp.*	Ciperaceae				√	
86	*Dactylocladus stenostachys* Oliv.	Melastomataceae		√		√	
87	*Dalbergia ferruginea* Roxb.	Fabaceae			√		
88	***Daphniphyllum laurinum* (Benth.) Baill.**	Daphniphyllaceae	√				
89	*Davallia solida* Ogata	Davalliaceae				√	
90	*Dendrophthoe pentandra* (L.) Miq.	Loranthaceae				√	
91	*Derris heptaphylla* (L.) Merr.	Leguminosae				√	
92	*Dialium indum* L.	Fabaceae					√
93	*Dialium patens* Baker	Fabaceae	√	√			
94	*Dialium platysepalum* Baker	Fabaceae		√			
95	*Dicranopteris linearis* (Burm. f.) Underw.	Gleicheniaceae				√	
96	*Diospyros bantamensis* Koord. & Valeton ex Bakh	Ebenaceae		√		√	√
97	*Diospyros* cf. *Evena*	Ebenaceae				√	

98	***Diospyros* cf. *hermaphroditica* (Zoll.) Bakh.**	Ebenaceae	√				
99	*Diospyros confertiflora* (Hiern) Bakh.	Ebenaceae				√	
100	*Diospyros curraniopsis* Bakh.	Ebenaceae		√			
101	***Diospyros curranii* Merr.**	Ebenaceae	√				
102	*Diospyros dajakensis* Bakh.	Ebenaceae				√	
103	*Diospyros foxworthyi* Bakh.	Ebenaceae				√	
104	*Diospyros hermaphroditica* (Zoll.) Bakh. ex Steenis	Ebenaceae	√			√	
105	*Diospyros maingayi* (Hiern) Bakh.	Ebenaceae				√	
106	***Diospyros oblonga* Wall. ex G.Don**	Ebenaceae	√				
107	*Diospyros pendula* Hasselt ex Hassk.	Ebenaceae			√	√	
108	*Diospyros polyalthioides* Hiern	Ebenaceae			√		
109	*Diospyros pseudomalabarica* Bakh.	Ebenaceae				√	
110	*Diospyros siamang* Bakh.	Ebenaceae				√	√
111	*Diospyros* spp. (exc. *bantamensis*/*pseudo-malabarica* and *siamang*)	Ebenaceae					√
112	*Diospyros toposioides* King & Gamble	Ebenaceae		√			
113	*Dipterocarpus acutangulus* Vesque	Dipterocarpaceae		√			
114	*Dipterocarpus borneensis* Slooten	Dipterocarpaceae		√			
115	*Dipterocarpus elongatus* Korth.	Dipterocarpaceae	√	√			
116	*Dipterocarpus fagineus* Vesque	Dipterocarpaceae					√
117	*Disepalum coronatum* Becc.	Annonaceae			√		
118	*Drynaria sparsisora* (Desv.) T. Moore	Polypodiaceae				√	
119	*Dryobalanops lanceolata* Burck	Dipterocarpaceae				√	
120	*Dyera costulata* (Miq.) Hook.f.	Apocynaceae		√	√	√	
121	*Dyera lowii* Hook.f.	Apocynaceae				√	√
122	*Dyera polyphylla* (Miq.) Steenis	Apocynaceae				√	

(continued)

(continued)

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
123	***Elaeocarpus petiolosus* F.Muell.**	Elaeocarpaceae	√				
124	*Elaeocarpus acmocarpus* Stapf ex Weibel	Elaeocarpaceae			√		
125	*Elaeocarpus* cf. *griffithii*	Elaeocarpaceae				√	
126	*Elaeocarpus floribundus* Blume	Elaeocarpaceae				√	
127	*Elaeocarpus griffithii* (Wight) A.Gray	Elaeocarpaceae	√		√		
128	*Elaeocarpus marginatus* Stapf ex Weibel	Elaeocarpaceae				√	
129	*Elaeocarpus mastersii* King	Elaeocarpaceae				√	√
130	*Elaeocarpus ovalifolius* Wall. ex Müll.Berol.	Elaeocarpaceae				√	
131	*Elaeocarpus petiolatus* (Jacq.) Wall.	Elaeocarpaceae	√	√			
132	*Elaeocarpus* sp.	Elaeocarpaceae				√	
133	*Elatostema* sp.	Urticaceae				√	
134	***Elongatus* sp.**	Dipterocarpaceae	√				
135	*Embelia* sp.	Primulaceae				√	
136	*Endiandra rubescens* (Blume) Miq.	Lauraceae			√		
137	*Engelhardia serrata* BL	Juglandaceae		√			
138	*Eugenia castaneum*	Myrtaceae				√	
139	*Eugenia cerina* M.R.Hend.	Myrtaceae		√			
140	*Eugenia* cf. *spicata*	Myrtaceae				√	
141	*Eugenia densinervia Merr.*	Myrtaceae				√	
142	*Euthemis leucocarpa* Jack	Ochnaceae				√	
143	*Fagraea auriculata* Jack	Gentianaceae				√	
144	*Fagraea ceilanica* Thunb.	Gentianaceae				√	
145	*Fagraea racemosa* Jack	Gentianaceae				√	
146	*Fibraurea chloroleuca* Miers	Menispermaceae				√	
147	*Ficus consociata* Blume	Moraceae				√	

148	*Ficus deltoidea* Jack	Moraceae			√	√	
149	*Ficus* sp.1	Moraceae				√	
150	*Ficus* sp.2	Moraceae				√	
151	*Ficus sumatrana* Miq.	Moraceae				√	
152	*Ficus xylophylla* (Miq.) Wall. ex Miq.	Moraceae				√	
153	*Freycinetia angustifolia* Blume	Pandanaceae				√	
154	*Gaertnera vaginans* (DC.) Merr.	Rubiaceae				√	
155	*Garcinia bancana* Miq.	Clusiaceae	√	√		√	
156	***Garcinia candiculata* Ridl.**	Clusiaceae	√				
157	*Garcinia* cf. *parvifolia*	Clusiaceae					√
158	***Garcinia* cf. *vidua* Ridley**	Clusiaceae	√				
159	*Garcinia forbesii* King	Clusiaceae			√		
160	*Garcinia havilandii* Stapf	Clusiaceae		√			
161	***Garcinia merguensis* Wight**	Clusiaceae	√				
162	*Garcinia nitida* Pierre	Clusiaceae		√			
163	*Garcinia rigida* Miq.	Clusiaceae		√	√		
164	***Garcinia rostrata* Hassk. ex Hook.f.**	Clusiaceae	√				
165	*Garcinia* sp.	Clusiaceae			√		
166	*Garcinia* spp. (exc. cf. *parvifolia*. SA sp. 1 and TU sp.1)	Clusiaceae				√√	√
167	*Garcinia vidua* Ridl.	Clusiaceae		√			
168	*Gardenia leiocarpum*	Clusiaceae					√
169	*Gardenia pterocalyx* Valeton	Rubiaceae				√	
170	*Gardenia tubifera* Wall. ex Roxb.	Rubiaceae				√	
171	*Glochidion rubrum* Blume	Phyllanthaceae				√	
172	***Gluta aptera* (King) Ding Hou**	Anacardiaceae	√				
173	***Gluta renghas* L.**	Anacardiaceae	√				
174	*Gluta sabahana* Ding Hou	Anacardiacea			√		

(continued)

(continued)

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
175	*Gluta wallichii* (Hook.f.) Ding Hou	Anacardiaceae		√			
176	*Gnetum neglectum* Blume	Gnetaceae				√	
177	*Gonystylus bancanus* (Miq.) Kurz	Thymelaeacea				√	
178	*Guioa diplopetala* (Hassk.) Radlk.	Sapindaceae			√		
179	*Gymnacranthera contracta* Warb.	Myristicaceae				√	
180	*Gymnacranthera eugeniifolia* (A.DC.) J.Sinclair	Myristicaceae				√	
181	*Gymnacranthera farquhariana* (Hook.f. & Thomson) Warb.	Myristicaceae					√
182	***Gymnacranthera forbesii* (King) Warb.**	Myristicaceae	√				
183	*Gymnostoma sumatranum* (Jungh. ex de Vriese) L.A.S.Johnson	Casuarinaceae				√	
184	*Gynotroches* sp.1	Rhizophoraceae				√	
185	*Hopea beccariana* Burck	Dipterocarpaceae		√			
186	***Hopea* cf. *cernua* T. et B**	Dipterocarpaceae	√				
187	*Hopea ferruginea* Parijs	Dipterocarpaceae	√	√			
188	***Horsfieldia brachiata* (King) Warb.**	Myristicaceae	√				
189	*Horsfieldia crassifolia* (Hook.f. & Thomson) Warb.	Myristicaceae		√	√	√	√
190	*Horsfieldia glabra* (Reinw. ex Blume) Warb.	Myrysticaceae		√			
191	***Horsfieldia irya* (Gaertn.) Warb.**	Myristicaceae	√				
192	*Horsfieldia polyspherula* (Hook.f. ex King) J.Sinclair	Myristicaceae		√			
193	*Ilex* cf. *hypoglauca* (Mig.) Loes.	Aquifoliaceae			√		
194	***Ilex* cf. *macrophylla* Wall. ex hook. f.**	Aquifoliacea	√				

195	*Ilex cymosa* Blume	Aquifoliaceae	√	√			
196	*Ilex hypoglauca* Loes.	Aquifoliaceae				√	
197	*Ilex macrophylla* wall. Ex hook. f.	Aquifoliaceae		√			
198	*Ilex pleiobrachiata* Loes.	Aquifoliaceae			√		
199	***Ilex wallichii* Hook. f.**	Aquifoliacea	√	√		√	
200	*Isonandra lanceolata* Wight	Sapotaceae				√	
201	*Isonandra* sp.1	Sapotaceae				√	
202	*Ixora havilandii* Ridl.	Rubiaceae				√	
203	*Kayea borneensis* P.F.Stevens	Calophyllaceae		√			
204	***Knema cf. latericia* Elmer**	Myristicaceae	√				
205	*Knema cinerea* Warb.	Myristicaceae				√	
206	*Knema intermedia* Warb.	Myristicaceae				√	
207	*Knema latericia* Elmer	Myristicaceae				√	
208	*Knema laurina* Warb.	Myrysticaceae		√			
209	*Kokoona ovatolanceolata* Ridl.	Calastraceae			√		
210	*Koompassia malaccensis* Benth.	Leguminosae				√	√
211	*Labisia acuta* Ridl.	Primulaceae				√	
212	*Labisia pumila* (Blume) Mez.	Primulaceae				√	
213	*Lepironia articulata* (Retz.) Domin	Cyperaceae				√	
214	*Lithocarpus leptogyne* (Korth.) Soepadmo	Fagaceae			√		
215	*Licania splendens* (Korth.) Prance	Chrysobalanaceae				√	√
216	*Lithocarpus rassa* (Miq.) Rehder	Fagaceae		√			
217	*Lithocarpus bancanus* (Scheff.) Rehder	Fagaceae				√	
218	***Lithocarpus* cf. *gracilis* (Korth) Soepadmo**	Fagaceae	√				
219	*Lithocarpus conocarpus* (Oudem.) Rehder	Fagaceae		√			
220	*Lithocarpus dasystachyus* (Miq.) Rehder	Fagaceae	√	√			
221	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo	Fagaceae				√	

(continued)

(continued)

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
222	***Lithocarpus korthalsii* (Endl.) Soepadmo**	Fagaceae	√				
223	*Lithocarpus leptogyne* (Korth.) Soepadmo	Fagaceae		√			
224	*Lithocarpus* spp.	Fagaceae				√	√
225	*Litsea angulata* Blume	Lauraceae			√		
226	*Litsea* cf. *elliptica*	Lauraceae				√	
227	*Litsea* cf. *resinosa*	Lauraceae				√	
228	*Litsea* cf. *rufo-fusca*	Lauraceae				√	
229	*Litsea elliptica* Blume	Lauraceae		√			
230	*Litsea fufo-fusca*	Lauraceae				√	
231	*Litsea gracilipes* Hemsl.	Lauraceae				√	
232	*Litsea* spp.	Lauraceae				√	√
233	*Lophopetalum javanum* Turcz.	Celasteraceae				√	
234	*Lophopetalum* sp.1	Celesteraceae				√	
235	*Lucinaea bilitonensis* Valleton	Rubiaceae				√	
236	*Lycopodiella cernua* (L.) Pic. Serm.	Lycopodiaceae				√	
237	*Macaranga caladifolia* Becc.	Clusiaceae				√	
238	***Macaranga peltata* (Roxb.) Müll.Arg.**	Clusiaceae	√				
239	*Macrosolen retusus* Blume	Loranthaceae				√	
240	*Madhuca korthalsii* (Pierre ex Burck) H.J.Lam	Sapotaceae		√			
241	*Madhuca motleyana* (de Vriese) J.F.Macbr.	Sapotaceae				√	√
242	*Magnolia bintuluensis* (A.Agostini) Noot.	Magnoliaceae				√	
243	*Magnolia* sp.	Magnoliaceae					√
244	*Mangifera swintonioides* Kosterm.	Anacardiaceae		√			
245	*Medinilla crassifolia* Blume.	Melastomataceae				√	

246	*Melastoma malabathricum* L.	Melastomataceae				√	
247	***Memecylon edule* Roxb.**	Melastomataceae	√				
248	*Memecylon* sp.1	Melastomataceae				√	
249	*Mesua* sp.1	Clusiaceae				√	
250	*Mezzettia leptopoda* (Hook. f. & Thomson) Oliv.	Annonaceae				√	√
251	*Mezzettia umbellata* Becc.	Annonaceae				√	
252	*Mezzettia parviflora* Becc.	Annonaceae		√		√	
253	*Microcos* sp.	Tiliaceae					√
254	*Mussaendopsis beccariana* Baill.	Rubiaceae					√
255	*Myristica lowiana* King	Myristicaceae				√	
256	***Myristica maxima* Warb.**	Myristicaceae	√				
257	*Neonauclea calycina* (Bartl. ex DC.) Merr.	Rubiaceae			√		
258	*Neoscortechinia kingii* (Hook.f.) Pax & K.Hoffm.	Euphorbiaceae	√	√	√		√
259	*Neoscortechinia philippinensis* (Merr.) Welzen	Euphorbiaceae				√	
260	*Nepenthes mirabilis* (Lour.) Druce	Sapindaceae				√	
261	*Nepenthes ampullaria* Jack	Sapindaceae				√	
262	*Nepenthes gracilis* Korth.	Sapindaceae				√	
263	*Nephelium lappaceum* L.	Sapindaceae				√	
264	*Nephelium mangayi* Hiern	Sapindaceae	√	√			
265	*Nephelium ramboutan-ake* (Labill.) Leenh.	Sapindaceae			√		
266	*Nephelium lappaceum* L.	Sapindaceae				√	
267	*Nephelium mangayi* Hiern	Sapindaceae				√	
268	*Nephellium* sp.1	Sapindaceae				√	
269	*Nepenthes rafflesiana* Jack	Sapindaceae				√	
270	*Nephrolepis hirsutula* (G. Forst.) C. Presl	Davalliaceae				√	

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No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
271	*Notaphoebe* sp.1	Lauraceae				√	
272	*Notaphoebe umbeliflora*	Lauraceae					√
273	*Pachycentria constricta* Blume	Melastomataceae				√	
274	*Afzelia rhomboidea* (Blanco) S.Vidal	Fabaceae		√			
275	***Palaquium gutta* (Hook.) Burck**	Sapotaceae	√				
276	*Palaquium leiocarpum* Boerl.	Sapotaceae		√			
277	*Palaquium ridleyi* King & Gamble	Sapotaceae		√			
278	*Palaquium rostratum* (Miq.) Burck	Sapotaceae		√	√		
279	*Palaquium calophyllum* (Teijsm. & Binn.) Pierre ex Burck	Sapotaceae		√			
280	*Palaquium cochleariifolium* P.Royen	Sapotaceae				√	√
281	***Palaquium dasyphyllum* Pierre ex Dubard**	Sapotaceae	√				
282	*Palaquium leiocarpum* Boerl.	Sapotaceae		√	√	√	√
283	*Palaquium pseudorostratum* H.J.Lam	Sapotaceae				√	√
284	*Palaquium ridleyii*/cf. *xanthochymum*	Sapotaceae				√	
285	*Palaquium ridleyi* King & Gamble	Sapotaceae					
286	*Palaquium rostratum* (Miq.) Burck	Sapotaceae			√		
287	*Palaquium sumatranum* Burck	Sapotaceae		√			
288	*Pandanus* sp.	Pandanaceae				√	
289	*Parartocarpus venenosa* Becc.	Moraceae				√	√
290	*Parastemon urophyllus* (Wall. ex A.DC.) A.DC.	Chrysobalanaceae		√			
291	***Payena* cf. *khoonmengiana* J.T.Pereira**	Sapotaceae	√				
292	*Payena leerii* (Teijsm. & Binn.) Kurz	Sapotaceae				√	√
293	*Phoebe* cf. *grandis* (Nees) Merr.	Lauraceae				√	

294	*Pimelodendron griffithianum* (Müll.Arg.) Benth. ex Hook.f.	Euphorbiaceae				√	
295	*Piper* sp.	Piperaceae				√	
296	*Pittosporum* sp.1	Pittosporaceae				√	
297	*Platea excelsa* Blume	Icacinaceae				√	
298	*Platea* sp.	Icacinaceae					√
299	*Platea* sp.1	Icacinaceae				√	
300	*Canthium glabrum* Blume	Rubiaceae	√	√			
301	*Ploiarium alternifolium* (Vahl) Melch.	Theaceae			√	√	√
302	***Podocarpus neriifolius* D.Don**	Podocarpaceae	√				
303	*Poikilospermum suaveolens* (Blume) Merr.	Urticaceae				√	
304	*Polyalthia glauca* (Hassk.) Boerl.	Annonaceae				√	
305	***Polyalthia glauca* (Hassk.) Boerl.**	Annonaccea	√				
306	*Polyalthia hypoleuca* Hook.f. & Thomson	Annonaceae				√	√
307	*Polyalthia sumatrana* (Miq.) Kurz	Annonaceae				√	
308	*Pometia pinnata* J.R. Forst. & G. Forst.	Sapindaceae					√
309	*Pouteria* cf. *malaccensis* (C.B.Clarke) Baehni	Sapotaceae					√
310	***Prunus grisea* Kalkman**	Rosaceae	√				
311	*Psychotria* sp.	Rubiaceae				√	
312	*Psychotria viridiflora* Reinw. ex Blume	Rubiaceae				√	
313	*Pteridium aquilinum* (L.) Kuhn	Dennstaedtiaceae				√	
314	*Pteris* sp.	Pteridaceae				√	
315	*Vitis cissoides* (Blume) Backer	Vitaceae				√	
316	*Pternandra* cf. *coerulescens/galeata*	Melastomataceae				√	
317	*Pternandra echinata* Wall.	Melastomataceae		√			
318	*Pternandra reticulata* (Cogn) Ohwi	Melastomataceae		√			
319	*Pyrostria* sp.	Rubiaceae				√	

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No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
320	*Quassia borneensis* Noot.	Simaroubaceae				√	
321	***Rapanea borneensis* (Scheff.) Mez**	Myrsinaceae	√				
322	*Rhodamnia cinerea* Jack	Myrtaceae					√
323	*Rhodomyrtus tomentosa* (Aiton) Hassk.	Myrtaceae				√	
324	*Rothmannia grandis*	Rubiaceae				√	
325	*Sagaraea lanceolata* Miq.	Annonaccea	√		√		
326	*Sandoricum beccarianum* Baill.	Meliaceae				√	√
327	*Sandoricum borneense* Miq.	Meliaceae			√		
328	*Sandoricum emarginatum* Hiern	Meliaceae				√	
329	*Santiria apiculata* A.W.Benn.	Burseraceae	√				
330	*Santiria griffithii* Engl.	Burseraceae		√		√	
331	*Santiria laevigata* Blume	Burseraceae	√	√			
332	*Santiria rubiginosa* Blume	Burseraceae		√			
333	*Santiria* spp.	Burseraceae				√	√
334	*Sarcotheca* spp.	Oxalidaceae					√
335	*Shorea atrinervosa* Symington	Dipterocarpaceae		√			
336	*Shorea balangeran* Burck	Dipterocarpaceae				√	
337	*Shorea bracteolata* Dyer	Dipterocarpaceae	√			√	
338	*Shorea brunnescens* P.S.Ashton	Dipterocarpaceae	√	√			
339	*Shorea* cf. *bracteolata* Dyer	Dipterocarpaceae		√			
340	*Shorea* cf. *faguetiana* F.Heim	Dipterocarpaceae		√			
341	***Shorea* cf. *gibbosa* Brandis**	Dipterocarpaceae	√				
342	***Shorea* cf. *scaberrima* Burck**	Dipterocarpaceae	√				
343	*Shorea crassa* P.S.Ashton	Dipterocarpaceae				√	
344	*Shorea guiso* Blume	Dipterocarpaceae				√	

345	*Shorea leprosula* Miq.	Dipterocarpaceae		√			
346	***Shorea materialis* Ridl.**	Dipterocarpaceae	√				
347	*Shorea parvifolia* Dyer	Dipterocarpaceae					√
348	*Shorea parvistipulata* F.Heim.	Dipterocarpaceae					√
349	***Shorea retusa* Meijer**	Dipterocarpaceae	√				
350	*Shorea rugosa* F.Heim	Dipterocarpaceae	√	√			
351	*Shorea* sp.	Dipterocarpaceae	√				
352	*Shorea teysmanniana* Dyer ex Brandis	Dipterocarpaceae	√	√	√	√	
353	*Shorea uliginosa* Foxw.	Dipterocarpaceae				√	
354	*Sindora leiocarpa* de Wit	Fabaceae	√	√			
355	*Sloetia elongata* Koord.	Moraceae			√		
356	*Stemonurus scorpioides* Becc.	Icacinaceae		√	√	√	
357	*Stemonurus secundiflorus* Blume	Icacinaceae	√	√	√	√	
358	*Stemonurus umbellatus* Becc.	Icacinaceae			√		
359	*Stenochlaena palustris* (Burm. f.) Bedd.	Blechnaceae				√	
360	*Sterculia bicolor* Mast.	Sterculiaceae				√	
361	*Sterculia coccinea* Roxb.	Sterculiaceae			√		
362	*Sterculia rhoidifolia* Stapf ex Ridl.	Sterculiaceae				√	
363	Sterculia sp.	Sterculiaceae				√	√
364	*Swintonia glauca* Engl.	Anacardiaceae		√			
365	*Syzygium caudatilimbum* (Merr.) Merr. & L.M.Perry	Myrtaceae		√			
366	*Syzygium oligomyrum* Diels	Myrtaceae		√			
367	***Syzygium bankense* (Hassk.) Merr. & L.M.Perry**	Myrtaceae	√				
368	***Syzygium borneense* (Miq.) Miq.**	Myrtaceae	√				
369	*Syzygium myrtifolium* Walp.	Myrtaceae				√	

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No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
370	*Syzygium castaneum* (Merr.) Merr. & L.M.Perry	Myrtaceae		√			
371	*Syzygium caudatilimbum* (Merr.) Merr. & L.M.Perry	Myrtaceae		√			
372	*Syzygium incarnatum* (Elmer) Merr. & L.M.Perry	Myrtaceae	√	√			
373	***Syzygium chloranthum* (Duthie) Merr. & L.M.Perry**	Myrtaceae	√				
374	*Syzygium claviflorum* (Roxb.) Wall. ex A.M.Cowan & Cowan	Myrtaceae				√	
375	*Syzygium creaghii* (Ridl.) Merr. & L.M.Perry	Myrtaceae			√		
376	*Syzygium densinervium* (Merr.) Merr.	Myrtaceae	√			√	
377	***Syzygium ecostulatum* (Elmer) Merr.**	Myrtaceae	√				
378	*Syzygium garciniifolium* (King) Merr. & L.M.Perry	Myrtaceae	√		√	√	
379	*Syzygium glanduligerum* (Ridl.) Merr. & L.M.Perry	Myrtaceae	√				
380	*Syzygium havilandii* (Merr.) Merr. & L.M.Perry	Myrtaceae				√	√
381	*Syzygium inophyllum* DC.	Myrtaceae				√	
382	*Syzygium laxiflorum* (Blume) DC.	Myrtaceae		√			
383	***Syzygium lineatum* (DC.) Merr. & L.M.Perry**	Myrtaceae	√				
384	***Syzygium macromyrtus* (Koord. & Valeton) Merr. & L.M.Perry**	Myrtaceae	√				
385	*Syzygium moultonii* (Merr.) Merr. & L.M.Perry	Myrtaceae		√	√		

386	*Syzygium muelleri* (Miq.) Miq	Myrtaceae		√			
387	*Syzygium oligomyrum* Diels	Myrtaceae		√			
388	*Syzygium remotifolium* (Ridl.) Merr. & L.M.Perry	Myrtaceae				√	
389	*Syzygium* sp.	Myrtaceae	√	√			
390	*Syzygium* sp.1	Myrtaceae		√			
391	*Syzygium* cf. *spicata*	Myrtaceae				√	√
392	***Syzygium tawahense* (Korth.) Merr. & L.M.Perry**	Myrtaceae	√				
393	*Syzygium valdevenosum* (Duthie) Merr. & L.M.Perry	Myrtaceae		√	√	√	
394	***Syzygium zeylanicum* (L.) DC**	Myrtaceae	√				
395	*Tarenna fragrans* (Blume) Koord. & Valeton	Rubiacea				√	
396	*Tarenna* sp.	Rubiacea				√	
397	*Ternstroemia aneura* Miq	Theaceae	√	√			
398	*Ternstroemia hosei* Ridl	Theaceae				√	
399	*Ternstroemia magnifica* Stapf ex Ridl	Theaceae				√	
400	*Tetractomia tetrandra* (Roxb.) Merr	Rubiaceae		√		√	
401	*Tetramerista glabra* Miq	Tetrameristaceae			√	√	
402	*Thrixspermum* sp.	Sebangau				√	
403	*Timonius flavescens* (Jacq.) Baker	Rubiaceae			√	√	
404	***Trigonopleura malayana* Hook.f.**	Euphorbiaceae	√				
405	***Tristaniopsis merguensis* subsp. *Merguensis***	Myrtaceae	√				
406	*Tristaniopsis merguensis* (Griff.) Peter G.Wilson & J.T.Waterh.	Myrtaceae		√	√		
407	*Tristaniopsis obovata* (Benn.) Peter G.Wilson & J.T.Waterh	Myrtaceae		√		√	

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(continued)

No	Species	Family	Heath forest	Peatland forest Bawan village	Peatland Hampangen	Peatland Sebangau[a, b]	Peatland Tuanan[b]
408	Tristaniopsis spp.	Myrtaceae				√	√
409	*Tristaniopsis whiteana* (Griff.) Peter G.Wilson & J.T.Waterh	Myrtaceae		√	√	√	
410	*Uncaria gambir* (Hunter) Roxb.	Rubiaceae				√	
411	*Urceola brachysepala* Hook.f.	Apocynaceae				√	
412	*Vatica mangachapoi* Blanco	Dipterocarpaceae				√	
413	***Vatica umbonata* Burck**	Dipterocarpaceae	√				
414	*Xanthophyllum ellipticum* Korth. ex Miq.	Polygalaceae		√		√	
415	*Xanthophyllum eurhynchum* Miq.	Polygalaceae				√	
416	*Xanthophyllum palembanicum* Miq.	Polygalaceae				√	
417	*Xanthophyllum amoenum* Chodat	Polygalaceae				√	
418	*Xanthophyllum ellipticum* Korth. ex Miq.	Polygalaceae		√			
419	*Xerospermum laevigatum/noronhianum*	Sapindaceae				√	√
420	***Xerospermum noronhianum* Blume**	Sapindaceae	√				
421	*Xylopia* cf. *malayana* Hook.f. & Thomson	Annonaceae				√	
422	*Xylopia coriifolia* Ridl.	Annonaceae				√	
423	*Xylopia elliptica* Maingay ex Hook.f.	Annonaceae				√	
424	*Xylopia fusca* Maingay ex Hook.f. & Thomson	Annonaceae		√	√	√	√
425	*Xylopia malayana* Hook.f. & Thomson	Annonaceae		√			
426	*Xylopia* spp. (exc. fusca)	Annonaceae					√

[a]Mirmanto (2010), [b]Anonim (2010) and Duma (2007)
Bold indicates species found only in the heath forest in Lahei Village

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