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Canopy Structure of Toh-Daeng Primary Peat Swamp Forest at Narathiwat Province, Southern Thailand

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ABSTRACT

Twelve of 10x50 m plots were sampled at 500 m interval at the northern portion of Toh-Daeng primary peat swamp forest, Narathiwat Province. Tree density and basal area of nine undisturbed plots were used for analysis. A polythetic agglomerative cluster analysis was used to classify sample plots into three groups: *Macaranga pruinosa* community, mixed peat swamp with *M. pruinosa* community and mixed peat swamp community. Structure of each community was described. Tree density, basal area and number of species are highest for mixed peat swamp community and less for *M. pruinosa* community.

INTRODUCTION

Peat swamp forest, a distinctive forest formation, with specific flora and environment. Peat is usually 0.5–10.0 m depth and is strongly acidic. It is a decomposed organic matter, debris and fibrous materials. Normally, the extensive peat swamp forest is convex and not subjected to flooding in dry season while flooding in rainy season. The forest mostly developed near the coast.

The area of peat swamp forest in Narathiwat Province is 26,600 ha, which is more than one half of the total area of peat swamp forest in Thailand. Only 6000 ha of primary peat swamp forest remain intact. For the remaining primary peat swamp forest, Toh-Daeng, is the largest primary peat swamp forest in Thailand, located in the districts of Sungai Padi and Sungai Kolok, Narathiwat Province.

Since most of studies in peat swamp forest in Thailand concentrated on flora (Phengklai and Niyomdham 1991, Samati 1990, Niyomdham 1986, Phengklai 1982). Only a few studies dealt with its structure, but all are described in general terms (Phengklai *et al.* 1989, Niyomdham 1988). This study aims to classify the primary peat swamp forest at Narathiwat Province into community types and to determine their structure as well.

LOCATION

Toh-Daeng primary peat swamp forest is located at the districts of Sungai Padi and Sungai Kolok, Narathiwat Province near the Malaysian border. It lies between 6°05′–6°13′ N and 101°56′–102°03′ E (Figure 1).

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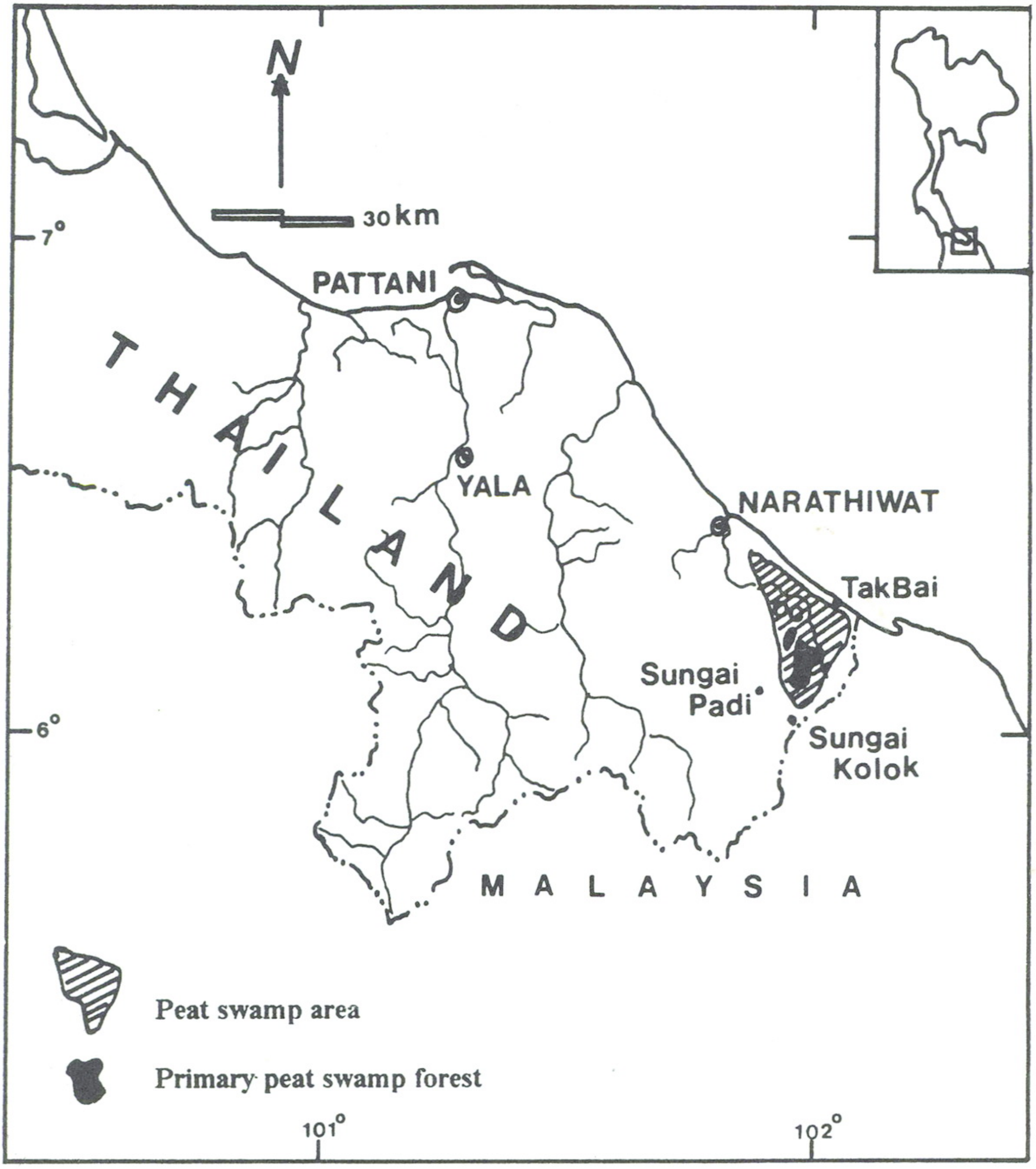


Figure 1. Location of study area.

The climate is hot-wet. Average annual rainfall is 2,465 mm and average mean temperature is 27.2°c. Walter climatic diagram of Narathiwat Province has shown in Figure 2.

FIELD PROCEDURES

Northern portion of Toh-Daeng primary peat swamp forest was selected for this study. Line plot method was used for field sampling. A base line laid through primary peat swamp forest in east-west direction, from eastern edge to western edge of the forest. Along the base line, 12 of 10x50 m plots were sampled at 500 m interval. In each sample plot all tree dhb>5.0 cm were measured, recorded and the species identified. Specimens of unidentified trees were collected and dispatched to the Forest Herbarium, Royal Forest Department in Bangkok for identification. Crown cover and profile diagram were prepared.

DATA ANALYSIS

Nine of twelve sample plots were selected for analysis. The first two sample plots from the eastern edge and the last plot were deleted from this study due to major disturbance. For each stand, density and basal area cover of each species were transformed to relative density and relative basal area cover. The importance value (IV= The sum of relative density and relative basal area cover) of each species was computed for all species, then the importance value of each species was transformed to relative importance value.

The similarity analysis for all stand was used to divide the gradational vegetation to homogeneous segment. The coefficient of similarity using Motyka's Index c= 2w/(a+b) (Bray and Curtis 1957) where w is the sum of the smaller of the two relative importance values of the species that are common to two sample stands, a is the sum of all relative importance values in one stand and b is the sum of the other stand. Dissimilarity values were calculated by 1-c. Dissimilarity indices matrix was used to cluster. The analysis is agglomerative, polythetic and hierarchical. The lowest dissimilarity index of the stand-pair was fused. The pair became a new group, procedure was continued until all stand was joined together.

RESULTS AND DISCUSSION

The dissimilarity values from the cluster were moderate with one group indicating a level of dissimilarity of 0.4 and the other two groups indicating a level of around 0.6 (Figure 3). The tree species composition of nine plots is given in Appendix 1. Based on importance values of species composition of the stands in each group, the primary peat swamp forest is classified into three communities.

1. *Macaranga pruinosa* community. This community is characterized by *Macaranga pruinosa* (Miq.) Muell.Arg., a pioneer species. Only *M. pruinosa* forms a continuous upper canopy at about 30–35 m. The middle canopy is also dominated by *M. pruinosa* with a height of 18–25 m, but does not form a continuous canopy. Some other species occurring in this middle canopy are *Nephelium maingayi* Hiern

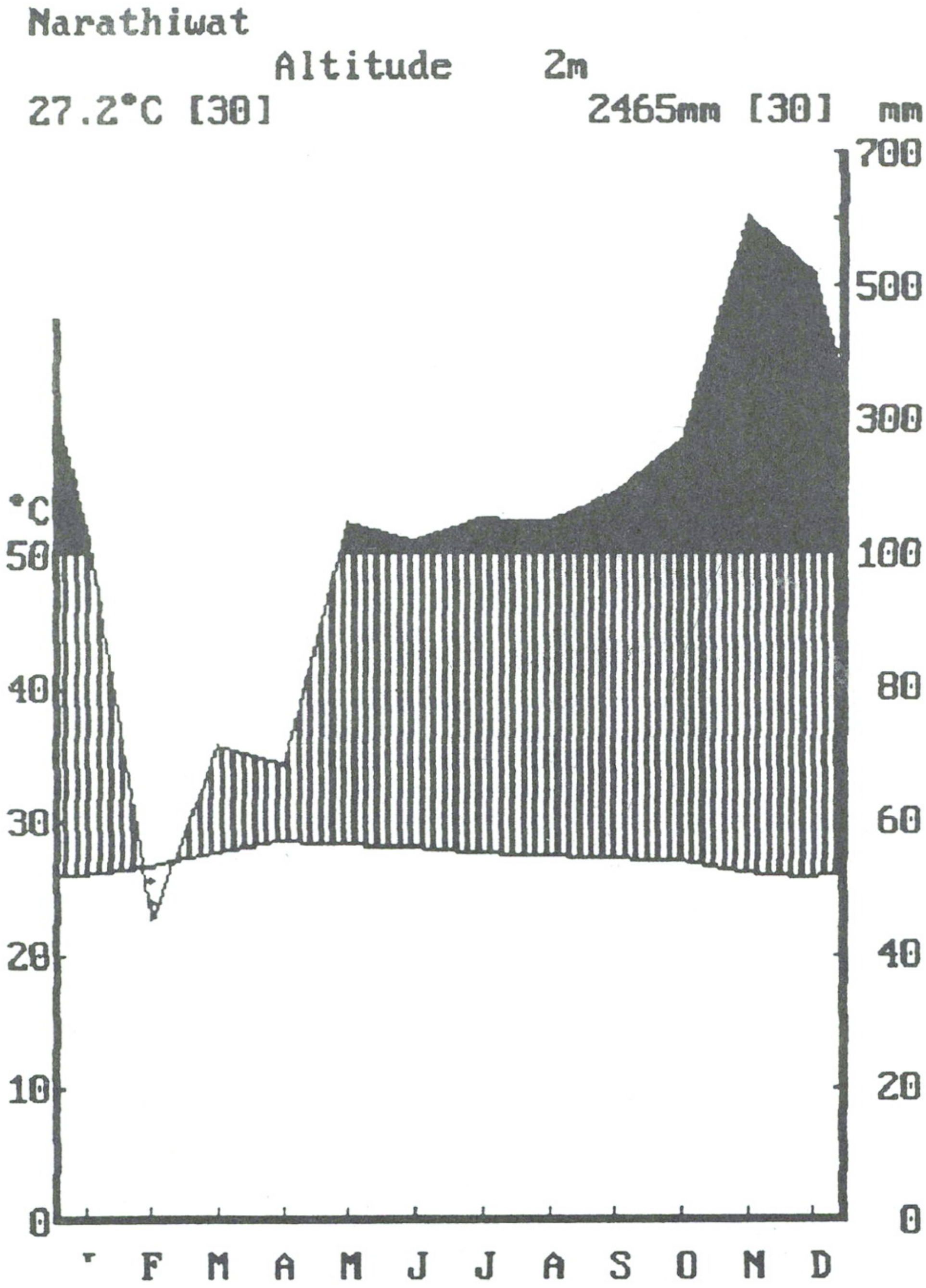


Figure 2. Walter climatic diagram of Narathiwat Province.
(Sources: Meteorological Department, Ministry of Communications).

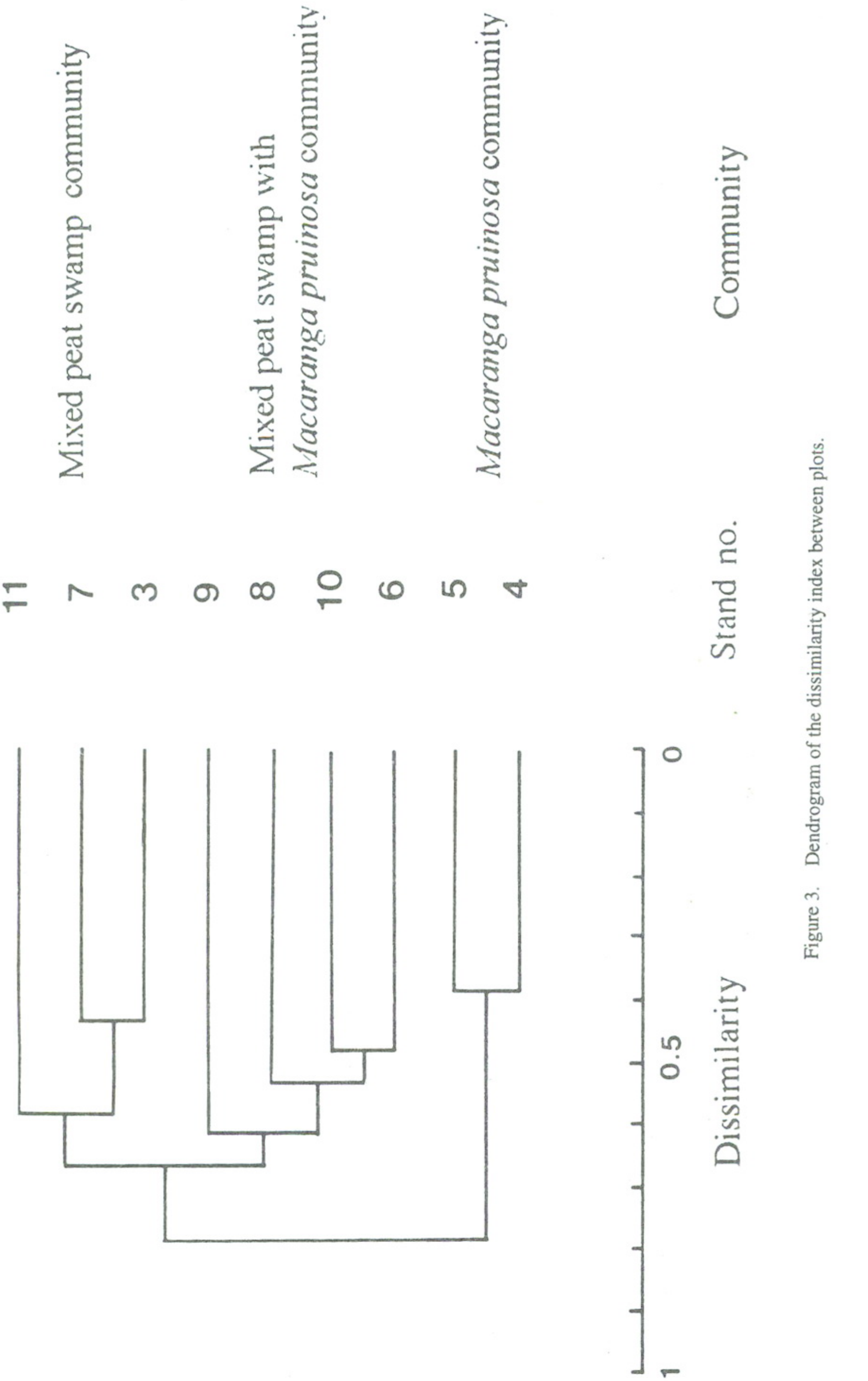


Figure 3. Dendrogram of the dissimilarity index between plots.

and *Neesia malayana* Bakh. Middle story is sparse. It is a story of small tree and pole size of intermediate tolerance species such as *N. malayana* and *Gymnacranthera eugeniifolia* (A.DC.) J.Sincl. This story is about 8–10 m. Undergrowth is dense with palm, *Licuala longecalycata* Furt., *Eleiodoxa conferta* (Griff.) Burr., and *Cyrtostachys renda* Bl., of 3–5 m high.

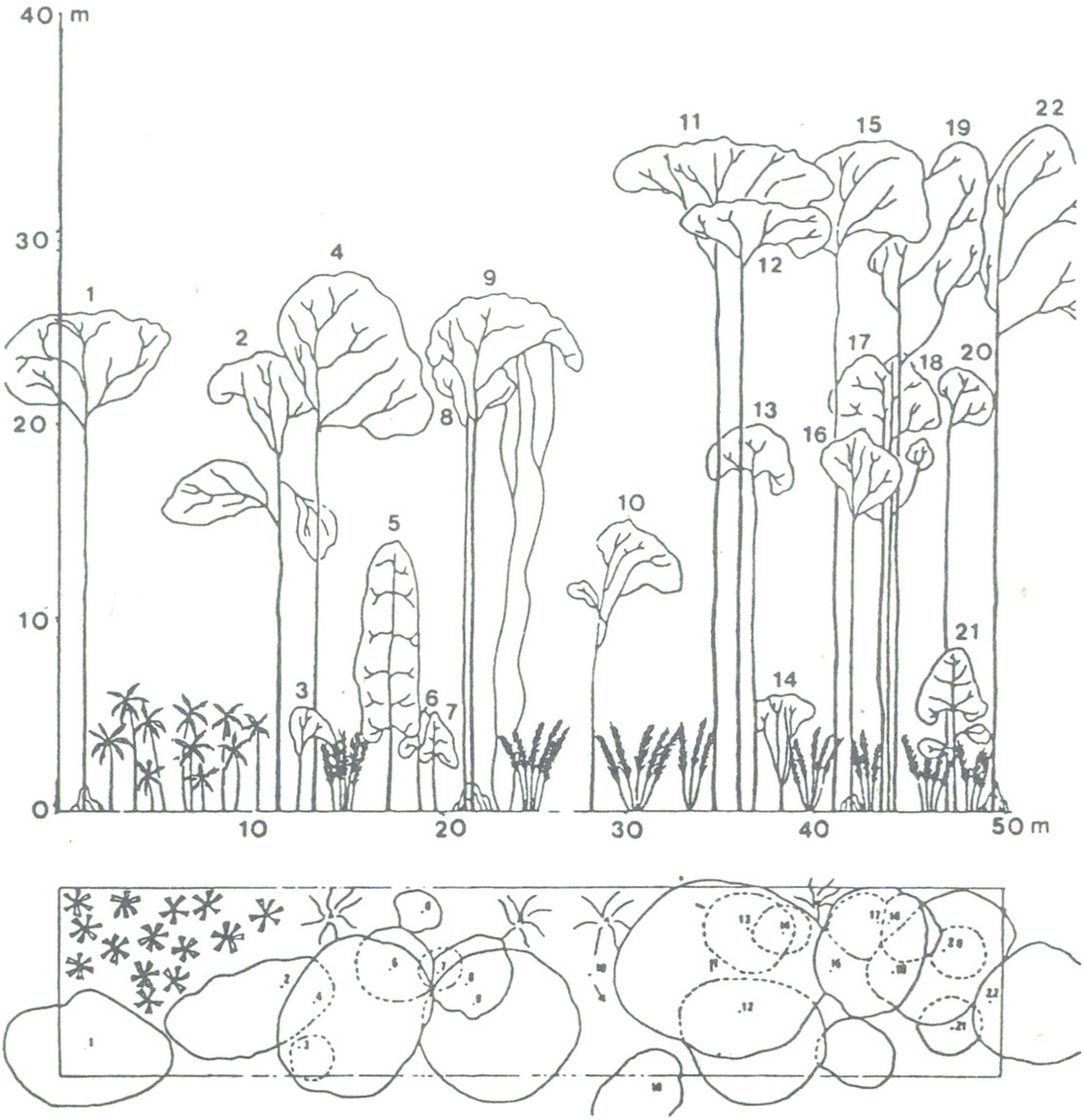
Profile diagram of *M. pruinosa* community was shown in Figure 4. The right portion of the diagram is the typical structure of *M. pruinosa* community. The left of the diagram should be the relic tree of the primary peat swamp forest before gap was created.

2. Mixed peat swamp with *Macaranga pruinosa* community. This community is dominated by 5 importance species for all ecological group of tree species. A pioneer species, *M. pruinosa*; intermediate tolerance or late secondary species, *N. malayana, Campnosperma coriaceum* (Jack) Hall.f. ex Steen. and *Sandoricum beccarianum* Baill; and tolerance species, *Ganua motleyana* Pierre ex Dubard. All species are the component of the upper canopy at about 30–38 m. The other species, *Horsfieldia crassifolia* (Hook.f.et Th.) Warb., *Eugenia oblata* Roxb., *Polyalthia glauca* (Hassk.) Boerl. *Garcinia cowa* Roxb., *Myristica maingayi* Hook.f. are occationally found. The upper canopy does not form as a continuous crown cover. The middle canopy is 20–30 m. Trees in this canopy usually fill in the upper canopy gaps. Common species are similar to those of the upper canopy. Lower canopy is sparse. Middle story is about 5–10 m, this layer consists of tolerance and intermediate tolerance species. Common species are the same of those of the upper story. Undergrowth is densed with palm. Common species are similar to those of the *M. pruinosa* community. Seedlings occur in patches. Profile diagram is shown in Figure 5.

3. Mixed peat swamp community. Upper canopy consists of mixed species of tolerance and intermediate tolerance. Dominant species are *Ganua motleyana, Horsfieldia crassifolia, Sandoricum beccarianum* associated with *Calophyllum teysmannii* Miq. var. *inophylloide* (King) Stevens, *Cratoxylum arborescens* (Vahl) Bl., *Campnosperma coriaceum, Dacryodes incurvata* (Engl.) Lamk. There is no dominant species for middle canopy. Common species are same as those of the upper canopy and associated with *Eugenia tumida* Duth, *Blumeodendron kurzii* (Hook.f.) Smith, *Parastemon urophyllus* A.DC., *Nephelium maingayi, Neesia malayana, Stemonurus secundiflorus* Bl., *Endiandra macrophylla* (Bl.) Boerl. Lower canopy and middle story are sparse for some stands but well developed for the other stands. Undergrowth is dense with various species of palm, *Eleiodoxa conferta, Licuala longecalycata, Cyrtostachys renda, Areca triandra* Roxb. and *Livistona saribus* Merr. Scandent shrubs are e.g. *Freycinetia* spp., Rattan eg. *Korthalsia laciniosa* (Griff.) Mart. Seedlings occur in cluster.

Although floristic composition of the three stands of the mixed peat swamp community is more or less similar but their structure is somewhat difference depending on site. Profile diagrams divided into three types are shown in Fig. 6–8.

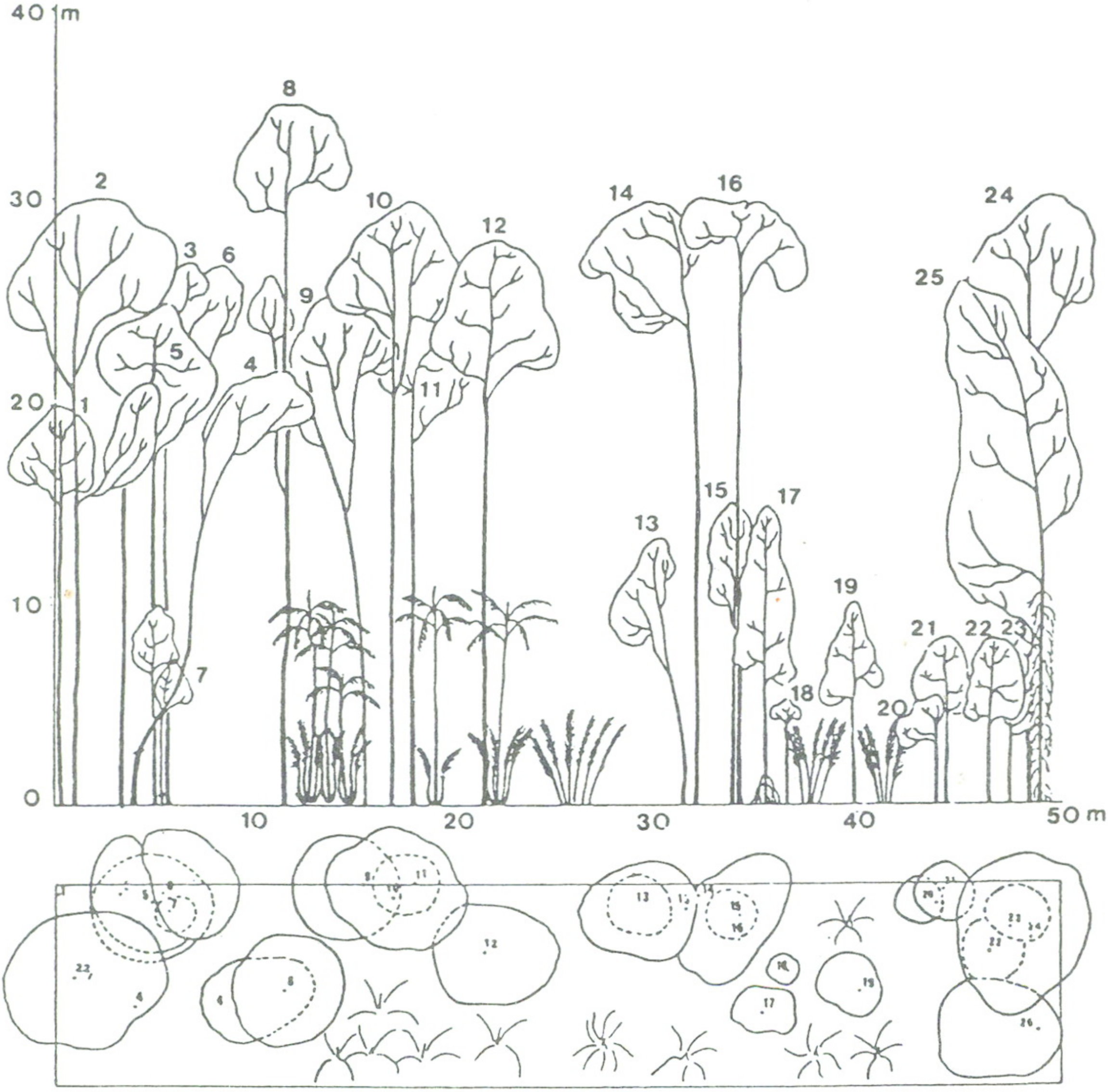
3.1 Forest on dome area (plot 7). This forest type occupies the dome which is located around the center of Toh-Daeng peat swamp forest. Duration of flooding was less than the rest of Toh-Daeng forest. Upper story is separated into three layers. Upper canopy, formed an even-continuous canopy, is about 35–40 m, middle canopy is 25–30 m and lower canopy is 15–20 m. Middle story is poorly developed. Undergrowth is dense with seedlings and palm.



Plot 5

1. *Blumeodendron kurzii*
2–3. *Eugenia tumida*
4. *Litsea resinosa*
5. *Stemonurus secundiflorus*
6. *Neesia altissima*
7. *Diospyros lanceifolia*
8. *Ilex cymosa*
9. *Eugenia oblata*
10. *Chisocheton divergens*
11–12. *Macaranga pruinosa*
13. *Nephelium glabrum*
14. *Neesia altissima*
15. *Macaranga pruinosa*
16. *Nephelium glabrum*
17–20. *Macaranga pruinosa*
21. *Gymnacranthera eugeniifolia*
22. *Macaranga pruinosa*

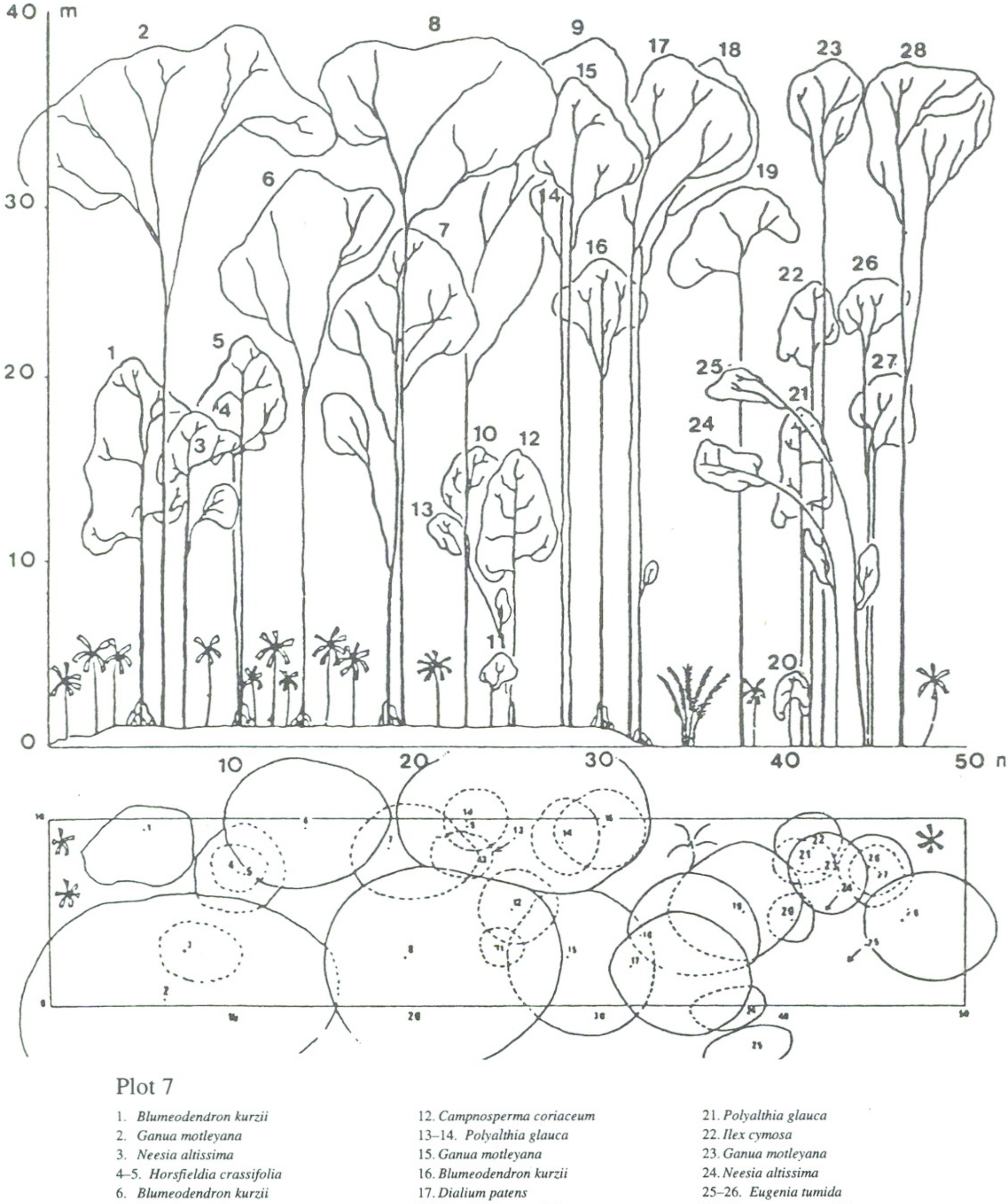
Figure 4. Profile diagram and bisection (10 x 50 m) of *Macaranga pruinosa* community (After Phengklai *et al.* 1989).



Plot 6

1. *Horsfieldia crassifolia*
2. *Parastemon urophyllus*
3. *Garcinia cowa*
4. *Amoora rubiginosa*
5. *Neesia altissima*
6. *Polyalthia glauca*
7. *Neesia altissima*
8. *Ganua motleyana*
9. *Baccauria bracteata*
10. *Ganua motleyana*
11. *Neesia altissima*
12. *Macaranga pruinosa*
13. *Sandoricum emarginatum*
14. *Macaranga pruinosa*
15. *Cratoxylum arborescens*
16. *Macaranga pruinosa*
17. *Blumeodendron kurzii*
18–19. *Horsfieldia crassifolia*
20–22. *Campnosperma coriaceum*
23. *Gymnacranthera eugeniifolia*
24. *Ganua motleyana*
25. *Camnosperma coriaceum*

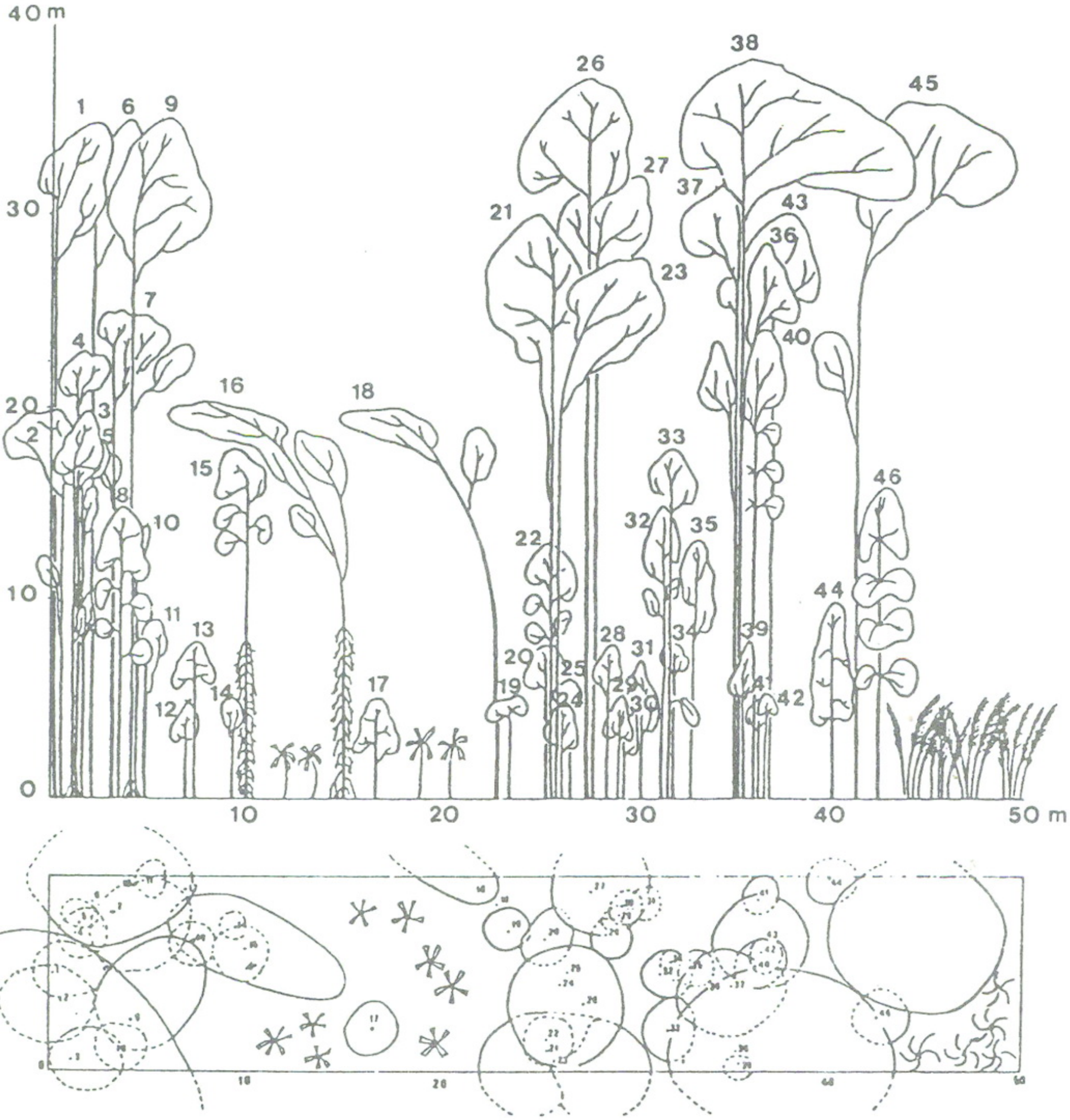
Figure 5. Profile diagram and bisection (10 x 50 m) of mixed peat swamp with *Macaranga pruinosa* community (After Phengklai *et al.* 1989).



Plot 7

1. *Blumeodendron kurzii*
2. *Ganua motleyana*
3. *Neesia altissima*
4–5. *Horsfieldia crassifolia*
6. *Blumeodendron kurzii*
7. *Eugenia tumida*
8–9. *Sandoricum emarginatum*
10–11. *Eugenia tumida*
12. *Campnosperma coriaceum*
13–14. *Polyalthia glauca*
15. *Ganua motleyana*
16. *Blumeodendron kurzii*
17. *Dialium patens*
18. *Horsfieldia crassifolia*
19. *Parastemon urophyllus*
20. *Xylopia fusca*
21. *Polyalthia glauca*
22. *Ilex cymosa*
23. *Ganua motleyana*
24. *Neesia altissima*
25–26. *Eugenia tumida*
27. *Stemonurus secundiflorus*
28. *Ganua motleyana*

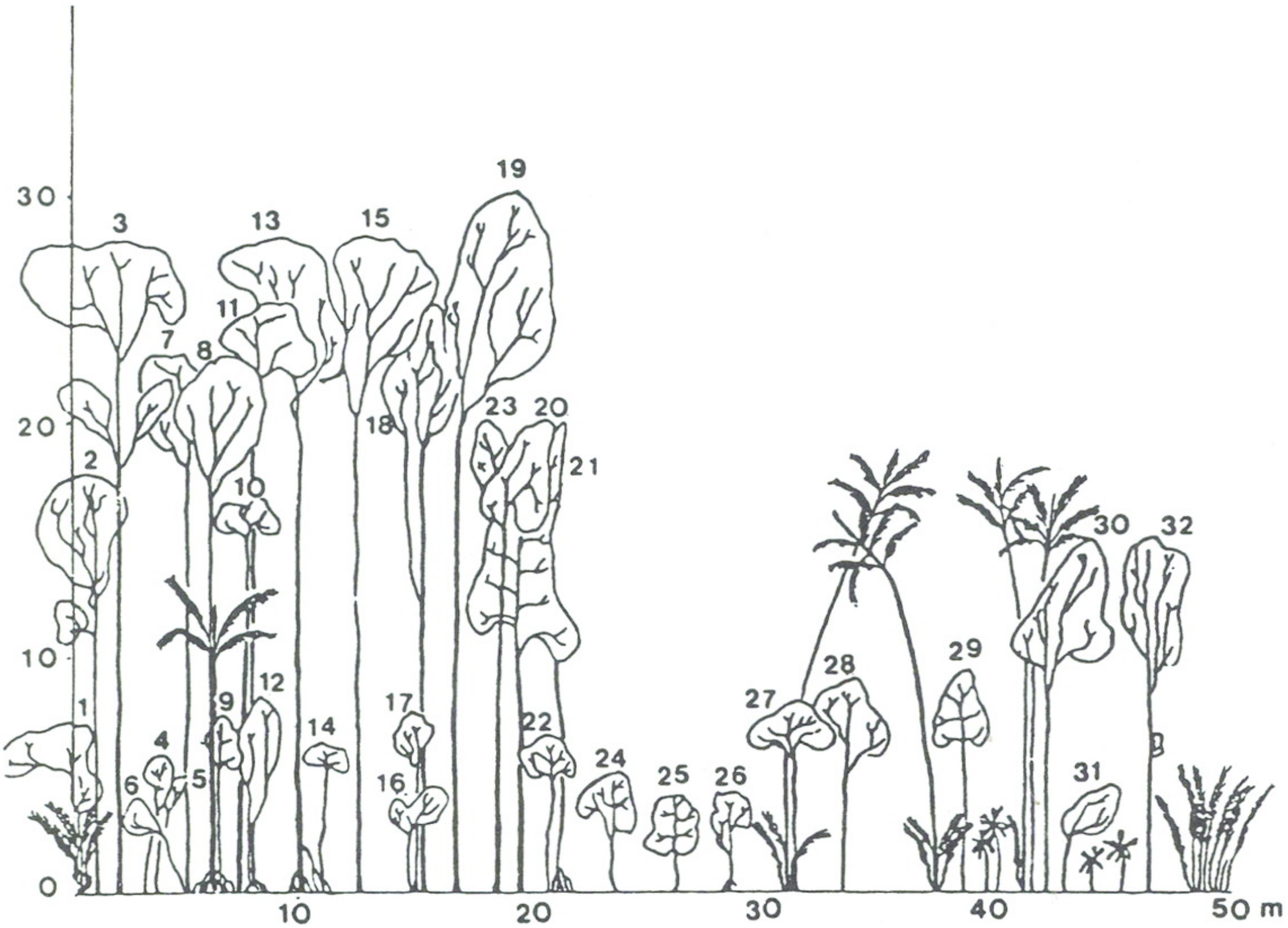
Figure 6. Profile diagram and bisection (10 x 50 m) of mixed peat swamp community (forest on dome area) (After Phengklai *et al.* 1989).



Plot 11

1. *Horsfieldia crassifolia*
2. *Eugenia tumida*
3. *Melanochyla bracteata*
4. *Endiandra macraphylla*
5. *Chisocheton divergens*
6. *Campnosperma coriaceum*
7. *Sandoricum emarginatum*
8. *Stemonurus secundiflorus*
9. *Calophyllum teysmanii*
10. *Myristica maingayi*
11. *Ilex cymosa*
12. *Sterculia bicolor*
13. *Eugenia tumida*
14. *Litsea resinosa*
15. *Stemonurus secundiflorus*
16. *Eugenia tumida*
17. *Dialium patens*
18. *Horsfieldia crassifolia*
19. *Nephelium glabrum*
20. *Goniothalamus giganteus*
21. *Horsfieldia crassifolia*
22. *Campnosperma coriaceum*
23. *Neesia altissima*
24. *Stemonurus secundiflorus*
25. *Litsea resinosa*
26–27. *Ganua motleyana*
28. *Cinnamomum rhynchophyllum*
29. *Stemonurus secundiflorus*
30. *Gymnacranthera eugeniifolia*
31. *Diospyros lanceifolia*
32. *Litsea resinosa*
33. *Eugenia tumida*
34. *Dialium patens*
35. *Eugenia tumida*
36. *Nephelium glabrum*
37. *Calophyllum teysmanii*
38. *Eugenia tumida*
39. *Calophyllum teysmanii*
40. *Myristica iners*
41. *Neesia altissima*
42. *Ganua motleyana*
43. *Gymnacranthera eugeniifolia*
44. *Sandoricum emarginatum*
45. *Stemonurus secundiflorus*

Figure 7. Profile diagram and bisection (10 x 50 m) of mixed peat swamp community (forest on plain area) (After Phengklai *et al.* 1989)



Plot 3

1–3. *Ganua motleyana*
4–6. *Eugenia tumida*
7. *Litsea resinosa*
8. *Blumeodendron kurzii*
9. *Eugenia tumida*
10. *Dialium patens*
11. *Parastemon urophyllus*
12. *Eugenia tumida*
13. *Dacryodes incurvata*
14. *Horsfieldia crassifolia*
15. *Ganua motleyana*
16. *Neesia altissima*
17. *Eugenia tumida*
18. *Amoora rubiginosa*
19. *Cratoxylum arborescens*
20. *Parastemon urophyllus*
21. *Ganua motleyana*
22. *Neesia altissima*
23. *Blumeodendron kurzii*
24–25. *Macaranga pruinosa*
26–28. *Blumeodendron kurzii*
29. *Endiandra macrophylla*
30. *Blumeodendron kurzii*
31. *Dillenia pulchella*
32. *Ganua motleyana*

Figure 8. Profile diagram and bisection (10 x 50 m) of mixed peat swamp community (forest on less develop peat area) (After Phengklai *et al.* 1989)

3.2 Forest on plain area (plot 11). This type occupies main area of Toh-Daeng forest. Upper canopy is 30–35 m, uneven and discontinuous. Middle canopy fills the gap in the upper canopy of 20–28 m high. Lower canopy is 10–15 m. Middle story is dense with 5–10 m small trees. Palms are common as undergrowth.

3.3 Forest on less developed peat area (plot 3). Water table in dry season of this type is shallower than the previous types. Some areas especially the southern portion of Toh-Daeng forest are flooded throughout the year. Upper story consists of 2 layers, the upper canopy is 25–30 m and the middle canopy is 15–20 m high. Middle story is dense. Palms are also common in undergrowth.

Basal area cover, tree density and number of species are highest for mixed peat swamp community and lowest for *Macaranga pruinosa* community (Figure 9). Distribution of dbh class for all trees of the three communities are shown in Figure 10. Only mixed peat swamp community was fixed for a negative exponential form or reversed J-shaped distribution, which infered constant rates of mortality from one size-class to the next (Leak 1965).

From this study, all forest communities agreed with phase of the forest growth cycle; gap, building and mature (Whitmore 1982). Each phase has a difference structure from one stage of development to the next. From *Macaranga pruinosa* community the development proceed to mixed peat swamp with *Macaranga pruinosa* community and then to mixed peat swamp community. These caused the primary peat swamp forest to be a mosaic-like. The growth cycle will be successive when big gaps in the forest were created by some large scale disturbance (not a catastrophic disturbance). For tropical forest, a pioneer stand commonly occurred in gap of over 1000 m^2 (Whitmore 1982).

Crown projection (bisection) in Fig. 4–8 indicates that small gaps are scattered through primary peat swamp forest. These gaps might be a result of the death of individual or a few trees, which are replaced by shade tolerance or intermediate shade tolerance species or by palm. Schematic diagram for growth cycle of Toh-Daeng primary peat swamp forest was shown in Figure 11.

Basal area cover of mixed peat swamp community was 33.5 m^2/ha which was more or less similar to those of the other forest formations in Thailand. (Table 1). It indicates that this forest community is one of the productive forest in Thailand. Peat swamp forest is also a species rich forest formation with 109 families and 437 species of flowering plant and 15 families and 33 species of fern including 48 species newly recorded for Thailand. Since Toh-Daeng primary peat swamp forest is the last area of primary peat swamp forest in Thailand, this forest should be preserved for its unique ecosystem and sustaining its diversity. Timber harvesting must be avoided. Utilization of peat swamp forest should be concentrated on minor products eg. edible fruits and plants, and fishery.

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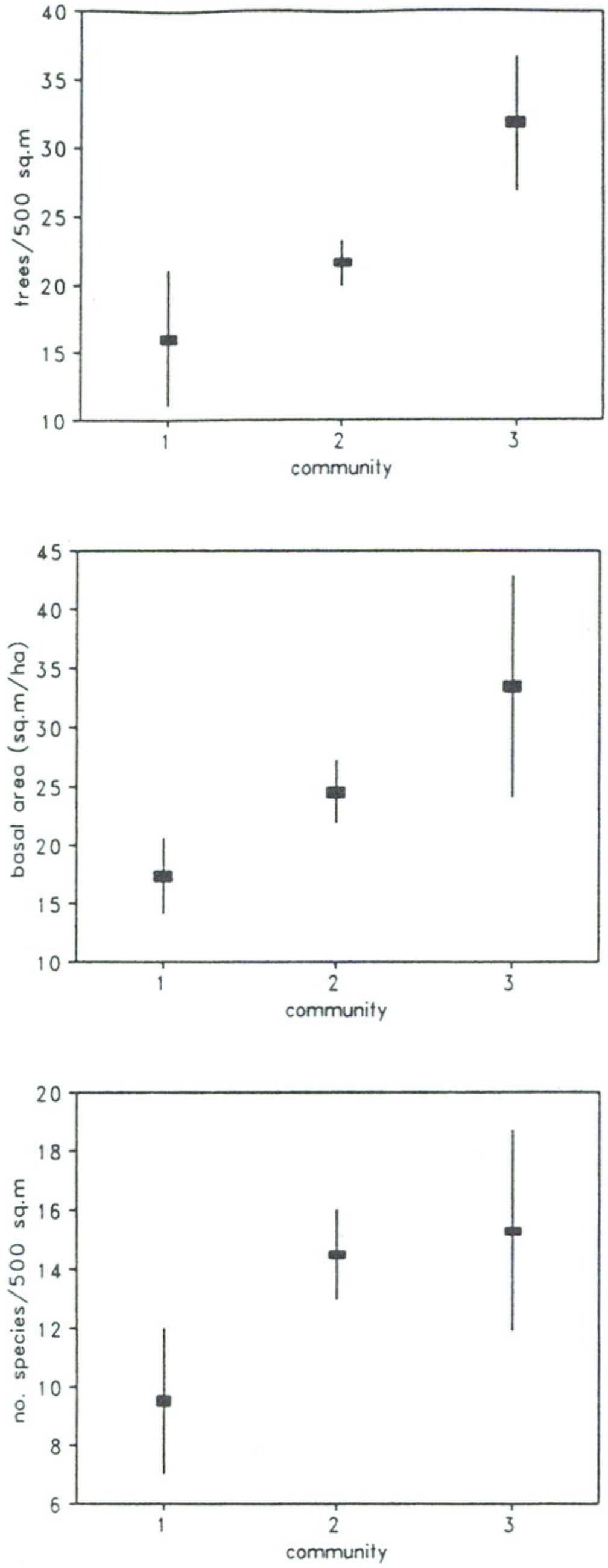
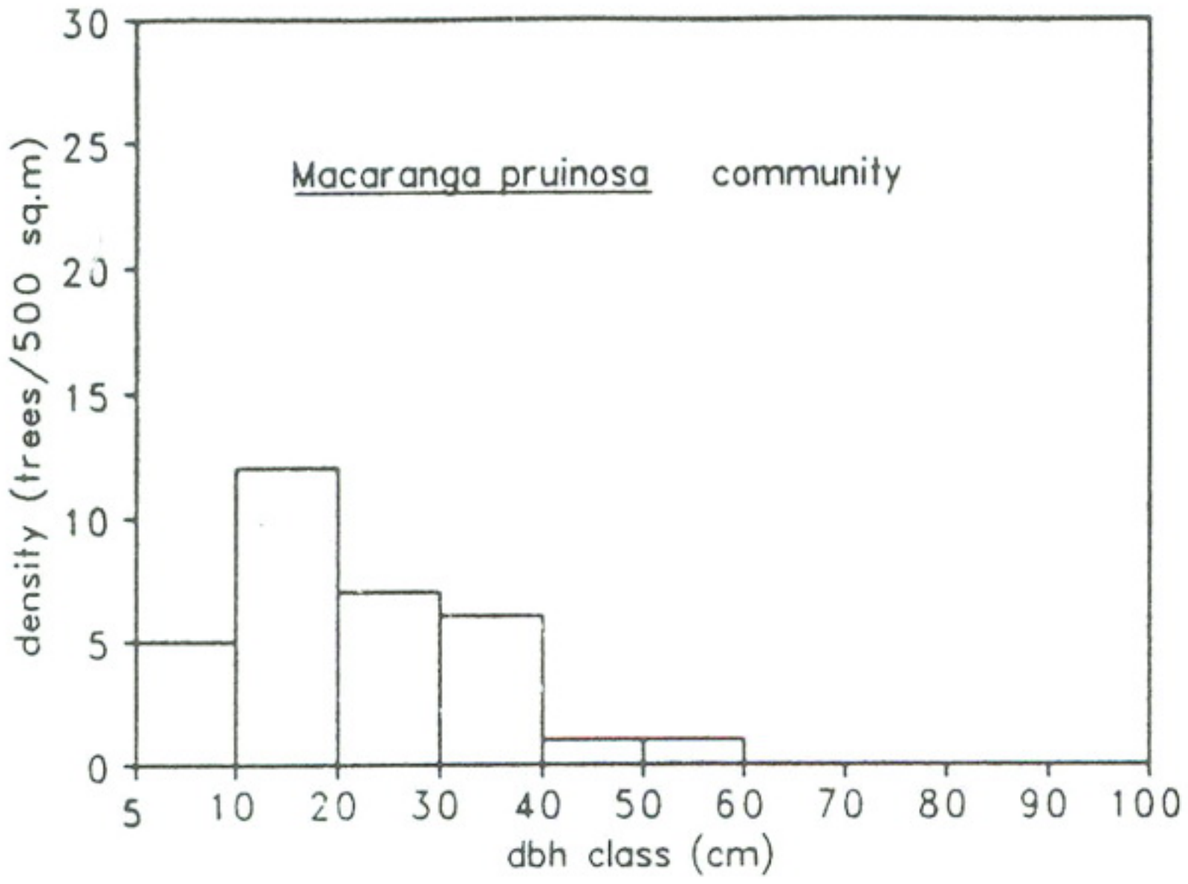
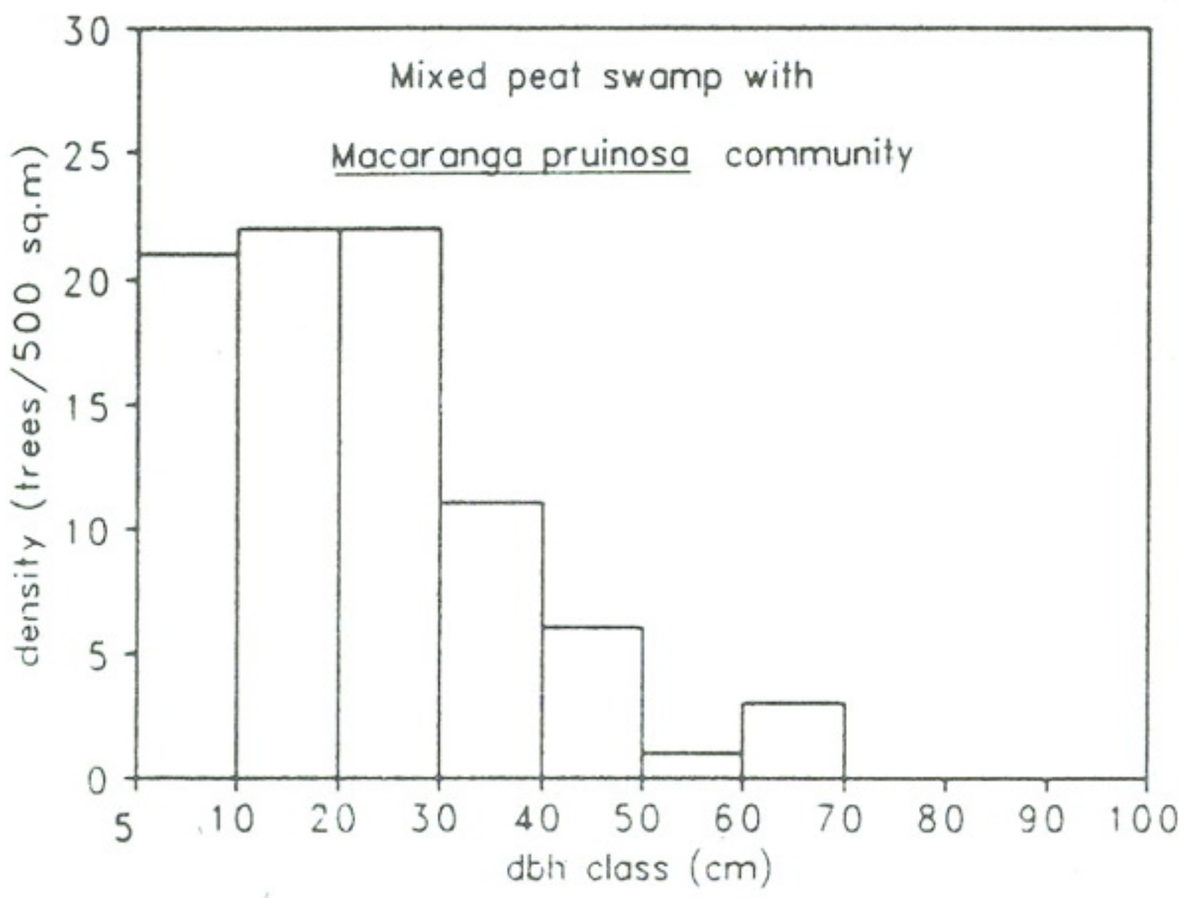


Figure 9. Density, basal area and number species of the three communities of Toh-Daeng primary peat swamp forest. Vertical bars represent standard deviation.





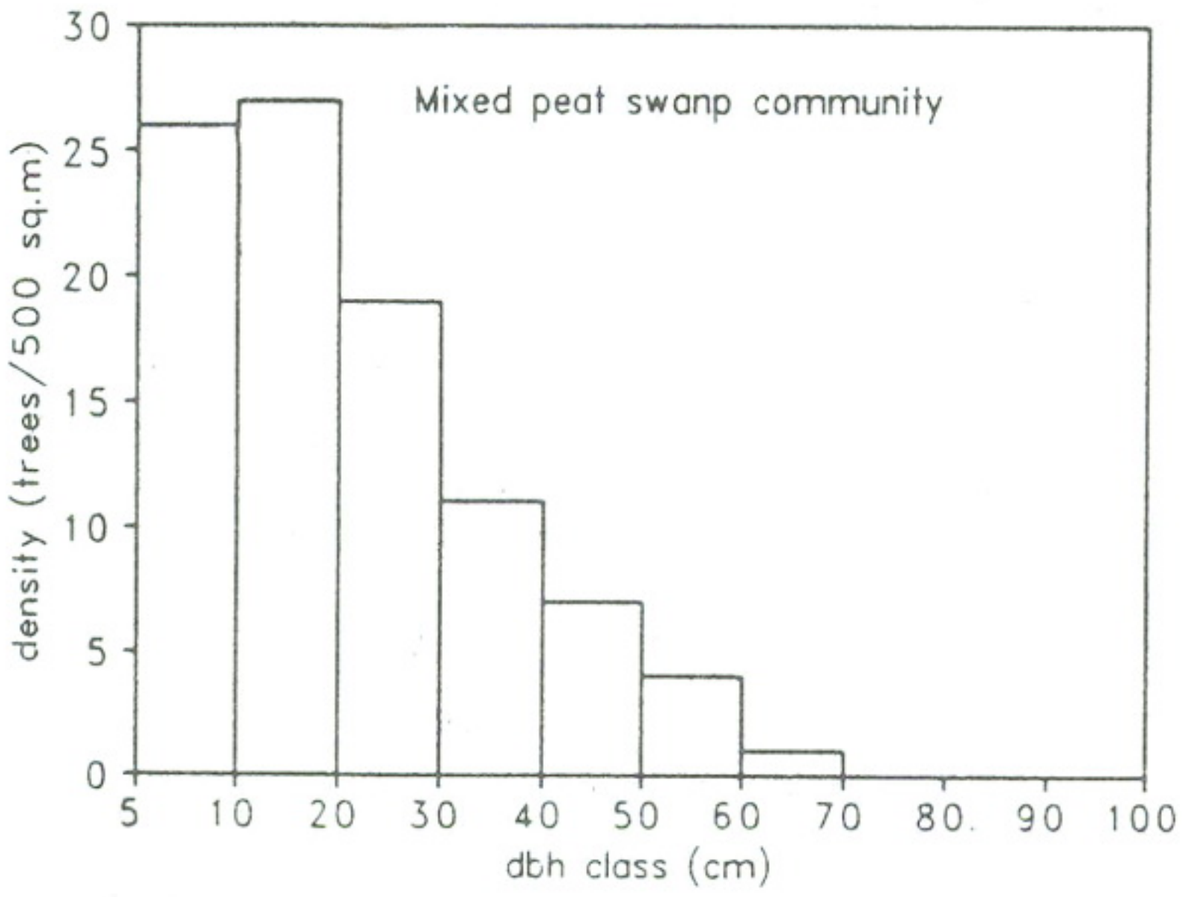


Figure 10. Dbh class distribution of the three communities of Toh-Daeng primary peat swamp forest.

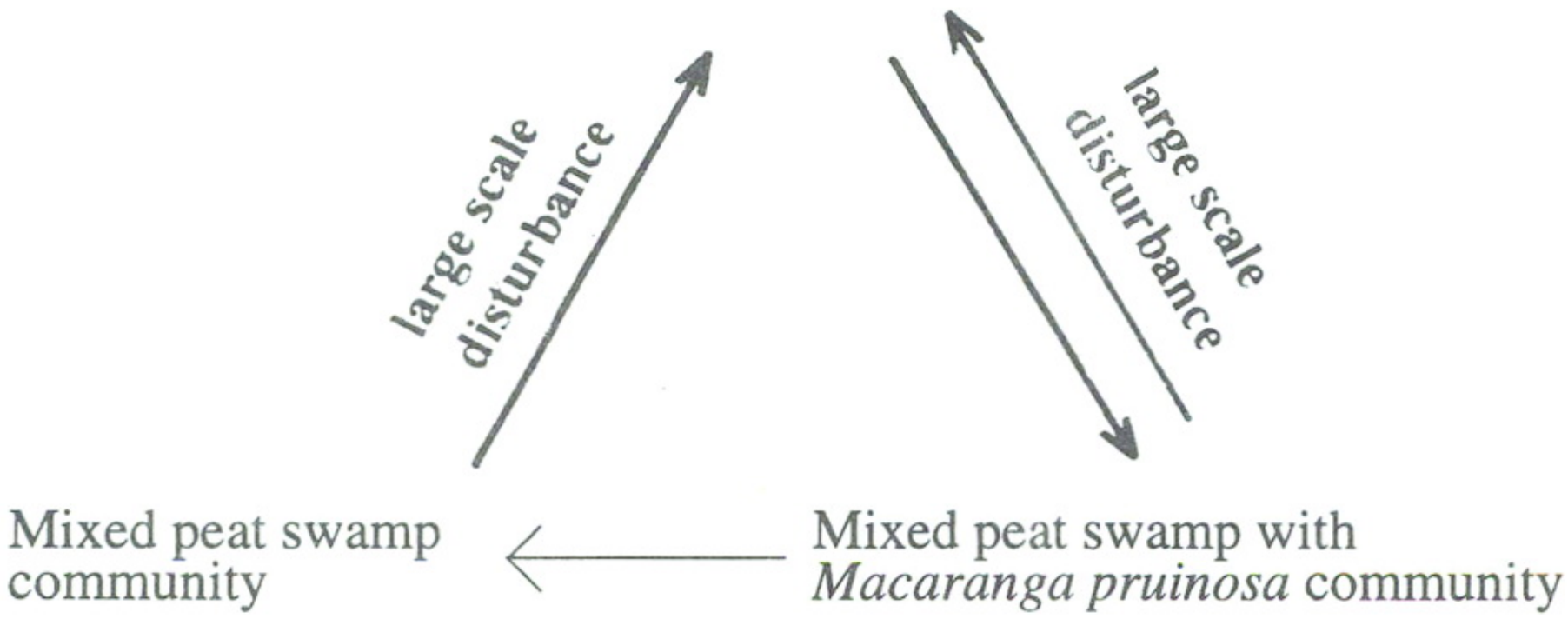


Figure 11. Schematic diagram for growth cycle of Toh-Daeng primary peat swamp forest.

Table 1. Basal area cover ($\overline{X}$±SD) of various forest formation in Thailand

Forest formation	Basal area (m^2/ha) dbh>10 cm
Primary peat swamp forest at Narathiwat Province (dbh>5.0 cm) (this study)	
Macaranga pruinosa community	17.3±3.3
mixed peat swamp with *M. pruinosa* community	24.5±2.7
mixed peat swamp community	33.5±9.4
Tropical evergreen rain forest at Khao Sok, Surat Thani Province (Parktoop, 1980)	
valley	25.0
hill	32.0
ridge	41.0
Tropical semi-evergreen forest at Sakaerat, Nakhon Ratchasima Province (Bunyavejchewin, 1986)	
Hopea ferrea type	30.0
Shorea henryana type	26.9
Tropical dry deciduous forest (Bunyavejchewin 1983 b)	
Tectona grandis type	38.4±10.5
Lagerstroemia calyculata type	33.1±14.3
Tropical dry deciduous dipterocarp forest (Bunyavejchewin 1983 a)	
Shorea siamensis type	20.3±7.5
Shorea obtsa type	16.7±5.5
Dipterocarpus obtusifolius – S. obtusa type	23.5±8.0
D. tuberculatus – S. obtusa type	23.9±8.1
Pine-dipterocarp type	24.4±5.2

Appendix 1. Floristic composition in the sample plots. BA = basal area (sq.cm) per 500 sq.m.; % = relative percent of basal area; D = tree density per 500 sq.m.

Species	Plot number																											
	4			5			6			8			9			10			3			7			11		
	BA	%	D	BA	%	D	BA	%	D	BA	%	D	BA	%	D	BA	%	D	BA	%	D	BA	%	D	BA	%	D
Macaranga pruinosa	4051.2	57.8	4	6227.2	60.3	8	2039.9	16.5	3	3926.4	32.8	2	1346.7	12.8	1	1225.9	8.5	1	96.6	0.9	2							
Neesia altissima	1055.1	15.1	2	447.3	4.3	2	885.7	7.1	3	3550.6	29.7	3				5802.2	40.5	4	153.0	1.5	2	465.6	2.4	2	716.6	3.4	1
Nephelium glabrum	1052.5	15.0	1	183.9	1.8	1																			1522.6	7.3	2
Blumeodendron kurzii	471.6	6.7	1	390.7	3.8	1	109.4	0.9	1	28.3	0.2	1	35.3	0.3	1	18.1	0.1	1	780.3	7.6	6	969.2	5.1	3			
Nothaphoebe umbelliflora	257.4	3.7	1																								
Dacryodes incurvata	70.9	1.0	1							147.2	1.2	2							730.9	7.1	1						
Ixora grandifolia	45.4	0.6	1																								
Eugenia oblata				1244.6	12.1	1				126.7	1.1	1	1146.5	10.9	1	81.7	0.6	1									
Eugenia tumida				543.1	5.3	2				109.4	0.9	1							204.6	2.0	6	1836.7	9.6	4	1028.0	4.9	6
Litsea resinosa				572.8	5.5	1													268.9	2.6	1				96.8	0.5	1
Ilex cymosa				240.6	2.3	1																198.6	1.0	1	18.1	0.1	1
Diospyros lanceifolia				236.8	2.3	2				109.4	0.9	1													485.7	2.3	2
Nepherium glabrum				115.0	1.1	1																					
Stemonurus malaccensis				86.6	0.8	1				248.9	2.1	1	153.6	1.5	3	38.5	0.3	1				198.6	1.0	1	1146.1	5.5	4
Gymnacranthera eugenilfolia				38.5	0.4	1							66.5	0.6	1	390.7	2.7	1							70.9	0.3	2
Horsfieldia crassifolia							2408.0	19.4	2										62.2	0.6	1	1580.4	8.3	3	3369.7	16.1	3
Ganua motleyana							3520.2	28.4	3	750.2	6.3	1	929.3	8.8	2	4258.4	29.7	3	3548.6	34.7	6	7001.1	36.7	4	3834.7	18.3	3
Parastemon urophyllus							962.5	7.8	1										891.6	8.7	2	572.8	3.0	1			
Campnosperma coriaceum							471.7	3.8	3	25.5	0.2	1	4027.7	38.3	3	1244.6	8.7	1				126.7	0.7	1	2036.4	9.7	2
Amoora rubiginosa							642.7	5.2	1										1282.4	12.5	1						
Baccaurea bracteata							510.9	4.1	1	25.5	0.2	1															
Polyalthia glauca							422.9	3.4	1	213.9	1.8	1	630.7	6.0	3	401.3	2.8	2				695.2	3.6	3			
Garcinia cowa							314.3	2.5	1																		
Sandoricum emarginatum							54.1	0.4	1	2222.9	18.6	3	563.8	5.4	2							5025.4	26.3	2	2358.5	11.2	2
Cratoxylum arborescens							50.3	0.4	1				642.7	6.1	1				2035.6	19.9	1						
Brackenridgea palustris										471.6	3.9	1	62.2	0.6	1												
Dialium patens													58.1	0.6	1	447.3	3.1	2	103.9	1.0	1	412.0	2.2	1			
Calophyllum teysmanii													38.5	0.4	1										3300.5	15.7	3
Myristica maingayi													602.9	5.7	1										160.7	0.8	1
Polyalthia curtisii													18.1	0.2	1	191.2	1.3	1									
Goniothalamus gigantius													50.3	0.5	1										70.9	0.3	1
Melanochyla bracteata													132.8	1.3	1										224.4	1.1	1
Endiandra macrophylla																50.3	0.4	1	58.1	0.6	1				390.7	1.9	1
Gynotroches axillaris																96.8	0.7	1									
Plernandra caerulescens																96.8	0.7	1									
Dillenia pulchella																			20.4	0.2	1						
Cinnamomum rhynchophyllum																									70.9	0.3	1
Myristica iners																									50.3	0.2	1
Sterculia bicolor																									20.4	0.1	1
TOTAL	7004.1	100	11	10327.1	100	22	12392.6	100	22	11956.5	100	20	10505.7	100	25	14343.8	100	21	10237.1	100	32	19082.3	100	26	20972.9	100	39

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