
Research article

Canopy Structure of a Logged-over Forest: Thirty Years After Logging

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ABSTRACT. Phytosociological studies were carried out in Compartment 128, Pasoh Forest Reserve, Negeri Sembilan, in order to assess the canopy structure and vegetation composition of the logged-over dipterocarp forest, thirty years after logging. A total of ten plots, each with the size of 60 x 40 m, were established to assess the vegetation composition, species dominance and stand structure for the compartment. Studies showed that the stand can be categorized as a *Syzygium - Canarium* stand. Meanwhile, the species composition of the study area can be differentiated into two communities, namely, *Dialium kunstleri - Baccaurea sumatrana* community and *Hopea odorata - Palaquium rostratum* community, and these communities can be further differentiated into four sub-communities. The vegetation of the compartment recorded the average of 12.5% canopy layer recovery of the emergent layer (ST), and 40%, 41.5%, 25.5%, and 17.5% for the dominant and co-dominant (T1), understorey (T2), shrub (S) and herb (H) layers, respectively. The family with the most representative was Dipterocarpaceae with twelve species representing three genera, followed by Leguminosae.

INTRODUCTION

Peninsular Malaysia is blessed with a unique tropical forest ecosystem. The forest, which is a highly valuable economic resource, has been systematically managed by the Forestry Department Peninsular Malaysia since 1901. For instance, the lowland and hill dipterocarp forests have been managed under the Malayan Uniform System (MUS) and Selective Management System (SMS), respectively. Even though the forest is being harvested annually, harvesting is carried out according to the strict guidelines of MUS and SMS.

The MUS was first formulated into the approved system at the 1949 Conference of Malayan State Forest Officers (Wyatt-Smith, 1995), and was first implemented in 1955 (Yusuf *et al.*, 1986). According to the guideline of the system, all mature trees of commercial species above 45 cm in DBH are to be removed in a single harvesting.

Naturally, the forest will recover after harvesting, and in the case of the MUS, the forest is expected to recover within 50 to 55 years (Wyatt-Smith, 1995). However the rate

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of recovery very much depends on the extent of the damage during harvesting. An assessment based on the phytosociological study was carried out in Pasoh Forest Reserve, Negeri Sembilan, to assess the recovery status of the logged-over lowland forest which was harvested in 1970s under the MUS.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Compartment 128 of Pasoh Forest Reserve, Negeri Sembilan (Fig. 1). According to the unpublished record of the Forestry Department of Negeri Sembilan, the compartment was first harvested in the 1960s and later in 1974.

According to the unpublished data obtained from the Malaysia Meteorological Service, the study area in general receives relatively moderate average annual rainfall of 1804 mm (1990 to 1997). The site is classified as an area which receives heavy rainfall (wet month) in November and December (Anon., 1992).

Method

The recovery assessment of Compartment 128 was mainly based on the rate of natural recovery (succession) of the logged-over forests toward achieving their natural status prior to harvest.

Vegetation studies based on the method of Braun-Blanquet (Fujiwara, 1987; Mohd Zaki, 1999; Mohd Zaki *et al.*, 2004; 2006) were carried out in the study site. A total of 10 phytosociological relevés or sample plots (each with the size of 60 x 40 m) were established randomly in the compartment. The phytosociological relevés could be simply characterized as:

- a) Selection of sites without gaps and creation of sample plots,
- b) Identification and record of all species found in each of the five layers: emergent or super tree (ST: above 30 m in total height), dominant (T1: 15 – 30 m), co-dominant and understory (T2: 8 – 15 m), suppressed and shrub (S: 2 – 8 m) and herb (H: lower than 2 m),
- c) Estimation of canopy coverage and sociability for each species in each layer (based on Fujiwara (1987)), and
- d) Identification of phytosociological communities.

RESULTS AND DISCUSSION

Canopy structure recovery

The emergent layer (ST) of Compartment 128 which was harvested in 1974 (F74) has reached an average height of 36 m, with five relevés recorded the height of 40 m, while the lowest ST-layer was recorded by Relevés 1, 2 and 6 (each with the total height of 30 m) (Table 1). The results also show that the average height of the T1-layer was 25 m, while the mean height of the T2, S and H were 16 m, 7.1 m and 1.65 m, respectively.

As shown in Table 1, the stand in general attained low to moderate ST-layer coverage of 5% to 20%, with the average of 12.5%. On the other hand, the compartment has moderate to high coverage of T1 and T2 layers, with the mean percent coverage of 40% and 41.5%, respectively. The canopy-layer coverage of the S-layers ranged from 20% to 30%, and the percent coverage of the H-layers ranged from 10% to 25%.

In order to elucidate the recovery status of the stand, the height recovery and canopy-coverage recovery of the stand were compared

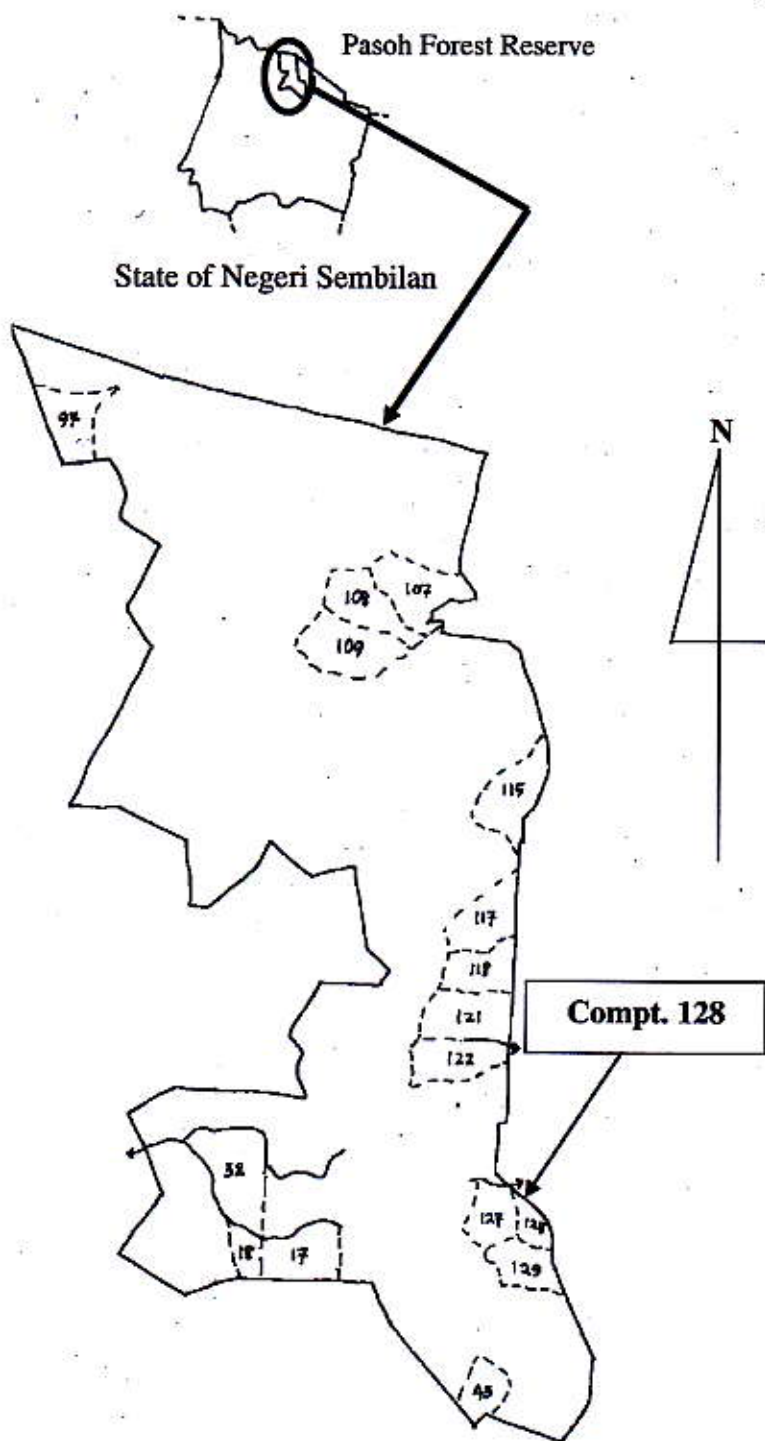


Figure 1: Location of Compartment 128, Pasoh Forest Reserve, Negeri Sembilan

to the data of the primary forest (PF), which were obtained and reported previously by Mohd Zaki (1999). The results show that the average height of the ST-layer of Compartment 128 (F74) is statistically lower than the average height of the PF of 48 m. The same can be said for the mean ST-layer coverage of the F74 sites of 12.5% which is significantly lower than the PF (mean coverage of 26%) (Table 2). Table 2 also shows that the canopy coverage of T1 and T2 is comparable to that of the PF, however, the coverage of the S and H is lower.

According to the statistical analysis, there were significant differences between the coverage-percentage of T1 layer of the 10 relevés. On the other hand, there was no significant difference for the other four layers (T1 to H).

Species richness and composition

A total of 101 species representing 73 genera and 40 families were enumerated in the ten relevés. The relative richness of genus to species richness was 72%, and the relative richness of family to genus richness was 55% (Table 3). These figures are comparable to the studies conducted on the stands harvested in 1978 in Senaling Inas Forest Reserve, Negeri Sembilan by Azzuliani (2002).

The vegetation of the compartment can be classified as the Kelat – Kedondong stand (*Syzygium* – *Canarium* stand). The most common species in the compartment besides *Syzygium* sp. and *Canarium* sp. are *Parkia speciosa*, *Garcinia* sp., *Arenga obtusifolia* and *Licuala longipes*, which are represented in nine out of ten relevés (Table 4). The vegetation composition of the stand can be differentiated into two communities of *Dialium kunstleri* - *Baccaurea sumatrana* and *Hopea odorata* - *Palaquium rostratum*. The former community is discovered in seven relevés at elevation ranging from 200 to 260 m

above sea level (a. s. l.). Amongst the main species in this community are *D. kunstleri*, *B. sumatrana*, *Artocarpus* sp., *Dipterocarpus cornutus*, *Memecylon* sp., *Shorea macroptera* and *S. acuminata*. The latter community which occurs at 200 to 230 m a. s. l. is represented by common species of the community, such as *H. odorata*, *Palaquium maingayi*, *P. rostratum*, *Dipterocarpus grandiflorus* and *Sindora velutina*.

Species dominance recovery

In general, these stands have recovered fairly well with low to moderate ST-layer, and moderate to sound coverage of T1 and T2 layers. However, since the original state of the stands before harvest was that of the lowland dipterocarp or mixed dipterocarp forest (Soepadmo, 1978; Anon., 1991), the high coverage of dipterocarp is necessary before the stands can be considered as recovered. Even though the Dipterocarpaceae is the most represented family with 12 species representing 3 genera, the number of individuals in each of the top two layers is apparently small. The ST and T1 layers, for example, are mainly dominated by non-dipterocarps, such as *Syzygium* sp., *Canarium* sp., *Garcinia* sp., *Scaphium macropodon* and *Artocarpus* sp. On the other hand, dipterocarps, such as *Dipterocarpus cornutus*, *Hopea odorata*, *Shorea acuminata* and *S. macroptera* are only dominating the T2 and S layers.

Previous reports by Mohd Zaki (1999) and Mohd Zaki *et al.* (2004) stated that most of the stands harvested under the MUS tend to be dominated by the dipterocarps due to the poison girdling of non-commercial species (mainly non-dipterocarps) immediately after harvesting. The phenomenon is not reflected in the present study. The only explanation for the lack of dipterocarps in the stands may lie in the total number of dipterocarps taken out

Table 1: Height (m) and Coverage Percentage (%) for each canopy layer for different relevé

Relevé Number	1	2	3	4	5	6	7	8	9	10	Mean
Ht of ST-layer (m)	30	40	40	30	40	30	40	40	35	35	36
Cover of ST-layer (%)	20	5	10	10	5	20	15	5	15	20	12.5
Ht of T1-layer (m)	20	30	25	20	30	25	25	25	25	25	25
Cover of T1-layer (%)	50	35	40	35	30	40	40	40	50	40	40
Ht of T2-layer (m)	15	20	15	15	20	15	15	15	15	15	16
Cover of T2-layer (%)	40	40	50	45	30	50	30	50	40	40	41.5
Ht of S-layer (m)	5	8	8	5	8	5	8	8	8	8	7.1
Cover of S-layer (%)	30	25	20	20	25	20	30	30	25	30	25.5
Ht of H-layer (m)	2	1.5	1.5	2	1.5	2	1.5	1.5	1.5	1.5	1.65
Cover of H-layer (%)	20	15	10	10	25	20	20	20	15	20	17.5

Table 2: Comparison of average forest-layer coverage between F74 and Primary forest

Average coverage at different forest layers (%)	F74	Primary forest1
ST	12.5	26
T1	40	43
T2	41.5	50
S	25.5	61
H	17.5	28

Note: from Mohd Zaki (1999)

Table 3: Comparison of taxonomic richness between two study areas

Forest Type	Plot Size (ha)	No. of Species	No. of Genera	No. of Families
F74	2.4	101	73 (72%) ²	40 (55%)
F78 ¹	2.4	120	104 (87%)	52 (50%)

Note: ¹ from Azzuliani (2002).

²The number in parentheses indicates richness relative to that of the next lower taxonomic level: ratio of genus to species richness (genus column) and ratio of family to genus richness (family column).

Table 4: Summary of the common species and differential species of the communities

Relevé No.		9	10	4	8	5	6	7	2	3	1
Altitude (m)		220	210	260	210	240	250	220	230	230	200
Aspect		N	N	N	E	E	N	N	E	N	N
Slope (%)		20	15	10	12	14	15	20	20	15	15
No. of species		53	51	39	50	49	41	43	31	37	34
Common species:	Layer										
<i>Syzygium</i> sp.	T1, T2,S	1.2 ²	2.3	2.3	1.2	2.1	2.2	2.3	2.1	2.3	2.3
<i>Canarium</i> sp.	T1, T2,S	1.1	2.2	2.2	2.2	2.2	1.1	2.2	1.2	2.2	2.3
<i>Parkia speciosa</i>	T2,S,H ¹	1.1	1.1	1.1	1.1	1.1	-	1.1	2.2	1.2	1.1
<i>Licuala langipes</i>	S	+	1.3	1.1	2.3	+	1.1	3.2	1.2	2.3	-
<i>Arenga obtusifolia</i>	S,H	2.3	2.2	1.1	1.1	1.1	+	1.1	-	1.1	2.1
<i>Scaphium macropodan</i>	T1, T2,S	2.3	2.2	+	1.2	-	2.2	-	1.1	2.2	3.2
<i>Pometia pinnata</i>	T2	2.2	2.2	+	2.2	1.2	1.1	1.1	-	-	2.2
Differential species of Community 1:											
<i>Dialium kunstleri</i>	T2,S	2.3	2.3	2.2	+	1.2	2.1	+	-	-	-
<i>Baccaurea sumatrana</i>	T2	2.3	2.3	+	2.2	2.2	+	2.2	-	-	-
<i>Ariocarpus</i> sp.	T1, T2,S	+	2.2	+	1.1	1.1	1.1	1.1	-	-	-
<i>Dipterocarpus cornutus</i>	T2,S	+	+	1.1	1.1	2.2	1.1	+	-	-	-
<i>Memecylon</i> sp.	S,H	+	1.1	2.2	+	+	2.2	1.1	-	-	-
<i>Shorea macroptera</i>	T2,S	-	+	1.1	1.1	+	1.1	1.1	-	+	-
<i>Shorea acuminata</i>	T2,S	-	+	+	+	+	1.1	1.1	-	-	-
<i>Intsia palembanica</i>	T2,S	-	1.1	+	1.1	1.1	1.1	1.1	-	-	-

Table 4. continued

Differential species of sub-community:

<i>Artocarpus elasticus</i>	S	2.2	3.2	2.3	3.4	2.2	-	-	-	-	-
<i>Balakata baccatum</i>	S,H	+	1.1	1.1	1.1	1.1	-	-	-	-	-
<i>Callerya atropurpurea</i>	T2,S	2.1	+	+	1.2	1.1	-	-	-	-	-
<i>Ormosia bancana</i>	T2,S,H	+	+	+	1.1	1.1	-	-	-	-	-
<i>Shorea leprosula</i>	T2,S	+	+	+	+	+	-	-	-	-	-
<i>Xerospermum intermedium</i>	T1, T2	2.2	2.2	-	2.2	2.2	-	-	-	-	-
<i>Dipterocarpus costulatus</i>	T2,S	+	+	1.1	1.1	-	-	-	-	-	-
<i>Albizia splendens</i>	H	-	-	-	-	-	1.2	+	-	+	-
<i>Dipterocarpus crinitus</i>	S	-	-	-	-	-	1.1	+	-	+	-
<i>Hopea beccariana</i>	S	-	-	-	-	-	1.1	+	-	-	-
<i>Sandoricum koetjape</i>	T2,S	-	-	-	-	-	+	+	-	-	-
Differential species of Community 2:											
<i>Hopea odorata</i>	T2,S	-	-	-	-	-	-	-	3.2	1.2	1.1
<i>Palaquium rostratum</i>	T2	-	-	-	-	-	-	-	+	1.1	1.1
<i>Palaquium maingayi</i>	S	-	-	-	-	-	-	-	+	1.1	1.1
<i>Dipterocarpus grandiflorus</i>	T2	-	-	-	-	-	-	-	1.1	1.1	-
<i>Sindora velutina</i>	S	-	-	-	-	-	-	-	+	+	-
Differential species of sub-community:											
<i>Shorea bracteolata</i>	T2	-	-	-	-	-	-	-	1.1	+	-
<i>Artocarpus rigidus</i>	T2	-	-	-	-	-	-	-	1.1	+	-
<i>Vitex pubescens</i>	S	-	-	-	-	-	-	-	+	+	-
<i>Elasterospermum tapos</i>	T2	-	-	-	-	-	-	-	-	-	2.3
<i>Xanthophyllum sp.</i>	T1, T2	-	-	-	-	-	-	-	-	-	+
<i>Bouea macrophylla</i>	T2	-	-	-	-	-	-	-	-	-	+
<i>Cinnamomum iners</i>	S	-	-	-	-	-	-	-	-	-	+
<i>Oncospermum horridum</i>	T2	-	-	-	-	-	-	-	-	-	+

Note:

- Parkia speciosa* (T2,S,H) denotes the presence of the species in the T2, S and H layers.
- 1.2 denotes the cover (and abundance) of 1, and the sociability level of 2.
- Cover (and abundance) (from Fujiwara, 1987):
 - + = Few individuals; covering less than 5% of the plot
 - 1 = Covering less than 5%, but with more cover
 - 2 = 5-25% cover
 - 3 = 25-50% cover
 - 4 = 50-75% cover
 - 5 = 75-100% cover
- Sociability level (from Fujiwara, 1987):
 - 1 = Growing solitary
 - 2 = Growing in small group of few individuals
 - 3 = Growing in small patches
 - 4 = Growing in extensive patches
 - 5 = Growing in large crowd

of the stand during harvesting. The records of Forestry Department of Negeri Sembilan reveal that the stands were harvested at least twice, in 1960s and 1974, and many dipterocarps, which may have reached the DBH of more than 45 cm could have been taken out. The dipterocarps which are currently present in the T2 layer will require some time for them to emerge and dominate the stands.

The stands can also be classified as at the early phase of a middle-succession period due to the dominant presence of middle-successional species, such as *Balacata baccatum*, *Endospermum diadenum* and *Neolamarckia cadamba*. The openness of the area after two harvests has encouraged these species and other non-dipterocarps to dominate the stands. Since the number and coverage of dipterocarps are relatively small, these stands could be planted with some dipterocarps to enrich them.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be made from this study:

1. The forest in the compartment has recovered fairly well (low to moderate) in terms of height and canopy coverage in a short period of time (about thirty years).
2. The stands, however, are dominated by the non-dipterocarps thirty years after harvest. These stands require replanting of some species from the dipterocarp family to enrich them.
3. It is recommended that further analyses be made on the data from the vegetation studies, previous logging and pre-felling inventories to elucidate the degree of closeness or difference of the recovering forests with respect to the natural state.

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