FLORISTIC COMPOSITIONS AND STRUCTURES OF FOREST AT BARIO HIGHLANDS, SARAWAK

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ABSTRACT

Four localities, viz., Bario *Asal, Pa' Ukat, Aur Bilak* Ligan *and Batu* Lawi *were surveyed using 20m x 20m plots. The flonstic composition and structures of the forest in this plots were determined. The types of forest associations established from the survey included* Cratoxylum formosum—Eugenia rugosa *association for Bario Asal,* Gymnostoma nobile— Calophyllum griseum *association for Pa' Ukat,* Agathis borneensis—Myristica malaccensis *association for Aur Bilak Ligan and* Agathis borneensis—Payena maingayi *association for Batu Lawi. The number and species diversity of trees surveyed revealed that the degree of stratification and tree size varied between localities. The biomass of these forests ranged between 74.24 tlha to 2,225.49 tlha. The total above ground biomass values from Batu Lawi (1650m a.s.l.) was comparatively high compare to the forest of Bario Asal. The high value of biomass at this particular location was mainly contributed by mature Agathis borneensis trees.*

INTRODUCTION

Bario is located at the interior parts of Baram basin and administratively is part of Miri Division. It has steep dissected terrains with large tracts of mixed dipterocarp forests, kerangas, sub-montane and montane forest. It is enclosed by international boundary with Indonesia at the western part, Mount Murud at the northern part and Bätu Lawi at the eastern part. It has an average annual rainfall of 2,500mm.

Due to difficulty in accessibility to Bario, no extensive scale forest exploitation occurs here. The local people conservatively utilize the forest resources for their own needs. They extract forest products in limit capability for their basic and daily needs including timber for housing construction and *Gymnostoma nobile* or *Tristania alata* for firewood. Unlike other ethnic races of Sarawak, the Kelabits of Bario do not practise shifting cultivation. They can sustainably produce high quality rice mainly for self-consumption. However, the logging roads from Marudi are rapidly approaching this area. Once Bario becomes accessible by road, there is a high tendency that most of the undisturbed forested areas of Bario will be encroached by loggers. Highly valuable timber such as *Agat his borneeinsis* occurs in abundance here.

To date, there is no serious attempt to quantitatively and floristically survey various formation of vegetations in Sarawak. Proctor et al. (1983) described some important floristic characteristics of Mulu National Park. As major portions of virgin forests in Sarawak are increasingly experiencing unprecedented rate of clearance today, it is extremely necessary to describe structurally, physi-

ognomically, floristically and quantitatively the forest types and formations to provide a scientific baseline information on the extend of deforestation occurring in the state. The objective of this survey was to describe the structure, physiognomy and floristic composition of the selected forest locations in the Kelabit Highlands, the Bario Asal and Batu Lawi.

MATERIALS AND METHODS

The field survey was carried out in April, 1995 during a scientific expedition jointly organized by the Universiti Malaysia Sarawak and Sarawak Forestry Department. Plots of 20m x 20m plots and lOin x lOin of sub-plots were established during the survey These plots were selected at every lOOm altitudinal intervals. All plants of _3cm diameter breast height (DBH) were enumerated and voucher specimens were collected for identification. The above ground bioinass, total leaf area (one side only), basal area, relative frequency, relative density, relative dominance and importance values of tree species were determined. The profile and physiognomy of every sampling station were developed simultaneously in the field. Ferns, orchids, palms, bamboos, rhododendrons, parasitic plants, ant plants and carnivorous, plants were also collected. and identified.

RESULTS

At Bario Asal, the utilization of forest products are mainly for fire-woods, housing materials and construction of shelters in the rice-fields or fences for buffalo rearing. *Cratoxylum formosum* was identified as the most dominant species in this locality; having highest Importance Value (Iv = 117.97), relative frequency (Rf = *18.75),* relative density (Rd = 33.95) and relative dominance (RD = *65.25).* The ranking in dominance was followed by Eugenia *rugosa* (Iv = *82.57), Quercus chrysotricha* (Iv = 23.94), *hex cymosa* (Iv = 17.19) and *Tristania whitiana* (Iv = 16.91) as shown in Table 1. The estimated total above ground biomass was 74.24 t/ha with the basal area of *23.15* mQha and leaf area index of 1.99 ha/ha. *C. formo*sum has the highest estimated total above ground biomass of 47.56 t/ha and followed by E. *rugosa* and Q. *chrysotricha* (Table 2).

Table 1. Relative density (Rd), relative frequency CR]), relative dominance (RD) and importance value (Iv) of trees species with a DBH of ≥ 5cm at Bario Asal, Bario.

Species	**Rf**	**Rd**	**RD**	**Iv**
Cratoxylumforniosum	18.75	33.96	65.26	117.97
Eugcnia rugosa	18.75	39.62	24.20	82.57
Quercus chrysotncha	12.50	7.55	3.89	23.94
Ilexcyrnosa	12.50	3.77	0.92	17.19
Tristania whitiana	12.50	3.77	0.64	16.91
Cant hiuni didymum	*6.25*	3.77	1.31	11.33
Ternstroemia denticulata	6.25	1.89	2.72	10.86
Quercus sp	6.25	1.89	0.56	8.70

Vacciniuni bancanurn	6.25	1.89	0.49	8.63

A total of 21 species from 88 trees had been enumerated in the plots at Pa' Ukat. Of these, *Gymnostoma nobile* was the most dominant; followed by *Calophyllum griseum* (Iv = 35.98), *Tristinia alata* (Iv = 34.54), *Chionanthus laxiflorus* (Iv = 24.04) and *Agathis alba* (Iv = 23.58) as shown in Table 3. The least dominant species was *Canthium* (Iv = 4.08). *Calophyllum griseum* was the most abundant with the average DBH and height of 10.3cm and 1 l.8m respectively. The relative dominance value of *C. griseum* was 7.28 and the total above ground biomass was 22.29 t/ha. The total above ground biomass from this forest is 440.21 t/ha. *Tristania alata* has highest value of estimated above ground biomass (86.68 t/ha) followed by G. *nobile* (81.75 t/ha), *Chionathus laxiflorus* (72.28 t/ha), *Payena obscura* (49.64 t/ha), *Eugenia chlorantha* (42.81 t/ha) and *Agat his alba* (38.0 t/ha). Four saplings of *Eurycoma longifolia* were recorded in these plots which contributed 2.09 t/ha of estimated total above ground biomass (Table 4).

Table 2. Estimated above ground biomass of trees with a DBH of_5cm found at Bario Asal, Barb (Ws = Weight of stems; V/b = Weight of branches; Wi = Weight of leaves).

Species	Total Tree	Average DBH (cm)	Average Height (cm)	Ws (kg)	Wb (kg)	Wi (kg)	Biomass (kg)
Cratoxylum formosum	18	15.8	8.1	1,598.7	265.1	38.6	1,902.4
Eugenia rugosia	21	10.7	7.4	629	94.8	22.5	746.3
Quercus chrysotricha	4	10.1	9.8	127.8	19.1	4.7	151.6
Ternstroemia denticulata	1	17.9	10	79.9	12.3	2.5	94.7
Canthium didymum	2	8.8	7.5	29.5	4.1	1.4	35
Ilex cymosa	2	7.4	4.5	12.8	1.7	0.8	15.3
Tristania whitiana	2	6.2	4.0	7.8	1.0	0.5	9.3
Vaccinium bancanum	1	7.6	5.0	7.5	1.0	0.4	8.9
Quercus sp	1	8.1	3.0	5.2	0.7	0.3	6.2
							2,969.7

Floristically, forests at Aur Bilak Ligan, Ulu Limbang was moderately rich and possessed the highest number of species in relation to other forest areas surveyed during our study of Bario Highlands. A total of 91 trees was enumerated belonging to 41 species. Their average diameter breast height and height ranged from 5.1cm to 36.8cm and Sm to 39m respectively (Table 6). All enumerated trees were to non-dipterocarpaceae group only

Table 3. *Relative density (Rd), relative frequency* ER]), *relative dominance (1713) and importance value (Iv) of trees species with a DBH of* $\geq$ *Scm at Pa' Ukat, Bario.*

Species	RI	Rd	RD	IV
Gymnostoma nobile	7.89	15.91	17.82	41.62
Calophyllum griseum	10.52	18.18	7.28	35.98

Tristaniaalata	7.89	10.22	16.43	34.54
Chionanthus laxWorus	5.26	2.27	16.51	24.04
Agathis borneensis	*5.26*	10.23	8.09	23.58
Paycnaobscura	5.26	4.55	11.74	21.55
Eugenia chlorantha	5.26	4.55	7.46	17.27
Stemonnurus malacensis	7.89	5.68	2.58	16.15
Schima wallichii	5.26	4.55	1.90	11.71
Cratoxylumarborescefls	5.26	2.27	2.12	9.65
Garcinia cunnfolia	5.26	2.27	0.69	8.22
Garcinia haricana	2.63	3.18	2.23	8.04
Eurycoma longifolia	2.63	4.55	0.79	7.97
CinnamomumjavclnicUm	5.26	2.27	0.43	7.96
Elaeocarpus clementis	2.63	2.27	0.99	5.89
Artocarpus kemando	2.63	1.14	0.65	4.42
Polyosnta integr~folia	2.63	1.14	0.39	4.16
Vernonia arborea	2.63	1.14	0.37	4.14
Fagraearacetnosa	2.63	1.14	0.36	4.13
Mevmecylon bornensis	2.63	1.14	0.33	4.10
Canthium	2.63	1.14	0.31	4.08

Agathis borneensis or locally known as 'Bindang' was the most dominant species with an importance value of 69.74 (Table *5).* These trees were conspicuously found and occurred in every plot surveyed, Its dominance were clearly reflected in their having the highest relative frequency, relative density and relative dominance values. Other dominant species that followed in order ranking included *Myristica malaccensis, Knema cinerea, Garcinia* sp., *Magnolia candollii, Eugenia arigosepala* and *Calophyllum biflorum. Eugenia alcinae* was observed to be the least dominant species.

Table 4. Estimated above ground biomass of trees with a DBH of _5cm found at Pa' Ukat, Bario (V/s = Weight of stems; V/b = Weight of branches; Wi = Weight of leaves).

Species	**Total Tree**	**Average DBH (cm)**	**Average Height (cm)**	**Ws (kg)**	**Wb (kg)**	**Wi (kg)**	**Biomass (kg)**
Tristania alata	9	20.0	20.3	2,908.3	504.6	54.1	3,467.0
Gymnostoma nobile	14	17.9	19.6	2,749.8	460	60.1	3,269.9
Chionanthus laxiflorus	2	48.6	21.5	2,417.3	438.2	35.8	2,891.3
Payena obscura	4	25.5	19.0	1,665.3	290.3	30	1,985.6
Eugenia chlorantha	*4*	21.8	24.3	1,438.3	246.3	27.9	1,712.5
Agathis borneensis	9	14.4	16.7	1,278.1	213	29.1	1520.2
Calophyllum riseum	16	10.3	11.8	751.9	115.7	24.1	891.7
Cratoxyllum arborescens	2	14.8	17.5	409.2	69.3	8.4	486.9
Stemonurus malacensis	5	11.8	13.2	260.4	39.7	8.6	308.7
Garcinia baricana	3	16.6	19.0	240.0	36.7	7.7	284.4

Schima wallichii	4	11.7	13.0	178.1	26.6	6.4	211.1
Elaeocarpus clementis	2	11.9	13.0	92.8	13.9	3.3	110.0
Artocapus kemando	1	13.7	17.0	79.7	12.3	2.4	94.4
Eurycoma longifolia	4	7.5	11.8	70.4	10.0	3.2	83.6
Garcinia cuncifolia	2	10	12.0	60.5	8.8	2.4	71.7
Memecylon bornensis	1	9.7	15.0	35.8	5.3	1.4	42.5
Cinnamomum javanicum	2	7.8	11.0	35.6	5.0	1.6	42.2
Vernonia arborea	1	10.3	12.0	32.3	4.7	1.3	38.3
Poy osma integrifolia	1	10.5	11.0	30.8	4.5	1.2	36.5
Canthium	1	9.4	12.0	27.0	3.9	1.1	32.0
F*agraea racemosa*	1	10.1	9.0	23.5	3.4	1	27.9
							17,608.4

The estimated total above ground biomass of this locality was 1,136.3 t/ha. *Agathis borneensis* contributed almost 50% or 566.08 t/ha of the total biomass. The ranking was then followed by *Myristica malaccensis*, *Knema. cinerea*, *Garcinia* sp., *Axinandra coriacea*, *Lophopetalum beccarianum* and *Tetramerista glabra.* The total basal area was 88.38 t/ha to which *A. bornecnsis* contributes almost half. The leaf area index of this forest was 14.23 ha/ha.

Table 5. Relative density *(Rd), relative frequency QRj), relative dominance (RD) and importance* value *(Iv) of trees species with a DBH of ≥ 5cm at Aur Bilak Ligan, Bario.*

Agathis borneensis	7.84	16.25	*45.65*	*69.74*
M*yristica malaccensis*	*5.88*	5.00	12.26	23.14
Knema cinerea	*5.88*	5.00	8.21	19.09
Garcinias	3.92	5.00	7.25	16.17
Maagnolia candollii	3.92	5.00	1.39	10.31
Eugenia arigosepala	1.96	5.00	1.25	8.21
Calophyllum biflorum	1.96	5.00	0.47	7.43
Eugenia sp	1.96	3.75	1.45	7.16
Lophopetalum beccarianum	1.96	2.50	2.61	7.07
Endiandra scrobienlata	3.92	2.50	0.14	6.56
Garcinia maingayi	1.96	2.50	1.61	6.07
Axinandra coriacea	1.96	1.25	2.80	6.01
Linociera cuspidata	1.96	3.75	0.26	5.97
Tetramerista glabra	1.96	1.25	2.07	5.28
Calophyllum teysmannii	1.96	2.50	0.49	4.95
Beilschmiedia micrantha	1.96	2.50	0.28	4.74
Talauma gracilior	1.96	1.25	1.13	4.34
Lithocarpus bennettii	1.96	1.25	1.07	4.28
Lithocarpus conocarpus	1.96	1.25	1.07	4.28
Ardisia copelandii	1.96	1.25	0.93	4.14
Lithocarpus sp.	1.96	1.25	0.93	4.14

Litthocarpus cf. andersonii	1.96	1.25	0.83	4.04
Xanthophyllum affine	1.96	1.25	0.82	4.03
Cryptocarya rugulosa	1.96	1.25	0.72	3.93
Eugenia chlorantha	1.96	1.25	0.72	3.93
Antidesma hosei	1.96	1.25	0.68	3.89
Eugenia corymbifera	1.96	1.25	0.50	3.71
Adinandra acunminata	1.96	1.25	0.45	3.66
Chionanthus pluriflorus	1.96	1.25	0.25	3.46
Litsea insignis	1.96	1.25	0.22	3.43
Adina *minutiflora*	1.96	1.25	0.21	3.42
Beilschmiedia sp	1.96	1.25	0.20	3.41
Elaeocarpus griffithii	1.96	1.25	0.20	3.41
Ad*inandra sp*	1.96	1.25	0.19	3.40
Litsea oppositifolia	1.96	1.25	0.19	3.40
Tetractomia beccarrii	1.96	1.25	0.16	3.37
Euodia gliabra	1.96	1.25	0.14	3.35
Litsea sp	1.96	1.25	0.12	3.33
Tetractomia tetrandrum	1.96	1.25	0.11	3.32
Xylopia ferruginea	1.96	1.25	0.09	3.30
Eugenia alcinae	1.96	1.25	0.06	3.27

The ground vegetation was somewhat sparse, though small palms *(Licuala* and *Pinanga)* were widespread. Herbs were abundant and generally scattered becoming more common in the vicinity of small streams. Epiphytes were considerably éonspicuous with abundant formation of sun-epiphytes in crowns of upper canopy trees. Large woody climbers, attaining the upper canopy were of frequent occurrence and included several species of rattans. Epiphytes were also numerous on the bryophyte covers and crowns of trees. This forest seemed to ‘have a notable in which scrambling bamboo, *Racemobambos glabra* occurred in abundance. *Lomariopsis* and *Teratophyllum* ferns were also observed.

At about 1,650m a.s.l. on the ridge of the Batu Lawi mountain, there was a marked change in floral. Twenty six species were identified from 72 trees enumerated. The most dominant species was *Agathis borneensis* having values for relative frequency of 8.51, relative density of 11.11, relative dominance of 43.62 and importance value of 63.24 (Table 7). Eight *A. borneensis* trees were observed which had an average DBH and heights of 35.4cm and 22. in respectively Other co-dominant species included *Payena maingayi* (Iv = 26.42), *Memecylon* (Iv = 19.11), *Shorea* sp. (Iv = 18.75), and *Beilschiedia maingayi* (Iv = 17.84). *Payena maingayi* and *Shorea* sp. were mainly of the large emergent trees that had respectively attained the average heights of 60m and 50.8m respectively Their DBH values exceed 50cm. Two protected species of fig trees namely *Ficus glandulifera* and F *treubii* were found in this area. *Pleiocarpidia cephalotes* was the least dominant with an importance value of 3.57 and found to occur as tree saplings.

This vegetation gave the highest total above ground biomass in relation to other areas surveyed in this study. Of the total biomass value of 2,225.49 t/ha, *Agathis bonieensis* contributed almost 50% or 1,007.9 t/ha (Table 8). This was followed by *Payena* maingayi (529.4 tlha), *Shorea* sp.

(308.4 t/ha) and *Canarium littorale* (126.6 t/ha). *Pleiocarpidia cephalotes* contributed the least through its value of 0.18 t/ha. The basal area and leaf area index of this vegetation were 22.76 m^2/ha and 16.68 ha/ha respectively

A total of 21 species from 88 trees was enumerated in the plots at Pa' Ukat. Of these, *Gymnostoma nobile* was the most dominant; followed by *Calophyllum griseum* (Iv = 35.98), *Tristinia alata* (Iv = 34.54), *Chionanthus laxiflorus* (Iv = 24.04) and *Agathis alba* (Iv = 23.58) as shown in Table 3. The least dominant species was *Canthium* (Iv = 4.08). *Calophyllum griseum* was the most abundant with the average DBH and height of 10.3 cm and ii Bin respectively The relative dominance value of *C. griseum* was 7.28 and the total above ground biomass was 22.29 tlha. The total above ground biomass from this forest is 440.21 t/ha. *Tristania alata* has the height value of estimated above ground biomass (86.68 t/ha) followed by G. *nobile* (81.75 tlha), *Chionathus laxiflorus* (72.28 t/ha), *Payena obscura* (49.64 t/ha), *Eugenia chlorantha* (42.81 tlha) and *Agathis alba* (38.0 tlha). Four saplings of *Eurycoma longifolia* were recorded in these plots which contributed 2.09 tlha of estimated total above ground biomass (Table 4).

Floristically, forest areas at Aur Bilak Ligan, UIu Limbang were moderately rich and possessed the highest number of species in relation to other forest surveyed during our study of Bario Highlands. A total of 91 trees was enumerated belonging to 41 species. Their average diameter breast height and height ranged from 5.1cm to 36.8cm and Sm to 39m respectively (Table 6). All enumerated trees were to non-dipterocarpaceae group only
Agathis borneensis locally known as "Bindang" was the most dominant species with an importance value of 69.74 (Table 5). These trees were conspicuously found in every plot surveyed. Its dominance was clearly reflected in their having the highest relative frequency, relative density and relative dominance values. Other dominant species that followed in order of ranking included *Myristica malaccensis, Knema cinerea, Garcinia* sp., *Magnolia can*dollii, *Eugenia arigosepala* and *Calophyllum* biflorum. *Eugenia* atci*nae* was observed to be the least dominant species.

Table 6. Estimated above ground biomass of trees with a DBH of _Scm found at Aur Bilak Ligan, Bario
(Ws = Weight of stems; Wb = Weight of branches; Wl = Weight of leaves).

Agathis borneensis	13	33.9	30.6	18807.8	3,608.9	226.4	2 2643.1
M*yristica malaccensis*	4	36.8	37.4	4789.2	869.1	70.7	5 729.0
Knema cinerea	4	29.3	38.8	3816.2	689.8	57.7	4 563.7
Garcinia sp	4	25.8	30.5	2869.2	514.5	45.1	3 428.8
Axinandra conacea	1	35.5	39.0	1165.8	210.8	17.5	1 394.1
Lophopetalum beccananum	2	23.8	31.0	971.6	168.8	17.7	1158.1
Tetramerista glabra	1	30.5	38.0	843.7	149.7	13.8	1 007.2
Eugenia sp	3	13.8	22.3	460.0	76.0	10.7	546.7
Garcinia maingayi	2	19.0	25.0	443.9	72.8	10.3	527.0
Talauma gracilior	1	22.5	28.0	344.1	57.9	7.1	409.1
Lithocarpus	1	22.0	27.0	317.7	53.2	6.7	377.6

conocarpus							
Lithocarpus bennettii	1	22.0	26.0 -	306.0	51.2	6.6	363.8
Eugenia arigosepala	4	10.9	16.8	287.3	45.5	8.2	341.0
Ardisia copelandii	1	20.5	25.0	256.5	42.4	5.8	304.7
*Magnolia candoll*ii	4	11.9	15.0	252.5	38.9	7.9	299.3
Lithocarpus s .	1	20.5	24.0	246.4	40.7	5.6	292.7
Lithocarpus andersonii	1	19.3	25.0 -	227.9	37.4	5.3	270.6
Xanthophyllum affine	1	19.2	25.0	225.6	37.0	5.2	267.8
Crytocarya rugulosa	1	18.0	25.0 -	198.7	32.4	4.8	235.9
Eugenia chlorantha	1	18.0	23.0	183.1	29.7	4.5	217.3
Antidesma hosei	1	17.5	22.0	165.9	26.7	4.2	196.8
Eugenia corymbifera	1	15.0	20.0	1116	17.6	3.1	132.3
Calophyllum teysmannii	2	10.5	18.0	101.8	15.3	3.5	120.6
Adinandra acuminata	1	14.2	17.0	85.5	13.2	2.6	101.3
Calophyllum biflorum	4	14.4	21.0	59.8	8.4	2.8	71.0
Chionanthus pluriflorus	1	10.7	15.0	43.4	6.5	1.6	51.5
Beischmiedia micrantha	2	7.7	12.0	42.9	6.2	1.8	50.9
Linociera cuspidata	3	6.2	12.0	36.7	5.1	1.8	43.6
Litsea insignis	1	10.0	13.0	33.0	4.8	1.3	39.]
Adinandras sp	1	9.2	15.0	32.2	4.7	1.3	38.2
Beilschmiedia sp	1	9.5	13.0	29.8	4.3	1.2	353
Litsea oppositifolia	1	9.2	13.0	28.0	4.]	1.1	33.2
Elaeocarpus griffithii	1	9.5	12.0	27.6	3.9	1.1	32.6
Litsea sp	1	7.5	15.0	21.6	3.1	0.9	25.6
Tetractomia beccarrii	1	8.5	10.0	18.5	2.6	0.8	21.9
Euodia glabra	1	7.8	11.0	17.2	2.4	0.8	20.4
Adina minutiflora	1	9.7	7.0	16.9	2.4	0.8	20.1
Endiandra scrobienlata	2	5.5	6.5	10.3	1.4	0.7	12.4
Xylopia ferruginea	1	6.5	9.0	9.9	1.3	0.5	11.7
Eugenia alcinae	1	5.1	10.0	6.8	0.9	0.4	8.1
Tetractomia tetrandrum	1	7.1	5.0	6.6	0.9	0.4	7.9
							45452.0

The estimated total above ground biomass of this locality was 1,136.3 t/ha. *Agathis borneensis* contributed almost *50%* or 566.08 t/ha of the total biomass. The ranking was then followed by *Myristica malaccensis, Knema, cinerea, Garcinia* sp., *Axinandra coriacea, Lophopetalum*

beccarianum and *Tetramerista glabra.* The total basal area was 88.38 t/ha to which *A. borneensis* contributed almost half. The leaf area index off this forest was 14.23 ha/ha.

The ground vegetation was somewhat sparse, though small palms *(Licuala and Pinanga)* were widespread. Herbs were abundant and generally scattered becoming more common in the vicinity of small streams. Epiphytes were considerably conspicuous with abundant formation of sun-epiphytes in crowns of upper canopy trees. Large woody climbers, attaining the upper canopy, were of frequent occurrence and included several species of rattans. Epiphytes were also numerous on the bryophyte covers and crowns of trees. This forest seemed to have a notable feature in which scrambling bamboo, *Racemobambos glabra* occurred in abundance. *Lomariopsis* and *Teratophyllum* krns were also observed.

At about 1,650m a.s.l. on the ridge of the Batu Lawi mountain, there was a marked change in floral. Twenty six species were identified from 72 trees enumerated. The most dominant species was Agthis *borneensis* having values for relative frequency of 8.51, relative density of 11.11, relative dominance of 43.62 and importance value of 63.24 (Table 7). Eight A. *borneensis* trees were observed which had an average DBH and heights of 35.4cm and 22. in respectively Other co-dominant species included *Payena maingayi* (lv = 26.42), *Mcmecylon* (lv = 19.11), *Shorea* sp. (lv = 18.75), and *Beilschiedia maingayi* (lv = 17.84). *Payena maingayi* and *Shorea* sp. were mainly of the large emergent trees that had respectively attained the average heights of 60m and 50.8m respectively Their DBH values exceeded 50cm. Two protected species of fig trees namely *Ficus glandulifera* and F *treubii* were found in this area. *Pleiocarpidia cephalotes* was the least dominant with an importance value of 3.57 and found to occur as tree saplings.

This vegetation gave the highest total above ground biomass in relation to other areas surveyed in this study Of the total biomass value of 2,225.49 tlha, *Agathis borneensis* contributed almost 50% or 1,007.9 t/ha (Table 8). This was followed by *Payena maingayi* (529.4 t/ha), *Shorea* sp. (308.4 t/ha) and *Canarium littorale* (126.6 t/ha). *Pleiocarpidia cephalotes* contributed the least through its value of 0.18 t/ha. The basal area and leaf area index of this vegetation were 22.76m^2/ha and 16.68 ha/ha respectively

Table 7. Relative density (Rd), relative frequency (Rj), relative dominance (RD) and importance value (Iv) of trees species with a DBH of $\geq$ 5cm at Batu Lawi (1,650m a.s.l), Bario.

Species	Rf	Rd	RD	Iv
Agathis borneensis	8.51	11.11	43.62	63.24
Payena maingayi	6.38	4.17	15.87	26.42
Memycylon	6.38	11.11	1.62	19.11
Shorea sp	2.13	2.78	13.84	18.75
Beilsaamiadia maingayi	6.38	*6.95*	4.51	17.84
Beilsaamiadia sp	6.38	8.33	2.04	16.75
Garcinia blumei	4.26	6.95	*5.24*	*16.45*
Eugenia viridifilia	6.38	*5.56*	0.37	12.31

Knema ashtonii	6.38	5.56	0.29	12.23
Eugenia baramensis	4.26	4.17	1.38	9.81
Canarium littorale	2.13	1.39	4.84	8.36
Dialium sp	2.13	2.78	2.92	7.83
Knema latericia	4.26	2.78	0.25	7.29
Helicia petiolaris	4.26	2.78	0.16	7.20
Xanthophllum pulchrum	4.26	2.78	0.16	7.20
Ficus treubii	4.26	2.78	0.10	7.14
Hehiciopsis artocapoides	4.26	2.78	0.10	7.14
Dehaasia c. firma	2.13	2.78	0.57	5.48
Ficus glanduhifera	2.13	2.78	0.47	5.38
Garcinia dulcis	2.13	1.39	0.58	4.10
llexc cymosa	2.13	1.39	0.33	3.85
Xanthophllum tenue	2.13	1.39	0.25	3.77
Lithocarpus sundaicus	2.13	1.39	0.24	3.76
Xanthophyllum ellipticum	2.13	1.39	0.11	3.63
Polygala venenosa	2.13	1.39	0.08	3.60
Pleiocarpidiace cephalotes	2.13	1.39	0.05	3.57

Table 8. Estimated above ground biomass of trees with a DBH of _5cm found at Batu Lawi (1 650mm ash), Bario (V/s = Weight of stems; V/b = Weight of branches; Wi = Weight *of leaves).*

Species	Total Tree	Ave rage dbh (cm)	Average height (cm)	Ws (kg)	Wb (kg)	Wi (kg)	Biomass (kg)
Agathis borneensis	8	*35.4*	22.1.0	33,084.9	6,983.8	*245.5*	40,314.2
Payena maingayi	3	*57.5*	60.0	18,337.2	2,695.8	142.9	21,175.9
Shorea sp	2	65.2	50.8	10,212.2	2,021.9	101.9	12,336.0
Canarium littorale	1	55.0	60.0	4,201.3	819.3	44.7	5,065.3
Beilsaamiadia sp	6	18.2	19.7	2,566.3	472.1	38.1	3,076.5
Garcinia blumei	5	24.3	25.8	2,440.2	430.9	42.3	2,913.4
Dialium sp	2	30.2	38.0	1,655.0	293.2	27.2	1,975.4
Beilsaamiadia maingayi	5	15.9	11.0	340.9	52.1	10.9	403.9
Eugenia baramensis	3	16.4	13.0	265.8	41.5	7.8	315.1
Garcinia dulcis	1	19.1	25.0	223.3	36.6	5.2	265.1
Memycylon	8	11.5	9.0	203.7	29.4	8.5	241.6
Dehaasia cf. Firma	2	12.3	16.5	184.7	29.5	4.9	219.1
Ficus glandurifera	2	11.7	14.2	117.5	18.1	3.7	139.3
Ilex cymosa	1	14.3	20.0	101.6	15.9	2.9	120.4
Eug*enia viridifilia*	4	7.6	10.0	59.6	8.4	2.8	70.8
*Xantho*phyll*ium tenue*	1	12.5	15.0	58.8	8.9	1.9	69.6
Knema latericia	2	8.9	12.5	50.5	7.3	2.1	59.9
Lithocarpus sundaicus	1	12.2	13.0	48.6	7.3	1.7	57.6
Knema ashtonii	4	6.7	10.0	46.5	6.4	2.4	55.3
Xanthophyllum pulchrum	2	7.2	12.0	32.0	4.6	1.5	38.1

Hellicia petiolaris	2	7.2	10.5	28.0	3.9	1.4	33.3
Xanthophyllum ellipticum	1	8.2	12	20.7	2.9	0.9	24.5
Polygala venenosa	1	6.9	10.5	12.9	1.8	0.6	15.3
Ficus treubii	2	5.5	7.0	11.2	1.5	0.7	13.4
Heliciopsis artocarpoides	2	5.5	7.0	11.2	1.5	0.7	13.4
Pleiocarpidia cephalotes	1	5.5	7.5	6.0	0.8	0.4	7.2
							89,019.6

DISCUSSION

With the present conservative farming practices and a fairly stable resident population of Bario Highlands forests in the vicinity of the Kelabit settlements can be expected to remain generally undisturbed not exploited. The Kelabits do exploit the forest resources from which they sustainably extract plant products such as wild vegetables, rattan, damar, gums from *Dyera costulata* and gutta percha *(Palaquium* spp.). Selected plant species provide materials for such diverse uses such as building materials, roofing, firewood, blow pipes, darts, poisons (ipoh), containers, musical instruments, dyes, scraps, garments and medicines. *Licuala lanata,* an endemic palm of Borneo was the preferred species for thatching. Traditionally the forests has also provided food and material needs of the Penans except metal objects, cloth, sugar, saltand tobacco. These exploitations are however on a limited scale. These forests are particularly important as water catchment for entire Bario Highlands communities. Sufficient supply of water is undoubtedly an important resource for sustainable rice planting in Bario.

The virgin forests within the immediate vicinity of the Bario Asal still harbours a rich diversity of plant species. The destructive nature of shifting cultivation practices was hardly evident through-out Bario Highlands is contrast to other interior part of Sarawak. Species such as *Gymnostoma nobile* and *Tristania* dominated the area. These species however are widely used for firewoods by the locals. *Agathis borneensis* a highly priced commercial timber species in Sarawak occurs as stable population throughout the forest areas surveyed, even in areas that have been heavily disturbed. Some of these trees have been marked or tagged by the locals indicating their intention to utilize the trees in the near future.

The different forests surveyed showed significant variation with respect to their total number of species composition and tree density. The least number of trees and species composition was found at Bario Asal. It was observed that forests here have been continuous harvested by local residents. This was also evident from our observation that the tree species of less commercial or economic importance remained undisturbed in close proximity to Bario Asal. *Tristania whitiana* that were left standing included those having small trunk size unsuitable for firewood. *Gymnostoma nobile* and *Agathis borneensis* were rarely found in this area. Due to the high demand and uncontrolled exploitation, these species failed to sustain a big population diversity in this area.

A total of 41 plant species was enumerated at Aur Bilak Ligan. within limited sampled size. This value compares well with the species-rich lowland dipterocarp forests reported by Poore (1968), Ogawa (1974), Kira (1976), Proctor et al. (1983) and Sukardjo et al. (1990). The high species

diversity in tropical rain forests of Borneo has also been reported by Burges (1961), Nicholson (1965), Fox (1967), Proctor et al. (1983a and b) and Anderson et al. (1983) in Sabah, Anderson *(1957)*, Ashton (1964) and Brunig (1973) in Brunei, Richards (1936), Brunig (1970 and 1973) in Sarawak and Whitmore (1984) in North Borneo. Sukardjo et al. (1990) enumerated 276 species of trees _ 10cm DBH and 320 species of trees _ 4.5cm DBH in Indonesian Borneo. The species diversity of rainforest trees varies regionally and according to site conditions (Fedorov, 1966). Nutrients in the soil can be one of the major factors in influencing floristic variation (Ashton, 1992). However, all the surveyed areas in Bario Highlands displayed an extremely low composition of dipterocarps. Aragones (1992) found in his study at Mt. Banahoa, Philippines no Diptrerocarpaceae occurred at altitude from 75Om to 2,lOOm. Proctor et al. (1988) also observed no dipterocarp occurred beyond 770m altitude of Gunung Silam, Sabah. Burgess (1969) and Whitmore (1984) had explained some enigmatic aspects of the distribution of Dipterocarps group. Dipterocarps were mainly confined to lowland zones and decreased in number at high elevation or rugged land surfaces. At microsite level, the dipterocarp seedling could hardly survive.

The tree heights and girths contributes to the various stratification of forests. The variations that exist between individual trees, species and their localities are major factors determining the types of forest encountered in the rainforest. The natural forest communities are made up of different overlapping elementary sub-populations consisting of individuals of different species and ages. The high frequency of tall trees such as the dipterocarps can reach a height of more than 60m (Whitmore 1984; Ashton, 1964; Meijer and Wood, 1964; Yamakura et al. 1990). The individual trees in the forests are also different in their dimensions and geometrical shapes (Richards 1952 and Whitmore 1984). To add to the complexity each individual tree can also be severely affected by the presence of land interaction with its neighbours in a specific area (Hozumi et at., 1955; Mithen et al. 1984). Forest stratification can also be primarily influenced by the shading of small trees by the canopy of big trees in the forest.

Our results of the total above ground biomass, basal area and leaf area index seemed to agree with the data previously reported in several studies in tropical forests (Folster et at. (1976); Ogino et al. (1967); Ogawa (1969); Ogawa et at. (1965); Hozumi et at. (1969); lKato et at. (1978); Edwards and Grubb (1977) and Yamakura et at. (1990). Their results ranged from 28.3 t/ha to 873.2 t/ha for total above ground biomass, 3.3 m^2/ha to 70.0 m^2/ha for basal area and 0.4 ha/ha to 12.3 ha/ha for leaf area index. However, the values obtained for forests within the vicinities of Aur Bilak Ligan, Ulu Limbang and Batu Lawi were higher than those previously reported. The high total above ground biomass in these areas was also reported by Soepadmo (1979) in his study at Gunung Janing Barat, Endau Rompin.

These sample sites were conspicuously dominated by mature trees of Eugenia *baramkensis, Agathis borneensis, Payena maingayi* and *Tristania anomala.* Yamakura et at. (1990) explained the different in the plant biomass values obtained probably due to the differences in the plant mass packing and forest heights. The higher number of species occurring at tow attitudes at Aur Bilak Ligan, Ulu Liinbang suggest the preponderance of generalist species in the tropics which have wider ecological tolerance.

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