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Research Article

Stand structure and tree composition of Timbah Virgin Jungle Reserve, Sabah, Malaysia

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ABSTRACT

The stand structure and tree composition of Timbah Virgin Jungle Reserve (VGR Timbah) were studied. Three locations in the VJR were selected, and at each location, 1-ha study plot was established. The plots were sub-divided into 10×10 m^2 sub-plots, and in each sub-plot, stem diameters of trees ≥ 5 cm diameter-at-breast-height (DBH) were measured. The trees were identified, and their relative density and relative basal area per hectare were calculated. Little difference was found in tree density and basal area per ha between the plots. From the plots, 2,369 trees ≥ 5 cm DBH were enumerated. Total basal area of the trees was 119.5 m^2. Stem diameter class distribution of the trees was found to follow the inverse J-shape pattern. Many of the trees had 5 – < 20 cm DBH (75.9 % of the total stem). Only 4.2% had ≥ 60 cm DBH. Total densities of the trees ≥ 5 cm and ≥ 10 cm DBH were 790 and 474 trees ha^{-1}, respectively and total basal areas per ha were 39.8 and 38.4 m^2 ha^{-1}, respectively. In this study, 47 tree families, 118 genera and 117 species of trees were identified. Many of the trees were Dipterocarpaceae (20% of the total stems). The most abundant species was *Dryobalanops beccarii* (4.3% of the total stems; 34 trees ha^{-1}). Pioneer and disturbed forest trees were found at a very low density. The results suggest that VJR Timbah's soils are infertile, since *D. beccarii*, the most abundant species in the plots, prefers leached whitish or yellowish sandy soils. The results also suggest that the VJR had experienced a less significant logging encroachment or invasion of disturbed forest trees. The results imply that VJR Timbah still maintains its undisturbed forest stand structure and tree composition, although it is relatively small in size and surrounded by a large matrix of heavily logged forest.

Keywords: Sabah, Timbah Virgin Jungle Reserve, forest ecology

INTRODUCTION

Of the many forest enumeration activities in Sabah, only a few are in virgin jungle reserves (VJR). The scenario would be that many foresters and researchers are not interested to study the biological components of VJRs because many of these forests are comparatively small and surrounded by a dense matrix of disturbed forests. To date, little is documented about the stand structure and tree composition of the forests in VJRs. In this paper, the stand structure and tree composition of VJR Timbah are reported. The information would be important to assist in the development of management prescriptions for the VJR or for the logged-over commercial forest surrounding the VJR.

METHODS

Study Site

VJR Timbah is a 110 ha area situated in compartment 53 of the Tangkulap Forest Reserve (Fig. 1). The general climatic and ecological condition of the VJR have not yet been described. In Tangkulap, the annual rainfall averages 3,000 mm, but it is highly variable (1,777 mm to 3,708 mm), with a major deficit occurs every 6 years (Sabah Forestry Department, 2006). May – August and November – February are the wettest seasons and March – April and September – October are the driest seasons. The daily temperature averages 27°C. The main rock types of the area derived from Kolapis formation and Ultrabasic Igneous. The main soil association is Lokan with orthic acrisol as the main soil unit. The natural vegetation of the area is predominantly lowland mixed dipterocarp forest and is dominated by *Shorea johorensis* and its associated Dipterocarpus species, or by *Dryobalanops beccarii* and its associated *Shorea* species (Sabah Forestry Department, 2006).

Vegetation Sampling and Data Analysis

The study was carried out in 2004. Three 1-ha plots were established in the VJR at 2 km interval distance: plot 1 (5°26'8.099"N; 117°12'12.036"E), plot 2 (5°26'5.411"N; 117°12'2.793"E) and plot 3 (5°26'2.218"N; 117°11'54.296"E; Figure 1). The plots were sub-divided into 10×10 m^2 sub-plots to facilitate the enumeration of trees down to 5 cm stem-diameter at breast-height (DBH). The DBH of the trees was measured and the trees

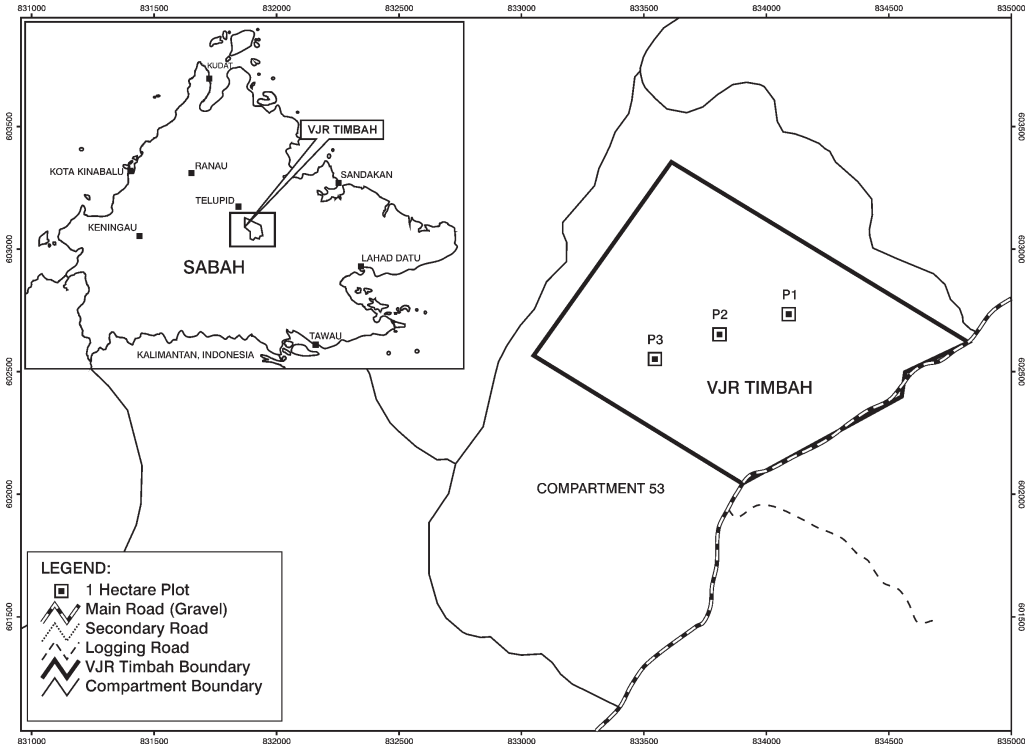

Figure 1: Location of VJR Timbah in Sabah and the three study plots (P1 – P3) in the VJR

were identified. The number of saplings of dipterocarps (< 5 cm DBH to down to 50 cm tall) was also counted. Relative density and basal area per ha were calculated for every species. Relative density (or relative basal area per ha) of species was calculated as sum of density (or sum of relative basal area per ha) of the species divided by sum of density (or sum of relative basal area per ha) of all species. Voucher specimens were kept at Sandakan Herbarium (SAN). Nomenclature in this study follows largely the Tree Flora of Sabah and Sarawak (Soepadmo *et al*., 1995, 1996, 2000, 2002 & 2004).

RESULTS

Little difference was found in tree density and basal area per ha between the plots. The three 1-ha study plots included 2,369 trees ≥ 5 cm DBH (average = 790 trees ha^{-1}) and 1,411 trees ≥10 cm DBH (average = 474 trees ha^{-1}). Many of the trees had 5 < 20 cm DBH (75.9%; Figure 2 and Table 1 – see DBH's mode). Only 4.2% had ≥ 60 cm DBH. Dipterocarps composed most of the trees ≥ 60 cm DBH (Appendix 1 – see Maximum DBH). At 180 cm DBH, *Dryobalanops beccarii* (Dipterocarpaceae) was the largest tree in the plots.

Total basal area of the trees ≥ 5 cm DBH was 119.5 m^2 (average = 39.8 m^2 ha^{-1}). For the trees ≥ 10 cm DBH, it was 115.3 m^2 (average = 38.4 m^2 ha^{-1}). As was expected, trees ≥ 100 cm DBH had the highest contribution to the total basal area per ha (24.3%; Fig. 2). It was followed by the trees 10 < 30 cm DBH (22%). Stocking of dipterocarp saplings in the plots were 558 saplings ha^{-1}.

There were 47 families, 118 genera and 117 species identified from the plots. Most of the species were Dipterocarpaceae (35 species), Euphorbiaceae (20 species), Anacardiaceae (7 species), Sapotaceae (6 species), and Moraceae (5 species; Appendix 1). A small number of the trees (14.4%), however, were unable to be identified to genus or species.

The most abundant trees in the plots were Dipterocarpaceae, Euphorbiaceae, Myristicaceae, Myrtaceae and Lauraceae. The relative densities

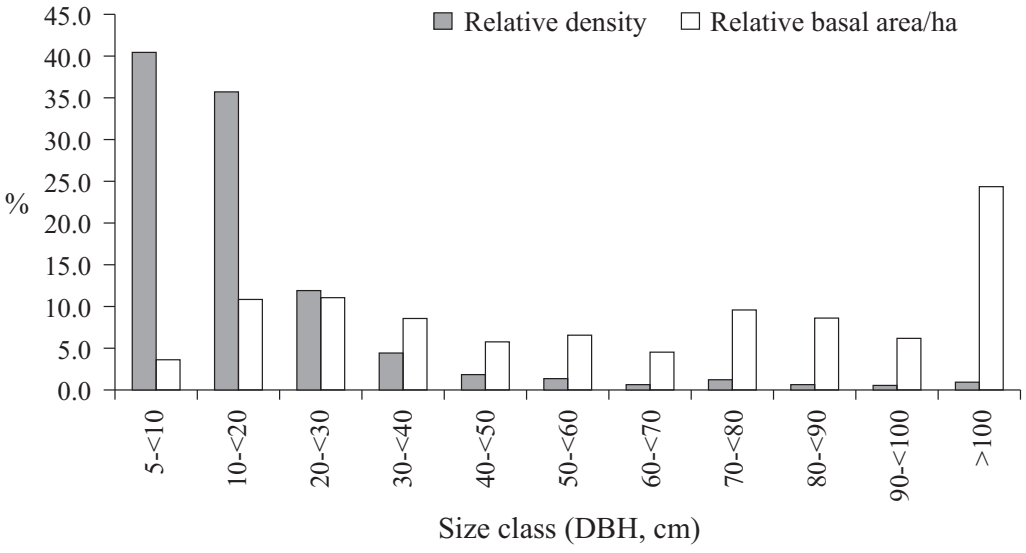

Figure 2: Size class distribution for all trees = 5 cm DBH in the study plots

of trees from these families were 20%, 10.4%, 8.5%, 7.6% and 4.3% respectively (Table 1). Other important families were Annonaceae, Anacardiaceae, Burseraceae, Clusiaceae, Bombacaceae and Verbenaceae. The relative densities of trees from the latter were 3.5%, 2.7%, 2.6%, 2.5%, 2.4% and 2.4% respectively. Thirteen (29.8%) of the families had <5 individuals (<0.2% relative density).

In terms of basal area, Dipterocarpaceae had the highest contribution to the total basal area per ha (55.4%), followed by Myrtaceae (4.5%), Myristicaceae (3.4%), Euphorbiaceae (3%), Sterculiaceae (2.8%), Lauraceae (2.5%) and Bombacaceae (2.2%; Table 1). Other families that had more than 1% contribution to the total basal area per ha were Clusiaceae (1.3%), Fagaceae (1.3%), Anacardiaceae (1.2%), Moraceae (1.2%), Sapotaceae (1.2%), Burseraceae (1.1%), Lecythidaceae (1.1%) and Melastomataceae (1.1%).

Of the 117 species known from the plots, only six had more than 1% relative density (>24 trees ha-1), namely, *Dryobalanops beccarii* (4.3%), *Pternandra coerulescens* (1.9%), *Knema laurina* (1.6%), *Shorea mecistopteryx* (1.5%), *Teijsmanniodendron simplicifolium* (1.2%) and *Durio grandiflorus* (1%; Appendix 1). Only 16 species of these 117 species had more than 1% (>1.2 m^2 ha^{-1}) contribution to the total basal area per ha. They were mainly dipterocarps (13 species): *Dryobalanops beccarii* (14%), *Shorea mecistopteryx* (4.5%), *Dipterocarpus stellatus* (2.6%), *Dipterocarpus pachyphyllus* (1.8%), *Shorea argentifolia* (1.7%), *Dryobalanops lanceolata* (1.7%), *Shorea pauciflora* (1.2%), *Shorea laevis* (1.1%), *Shorea hypoleuca* (1.1%), *Shorea macroptera* (1%), *Parashorea tomentella* (1%) and *Dipterocarpus globosus* (1%).

DISCUSSION

The results indicate that much of VJR Timbah's stand structure and tree composition are similar to that of undisturbed mixed dipterocarp forests. Stem diameter class distribution of trees in the VJR follows the inverse J-shape pattern, which is similar to that of lowland primary forest of Danum Valley (Newbery *et al*., 1992; Newbery *et al*., 1996) and Segaliud-Lokan (Fox, 1967). The VJR, however, supports a slightly lower density of trees compared with several other undisturbed mixed dipterocarp forests. Its density of trees ≥10 cm DBH was 474 trees ha^{-1} compared to 487 – 569 trees ha^{-1} in Danum Valley (Newbery *et al*., 1999; Bischoff *et al*., 2005), 477 trees ha^{-1} in Sungai Menyala and 546 trees ha^{-1} in Pasoh (Manokaran & Swaine, 1994). On the other hand, it appears to facilitate many large trees to co-exist compared to the other forests, just as one could imply from its higher total basal area per hectare (38.4 m^2 ha^{-1}). In Danum Valley, Sungai Menyala and Pasoh, the average basal areas per ha of trees ≥10 cm DBH were 30.6, 31.8 and 29.1 m^2 ha^{-1}, respectively. It has a closely similar average basal area per ha to Bukit Lagong (41.1 m^2 ha^{-1}; Manokaran & Swaine, 1994), a hill mixed dipterocarp forest in Peninsular Malaysia, but again its density of trees ≥10 cm DBH is lower than that of the latter. Generally, the results imply that VJR Timbah still maintains its undisturbed forest stand structure and tree composition, although it is relatively small and being surrounded by a large matrix of logged forest.

The VJR has a closely similar number of families and genera (47 and 118, respectively) to Sungai Menyala (45 and 116, respectively). However, those numbers are lower than that of Danum Valley (59 and 164 respectively) and Bukit Lagong (51 and 139 respectively). It has again a similar number of families to Pasoh (45-48), but its number of genera is lower than that of the latter (125-14). Even so, the top-ten list of family of higher density in the VJR is closely similar to that of Danum Valley, Bukit Lagong, Sungai Menyala and Pasoh. The list differs only in the positions of the families in the ranking. On the top the ranking are Dipterocarpaceae and Euphorbiaceae, and these families are followed by any of these families: Myristicaceae, Myrtaceae, Annonaceae, Anacardiaceae,

Table 1: Family composition, density (D), relative density (Rd) and relative basal area per hectare (Rba/ha) of trees ≥ 5 cm DBH in the study plots (N = number of individuals; Total = 2,369)

Family	N	D (trees ha^{-1})	Rd (%)	Rba/ha (%)	Maximum DBH (cm)	DBH's mode
Alangiaceae	9	3	0.4	0.1	20.4	6.4
Anacardiaceae	65	21.7	2.7	1.2	39.5	7.0
Annonaceae	82	27.3	3.5	0.9	51.6	8.9
Apocynaceae	2	0.7	0.1	0.1	35.4	18.5
Bombacaceae	58	19.3	2.4	2.2	125.0	5.7
Burseraceae	61	20.3	2.6	1.1	52.5	7.2
Celastraceae	10	3.3	0.4	0.3	35.4	8.0
Chrysobalanaceae	10	3.3	0.4	0.1	24.2	7.0
Combretaceae	4	1.3	0.2	0.0	8.0	6.1
Crypteroniaceae	2	0.7	0.1	0.1	25.8	17.5
Dilleniaceae	1	0.3	0.0	0.0	14.0	14.0
Dipterocarpaceae	473	157.7	20.0	55.4	180.0	5.4
Ebenaceae	46	15.3	1.9	0.6	53.2	6.1
Elaeocarpaceae	3	1	0.1	0.0	15.0	10.2
Euphorbiaceae	247	82.3	10.4	3.0	90.0	6.4
Fagaceae	30	10	1.3	1.3	70.0	12.1
Flacourtiaceae	30	10	1.3	0.9	80.0	10.2
Clusiaceae	59	19.7	2.5	1.3	55.4	10.2
Hypericaceae	1	0.3	0.0	0.0	25.5	25.5
Icacinaceae	6	2	0.3	0.1	15.6	8.0
Lauraceae	103	34.3	4.3	2.5	78.0	7.3
Lecythidaceae	35	11.7	1.4	1.1	90.0	8.9
Leguminosae	30	10	1.3	0.7	69.0	5.4
Magnoliaceae	4	1.3	0.2	0.0	13.4	8.9
Melastomataceae	46	15.3	1.9	1.1	38.2	6.1
Meliaceae	19	6.3	0.9	0.4	44.6	22.3
Moraceae	28	9.3	1.2	1.2	71.0	6.4
Myristicaceae	203	67.7	8.5	3.6	70.0	7.6
Myrsinaceae	2	0.7	0.1	0.0	8.3	8.0
Myrtaceae	181	60.3	7.6	4.5	72.0	10.2
Olacaceae	5	1.7	0.2	0.2	43.3	11.5
Oleaceae	1	0.3	0.0	0.0	7.3	7.3
Unidentified taxon	227	75.7	9.6	8.4	92.0	6.1
Polygalaceae	10	3.3	0.4	0.5	72.0	5.7
Rhamnaceae	5	1.7	0.2	0.3	46.8	20.1
Rubiaceae	47	15.7	2.0	0.7	41.4	6.1
Rutaceae	3	1	0.1	0.0	13.7	8.6
Sabiaceae	1	0.3	0.0	0.0	6.4	6.4
Sapindaceae	16	5.3	0.7	0.4	44.9	10.2
Sapotaceae	46	15.3	1.9	1.2	51.6	7.0
Simaroubaceae	6	2	0.3	0.1	27.1	4.8
Sterculiaceae	38	12.7	1.6	2.8	79.3	8.9
Theaceae	3	1	0.1	0.0	16.6	6.1
Thymelaeaceae	13	4.3	0.5	0.1	29.0	5.1
Tiliaceae	39	13.0	1.6	0.4	25.8	9.6
Ulmaceae	1	0.3	0.0	0.0	5.1	5.1
Verbenaceae	58	19.3	2.4	0.9	36.9	11.1

Burseraceae, Lauraceae, Clusiaceae, and Bombacaceae. The position of the families, however, changes with inclusion of trees < 10 cm DBH or < 5 cm DBH in the data analyses. Such inclusion favours families composed mainly by small-sized trees to be on the top of the ranking.

The number of known species in the VJR (117 species) is incomparable to that of Danum Valley (307; Bischoff *et al*., 2005), Bukit Lagong (253), Sungai Menyala (232) and Pasoh (235 – 276). This is because the number of species identified positively in this study is much lower than that of the latter. Notwithstanding, of the known species, the top-ten list of abundant species in the VJR is differing from that of the latter. Of the 10 abundant species in the VJR, none is found in Danum Valley, only one in Bukit Lagong (*S. laevis*), three in Pasoh (*Ochanostachys amentacea*, *Shorea parvifolia*, *S. pauciflora*), and four in Sungai Menyala (*S. macroptera*, *O. amentacea*, *S. parvifolia*, *S. pauciflora*).

In the VJR, *Dryobalanops beccarii*, a dipterocarp, was the common species, but in Danum Valley, Bukit Lagong, Sungai Menyala and Pasoh, it was the non-dipterocarps. It was *Mallotus wrayi* in Danum (Newbery *et al*., 1992), *Hydnocarpus filipes* in Bukit Lagong, *Santiria laevigata* in Sungai Menyala and *Xerospermum noronhianum* in Pasoh. A strong preference of a few dipterocarp species for certain soil conditions has been reported in Borneo (Palmiotto *et al*., 2004). In Sabah, *D. beccarii* was reported to prefer leached whitish or yellowish sandy soils and to occur as a pure stand in areas of such soil condition (Fox, 1972). Thus the latter could explain the above result, although the density of *D. beccarii* in the VJR appears to be lower than that of found by Fox (1972) in the forest at the mouths of the Segama and Sugut Rivers or that of forest at the upper stream of the Imbak River (personal observation, 2005).

The high density of *D. beccarii* and *Shorea mecistopteryx* in the study plots suggests that VJR Timbah has a slightly different ecological condition than that of *Parashorea tomentella-Eusideroxylon zwageri* forest type, the forest type of the general area (Tangkulap Forest Reserve) where the VJR is situated. While these two species were found abundantly in the plots, *Parashorea tomentella* and its three common associated species, *Dryobalanops lanceolata*, *Dipterocarpus caudiferus* and *Shorea leprosula*, occur at very low density. *Shorea johorensis* and *Eusideroxylon zwageri*, the other two important species associated with *Parashorea tomentella*, were also not found in the plots. In other words, *Parashorea tomentella* and its associated species are very scarce in the plots, although they are markedly abundant in the adjacent forests to the VJR (Fox, 1967; Seino *et al*., 2005). Therefore, based on Fox's (1972) classification of forest types in Sabah, VJR Timbah's vegetation can be loosely classified as lowland mixed dipterocarp forest of *Parashorea tomentella-Eusideroxylon zwageri* forest type with a strong influence of inland heath forest of swampy-padang forest type.

There are five important points that can be postulated from the results. First, soil characteristics are suspected to be the determining factor for the current tree composition in the VJR. The two abundant trees in the VJR, *D. beccarii* and *S. mecistopteryx*, are reported to prefer leached whitish or yellowish sandy soils. Thus only trees that could tolerate such soil condition would successfully populate the VJR. Secondly, there will be other sites in Tangkulap that have similar soil condition to VJR Timbah. Such similarity also means that the sites are infertile. If so, the common and abundant trees in the typical *Parashorea tomentella-Eusideroxylon zwageri* forest type would not be suitable as planting material to reforest some degraded sites in Tangkulap. The sites could instead be appropriately reforested with *D. beccarii*, *S. mecistopteryx* and *S. macroptera*. Thirdly, the suspicion that many of the small VJRs in Sabah

had experienced heavy logging encroachment may only be half true. This is because a small VJR such as VJR Timbah has still had stand structure and tree composition that are similar to that of undisturbed forests, although it is surrounded by forest that was heavily logged. Fourthly, the invasion of disturbed forest trees into small VJRs is less prominent. As was the scenario in VJR Timbah, pioneer and disturbed forest trees were scarcely found in the study plots, although these trees were predominantly abundant in the adjacent forest to the VJR. Fifthly, as was the scenario in VJR Timbah, many of the small VJRs in Sabah may still maintain their undisturbed forest stand structures and tree compositions. If so, these VJRs still reserve important information on the pre-disturbance stand structures and tree compositions of the disturbed forests in adjacent areas to them. Therefore, future studies on the stand structures and species compositions of the forests in these VJRs are highly encouraged so that this information can be used in the management of the disturbed forests.

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Appendix 1: Species composition; N = Number of individuals; D = Density (trees ha^{-1}); Rd = Relative density; Rba/ha = Relative basal area per hectare of trees ≥ 5 cm DBH in the study plots; Max DBH = Maximum DBH (cm); Total = 2,369

Species	Family	N	D	Rd (%)	Rba/ha (%)	Max DBH	DBH's mode
Actinodaphne sp.	Lauraceae	3	1	0.1	0.1	42.7	6.4
Adinandra dumosa	Theaceae	3	1	0.1	0.0	16.6	6.1
Aglaia spp,	Meliaceae	12	4	0.5	0.4	44.6	22.3
Alangium javanicum	Alangiaceae	9	3	0.4	0.1	20.4	6.4
Alseodaphne sp.	Lauraceae	4	1.3	0.2	0.0	17.8	5.4
Antidesma leucopodum	Euphorbiaceae	2	0.7	0.1	0.0	22.0	6.7
Aporusa elmerii	Euphorbiaceae	21	7	0.9	0.2	21.7	8.6
Aporusa grandistipulata	Euphorbiaceae	3	1	0.1	0.0	10.2	5.7
Aporusa spp,	Euphorbiaceae	10	3.3	0.4	0.1	18.8	9.6
Aquilaria malaccensis	Thymelaeaceae	1	0.3	0.0	0.1	29.0	29.0
Archidendron jiringa	Leguminosae	2	0.7	0.1	0.0	9.9	6.4
Ardisia elliptica	Myrsinaceae	2	0.7	0.1	0.0	8.3	8.0
Artocarpus anisophyllus	Moraceae	2	0.7	0.1	0.3	70.0	7.6
Artocarpus dadah	Moraceae	6	2	0.3	0.3	45.2	7.0
Artocarpus elasticus	Moraceae	1	0.3	0.0	0.3	71.0	71.0
Artocarpus kemando	Moraceae	7	2.3	0.3	0.2	32.5	7.6
Artocarpus spp,	Moraceae	10	3.3	0.4	0.1	33.1	6.4
Artocarpus tamaran	Moraceae	1	0.3	0.0	0.0	11.8	11.8
Atuna cordata	Chrysobalanaceae	6	2	0.3	0.1	18.2	8.6
Atuna sp.	Chrysobalanaceae	3	1	0.1	0.0	13.1	8.3
Baccaurea latifolia	Euphorbiaceae	5	1.7	0.2	0.2	38.2	7.0
Baccaurea macrocarpa	Euphorbiaceae	18	6	0.8	0.4	42.0	7.0
Baccaurea parviflora	Euphorbiaceae	16	5.3	0.7	0.1	13.7	5.7
Baccaurea spp,	Euphorbiaceae	26	8.7	1.1	0.5	37.3	6.4
Barringtonia macrostachya	Lecythidaceae	5	1.7	0.2	0.1	26.1	10.2
Barringtonia spp,	Lecythidaceae	26	8.7	1.1	0.3	29.0	6.7
Barringtonia stipulata	Lecythidaceae	3	1	0.1	0.1	26.8	12.4
Beilschmiedia sp.	Lauraceae	4	1.3	0.2	0.3	53.5	12.1
Blumeodendron tokbrai	Euphorbiaceae	1	0.3	0.0	0.1	32.2	32.2
Calophyllum spp,	Clusiaceae	29	9.7	1.2	0.6	55.4	6.1
Canarium odontophyllum	Burseraceae	2	0.7	0.1	0.0	14.0	9.2
Canarium sp.	Burseraceae	3	1	0.1	0.0	9.9	6.7
Castanopsis motleyana	Fagaceae	15	5	0.6	0.9	70.0	6.7
Chionanthus pluriflorus	Oleaceae	1	0.3	0.0	0.0	7.3	7.3
Chisocheton pentandrus	Meliaceae	2	0.7	0.1	0.0	11.8	5.4
Chisocheton sp.	Meliaceae	3	1	0.1	0.0	10.8	7.0
Cleistanthus megacarpus	Euphorbiaceae	2	0.7	0.1	0.0	13.4	10.8
Cratoxylum cochinchinense	Hypericaceae	1	0.3	0.0	0.0	25.5	25.5
Croton oblongus	Euphorbiaceae	1	0.3	0.0	0.0	7.6	7.6
Crypteronia griffithii	Crypteroniaceae	3	1	0.1	0.1	25.8	17.5
Cryptocarya spp,	Lauraceae	12	4	0.5	0.5	59.2	6.1
Dacryodes costata	Burseraceae	3	1	0.1	0.0	14.0	5.7
Dehassia incrassata	Lauraceae	3	1	0.1	0.0	22.0	8.0
Dillenia excelsa	Dilleniaceae	1	0.3	0.0	0.0	14.0	14.0
Dimocarpus sp.	Sapindaceae	6	2	0.3	0.2	44.9	7.6
Diospyros discocalyx	Ebenaceae	4	1.3	0.2	0.0	7.6	5.1
Diospyros elliptifolia	Ebenaceae	3	1	0.1	0.0	17.5	9.2
Diospyros spp,	Ebenaceae	38	12.7	1.6	0.6	53.2	7.0
Diploknema sebifera	Sapotaceae	3	1	0.1	0.0	10.2	6.1

Species	Family	N	D	Rd (%)	Rba/ha (%)	Max DBH	DBH's mode
Dipterocarpus acutangulus	Dipterocarpaceae	5	1.7	0.2	1.6	109.2	38.2
Dipterocarpus applanatus	Dipterocarpaceae	1	0.3	0.0	0.0	14.6	14.6
Dipterocarpus caudiferus	Dipterocarpaceae	14	4.7	0.6	0.2	33.8	4.8
Dipterocarpus confertus	Dipterocarpaceae	4	1.3	0.2	0.0	10.5	9.2
Dipterocarpus globosus	Dipterocarpaceae	4	1.3	0.2	1.0	112.0	13.4
Dipterocarpus pachyphyllus	Dipterocarpaceae	10	3.3	0.4	1.8	112.0	9.9
Dipterocarpus spp,	Dipterocarpaceae	43	14.3	1.8	4.5	125.0	6.1
Dipterocarpus stellatus	Dipterocarpaceae	20	6.7	0.8	2.6	95.9	12.4
Dryobalanops beccarii	Dipterocarpaceae	102	34	4.3	14.6	180.0	5.7
Dryobalanops keithii	Dipterocarpaceae	1	0.3	0.0	0.0	17.2	17.2
Dryobalanops lanceolata	Dipterocarpaceae	4	1.3	0.2	1.1	98.0	4.8
Drypetes longifolia	Euphorbiaceae	5	1.7	0.2	0.1	26.8	5.4
Drypetes sp.	Euphorbiaceae	6	2	0.3	0.1	25.5	6.7
Durio grandiflorus	Bombacaceae	24	8	1.0	0.3	28.0	9.6
Durio spp,	Bombacaceae	22	7.3	0.9	1.6	125.0	29.6
Dyera costulata	Apocynaceae	2	0.7	0.1	0.1	35.4	18.5
Dysoxylum sp.	Meliaceae	1	0.3	0.0	0.0	15.0	15.0
Elaeocarpus stipularis	Elaeocarpaceae	3	1	0.1	0.0	15.0	10.2
Elateriospermum tapos	Euphorbiaceae	5	1.7	0.2	0.0	10.5	6.4
Eurycoma longifolia	Simaroubaceae	2	0.7	0.1	0.0	6.7	4.8
Ficus sp.	Moraceae	1	0.3	0.0	0.0	10.5	10.5
Fordia splendidissima	Leguminosae	19	6.3	0.8	0.0	10.2	5.4
Ganua kingiana	Sapotaceae	10	3.3	0.4	0.1	22.0	6.4
Ganua sarawakensis	Sapotaceae	1	0.3	0.0	0.1	42.7	42.7
Garcinia mangostana	Clusiaceae	3	1	0.1	0.1	26.4	12.4
Garcinia parvifolia	Clusiaceae	16	5.3	0.7	0.2	26.1	5.4
Garcinia parvifolia	Euphorbiaceae	1	0.3	0.0	0.0	4.8	4.8
Gironniera nervosa	Ulmaceae	1	0.3	0.0	0.0	5.1	5.1
Gluta oba	Anacardiaceae	20	6.7	0.8	0.5	39.5	7.0
Gluta spp,	Anacardiaceae	26	8.7	1.1	0.3	29.9	5.7
Gluta swintonia	Anacardiaceae	4	1.3	0.2	0.1	34.1	5.1
Gonystylus bancanus	Thymelaeaceae	12	4	0.5	0.1	20.1	5.1
Gymnacranthera spp,	Myristicaceae	43	14.3	1.8	0.4	33.1	8.3
Heritiera spp,	Sterculiaceae	32	10.7	1.4	2.4	79.3	8.9
Hopea beccariana	Dipterocarpaceae	2	0.7	0.1	0.6	75.0	59.2
Hopea nervosa	Dipterocarpaceae	7	2.3	0.3	0.2	29.9	9.2
Hopea pentanervia	Dipterocarpaceae	1	0.3	0.0	0.0	5.7	5.7
Hydnocarpus borneensis	Flacourtiaceae	17	5.7	0.7	0.2	28.3	4.8
Hydnocarpus woodii	Flacourtiaceae	10	3.3	0.4	0.6	80.0	5.1
Irvingia malayana	Simaroubaceae	4	1.3	0.2	0.1	27.1	9.6
Knema laurina	Myristicaceae	38	12.7	1.6	0.4	22.3	10.2
Koompassia excelsa	Leguminosae	2	0.7	0.1	0.0	9.2	8.3
Koompassia malaccensis	Leguminosae	3	1	0.1	0.5	69.0	24.5
Koordersiodendron pinnatum	Anacardiaceae	1	0.3	0.0	0.0	20.1	20.1
Lansium domesticum	Meliaceae	1	0.3	0.0	0.0	6.4	6.4
Lithocarpus echinifer	Fagaceae	1	0.3	0.0	0.0	20.4	20.4
Lithocarpus spp,	Fagaceae	11	3.7	0.5	0.3	36.3	10.2
Litsea spp,	Lauraceae	18	6	0.8	0.8	78.0	7.3
Lophopetalum beccariana	Celastraceae	1	0.3	0.0	0.0	22.9	22.9
Lophopetalum javanicum	Celastraceae	6	2	0.3	0.2	35.4	9.9
Lophopetalum sp.	Celastraceae	3	1	0.1	0.0	8.9	8.0
Macaranga sp.	Euphorbiaceae	1	0.3	0.0	0.0	5.7	5.7
Macaranga winkleri	Euphorbiaceae	5	1.7	0.2	0.1	19.1	8.9

Species	Family	N	D	Rd (%)	Rba/ha (%)	Max DBH	DBH's mode
Madhuca sp.	Sapotaceae	1	0.3	0.0	0.0	24.2	24.2
Magnolia sp.	Magnoliaceae	4	1.3	0.2	0.0	13.4	8.9
Mallotus muticus	Euphorbiaceae	3	1	0.1	0.1	36.0	7.6
Mallotus pinangensis	Euphorbiaceae	6	2	0.3	0.1	17.2	4.8
Mallotus spp,	Euphorbiaceae	66	22	2.8	0.3	14.6	7.6
Mallotus stipularis	Euphorbiaceae	24	8	1.0	0.1	13.7	5.4
Mallotus wrayi	Euphorbiaceae	14	4.7	0.6	0.1	13.7	4.8
Mangifera pajang	Anacardiaceae	3	1	0.1	0.0	18.8	7.0
Mangifera sp.	Anacardiaceae	2	0.7	0.1	0.0	19.4	9.6
Melanochyla beccariana	Anacardiaceae	4	1.3	0.2	0.0	20.1	7.0
Melicope luna-akenda	Rutaceae	3	1	0.1	0.0	13.7	8.6
Meliosma sumatrana	Sabiaceae	1	0.3	0.0	0.0	6.4	6.4
Memecylon laevigatum	Melastomataceae	1	0.3	0.0	0.0	8.9	8.9
Mesua macrantha	Clusiaceae	11	3.7	0.5	0.5	37.9	37.9
Microcos crassifolia	Tiliaceae	2	0.7	0.1	0.0	10.5	5.7
Microcos spp,	Tiliaceae	21	7	0.9	0.1	21.7	9.6
Myristica spp,	Myristicaceae	122	40.7	5.1	2.8	70.0	10.8
Nauclea sp.	Rubiaceae	6	2	0.3	0.1	26.1	9.6
Neesia spp,	Bombacaceae	12	4	0.5	0.3	38.9	7.3
Nephelium lappaceum	Sapindaceae	10	3.3	0.4	0.1	31.2	10.2
Ochanostachys amentacea	Olacaceae	2	0.7	0.1	0.0	21.3	11.5
Orophea sp.	Annonaceae	7	2.3	0.3	0.2	51.6	5.4
Palaquium rostratum	Sapotaceae	4	1.3	0.2	0.1	30.6	13.4
Parashorea malaanonan	Dipterocarpaceae	7	2.3	0.3	0.5	75.0	5.4
Parashorea tomentella	Dipterocarpaceae	5	1.7	0.2	1.0	84.0	11.8
Parinari sp.	Chrysobalanaceae	3	1	0.1	0.1	24.2	7.0
Parishia insignis	Anacardiaceae	3	1	0.1	0.0	8.3	5.1
Payena accuminata	Sapotaceae	3	1	0.1	0.1	39.5	9.9
Payena macrophylla	Sapotaceae	7	2.3	0.3	0.0	15.6	7.0
Peltophorum racemosum	Leguminosae	1	0.3	0.0	0.0	15.9	15.9
Pentace adenophora	Tiliaceae	10	3.3	0.4	0.1	22.3	12.1
Pentace laxiflora	Tiliaceae	5	1.7	0.2	0.1	25.8	10.2
Pentace sp.	Tiliaceae	1	0.3	0.0	0.0	9.9	9.9
Pentaspadon motleyana	Anacardiaceae	2	0.7	0.1	0.2	39.2	28.3
Pleiocarpidia sandakanica	Rubiaceae	7	2.3	0.3	0.2	41.4	6.1
Polyalthia spp,	Annonaceae	60	20	2.5	0.6	24.2	8.9
Polyalthia sumatrana	Annonaceae	16	5.3	0.7	0.2	28.3	8.0
Pternandra coerulescens	Melastomataceae	45	15	1.9	1.1	38.2	6.1
Ryparosa acuminata	Flacourtiaceae	4	1.3	0.2	0.1	22.9	6.4
Santiria sp.	Burseraceae	4	1.3	0.2	0.3	52.5	5.7
Scaphium sp.	Sterculiaceae	6	2	0.3	0.4	64.6	6.7
Scorodocarpus borneensis	Olacaceae	3	1	0.1	0.2	43.3	11.8
Shorea accuminatissima	Dipterocarpaceae	3	1	0.1	0.0	24.2	5.7
Shorea argentifolia	Dipterocarpaceae	6	2	0.3	1.7	89.0	13.4
Shorea falciferoides	Dipterocarpaceae	3	1	0.1	0.2	42.0	6.4
Shorea fallax	Dipterocarpaceae	17	5.7	0.7	0.5	40.8	7.3
Shorea gibbosa	Dipterocarpaceae	6	2	0.3	0.6	90.0	8.9
Shorea hypoleuca	Dipterocarpaceae	2	0.7	0.1	1.1	99.0	82.0
Shorea laevis	Dipterocarpaceae	2	0.7	0.1	1.1	104.0	75.0
Shorea leprosula	Dipterocarpaceae	4	1.3	0.2	0.3	68.5	5.4
Shorea macrophylla	Dipterocarpaceae	9	3	0.4	0.3	41.4	5.4
Shorea macroptera	Dipterocarpaceae	20	6.7	0.8	1.0	58.6	12.4
Shorea mecistopteryx	Dipterocarpaceae	36	12	1.5	4.5	170.0	10.5
Shorea ovalis	Dipterocarpaceae	10	3.3	0.4	0.1	24.5	4.8

Species	Family	N	D	Rd (%)	Rba/ha (%)	Max DBH	DBH's mode
Shorea parvifolia	Dipterocarpaceae	1	0.3	0.0	0.4	78.3	78.3
Shorea pauciflora	Dipterocarpaceae	2	0.7	0.1	1.2	135.0	19.1
Shorea smithiana	Dipterocarpaceae	3	1	0.1	0.0	17.2	6.4
Shorea spp,	Dipterocarpaceae	59	19.7	2.5	11.3	140.0	6.4
Shorea superba	Dipterocarpaceae	5	1.7	0.2	0.1	29.6	5.4
Shorea waltonii	Dipterocarpaceae	1	0.3	0.0	0.7	105.0	105.0
Shorea xanthophylla	Dipterocarpaceae	4	1.3	0.2	0.0	17.5	8.0
Sindora beccariana	Leguminosae	4	1.3	0.2	0.7	90.0	12.1
Stemonurus scorpioides	Icacinaceae	6	2	0.3	0.1	15.6	8.0
Syzygium spp,	Myrtaceae	180	60	7.6	4.5	72.0	10.2
Teijsmanniodendron bogoriensis	Verbenaceae	1	0.3	0.0	0.0	14.6	14.6
Teijsmanniodendron holophyllum	Verbenaceae	22	7.3	0.9	0.5	36.9	6.1
Teijsmanniodendron pteropodum	Verbenaceae	6	2	0.3	0.1	22.0	11.1
Teijsmanniodendron simplicifolium	Verbenaceae	29	9.7	1.2	0.4	34.7	5.4
Terminalia sp.	Combretaceae	4	1.3	0.2	0.0	8.0	6.1
Trigonobalanus verticillata	Fagaceae	3	1	0.1	0.1	25.2	25.2
Trigonopleura malayana	Euphorbiaceae	3	1	0.1	0.0	13.4	9.6
Triomma malaccensis	Burseraceae	9	3	0.4	0.0	11.1	7.0
Unidentified taxon	Burseraceae	40	13.3	1.7	0.7	41.1	7.3
Unidentified taxon	Lauraceae	58	19.3	2.4	0.6	28.7	5.7
Unidentified taxon	Sapotaceae	16	5.3	0.7	0.6	51.6	10.2
Unidentified taxa	Other trees	227	75.7	9.6	8.4	92.0	6.1
Urophyllum spp,	Rubiaceae	34	11.3	1.4	0.4	29.9	7.0
Vatica dulitensis	Dipterocarpaceae	16	5.3	0.7	0.3	48.4	5.4
Vatica oblongifolia	Dipterocarpaceae	11	3.7	0.5	0.2	25.8	6.4
Vatica spp,	Dipterocarpaceae	25	8.3	1.1	0.5	31.8	9.6
Xanthophyllum ellipticum	Polygalaceae	10	3.3	0.4	0.5	72.0	5.7
Zizyphus angustifolius	Rhamnaceae	5	1.7	0.2	0.3	46.8	20.1