E-1.1 Comparative studies on composition, distribution patterns and population structures of tree species in disturbed and undisturbed forests

Contact person Kaoru NIIYAMA
Senior researcher
Division of Forest Environment
Forestry and Forest Products Research Institute (FFPRI)
Ministry of Agriculture, Forestry and Fishery
Matsunosato 1, kukisaki, inashiki, Ibaraki, Japan 305-8687
Tel: +81-298-73-3211, ex.356、 Fax:+81-298-73-1542,
E-mail, niiya@ffpri.affrc.go.

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Abstruct Species composition, diversity, and population structures of tree species were compared between a 4-ha regenerated (logged forest) plot and a 6-ha primary (natural forest) plot in a hill dipterocarp forest in Semangkok Forest Reserve, Peninsula Malaysia. Total number of species was larger in the primary plot (464 species) than the regenerating plot (421 species). In the primary plot, 170 of 464 species were specific to the plot, and 127 of 421 species were specific to the regenerating plot. Total numbers of families and genera were larger in the regenerating plot. In the primary plot, species richness was as follows; γ = 464, α = 26.7, and β = 0.12. In the regenerating plot, γ = 421, α = 26.2, and β = 0.16. Species diversity *H'* was slightly larger in the primary plot (*H'* = 5.28) than the regenerating plot (*H'* = 5.13). However, species evenness *J'* was similar; 0.86 and 0.85 in the primary and regenerating plots, respectively. The composition of common 30 tree species remarkably altered between the plots. *Shorea curtisii*, which is the most important timber tree in the hill forests, was dominated in the primary plot. *Macaranga triloba* was the only light demanding tree species among the 30 species in the primary plot. On the contrary, pioneer or secondary tree species of Euphorbiaceae occupied the half of 30 common tree species in the regenerating plot. Size structures of emergent tree species (*Shorea curtisii*), canopy tree species (*Antidesma cuspidatum*) and typical light demanding tree species (*Macaranga triloba*) were compared between the two plots. Size structure of *Shorea curtisii* changed by selective cutting, but those of *Antidesma cuspidatum* and *Macaranga triloba* were not largely changed. Eco-physiological traits of these species were also investigated.

Key Words Hill dipterocarp forest, Selective logging, Pioneer species, Peninsula Malaysia

1. Introduction

A large area of tropical rain forests in the southeast Asia was already disturbed by logging, fires, and many other artificial activities. To manage and improve these disturbed forests was an important task for foresters. In hill forests logging is now continued under the Selective Management System in Malaysia. However, regeneration of timber trees was not confirmed. Logging damage was more severe in the hill forests than in lowland dipterocarp forests where topography were flat and timber trees were scarcely distributed throughout the forests. The topography of hill forests was very steep and a large timber stocking concentrated on the ridges. Advanced regeneration of dipterocarp species was scarce in the hill forests. In addition, logging affected the structure and dynamics of the tree species. Detailed ecological comparison between logged and unlogged forests were an important step to establish a sustainable forest management system in the hill forests. The purpose of this study was to compare the tree species diversity, species composition, and population structures of common tree species between a logged-over regenerating forest and an unlogged primary forest in hill forests.

2. Methods

We established a 6-ha primary forest plot in Semangkok Forest Reserve and a 4-ha regenerating plot in a selective logging area adjacent to the reserve. All trees larger than 15 cm in g.b.h. (girth at 1.3 m height) were tagged, measured and identified to species level. The regeneration plot was selectively cut 30 per cent of the timber volume in 1988. Trees were measured in 1993, 1995, and 1997 for primary plot and in 1994 and 1997 for regenerating plot. Data sets of primary and regenerating plots in 1997 were used for analysis in this report. Each study plot was divided into 20 m x 20 m quadrats. Tree species diversity was calculated at every 20 m x 20 m quadrat. Diversity was separated into species richness, diversity, and evenness. Species richness was calculated as follows;

$$\gamma = \alpha \cdot \beta \cdot Q \tag{1}$$

where γ is a number of species in the plot, α is a mean number of species in 20 m x 20 m quadrats, β is a turn over rate of species among quadrats, and Q is a number of quadrats in each plot. Species diversity was indicated by H' (Shannon-Wiener function).

$$H' = - \Sigma p_i \ln p_i, \tag{2}$$

$N = \Sigma n_i, \quad p_i = n_i / N,$ (3)

where n_i is a number of individuals in species i, N is a total number of individuals in the plot. Species evenness was indicated by J'.

$J' = H' / H'_{max} = H' / \ln S,$ (4)

where S is a number of species in the plot. These diversity indices were compared between the regenerating and primary plots. The common 30 species dominated in abundance were listed and their species composition were compared between the plots.

3. Results

Number of species depending on sample area and number of individuals were slightly larger in the regenerating plot than the primary plot (Fig. 2). Total number of species was larger in the primary plot (464 species) than the regenerating plot (421 species). In the primary plot, 170 of 464 species were specific to this plot, and 127 of 421 species were specific to the regenerating plot. Total numbers of families and genera were larger in the regenerating plot. In the primary plot, species richness was as follows; $\gamma = 464$, $\alpha = 26.7$, and $\beta = 0.12$. In the regenerating plot, $\gamma = 421$, $\alpha = 26.2$, and $\beta = 0.16$. Species diversity (H') was slightly larger in the primary plot ($H' = 5.28$) than the regenerating plot ($H' = 5.13$). However, species evenness (J') was similar; 0.86 and 0.85 in the primary and regenerating plots, respectively.

Composition of common tree species was altered remarkably (Tables 1 and 2). *Shorea curtisii*, which is the most important timber tree in the hill forests, was dominated in the primary plot. *Macaranga triloba* was the only light demanding tree species among the 30 species. On the contrary, pioneer or secondary tree species of Euphorbiaceae occupied the half of 30 common tree species in the regenerating plot.

Size structures of emergent tree species (*Shorea curtisii*), canopy tree species (*Antidesma cuspidatum*) and typical light demanding tree species (*Macaranga triloba*) were compared between the two plots (Fig. 3). Size structure of *Shorea curtisii* changed by selective cutting, but those of *Antidesma cuspidatum* and *Macaranga triloba* were not largely changed.

4. Discussion

Species diversity has been maintained or not is one of the important criteria to evaluate that the sustainable forest management was carried out in logged forests. Species richness, species diversity, and species evenness were similar both in the primary and regenerating plots. These diversity indices were obtained only from the species abundance not from the information of individual species. On the other hand composition of common tree species and a large number of sparse or rare species were altered or differed between the plots in spite of two plots apart from only several hundred meters. These results reveal that sustainability of both species diversity and species composition should be checked. It is difficult to separate the effect of selective cutting from those of the distance and environmental conditions on species composition. Complete data set before logging is needed to comparative studied in logged-over and primary forests.

The effect of logging on size structures of tree species was largely different among species. *Shorea curtisii* lost most of the mother trees larger than 60 cm d.b.h by logging. *Antidesma cuspidatum* lost only the large individuals. Density of *Macaranga triloba* increased drastically in the regenerating plot due to the increase of canopy gaps by logging, but its size structure was similar in the two plots. This light demanding species colonizing on large gaps seems to perform completely same ecological traits both in primary and regenerating plots.

5.Research output

Publications

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Table 1. Abundnce of 30 common tree species in the primary plot.

Species	Primary (no./ha)	Regenerating (no./ha)
1 *Shorea curtisii*	52.2	21.3
2 *Lithocarpus wallichianus*	29.3	6.0
3 *Teijsmanniodendron coriaceum*	24.2	4.8
4 *Antidesma cuspidatum*	19.3	23.0
5 *Scaphium macropodum*	19.3	5.5
6 *Eurycoma longifolia*	19.2	0.8
7 *Diospyros latisepala*	19.0	0.5
8 *Macaranga triloba**	**13.3**	**59.3**
9 *Pimelodendron griffithianum*	13.0	16.8
10 *Aidia wallichiana*	12.7	5.8
11 *Canarium patentinervium*	11.0	12.5
12 *Dacryodes rostrata*	10.8	8.3
13 *Artocarpus lanceifolius*	10.5	7.5
14 *Xanthophyllum griffithii*	10.5	1.3
15 *Diospyros venosa*	10.5	1.0
16 *Myristica iners*	10.0	2.8
17 *Vatica odorata*	10.0	
18 *Payena lucida*	9.5	6.3
19 *Dacryodes rugosa*	9.5	0.8
20 *Archidendron bubalinum*	8.5	8.8
21 *Millettia atropurpurea*	8.2	6.3
22 *Diospyros styraciformis*	7.7	2.8
23 *Anisoptera curtisii*	7.7	2.5
24 *Eugenia ridleyi*	7.2	0.8
25 *Baccaurea minor*	7.0	
26 *Ochanostachys amentacea*	6.8	5.8
27 *Vitex longisepala*	6.8	
28 *Artocarpus nitidus var. griffithii*	6.3	2.8
29 *Artocarpus integer*	6.2	8.5
30 *Santiria laevigata*	6.2	6.5

* : Pioneer, secondary , and late-seral tree species

Table 2. Abundnce of 30 common tree species in the regenerating plot.

Species (order in primary plot)	Primary (no./ha)	Regenerating (no./ha)
1 ***Macaranga triloba* *(10)**	**13.3**	**59.3**
2 ***Vitex gamosepala* ***	**4.8**	**58.8**
3 ***Mallotus griffithianus* ***	**0.7**	**26.5**
4 *Antidesma cuspidatum* (4)	19.3	23.0
5 ***Macaranga gigantea* ***	**0.2**	**22.5**
6 *Shorea curtisii* (1)	52.2	21.3
7 *Pimelodendron griffithianum* (8)	13.0	16.8
8 ***Pternandra echinata* ***	**6.0**	**16.3**
9 *Canarium patentinervium* (11)	11.0	12.5
10 *Shorea leprosula*	4.7	12.3
11 *Lithocarpus rassa*	0.7	11.0
12 ***Macaranga heynei* ***	**0.3**	**10.5**
13 *Diospyros sumatrana* (29)	6.0	9.0
14 *Elateriospermum tapos*	1.0	8.8
15 *Archidendron bubalinum* (20)	8.5	8.8
16 *Artocarpus integer*	6.2	8.5
17 *Dacryodes rostrata* (14)	10.8	8.3
18 *Shorea macroptera*	1.7	7.8
19 ***Endospermum malaccense* ***	**2.0**	**7.5**
20 *Artocarpus lanceifolius* (12)	10.5	7.5
21 ***Elaeocarpus nitidus* ***	**2.5**	**7.0**
22 *Timonius wallichianus*	1.5	6.5
23 *Shorea bracteolata*	0.7	6.5
24 *Santiria laevigata*	6.2	6.5
25 *Sapium baccatum*	0.7	6.3
26 *Santiria apiculata*	2.5	6.3
27 *Payena lucida* (19)	9.5	6.3
28 *Millettia atropurpurea* (21)	8.2	6.3
29 *Gynotroches axillaris*	3.3	6.3
30 *Lithocarpus wallichianus* (2)	29.3	6.0

* : Pioneer, secondary , and late-seral tree species

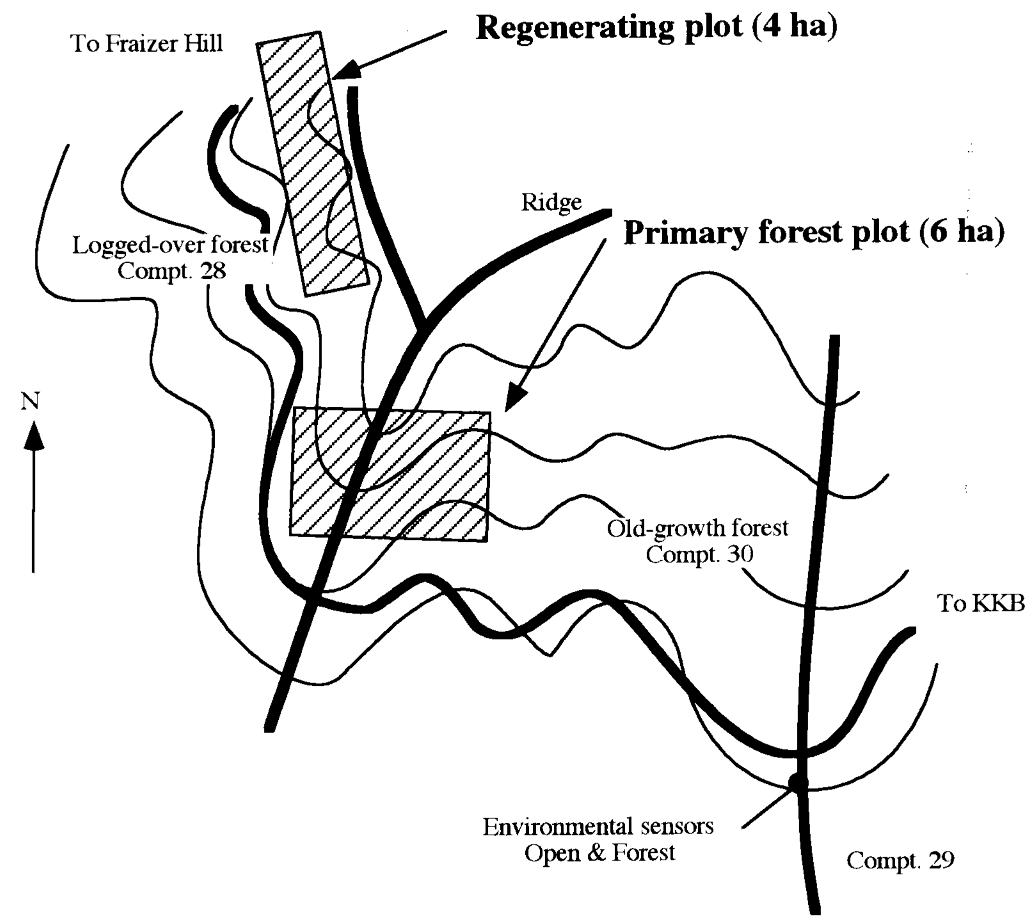

Fig. 1 Location of study plots.

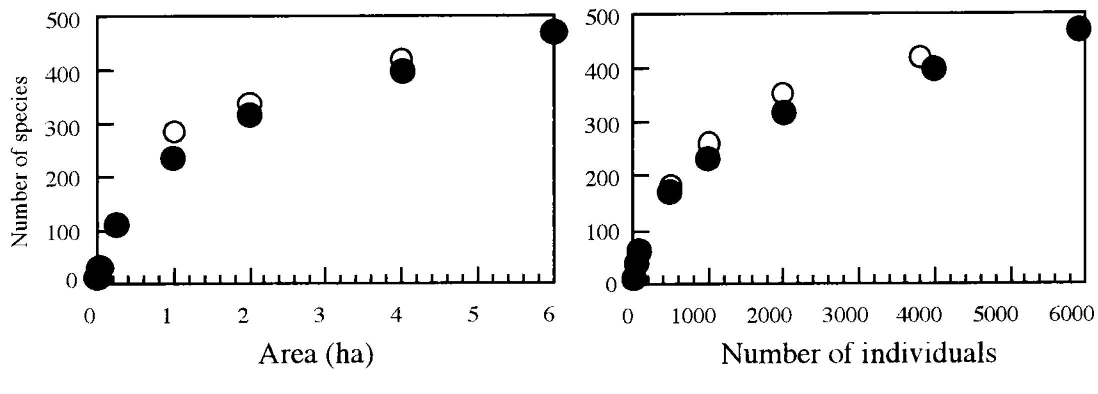

Fig. 2. Species-area and species-individual relationships in the two plots. Open circles are regenerating plot, closed circles are primary plot.

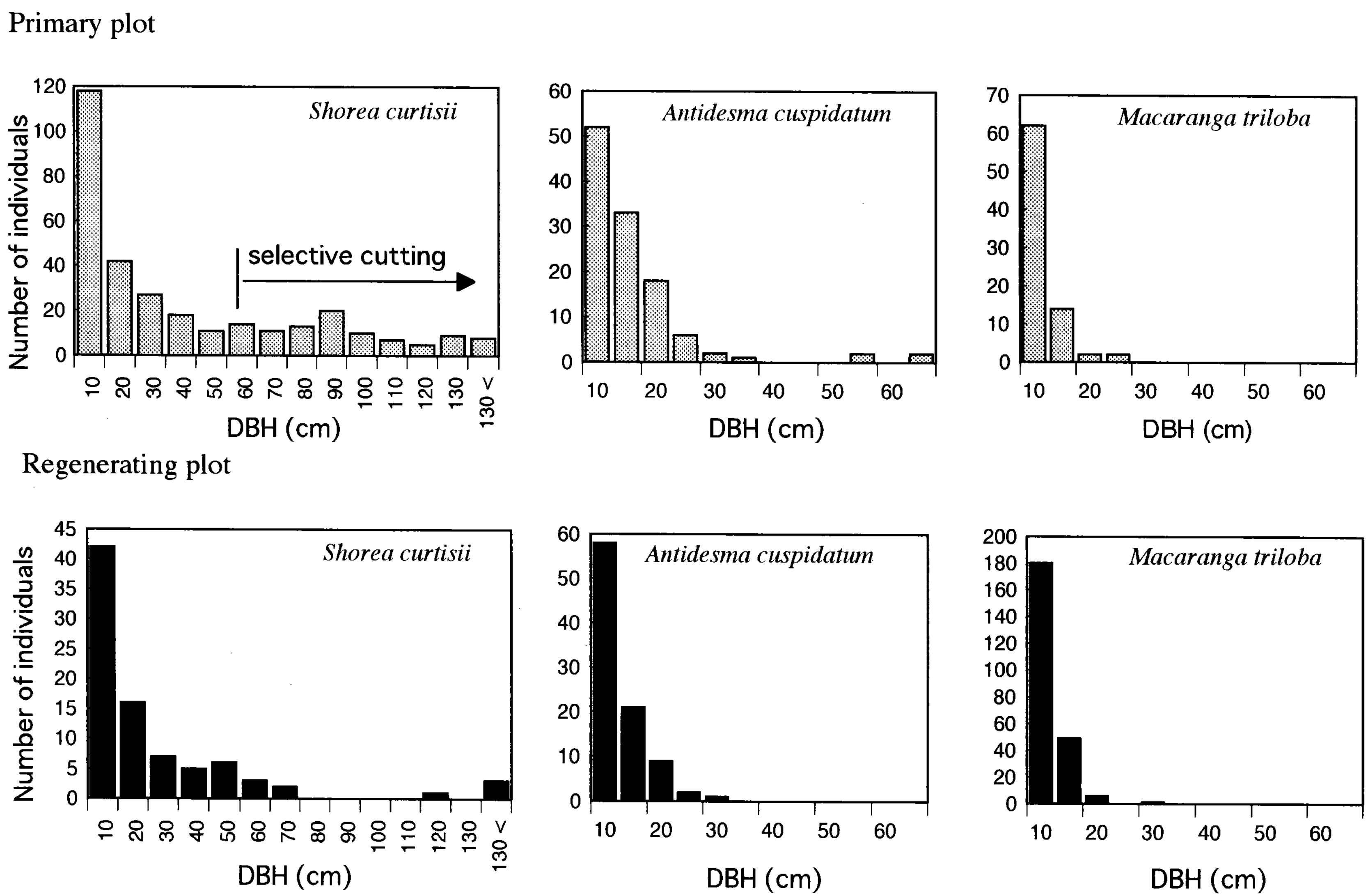

Fig. 3. Size structures of three common tree species in primary and regenerating plots