ECOLOGY AND CONSERVATION VALUE OF TANJUNG TUAN, THE MYRTACEAE-DOMINATED COASTAL FOREST RESERVE OF MALAYSIA

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MAT-SALLEH, K., TAMI, R. & LATIFF, A. 2003. Ecology and conservation value of Tanjung Tuan, the Myrtaceae-dominated coastal forest reserve of Malaysia. The 122-ha lowland forest of Tanjung Tuan is a unique coastal myrtaceaous forest remnant of the west coast of Peninsular Malaysia. Situated close to Port Dickson, the most popular beach nearest to Kuala Lumpur, the areas surrounding the forest are rapidly being converted into condominiums and resorts. A total of 0.75 ha of sampling area was selected in the reserve for basic ecological studies in which five 30 × 50 m plots were established to represent dominant habitats in different topographies of the forest. All trees in the plots with 5.0 cm dbh and above were measured and identified. A total of 834 trees belonging to 34 families, 85 genera and 125 species were recorded with average 14.03 cm dbh and 16.82 m height. Although the most diverse family is Euphorbiaceae with 12 genera and 19 species, the most dominant species is *Syzygium grande* (Myrtaceae). The above-ground biomass of the forest reserve was estimated at 233.4 t ha^{-1}. Among the trees in the plots, 78% represented by canopy trees (Class 4) and 88% were from Classes 3 and 4 trees. About 20% of the biomass was contributed by Myrtaceae and only 18% by the Dipterocarpaceae. Although no endemic or rare species were recorded from this site, the floristic composition of Tanjung Tuan is unique because it includes species from other forest types. Species such as *Callicarpa maingayi* (Verbenaceae) and *Mallotus penangensis* (Euphorbiaceae) are normally recorded in lowland dipterocarp forests up to about 1000 m altitudinal range, and *Breynia coronata* (Euphorbiaceae) normally inhabits montane areas of about 1200 m. Some other species recorded in this area such as *Gordonia singaporiana* (Theaceae) and *Aglaia odoratissima* (Meliaceae) are not common, the latter species normally found in hill to lower montane forests far away from coastal areas. Analysis of timber stumpage value in this study indicated that this forest is comparatively poor in timber stocks for commercial exploitation and too steep for logging operations. It is strongly recommended that this forest should not be developed, and instead be conserved for its important historical value, coastal ecological functions and unique biodiversity attributes.

Key words: Species composition - biomass - valuation - Tanjung Tuan Forest Reserve - Rachado - coastal myrtaceaous forest

MAT-SALLEH, K., TAMI, R. & LATIFF, A. 2003. Ekologi dan nilai pemuliharaan Tanjung Tuan, hutan simpan pesisiran pantai Malaysia yang didominasikan oleh Myrtaceae. Hutan pamah 122 ha di Tanjung Tuan merupakan hutan Myrtaceae pesisiran pantai yang unik dan masih kekal di pantai barat Semenanjung Malaysia. Kedudukan Tanjung Tuan yang berdekatan dengan kawasan perkelahan Port Dickson

menjadikannya kawasan pembinaan kondominium dan tempat istirahat. Kawasan pensampelan seluas 0.75 ha telah dipilih di Hutan Simpan Tanjung Tuan yang terdiri daripada lima petak kajian masing-masing berukuran 30 × 50 m. Semua pokok yang mempunyai dbh ≥ 5.0 cm diukur dan dikenal pasti. Sejumlah 834 pokok yang tergolong dalam 34 famili, 85 genus dan 125 spesies dicerap. Purata dbh dan ketinggian masing-masing ialah 14.03 cm dan 16.82 m. Spesies yang paling dominan ialah *Syzygium grande* (Myrtaceae). Famili yang paling besar ialah Euphorbiaceae dengan 12 genus dan 19 spesies. Biojisim atas tanah bagi hutan ini telah dianggarkan sebanyak 233.4 tan per ha. Sebanyak 78% daripada pokok adalah pokok kanopi atas (Kelas 4) dan 88% adalah daripada pokok Kelas 3 dan 4. Lebih kurang 20% daripada biojisim telah disumbangkan oleh Myrtaceae dan 18% oleh Dipterocarpaceae. Walaupun tidak wujud spesies endemik atau langka, kandungan spesies hutan simpan ini adalah unik. Beberapa spesies yang dijumpai di hutan ini seperti *Callicarpa maingayi* (Verbenaceae) dan *Mallotus penangensis* (Euphorbiaceae) biasanya dijumpai di hutan dipterokarpa tanah rendah sehingga altitud 1000 m dan *Breynia coronata* (Euphorbiaceae) biasanya tumbuh di hutan pergunungan pada 1200 m. Beberapa spesies lain yang dirakamkan di kawasan ini seperti *Gordonia singaporiana* (Theaceae) dan *Aglaia odoratissima* (Meliaceae) adalah langka. *Aglaia odoratissima* biasanya dijumpai di hutan bukit sehingga pergunungan rendah jauh daripada kawasan pantai. Analisis nilai stumpej balak dalam kajian ini menunjukkan bahawa hutan ini tidak banyak mempunyai simpanan balak untuk dieksploitasi secara komersial dan terlalu curam untuk operasi pembalakan. Disyorkan agar hutan ini tidak dibangunkan, dan sebaliknya dipulihara kerana nilai sejarahnya yang penting, fungsi ekologi pesisiran pantai dan ciri kepelbagaian biologinya yang unik.

Introduction

Tanjung Tuan (2° 24.2'–2° 24.8' N, 101° 55'–101° 55.7' E) was discovered by the Portuguese in the 16th century and the rocky peak of the ridge, known as Cape Rachado, was often used as a guide to the sea-faring sailors in the Straits of Malacca. This has led to the establishment of the Rachado Light House by the British in 1890, to complement other light houses in Pulau Undan and One Phantom Bank, Kelang. All three light houses were put under the jurisdiction of the Malacca port authorities. After independence in 1957, the Light House and the Tanjung Tuan Forest Reserve remained under the State of Malacca (Melaka), even though the remaining surrounding area is under the State of Negeri Sembilan administrative jurisdiction.

The 122-ha Tanjung Tuan Forest Reserve was gazetted as Virgin Jungle Reserve on 23 December 1921 by the Malacca State Government to include most of Tanjung Tuan. Undulating ridges of hills and steep slopes and cliffs reach the peak of 94 m elevation at the Rachado Light House (Figures 1 and 2). Geologically, the rocks are of granitoid, igneous, metamorph and quartz intrusions (Jones 1973, Ahmad Hafad 1982). There are three ridges in the forest, the main ridge extends northwest to southeast at the end of the peninsula with the Light House in the middle of it, while the other two extend north towards the Blue Lagoon and northeast towards Pantai Siginting. The forest reserve receives about 3230 mm rain a year and the mean temperature is 32 °C (Ahmad Hafad 1982) with direct effect from the sea, thus making the floristic elements and ecosystem of this reserve interesting.

Situated within the vacinity of the resort area of Port Dickson, one of the most popular recreational beaches on the west coast of Peninsular Malaysia, Tanjung Tuan is understandably subjected to tremendous development pressure. Several trails have been constructed in the forest and are utilized regularly by organizers of outward bound activities. However, current activities have little impact on the forest with most of the large trees undisturbed. The forest has become an island where areas around the reserve have been or are being extensively developed into resorts and condominiums.

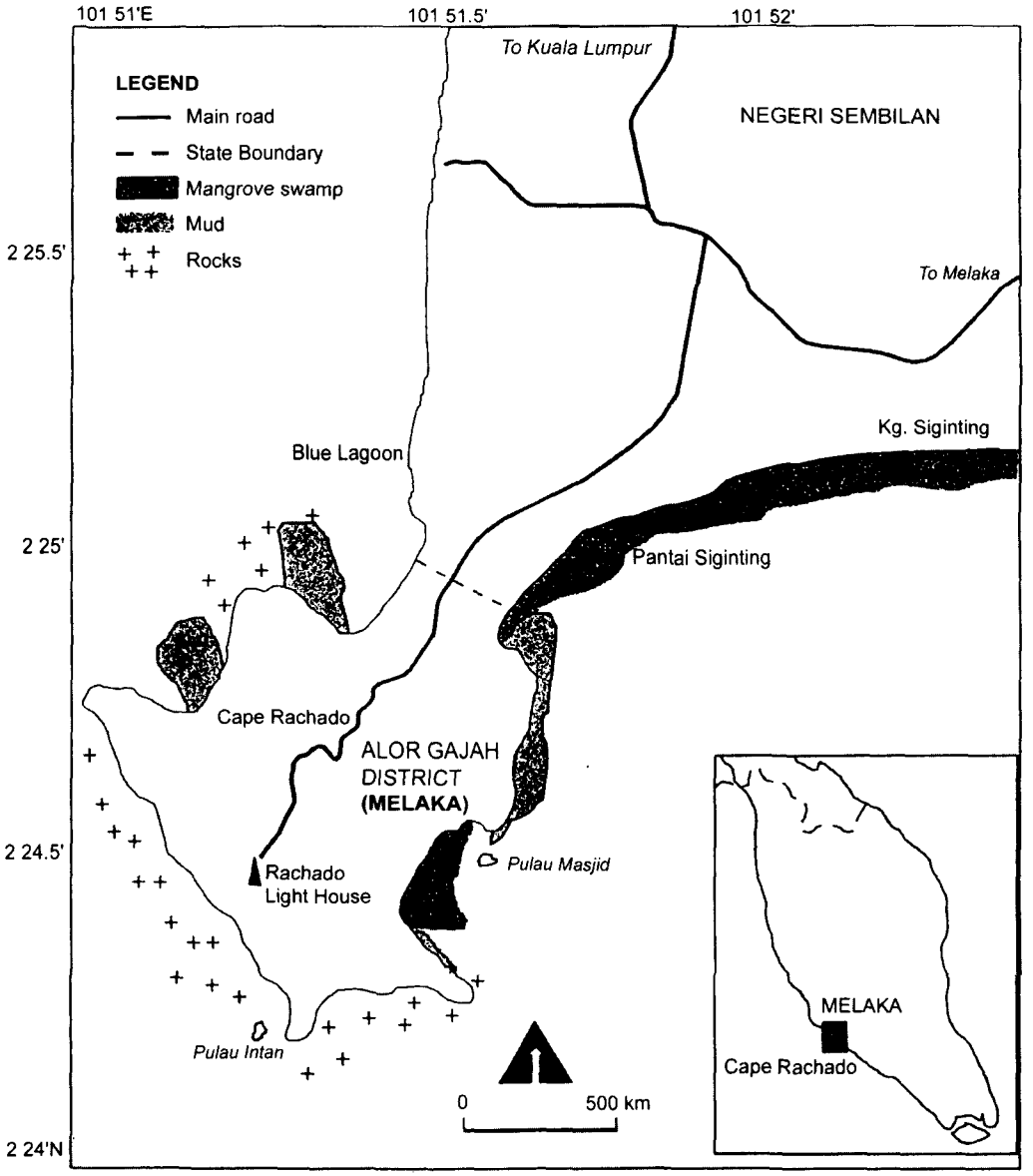


Figure 1 Location map of Tanjung Tuan Forest Reserve, Peninsular Malaysia

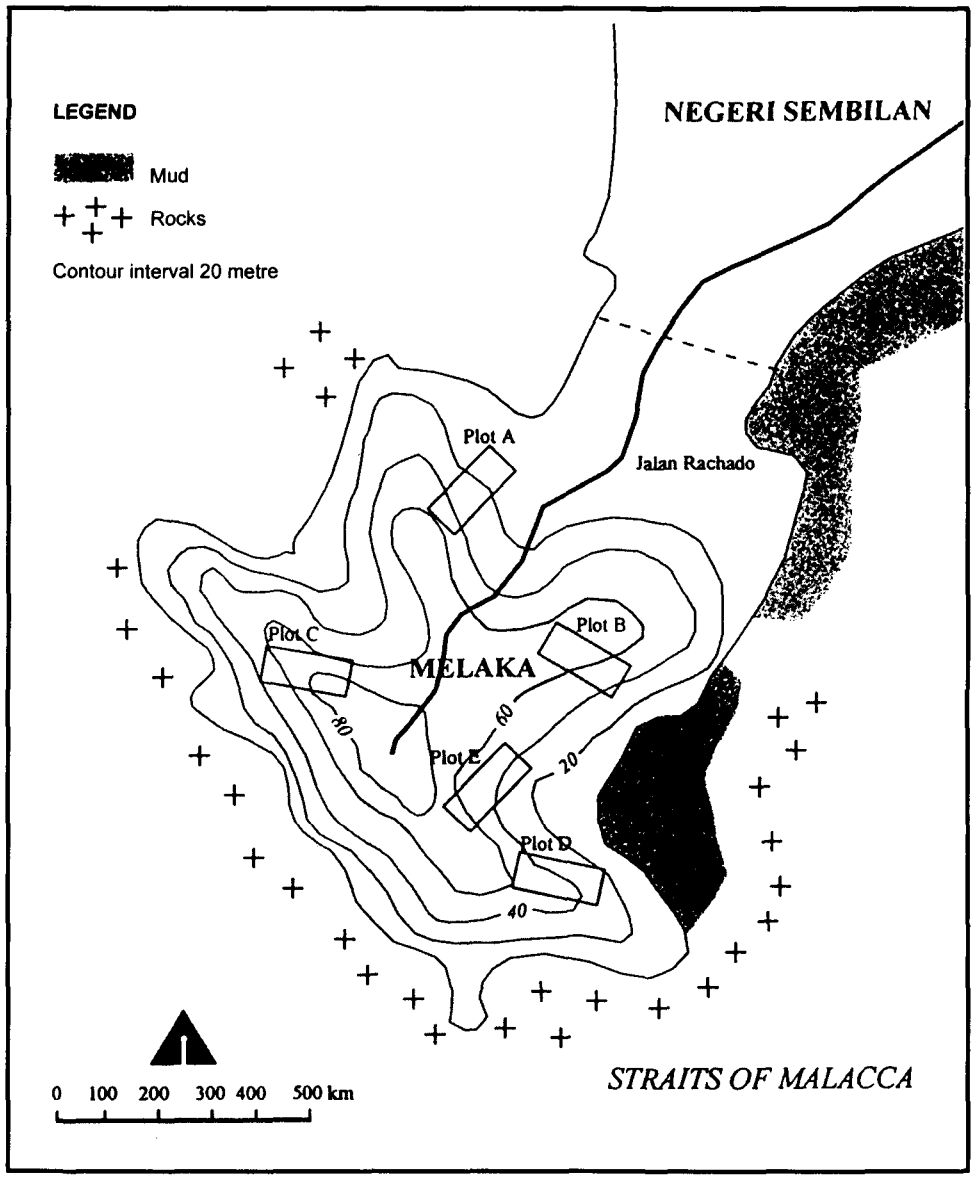


Figure 2 Topographic map of Tanjung Tuan Forest Reserve and plot location for this study

This study was initiated to analyse the basic ecological attributes of the Tanjung Tuan forest, viz. the above-ground biomass of trees, floristic composition and economic value of estimated timber stock. The analysis will assist administrators of such remnant forests to develop their conservation strategies. It will highlight the real value of this myrtaceaous forest reserve, its unique biodiversity and ecosystem attributes.

Material and methods

Plot establishment

A total of 0.75 ha of sampling area was selected in the reserve for the present study in which five 30 × 50 m plots, called Plots A to E, were established in July–December 1995. Sites were selected to represent habitats in different topographies of the forest (Figure 2). All trees with 5.0 cm dbh and above were marked with aluminium number tags and their dbh were manually measured at 1.3 m above ground with diameter tape.

Species enumeration

Voucher specimens representing individual trees enumerated from the plots were prepared and kept in the Herbarium Mohd. Kassim Rajab, Universiti Kebangsaan Malaysia (UKMB). Identification of these specimens was made by the technical staff of Herbarium UKMB using keys in Malaysian floras such as Tree Flora of Malaya series (Whitmore 1972, 1973, Ng 1978, 1989) and Wayside Trees of Malaya (Corner 1988). These identifications were verified by comparing the specimens with UKMB holdings as well as the collections in the Herbarium of the Forest Research Institute Malaysia (KEP).

Biomass calculation and estimates

Biomass estimates employed in this study followed a dbh-based regression established by Kato *et al.* (1978). This above-ground calculation is widely utilised by other studies such as by Soepadmo (1987). In this formula, for the known dbh (D, in cm) and height (H, in m), the biomass (in kg) for stem (W_S), branches (W_B) and leaves (W_L) can be calculated as follows:

$$W_S = 0.133(D^2H)^{0.9733}$$
$$W_B = 0.0390(D^2H)^{1.041}$$
$$W_L = 125 \times 0.124W_S^{0.794}/(0.124W_S^{0.794}+125)$$

The above-ground biomass is the sum of W_S, W_B and W_L. It is possible to infer the height (H, in m) from the dbh (D, measured in cm) with the formula:

$$H = 122 \times D/(2D + 61)$$

Economic valuation

The residual value technique (Awang Noor & Mohd Shahwahid 1997) was used to estimate timber resources inventoried in the five plots. Stumpage value (SV) was estimated as the net return less the logging costs and margin for profits and risks. Thus the stumpage value is given as:

$$SV_{ij} = (\text{log price}_{ij} - \text{logging cost} - \text{profit margin}_{ij}) \times \text{timber volume}_{ij}$$

where SV is the stumpage value of timber species i and diameter class j. The profit margin is calculated as:

$$PM_{ij} = (\text{price}_{ij} \times \text{profit ratio}) / (1 + \text{profit ratio})$$

Conversion return (CR) was also calculated which is defined as the difference between log price and logging cost, excluding profit margin, i.e.

$$CR_{ij} = (\text{log price}_{ij} - \text{logging cost}) \times \text{timber volume}_{ij}$$

Stumpage value and conversion return for the whole plot were calculated by summing up all values of the individual trees recorded in the sudy plots. The merchantable volume of each timber tree which took into consideration its form factor (set at 0.65) was calculated based on diameter breast height (dbh) and merchantable length (m). For ease of valuation, the profit ratio was fixed at 30% and the logging costs was set at RM75.00 per cubic meter as suggested by Awang Noor and Mohd Shahwahid (1997). Table 1 shows the log prices used in the analysis based on timber species and diameter class, adapted from Awang Noor and Mohd Shahwahid (1997).

Table 1 Log prices in RM of timbers according to group and class size

Group	Trade name	Symbol	Price (RM) for specific class size (cm)				
			15–30	30–45	45–60	50–60	60+
Dipterocarps	Dark Red Meranti	MTMT	233.3	331.7	384.4	450.6	471.7
	Light Red Meranti	MTMM	224.4	313.3	357.8	423.3	443.9
	White Meranti	MTP	140.0	212.2	281.7	333.3	343.3
	Yellow Meranti	MTK	94.4	142.2	186.7	229.4	242.8
	Meranti Melantai	MTML	156.7	247.2	330.6	386.1	394.4
	Mersawa	MA	191.7	322.2	441.7	511.1	537.2
	Merawan	MW	108.3	142.8	162.2	192.2	200.0
	Gerutu	GR	108.3	142.8	162.2	192.2	200.0
	Keruing Berminyak	KRM	271.7	343.9	411.7	466.1	475.6
	Keruing Tidak Berminyak	KRTM	85.6	110.0	134.4	212.8	228.3
	Kapur	KPR	85.6	110.0	134.4	212.8	228.3
	Balau	BL	195.6	287.2	381.4	479.4	503.3
	Cengal	CGL	249.4	375.6	527.8	648.9	697.2
	Giam/Resak	GMRK	115.0	152.2	174.4	214.4	230.0
	Other HHW	LL	115.0	152.2	174.4	241.4	230.0
Non-dipterocarps	Light Hardwood	K5	107.2	135.0	158.9	188.9	201.1
	Medium Hardwood	K6	85.6	110.0	134.4	212.8	228.3
	Heavy Hardwood	K7	115.0	152.2	174.4	214.4	230.0
	Semi-merchantable	K8	108.3	142.8	162.2	192.2	200.0
	Podo Damar Berminyak	K9	108.3	142.8	162.2	192.2	200.0

Results and discussion

Species and family composition

A total of 834 stems were enumerated in the study plot, with the largest tree being 129.5 cm dbh belonging to *Dipterocarpus kerrii* King and the mean diameter size 14.03 cm. The forest is unmistakably myrtaceaous, dominated mostly by *Syzygium grande* (Wight) Walp. (Tables 2 and 3; Figures 3 and 4). For trees with 5 cm DBH and above, the Myrtaceae has the greatest percentage of stems (23%), followed by the Clusiaceae (10%) and the Euphorbiaceae (9%). The Dipterocarpaceae represents only 7% of the total stems. This forest is quite different from other similar coastal forests on the west coast of Peninsular Malaysia. According to Turner (1989), the Dipterocarpaceae (34%), Rubiaceae (16%), Melastomataceae (10%), Anacardiaceae (8%), Guttiferae (4.5%) and Euphorbiaceae (4.3%) dominate the coastal hills of Pantai Acheh Forest Reserve, Penang. Utilising the same class sizes 1–4 as considered by Turner (1989), it is clear that Myrtaceae dominates all categories in Tanjung Tuan. In Class 3, the Myrtaceae has twice more than the Dipterocarpaceae (21 to 10%). Similarly in Class 4, only 13% of trees are members of the Dipterocarpaceae while the Myrtaceae maintains their dominance at 24% (Figures 5 and 6). This result clearly supports Whitmore's (1982) suggestion that *Syzygium* would dominate coastal ridges with shallow loam in rocky sediment up to 250 m elevation. This habitat appears to be less favorable for the establishment of the towering dipterocarps.

The most important species in the Tanjung Tuan Forest Reserve are *Syzygium grande* (Wight) Walp., *Norrisia malaccensis* Gardner, *Quercus subsericea* A. Camus, *Garcinia nigrolineata* Planch. *ex* T. Anderson and *Aidia densiflora* (Wall.) Masam. Other dominant species of Tanjung Tuan Forest Reserve are presented in Table 2 and the families with species and individual representations are shown in the Table 3.

Table 2 The 20 leading species based on importance values in the Tanjung Tuan Forest Reserve

Rank	Species	Family	n_i	RD_i	RF_i	RC_i	IV_i
1	*Syzygium grande* (Wight) Walp.	Myrtaceae	162	19.4	1.6	0.2	21.2
2	*Norrisia malaccensis* Gardner	Loganiaceae	45	5.4	1.6	3.2	10.2
3	*Quercus subsericea* A. Camus	Fagaceae	45	5.4	1.6	2.4	9.3
4	*Garcinia nigrolineata* Planch. *ex* T. Anderson	Clusiaceae	42	5.0	0.8	0.9	6.8
5	*Aidia densiflora* (Wall.) Masam.	Rubiaceae	10	1.2	1.2	4.3	6.7
6	*Dacryodes rostrata* (Blume) H.J. Lam	Burseraceae	19	2.3	2.0	2.2	6.5
7	*Garcinia eugeniaefolia* Wall. *ex* T. Anderson	Clusiaceae	12	1.4	2.0	1.5	4.9
8	*Swintonia floribunda* Griff.	Anacardiaceae	24	2.9	0.4	1.0	4.3
9	*Dipterocarpus kerrii* King	Dipterocarpaceae	31	3.7	0.4	0.1	4.2
10	*Ixonanthes icosandra* Jack	Rhizophoraceae	10	1.2	1.2	1.8	4.2
11	*Shorea curtisii* Dyer *ex* King	Dipterocarpaceae	12	1.4	0.8	1.7	4.0
12	*Calophyllum calaba* L.	Clusiaceae	12	1.4	1.2	0.6	3.2
13	*Croton argyratus* Blume	Euphorbiaceae	19	2.3	0.4	0.0	2.7
14	*Timonius wallichianus* (Korth.) Valeton	Rubiaceae	18	2.2	0.4	0.0	2.6
15	*Palaquium rostratum* (Miq.) Burck.	Sapotaceae	13	1.6	0.8	0.1	2.4
16	*Macaranga heynei* I.M. Johnst.	Euphorbiaceae	9	1.1	0.4	0.9	2.4
17	*Buchanania sessifolia* Blume	Anacardiaceae	9	1.1	0.8	0.5	2.3
18	*Diospyros lanceifolia* Roxb.	Ebenaceae	15	1.8	0.4	0.0	2.2
19	*Hopea dryobalanoides* Miq.	Dipterocarpaceae	12	1.4	0.4	0.1	1.9
20	*Aglaia odoratissima* Blume	Meliaceae	8	1.0	0.4	0.1	1.5

Note:
n_i = total number of trees
RD_i = relative density
RF_i = relative frequency
RC_i = relative coverage
IV_i = importance value (RD_i+RF_i+RC_i)

Biomass

The above-ground biomass based on the regression of Kato *et al.* (1978) for trees with 5 cm dbh and above was estimated at 233.4 t ha^{-1} (183.3 t of stems, 49.5 t of branches and 0.6 t of leaves). It was also inferred that 78% of these were from Class 4 timbers (more than 30 cm dbh) and mostly emergent trees. Together Class 4 and Class 3 (20–30 cm dbh) trees account for 88% of the total biomass (Figure 7). About 20% of the biomass from Class 4 and Class 3 trees were contributed by members of the Myrtaceae and 18% were from the Dipterocarpaceae (Figure 8). Other families which contributed significantly to the total biomass in Tanjung Tuan FR are Clusiaceae (14%), Anacardiaceae (5%), Euphorbiaceae (5%), Fagaceae (4%) and Loganiaceae (4%).

The top five contributing species for biomass are *Syzygium grande* (Wight) Walp., *Garcinia nigrolineata* Planch. *ex* T. Anderson, *Dipterocarpus kerrii* King, *Shorea curtisii* Dyer *ex* King, and *Hopea dryobalanoides* Miq. (Figure 9). The dipterocarps (*D. kerrii*, *S. curtisii* and *H. dryobalanoides*) are only the third, fourth and fifth dominating species from the gross total volume for all large trees (Classes 3 and 4) estimated at only 130.2 m^3 ha^{-1}.

Table 3 The number of species and trees in different dbh size classes in each tree family in Tanjung Tuan

Family	No. of species	No. of tress	% of trees in dbh classes			
			Class 1 (< 10 cm)	Class 2 (10 – 20 cm)	Class 3 (20 – 30 cm)	Class 4 (>30 cm)
Myrtaceae	8	191	59	25	6	10
Clusiaceae	11	79	65	19	8	9
Euphorbiaceae	19	77	62	29	0	9
Dipterocarpaceae	5	61	56	16	10	18
Loganiaceae	2	52	56	25	10	10
Fagaceae	3	50	46	32	8	14
Rubiaceae	8	43	60	19	14	7
Anacardiaceae	3	40	55	30	8	8
Myristicaceae	8	26	65	31	0	4
Ebenaceae	4	24	71	17	8	4
Fabaceae	5	23	61	30	4	4
Burseraceae	1	19	58	26	11	5
Sapotaceae	3	19	58	21	11	11
Verbenaceae	3	18	50	11	22	17
Meliaceae	2	13	69	23	8	0
Rhizophoraceae	2	13	54	38	8	0
Moraceae	4	11	82	0	18	0
Melastomataceae	5	10	80	10	0	10
Theaceae	2	9	44	44	0	11
Elaeocarpaceae	3	8	50	50	0	0
Rosaceae	3	8	63	13	25	0
Annonaceae	4	7	29	14	14	43
Lauraceae	3	4	25	50	25	0
Santalaceae	1	4	50	0	0	50
Sapindaceae	3	4	75	0	0	25
Celasteraceae	2	3	100	0	0	0
Myrsinaceae	1	3	67	33	0	0
Opiliaceae	1	3	33	0	33	33
Sterculiaceae	1	3	33	33	0	33
Tiliaceae	1	3	67	0	0	33
Flacourtiaceae	1	2	100	0	0	0
Thymelaeaceae	1	2	100	0	0	0
Linaceae	1	1	100	0	0	0
Polygalaceae	1	1	100	0	0	0

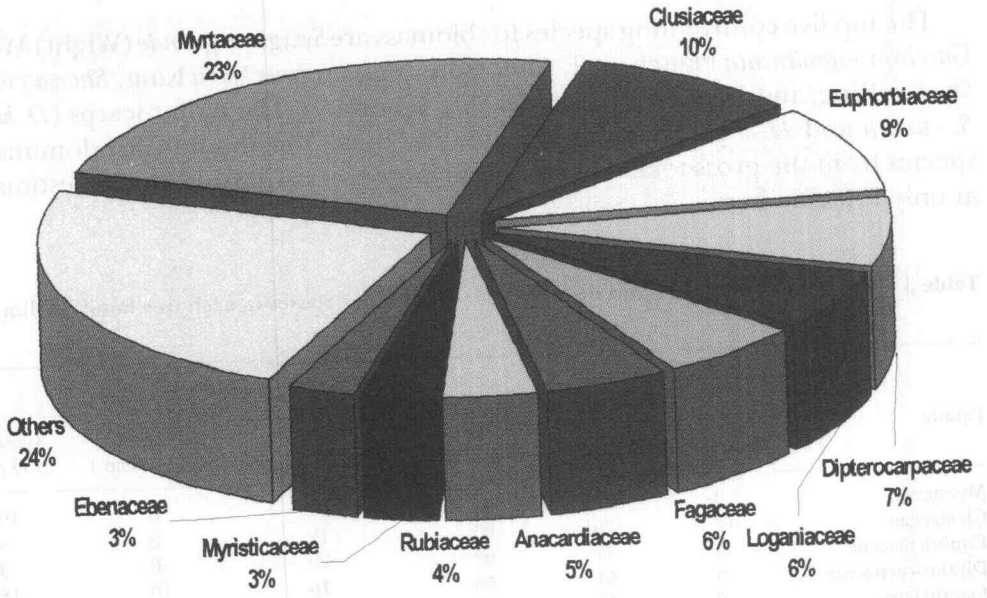


Figure 3 Relative abundance of families for all stems 5 cm dbh and above in Tanjung Tuan

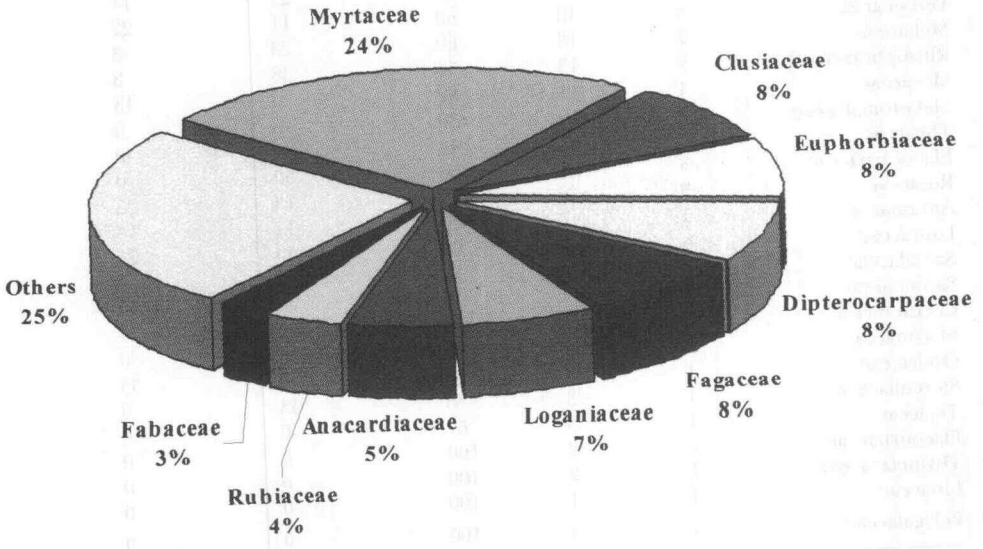
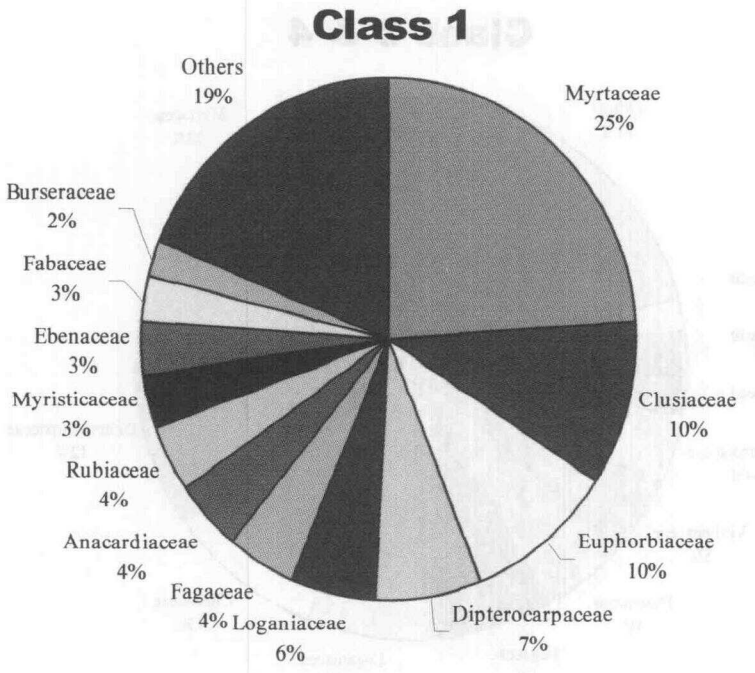


Figure 4 Relative abundance of families for all stems > 10 cm dbh in Tanjung Tuan



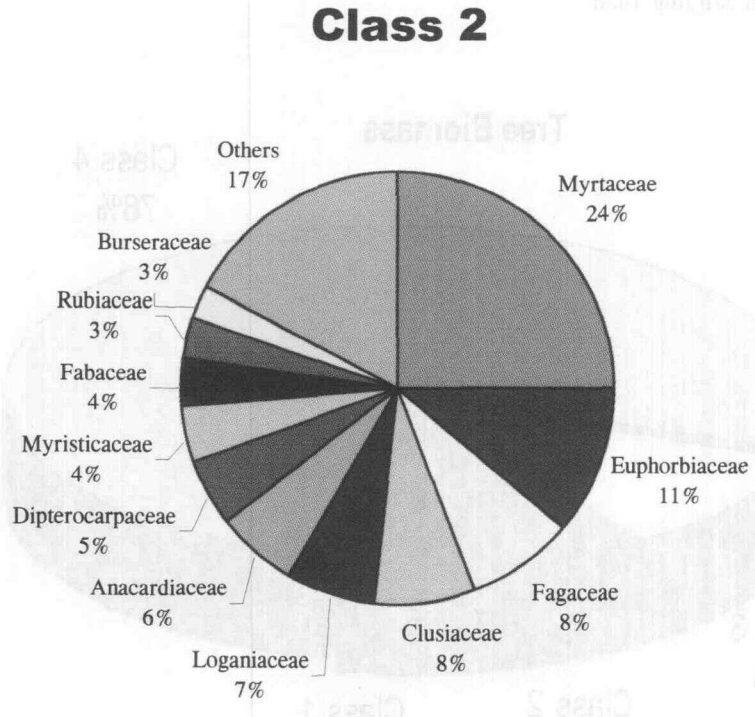


Figure 5 Relative abundance of families for class sizes 1 (below 10 cm dbh) and 2 (10.1–20 cm dbh) in Tanjung Tuan

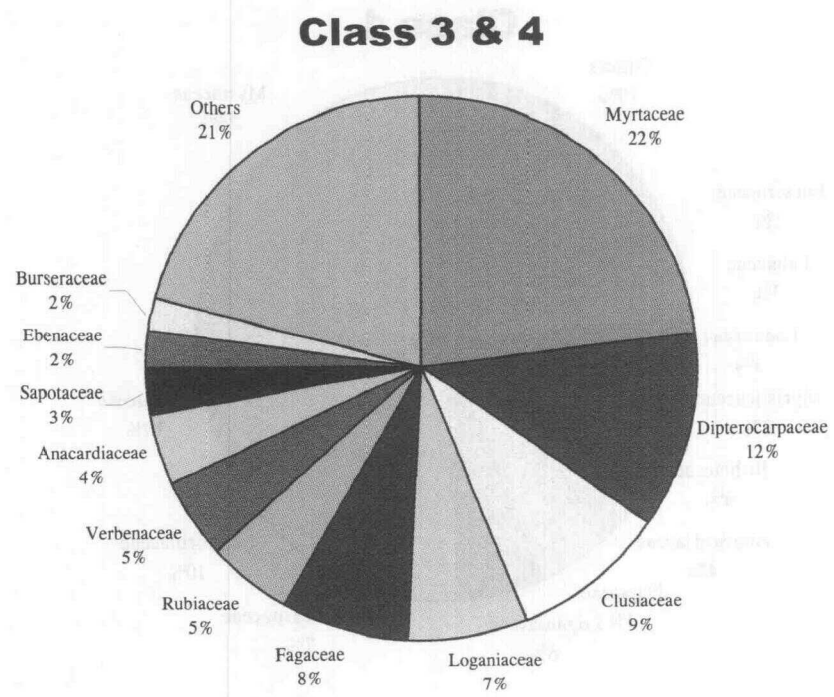


Figure 6 Relative abundance of families for Classes 3 (below 20.1 – 30.0 cm dbh) and 4 (>30 cm dbh) in Tanjung Tuan

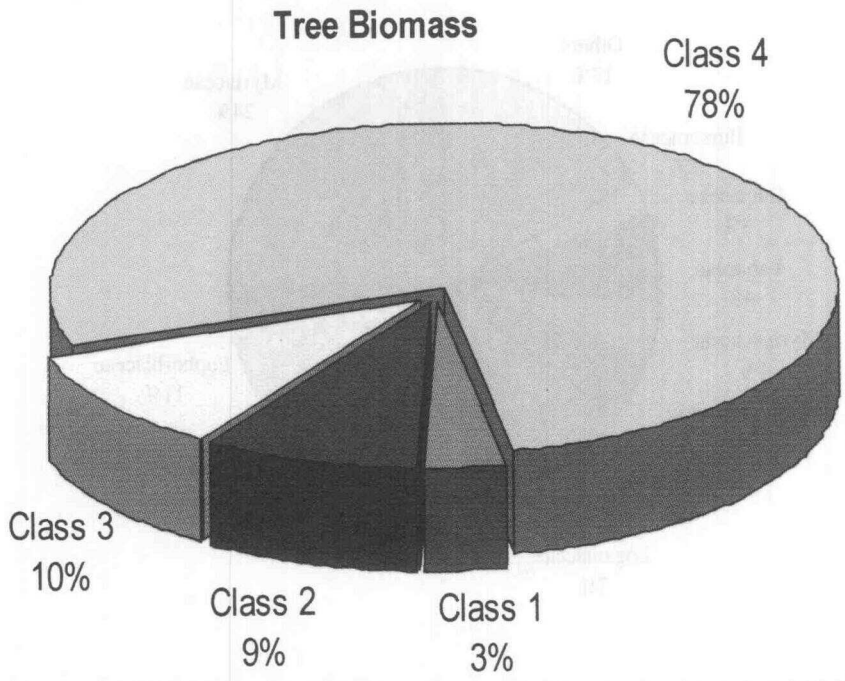


Figure 7 Above-ground biomass of trees 5 cm dbh and above in 0.75-ha plots of Tanjung Tuan

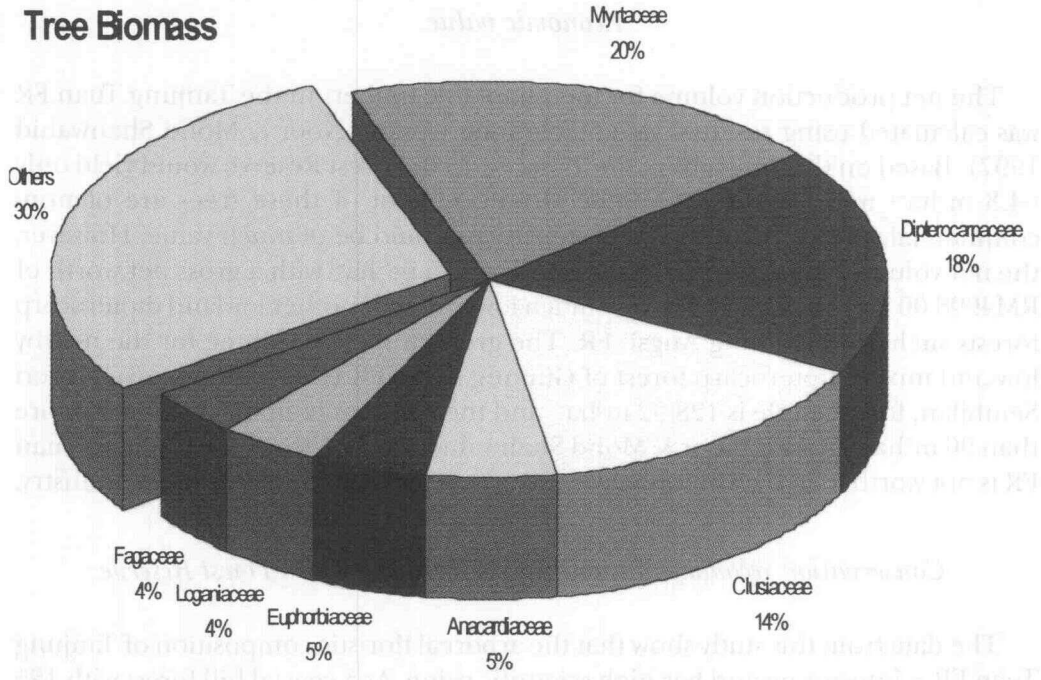


Figure 8 Above-ground biomass of major families in 0.75-ha plots of Tanjung Tuan

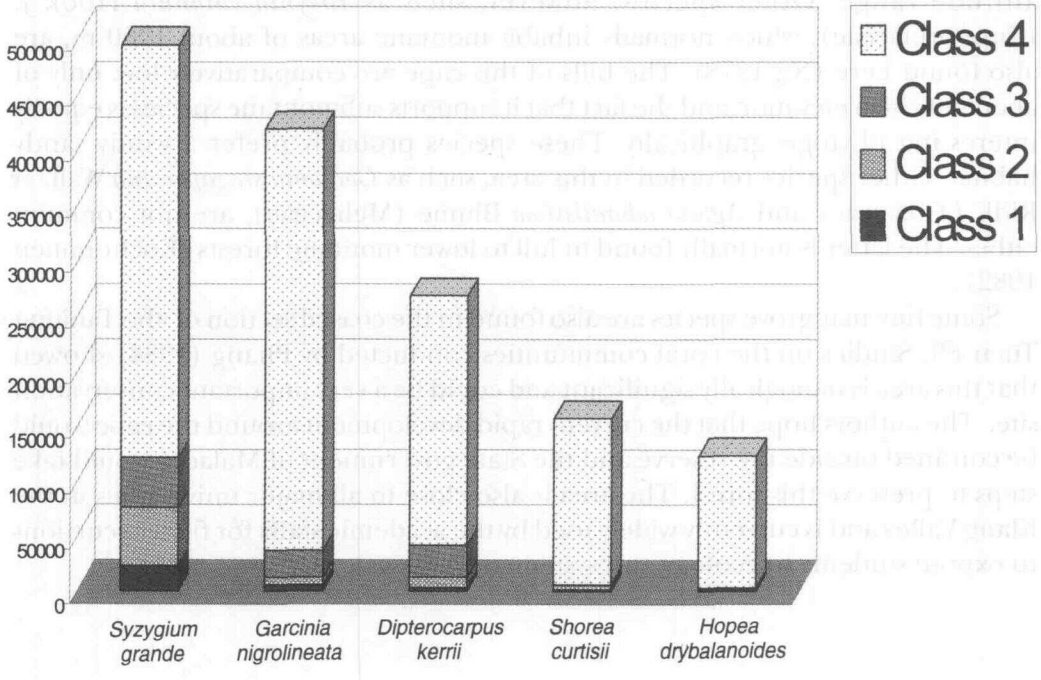


Figure 9 The top five contributors of above-ground biomass in Tanjung Tuan

Economic value

The net production volume for merchantable timbers in the Tanjung Tuan FR was calculated using residual value technique (Awang Noor & Mohd Shahwahid 1997). Based on this projection, the Tanjung Tuan Forest Reserve would yield only 44.3 m^3ha^{-1} merchantable timbers. However, most of these trees are of non-commercial species and only the dipterocarps would be of much value. However, the net volume for the dipterocarps is only 19.75 m^3 ha^{-1} with a gross net worth of RM4998.00 ha^{-1} in 1995. This is very much lower than for other lowland dipterocarp forests such as in Gunung Angsi FR. The gross stumpage volume for the nearby lowland mixed dipterocarp forest of Gunung Angsi FR (Compartment 6), Negeri Sembilan, for example is 128.92 m^3ha^{-1} and the net merchantable volume is more than 90 m^3ha^{-1} (Awang Noor & Mohd Shahwahid 1997). Clearly the Tanjung Tuan FR is not worth logging with whatever extraction methods available in the industry.

Conservation recommendations for the Tanjung Tuan Forest Reserve

The data from this study show that the arboreal floristic composition of Tanjung Tuan FR is interesting and has high scientific value. As a coastal hill forest with 125 species in 0.75 ha and totally dominated by myrtaceaous species, it offers some important conservation issues. Some species found in this forest such as *Callicarpa maingayi* King *et* Gamble (Verbenaceae) and *Mallotus penangensis* Müell.Arg. (Euphorbiaceae) are normally found in lowland inland forest up to about 1000 m altitude range. Other species, however, such as *Breynia coronata* Hook *f.* (Euphorbiaceae), which normally inhabit montane areas of about 1200 m, are also found here (Ng 1978). The hills of this cape are comparatively low, only of about 90–94 m elevation and the fact that it supports submontane species is equally interesting phytogeographically. These species probably prefer a windy sandy habitat. Other species recorded in this area, such as *Gordonia singaporiana* Wall. *ex* Ridl. (Theaceae) and *Aglaia odoratissima* Blume (Meliaceae), are not common either. The latter is normally found in hill to lower montane forests (Kochummen 1982).

Some fine mangrove species are also found in the coastal section of the Tanjung Tuan FR. Studies on the coral communities conducted by Phang (1988) showed that this area is biologically significant and could be a very important conservation site. The authors hope that the current rapid development around the cape would be confined outside the reserve and the State government of Malacca would take steps to preserve this forest. The area is also close to all major universities in the Klang Valley and is currently widely used by the academic staffs for field excursions to expose students to ecology and systematic courses.

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