Classification of Under-storey Vegetation Types in a Secondary Hill Dipterocarp Forest in Relation to Silviculture Planning in Brunei Darussalam

By

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Summary : The under-storey vegetation in the Proposed Plantation Area(PPA) neighbouring on the Andulau Forest Reserve in Brunei Darussalam was studied. The purpose of this study was to classify the under-storey vegetation types and clarify the relationships between topography, soil and vegetation types. Species composition and the coverage of each species were studied by the quadrat-method. Ninety-eight plots (size, 2m × 2m) were set on the study site every 20m along south to north survey lines. Under-storey vegetation was categorized into four types : Dipterocarp seedling or sapling type (D-type), Monocotyledon dominant type (M-type), Fern dominant type (F-type), and non-dipterocarp woody species type (N-type). D-type is mainly distributed on the ridge of the eastern part of the study site. M-type is restricted to the gentle slope and bottom. F-type is randomly distributed on the western part of the study site. N-type is the basic vegetation of this area. The relationship between soil type and vegetation type is not clear, however, M-type is usually distributed in Yellow wet soil and F-type in Yellow dry or moist soil. Ecological studies and zoning of the study site were found to be necessary.

Contents

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1 Introduction

Tropical rain forest has rapidly decreased throughout the world. Although a number of silvicultural systems have been proposed in S.E. Asia, the success of natural regeneration in tropical rain forest is not guaranteed. There are many woody species which have different ecological habits. Flowering and seed dispersal are not predictable. Moreover, conditions of seedling survival are not clear. It is important, therefore, to accumulate basic ecological data on forest dynamics.

A monograph of Dipterocarpaceae and an ecological study of mixed dipterocarp virgin forests in Brunei have already been published (ASHTON, 1964 a, b). However, little is known about secondary forests. The Proposed Plantation Area (PPA) is a typical secondary forest caused by logging and has to be investigated in detail. TAKAHASHI(1988), a JICA short-term expert in pedology, produced a soil and a topography map constituting half of the study area in the PPA. We, therefore, continued the topographic survey and constructed a map of the study area. A study of the under-storey vegetation was undertaken using this map.

The purpose of this study is to classify the under-storey vegetation and to clarify the relationships between topography, soil type, and vegetation type. The regeneration of dipterocarps is also discussed. The importance of ecological study will be discussed and zoning of the study site proposed.

The method used in the vegetation survey is easily mastered, but the difficulty of species identification does pose a problem. An illustrated book of local flora is essential to a vegetation survey.

2 Study area

2.1 Location

The Proposed Plantation Area is adjacent to the Conservation Forest, Compartment 7 and 8 of the Andulau Forest Reserve between Tutong and Seria (Fig.1). The study site in the PPA is an area of about 13ha near the Forestry Office at Sungai Liang.

2.2 Topography

The topography of the study area is shown in Fig.2. The difference in altitude was measured every 20m. Line numbers are 1 to 51 from east to west. The topography was categorized into ridge, slope, and bottom (valley). a gentle slope occupies a large area of the study site.

2.3 Climate

Annual rainfall is 1 770mm to 3 374mm at Sungai Liang and this fluctuates from year to year. Mean annual rainfall is about 3 000mm. Mean humidity is 80% and the mean annual temperature, 27℃. It is a typical tropical rainy climate.

2.4 Soil

The soils of the PPA and Andulau Forest Reserve form a mosaic of yellow podsolic soils and yellow sandy latosols (ASHTON, 1964). These soils are equivalent to Acrisols and Ferralsols (FAO/UNESCO, 1974), respectively. Details of the soil types in the study area were reported by TAKAHASHI (1988).

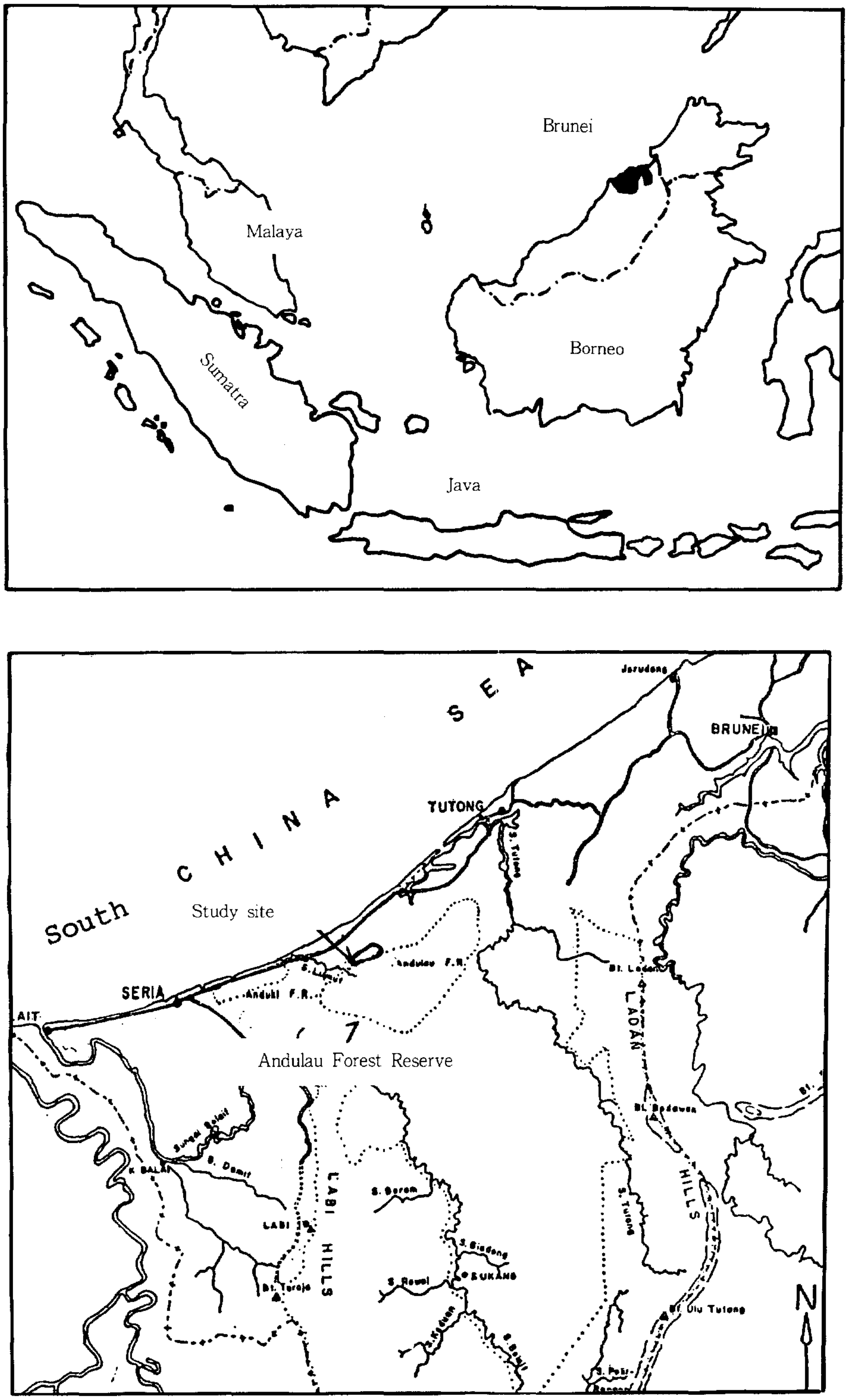

Fig.1. Location of the study site. The site is in the Proposed Plantation Area (PPA) adjacent to the Andulau Forest Reserve.

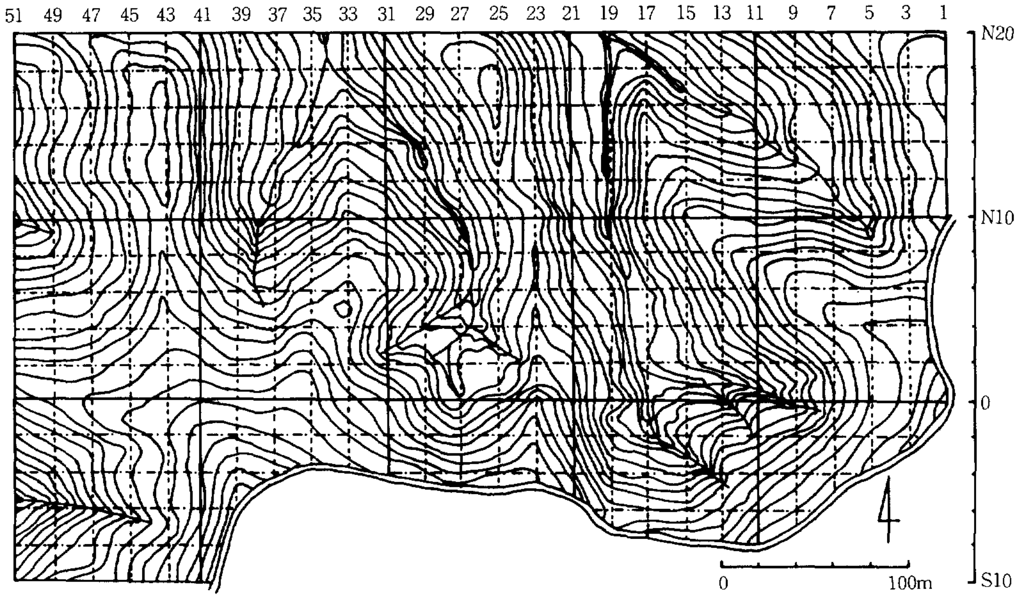

Fig.2. Topography of the study site. Line numbers are 1 to 51 from east to west.

3 Methods

3.1 Quadrat-method

The under-storey vegetation below 2m in height was studied by the quadrat-method. Ninety-eight plots(2m×2m) were set along lines 3 to 47 (Fig. 3). The quadrat size was usually determined by plant height and species diversity. First, the percentage of the canopy close (c.c) and the percentage of the total coverage (t.c) in the plot were estimated by eye. Secondly, the topography was described and the degree of the slope measured. Thirdly, all samples of species were numbered. Fourthly, the dominance of each species was estimated by coverage class(BRAUN-BLANQUET, 1964); +:0-1%, 1:1-10%, 2:10-25%, 3:25-50%, 4:50-75%, and 5:75-100%. Fifthly, the number of dipterocarp seedlings and saplings were counted. Finally, all samples were brought back to the laboratory and converted into dry specimens.

3.2 *Identification*

Plant samples were identified as accurately as possible. JILLI, Rosli Hj, the second author, identified the dipterocarp species and Mr. WON, K. M. was asked to identify the other species.

3.3 Classification of vegetation type

Firstly, vegetation was classified by physiognomy and the presence of dipterocarp species. Secondly, characteristic species of each physiognomy type were collected. Thirdly, the vegetation types of all plots were determined by the characteristic species. Finally, a vegetation map was drawn based on observations in the study area.

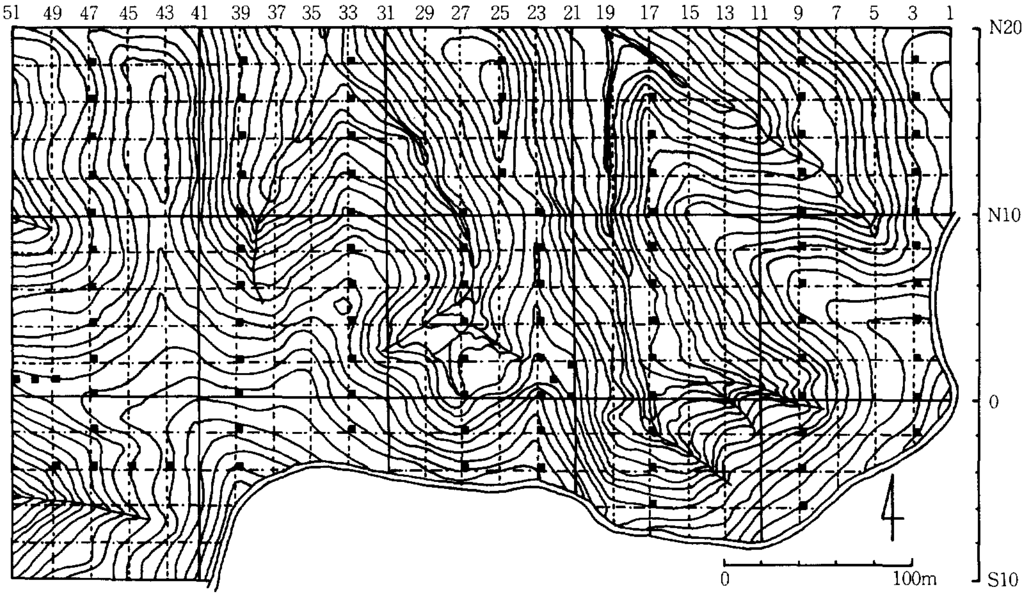

Fig.3. Position of 98 study plots. Plot size is 2m×2m.

4 Results and discussion

4.1 Classification of under storey-vegetation

Under-storey vegetation was categorized into four types as follows :

D-type : Dipterocarp seedling or sapling type. This type was mainly distributed on the ridge (Table 1). Seedlings of Damar hitam bukit (*Shorea angustifolia*) were abundant (Table 2).

M-type : Monocotyledon dominant type, such as *Mapania spp.* (Cyperaceae) and Zingiberaceae. This type was restricted to the gentle slope and near the bottom (Table 3).

F-type : Fern (*Gleichenia linearis*) dominant type (Table 4). *Scleria sp.*(Cyperaceae) was frequently present. *Melastoma sp., Macaranga caladiifolia,* and *Dillenia obovata* were sometimes present.

N-type : Non-Dipterocarp woody species type (Table 5). This type was the basic vegetation in the study area. If all these species were identified, N-type could be divided into sub-types.

The vegetation type, total coverage, number of species, degree of slope, topography, and soil type of the plots are shown in Table 1. D-type was characterized only by the presence of dipterocarp, therefore sub-types of D, D(M), and D(F) were recognized. D-type included dipterocarp and non-dipterocarp. D(M) was dipterocarp plus M-type, and D(F) was dipterocarp plus F-type. There was also overlapping of M- and F-types. The difference between M(F)- and F(M)-types was the dominant species.

Although M-type was mainly distributed at the bottom, the characteristic species of this type were sparsely distributed on the gentle slope and ridge where microtopography was slightly concave. F-type was distributed in light conditions under large canopy gaps. This type was probably a result of fire, as burnt wood was observed in some plots of it. Another reason for the large gaps may be a strong disturbance resulting from logging.

Table 1. Description of study plots.

No.	Plot	Soil	Top.	Slope (deg.)	C.c. (%)	T.c (%)	Species number	Vegetation type
1	3-S2	RD-s	ridge	13	80	30	20	D
2	3-SN0	YM-c	ridge	11	65	20	17	D
3	3-N2	RD-c	ridge	12	80	10	5	N
4	3-N4	RD-c	ridge	9	70	40	21	D
5	3-N6	RD-c	slope	4	70	20	24	N
6	3-N8	YM-c	slope	10	80	40	23	D
7	3-N10	RD-c	slope	9	80	40	17	D
8	3-N12		ridge	8	60	50	25	D
9	3-N14		ridge	18	60	30	17	M
10	3-N16		ridge	12	90	30	21	N
11	3-N18		ridge	9	80	25	13	N
12	9-S6	RD-c	ridge	12	70	40	25	D
13	9-S4	YM-c	slope	17	90	20	21	D
14	9-S2	YM-c	slope	20	90	20	20	D
15	9-SN0	YM-c	slope	2	80	35	26	D(M)
16	9-N2	YM-c	slope	23	90	20	21	D(M)
17	9-N4	YM-c	slope	20	90	20	20	N
18	9-N6	RD-c	ridge	1	80	20	14	M
19	9-N8	RD-c	ridge	21	80	20	15	D
20	9-N10	YM-c	slope	30	70	30	22	M
21	9-N12		bottom	0	70	10	25	M
22	9-N14		slope	3	90	20	19	N
23	9-N16		bottom	2	80	40	25	M
24	9-N18		slope		90	30	23	M
25	17-S6	YM-c	ridge	22	85	10	20	N
26	17-S4	YM-c	slope	21	90	20	18	N
27	17-S2	YW-c	bottom	16	80	30	19	M
28	17-SN0	YW-c	bottom	40	80	40	10	M
29	17-N2	YW-c	bottom	6	80	40	30	D(M)
30	17-N4	YW-c	slope	6	90	25	15	D(M)
31	17-N6	YW-c	slope	20	95	20	15	D(M)
32	17-N8	YM-c	slope	20	90	20	14	M
33	17-N10	YM-c	slope	14	90	20	15	N
34	17-N12		ridge	22	95	20	13	D(M)
35	17-N14		ridge	21	70	30	9	N
36	17-N16		ridge	12	80	25	15	N
37	17-N18		slope	35	90	15	9	D
38	23-S4	RD-c	ridge	10	90	20	20	D
39	23-S2	RD-c	ridge	3	70	30	18	D

Table 1. (continued)

No.	Plot	Soil	Top.	Slope (deg.)	C.c. (%)	T.c (%)	Species number	Vegetation type
40	23-SN0	RD-c	ridge				17	D
41	23-N2	RD-c	ridge		80	30	15	D
42	23-N4	RD-c	ridge		70	20	22	D(F)
43	23-N6	RD-c	ridge			25	17	D
44	23-N8	RD-c	ridge		50	50	27	N(M)
45	23-N10	RD-c	ridge		50	5	11	D
46	25-N12		ridge	16	95	15	18	N
47	25-N14		ridge	2	50	20	19	N(F)
48	25-N16		ridge	0	50	60	18	D(F)
49	25-N18		ridge	21	95	20	17	N
50	27-S4	YM-c	ridge	10	70	35	19	D
51	27-S2	YM-c	slope	15	70	30	17	D
52	27-SN0	YW-c	bottom		80	30	12	D(M)
53	27-N2	YM-c	slope		80	30	22	D(M)
54	27-N4	YW-c	bottom		80	20	17	D(M)
55	27-N6	YW-c	bottom		50	30	16	D(M)
56	27-N8	YW-c	bottom	35	90	25	12	N
57	27-N10	YW-c	bottom	32	75	20	18	M
58	33-S2	YD-s	ridge	9	90	12	23	D
59	33-SN0	YD-s	ridge	12	85	10	18	D
60	33-N2	YM-c	ridge	4	80	20	15	D
61	33-N4	YM-c	slope	11	90	12	14	N
62	33-N6	YD-s	ridge	9	70	30	20	N
63	33-N8	YD-s	ridge	10	80	20	15	N
64	33-N10	YM-c	slope	19	80	30	20	N
65	33-N12		slope	16	80	15	23	N
66	33-N14		slope	12	50	30	30	F(M)
67	33-N16		bottom	3	70	30	31	M(F)
68	33-N18		bottom	0	70	30	18	N(F)
69	39-S4	YD-s	ridge			10	15	N
70	39-S2	YD-s	slope			18	16	N
71	39-SN0	YD-s	slope			25	13	N
72	39-N2	YD-s	slope			40	16	N
73	39-N4	YW-c	slope			30	15	N
74	39-N6	YW-c	slope			50	19	M
75	39-N8	YW-c	bottom	15	60	30	15	M
76	39-N10	YW-c	bottom		50	50	16	M
77	39-N12		slope	13	70	50	14	M
78	39-N14		slope	14	70	45	18	M

Table 1. (continued)

No.	Plot	Soil	Top.	Slope (deg.)	C.c. (%)	T.c (%)	Species number	Vegetation type
79	39-N16		slope	14	50	30	19	M
80	39-N18		slope	8	70	35	22	F(M)
81	43-S4	YM-s	slope	8	70	40	22	N
82	45-S4	YM-s	slope	5		35	26	N
83	47-S4	YM-s	slope		70	45	12	F
84	47-S2	YM-s	slope		70	35	23	N
85	47-SN0	YD-s	ridge		60	30	18	N
86	47-N2	YD-s	slope		20	40	13	F
87	47-N4	YD-c	slope		30	15	10	F
88	47-N6	YD-c	slope		20	80	7	F
89	47-N8	YM-c	slope		30	85	7	F
90	47-N10	YM-c	slope		40	70	11	F
91	47-N12		slope	22	60	20	17	N(F)
92	47-N14		slope		20	70	4	F
93	47-N16		slope	25	80	15	16	N(F)
94	47-N18		slope	22	70	30	18	N
95	49-S4	YM-s	slope	22	20	30	15	F
96	49-N1	RD-s	ridge	10	90	15	15	N
97	50-N1	RD-s	ridge		90	10	12	N(F)
98	51-N1	RD-s	ridge	9	60	10	6	N
			Max.	40	95	85	32	
			Min.	0	20	5	4	
			mean	13.7	72.0	28.9	17.5	
			s.d.	8.9	18.3	14.8	5.4	
			n	70	89	97	98	

Symbols are as follows : Soil : soil type, after that of TAKAHASHI (1988); Top : topography; Slope:degree of slope; C.c:percentage of canopy close; T.c:total coverage of under-storey vegetation below 2m height. Under-storey vegetation is categorized into four types: D:dipterocarp seedlings or saplings type, F:fern dominant type, M: monocotyledon dominant type, N:non-dipterocarp woody species type.

4.2 Vegetation map

A vegetation map was drawn based on the four vegetation types (Fig.4). The vegetation of the study site can be divided into an eastern and a western part. Dipterocarp seedlings and saplings were distributed mainly on the ridge of the eastern part. F-type was randomly distributed on the western part. M-type was restricted to the gentle slope and bottom. N-type was not drawn because this type was the matrix of the site.

4.3 Distribution of dipterocarp seedlings and saplings

The number of seedlings and saplings of 8 dipterocarp species are shown in Table 2. The seedlings of Damar hitam bukit (*Shorea angustifolia*) were plentiful due to abundant fruiting in the

Table 2. Species composition of Dipterocarp seedlings or saplings.

No.	Plot	Soil	Sp. no.	Dipterocarp (individual no.) San	Sag	Sm	So	Sme	Sk	Sb	V	M (species no.)	F	N	O
1	3-S2	RD-s	20	41		1								16	2
2	3-SN0	YM-c	17	7										12	4
4	3-N4	RD-c	21	9		1		1						15	3
6	3-N8	YM-c	23	3	1									17	4
7	3-N10	RD-c	17	120										14	1
8	3-N12		25				1							16	9
12	9-S6	RD-c	25	10	38				1			1		16	4
13	9-S4	YM-c	21	54	1					1	5			13	4
14	9-S2	YM-c	20	6										17	2
15	9-SN0	YM-c	26	62								1		15	9
16	9-N2	YM-c	21	5			1					3		14	2
19	9-N8	RD-c	15				1							13	1
29	17-N2	YW-c	30			1	1					2		21	5
30	17-N4	YW-c	15				1					1		7	6
31	17-N6	YW-c	15	9								2		12	
34	17-N12		13	3								1		10	1
37	17-N18		9	1		2								6	1
38	23-S4	RD-c	20	12										18	1
39	23-S2	RD-c	18	14	1							2		10	4
40	23-SN0	RD-c	17	4	1							1		12	2
41	23-N2	RD-c	15	2								1		12	1
42	23-N4	RD-c	22	15								1	3	14	3
43	23-N6	RD-c	17	2										14	2
45	23-N10	RD-c	11	4								1	1	7	1
48	23-N16		18	110								1	3	12	1
50	27-S4	YM-c	19	29	6							1		11	5
51	27-S2	YM-c	17	62	5									13	2
52	27-SN0	YW-c	12	52								4		7	
53	27-N2	YM-c	22	1								3		14	4
54	27-N4	YW-c	17	2								2		12	2
55	27-N6	YW-c	16	12								1		8	6
58	33-S2	YD-s	23	1										21	1
59	33-SN0	YD-s	18	1							1			15	1
60	33-N2	YM-c	15				1							12	2

San:*Shorea angustifolia*, Sag:*S.agami*, Sm:*S.macroptera*, So:*S.ovalis*, Sme:*S. mecistopteryx*, Sk:*S.kustleri*, Sb:*S.beccariana*, and V: *Vatica sp.* M is a characteristic species of the monocotyledon dominant type. F is that of the fern dominant type. N is non-dipterocarp woody species. O is other plants, such as rotan, pandanas, palm, and climbers.

Table 3. Species composition of Monocotyledon dominant type.

No.	Plot	Soil	Sp.	Monocotyledon						F	N	O
			no.	C	Mb	Mc	L	A	G			
						(coverage)					(sp.no.)	
9	3-N14		17	1							13	3
18	9-N6	RD-c	14		1						11	2
20	9-N10	YM-c	22	+							20	1
21	9-N12		25	+							18	6
23	9-N16		25	+	1						20	3
24	9-N18		23	1							19	3
27	17-S2	YW-c	19	1	+			++			10	5
28	17-SN0	YW-c	10		1				2		2	6
32	17-N8	YM-c	14		1						13	
57	27-N10	YW-c	18	1							16	1
67	33-N16		31		1		+1			3	20	5
74	39-N6	YW-c	19				+			2	13	3
75	39-N8	YW-c	15				+			+	9	4
76	39-N10	YW-c	16				4				12	4
77	39-N12		14		1	2	1			1	7	3
78	39-N14		18	1	2						12	4
79	39-N16		19				1				15	3

C:Cyperaceae *sp.*, Mb:*Mapania* (Cyperaceae) *sp.*, Mc:*Mapania petiobata*, L:*Curculigo* and Liliaceae *spp.*, A:*Alpinia* and *Globba spp.*, G:Gesneiaceae ? *sp.*. For other symbols see Table 2. Coverage has six orders: $+<1\%$, $1\%<1<10\%$, $10\%<2<25\%$, $25\%<3<50\%$, $50\%<4<75\%$, $75\%<5<100\%$.

Table 4. Species composition of Fern dominant type.

No.	Plot	Soil	Sp.	Species					M	N	O
			no.	G	S	Me	Ma	D			
						(coverage)				(sp.no.)	
66	33-N14		30	1	+	+			3	22	2
80	39-N18		22	+	1				1	15	4
83	47-S4	YM-s	12		+	+		1	1	7	1
86	47-N2	YD-s	13	1			+			9	2
87	47-N4	YD-c	10	+	1					8	
88	47-N6	YD-c	7	4	+					3	2
89	47-N8	YM-c	7	5	+					5	
90	47-N10	YM-c	11	4	+					8	1
92	47-N14		4	4	+						2
95	49-S4	YM-s	15	1					1	12	1

G:*Gleicheneia linearis* (Filicales), S:*Scleria laevis* (Cyperaceae), Me:*Melastoma sp.* (Melastomaceae), Ma:*Macaranga caladiifolia*, D:*Dillenia sp.*. For other symbols see Table 2.

Table 5. Species composition of non-dipterocarp woody species type.

No.	Plot	Soil	Sp. no.	Species group (coverage)							Unident. (sp.no.)	Others (sp.no.)
				Uba	Bin	Amb	Med	Men	Ked	Ren		
3	3-N2	RD-c	5								3	2
5	3-N6	RD-c	24	+			1	1			15	6
10	3-N16		21				+4	+			15	3
11	3-N18		13	1				1	1		9	1
17	9-N4	YM-c	20					+++	++	+	10	4
22	9-N14		19				1		++		9	7
25	17-S6	YM-c	20	+1			++	+1	+		9	4
26	17-S4	YM-c	18				+	+++	+		6	7
33	17-N10	YM-c	15	+	+			1	+		7	4
35	17-N14		9				+	1			4	3
36	17-N16		15				1				11	3
44	23-N8	RD-c	27		+				+	+	18	6
46	25-N12		18			+	+	++	+		10	3
47	25-N14		19		+		1				14	3
49	25-N18		17	+1		1			+		9	4
56	27-N8	YW-c	12		+		++		+		6	2
61	33-N4	YM-c	14	+			+	+	1		7	3
62	33-N6	YD-s	20				1		++		10	7
63	33-N8	YD-s	15	1	+1		+				8	2
64	33-N10	YM-c	20	+1	+		1	1		1	6	8
65	33-N12		23	++	+		+				15	4
68	33-N18		18	11	+		1		+		6	7
69	39-S4	YD-s	15	1				+	+		7	5
70	39-S2	YD-s	16	+	+1			+	+	+	8	2
71	39-SN0	YD-s	13	+11	+			+			6	2
72	39-N2	YD-s	16	1	+			++			9	3
73	39-N4	YW-c	15	2	+	1					9	3
81	43-S4	YM-s	22	111		1	+11	+	1	1	6	5
82	45-S4	YM-s	26	+1	+1	+	+	+1		+	10	7
84	47-S2	YM-s	23	1++	++		11	+			11	4
85	47-SN0	YD-s	18	+	++			+	1		9	4
91	47-N12		17		+++			+			7	6
93	47-N16		16				111			+	9	4
94	47-N18		18								16	2
96	49-N1		15	+1		+				+	9	2
97	50-N1		12		1			1		+	6	3
98	51-N1		6	+1							4	2

The identification of species is difficult, therefore the vernacular names (HASAN and ASHTON, 1964) are used as species groups in this paper. Uba, Bin:Bintangor, Amb:Ambun ambun, Med:Medang, Men:Mempisang, Ked:Kedongdon, Ren:Rengas, Unident:unidentified woody species, Others:rotan, palm, pandanas, and climbers.

past. Seedlings of other dipterocarp were sparsely distributed around mother trees. Most seedlings were distributed on the ridge, but if there were mother trees, some appeared near the bottom (Figs. 5, 6). Natural regeneration of dipterocarp is not possible in the western part of this site.

4.4 Relationships between topography, soil type and vegetation

Table 6 shows the relationship between soil and vegetation type. M-type was strongly related to Yellow wet soil. Hence the characteristic species of M-type was a good indicator of soil condition. F-type appeared only in Yellow dry and moist soil. However, the F-type species is not a good indicator of soil, as its distribution depends on fire and an open habitat due to human disturbance. The relationship between D or N-type and soil was not clear. There were few differences between the number of species of plot in each soil type.

The relationships between topography and vegetation types is shown in Table 7. D-type appeared mainly on the ridge. On the other hand, M-type appeared on the slope and at the bottom. F-type only appeared on the slope. N-type was rare at the bottom. There is no difference in species number among the topography types, but there is a difference among the vegetation types. A lower number of species was recorded in F-type vegetation. It is clear that burning and cutting decreases the species diversity, as in F-type.

4.5 Monitoring of the regeneration process

In general, it is difficult to establish a natural regeneration method without ecological studies. Natural regeneration in tropical rain forest is particularly difficult because many species flower and bear fruit irregularly. If harvesting methods were different, canopy gap size and damage to seedlings by logging would also differ. Some species grow well unber large gaps but others do not. Therefore,

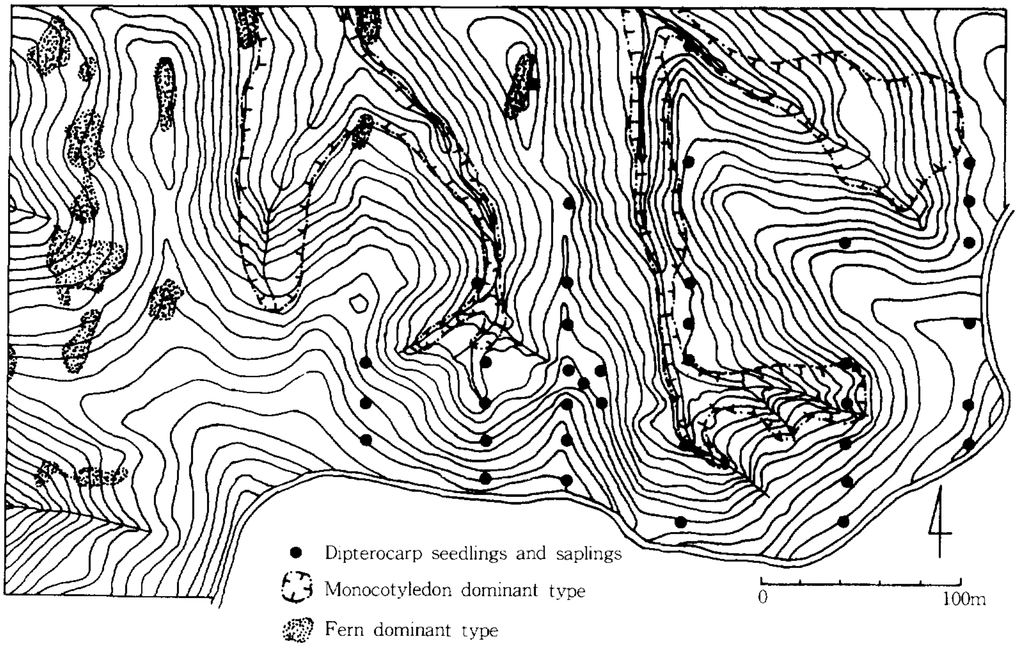

Fig.4. Vegetation map. Dotted area is Fern dominant type. Dash and dot line is Monocotyledon dominant type. Closed circles indicate the distribution of Dipterocarp seedlings or saplings.

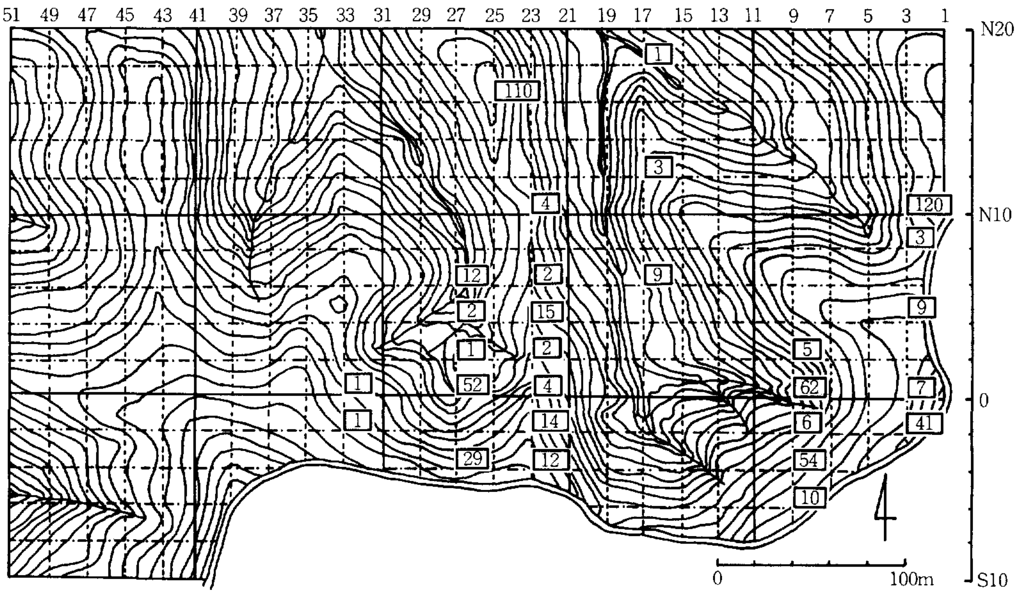

Fig.5. Seedling distribution of Damar hitam bukit (*Shorea angustifolia*). Individual numbers (no./4m^2) are shown in this Figure.

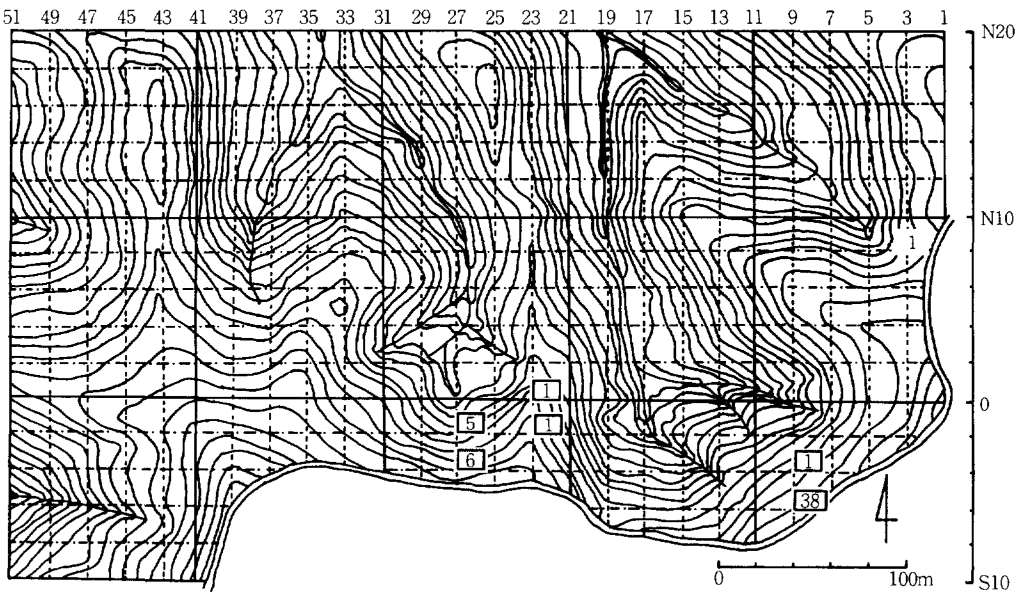

Fig.6. Seedling distribution of Meranti puthe timble (*Shorea agami*). Individual numbers (no./4m^2) are shown in this Figure.

Table 6. Relationships between soil type, vegetation type, and species number in 70 plots.

Soil type	Vegetation type				Total	Mean	s.d
	D	M	F	N		sp.no	
RD	12	1	0	6	19	16.5	6.0
YD	2	0	3	7	12	15.3	4.1
YM	10	2	4	9	25	18.5	4.6
YW	6	6	0	14	14	16.4	4.6
total	30	9	7	24	70	17.0	5.1

RD is red dry soil. YD is yellow dry soil. YM is yellow mesic soil. YW is yellow wet soil. For symbols of vegetation type see Table 1.

Table 7. Relationships between vegetation type, topography, and species number for all plots. For symbols see Table. 6.

Topography	Vegetation type				Total	Mean	s.d
	D	M	F	N		sp.no	
ridge	19	2	0	17	38	17.0	4.7
slope	11	7	10	18	46	17.4	5.3
bottom	4	8	0	2	14	18.9	6.3
Total	34	17	10	37	98	17.5	5.4
Mean sp.no	18.5	18.8	13.1	17.0			
s.d	4.4	5.0	7.4	4.8			

the relationship between light condition and the growth of commercial trees must be studied. For example, the study of dipterocarp seedlings grown in a shade house (SASAKI and MORI,1981) has been reported.

If the Malayan Uniform System or any other regeneration method were adopted, the most important task would be to evaluate whether the seedling populations are adequate for natural regeneration or not. If forest enrichment of the secondary forest is planned, a survey of seedling distribution, such as in this report, must be conducted. Next, the position and size of mother trees must be surveyed. Furthermore, the success of natural regeneration must be checked every five or ten years. An adequate system is required for monitoring regeneration.

4.6 Zoning of the plantation area

Site classification and the zoning of plantation areas are very important tasks. Soil surveys evaluate the potential productivity of the habitat. Vegetation surveys clarify the actual plant growth and seedling population, and biomass surveys analyze the forest structure as a mass. The zoning of a plantation area can be conducted using the results of these surveys. The study site is divided into two zones:the dipterocarp seedling zone in the eastern part and the disturbed zone in the western part. The dipterocarp seedling zone shows the probability of natural regeneration. Therefore, it is necessary to monitor the regeneration success and adopt the cutting of plants harmful to commercial trees or wilding plantations if necessary. On the other hand, dipterocarp species are unable to regenerate in the disturbed zone. It is essential to plant adequate dipterocarp or other commercial trees in each soil and vegetation type. For example, light-demanding trees are adequate for F-type vegetation.

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ブルネイの丘陵フタバガキ二次林における造林に関連した林床植生の分類

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摘　　要

ブルネイのアンドラウ森林保護区に隣接する、約13haの丘陵フタバガキ二次林で林床植生を調査した。目的は林床植生を分類し、地形、土壌及び林冠の状態と林床植生との関係を明らかにすることである。2ｍ×２ｍの調査方形区を20mごとに98地点に設置し、種組成と優占度を調べた。林床植生はフタバガキ稚樹型（D型)、単子葉植物型（M型)、シダ型（F型)、非フタバガキ木本型（N型）の四つに区分された。D型は尾根あるいは調査地の東側に分布し、M型は緩傾斜地や沢沿いに限って分布していた。F型は調査区西側の山火事の跡などにランダムに分布し、N型はこの調査地で基盤となる最も普遍的な林床型であった。土壌と林床型との関係はあまり明瞭ではなかったが、M型は湿性黄色土に、F型は乾性あるいは適潤性黄色土に分布していた。これらの林床植生の区分は造林のための立地区分の際の指標として用いることができると考えられる。

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