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A NOTE ON A KERANGAS (HEATH) FOREST AT SEBULU, EAST KALIMANTAN*)

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ABSTRACT

Kerangas (heath) forest, that forms islands within the lowland dipterocarp forest, occurred at Sebulu, East Kalimantan. Part of the two of the islands and the transition area between them were investigated. Phytosociologically three communities could be identified, i.e. the *Cratoxylum glaucum-Dactylocladus stenostachys, Eugenia palembanica-Ilex hypoglauca,* and *Shorea ovalis-Eugenia acuminatissima* communities. They occurred on sandstone flat, sandstone slope and swampy depression respectively. Only *Cratoxylum glaucum-Dactylocladus stenostachys* community can be considered kerangas forest proper, whereas the *Eugenia palembanica-Ilex hypoglauca* community the transition and the *Shorea ovalis-Eugenia acuminatissima* community a variant of the lowland dipterocarp forest. The soils under these communities were peaty, very acid and low in nutrient contents. The economic value of kerangas forest in terms of timber is very low, hence, it would be better to preserve all kerangas forest as conservation areas and utilize them for research, educational and recreational purposes.

ABSTRAK

Hutan kerangas, yang membentuk pulau-pulau di antara hutan Dipterocarpaceae tanah rendah, terdapat di Sebulu, Kalimantan Timur. Sebagian dari dua pulau dan hutan di antaranya telah diteliti. Secara fitososiologi dapat dikenal tiga buah komunitas, yaitu komunitas *Cratoxylum glaucum-Dactylocladus stenostachys,* komunitas *Eugenia palembanica-Ilex hypoglauca* dan komunitas *Shorea ovalis-Eugenia acuminatissima,* yang secara berturut terdapat pada dataran batuan pasir, lereng dan cekungan berawa. Hanya komunitas *Cratoxylum glaucum-Dactylo-*

*) The study was conducted while the author was attached to SEAMEO Regional Center for Tropical Biology (BIOTROP), Bogor. An Indonesian summary of this paper was presented in the Seminar Biologi IV at Yogyakarta in July 1975.

cladua stenostachys dapat dianggap sebagai hutan kerangas sejati, sedangkan komunitas *Eugenia palcmbanica-Ilex hypoglauca* merupakan komunitas transisi dan komunitas *Shorea ovalis-Eugenia acuminatissima* merupakan sebuah varian hutan Dipterocarpaceae tanah rendah. Tanah dalam komunitas-komunitas tersebut agak bergambut, sangat asam dan mempunyai kandungan hara yang rendah. Nilai ekonomi hutan kerangas, bila diukur dengan produksi kayunya, sangat rendah, sehingga semua hutan kerangas lebih baik dijadikan kawasan pelestarian dan pemanfaatarmya diarahkan pada segi-segi penelitian, pendidikan dan rekreasi.

INTRODUCTION

The dipterocarp forest in Kalimantan forms the main vegetation cover and generally occurs on yellow podsolic soils from the lowland to the mountainous region. Within this forest there exist islands of heath forests or known also as *kerangas* forests or *packing* forests, whose structures and compositions are totally different from the surrounding dipterocarp forests. They occur on tropical podsol overlying white sandstone formation.

The kerangas forest has been long known to occur in Kalimantan and Sumatra, Beccari (1904), Winkler (1914), Endert (1927), Steenis (1932), and Polak (1933) gave short descriptions of kerangas forests occurring in Kalimantan; Henderson (1932) described that occurring on the Anambas Islands; and Teysmann (1876) mentioned its occurrence on the Belitung Island, Karimata Islands, and at Landak on the west coast of Kalimantan. Wirakusumah (1973) noted also that kerangas forest occurred on the Nunukan Island in the northern part of East Kalimantan. The Padang Luwai Nature Reserve on the Upper Mahakam River is reported to be covered by a kerangas forest (Posthumus 1937; Posthumus & Witkamp 1932; Sutisna 1976). I have seen also a rather extensive coverage of secondary kerangas forest near Banjarmasin, South Kalimantan, and along the road near Semboja, east of Balikpapan, East Kalimantan. The occurrence of this forest in other parts of Indonesia has been reviewed by Kartawinata (1976).

The kerangas forest in the Malaysian part of Borneo has been intensively investigated (e.g. Richards 1936; Browne 1952; Gilliland 1959, 1960; Brunig 1965, 1968, 1969a, 1969b, 1970, 1971; Ashton 1971), while in Indonesia the studies of kerangas forests have been restricted to floristic recording made during various botanical and soil explorations.

The present study is concerned with an objective description of a kerangas forest at Sebulu, East Kalimantan, and was made during a five-day visit in January 1974.

STUDY AREA

The kerangas forest investigated occurs within the forest concession area of the P.T. Kutei Timber Indonesia, and is located about 18 km from the village of Sebulu (Lower Mahakam), at an altitude of approximately 150 m above sea level. On aerial photographs this forest appears to be very uniform and lower in structure than the surrounding dipterocarp forest. It is often interpreted as a secondary forest. It forms distinct islands with rather sharp boundaries within the matrix of dipterocarp forest (Fig. 1). These islands occur on flatland with peaty soils overlying white sandstone formation. The area between two of the nearest islands, A and B, forms a gentle slope and rather swampy depression and is covered with tall forest. The terrain of the surrounding dipterocarp forest is hilly.

The area is located within the everwet climatic type (Kartawinata 1975) or rainfall type A with the ratio of the number of wet months over the number of dry months (Q) of 13.4 (Schmidt & Ferguson 1951). The rainfall recorded for two years at the logging camp at Sebulu shows that the monthly rainfall ranges from 46 mm in February to 716 mm in September with the total of 3295 mm. The monthly temperature ranges from 30.20°C in July to 34.40°C in March (Tinal & Palinewen 1974). The climate diagram of the nearest rainfall station at Tenggarong is given in Fig. 2.

METHOD

In this study only a small portion of the two nearest islands, A and B, and the tall forest between them were investigated. The point centered quarter method (Curtis and Cottam 1962) was used. A line running and crossing the area between the islands A and B was drawn from north to south, and five transects, each of 150 m long, and perpendicular to the main line, were established (Fig. 1). The location of the first transect was selected subjectively on island A about 150 m from the edge. The second transect was placed 200 m from the first one, the third 100 m from the second, the fourth 100 m from the third, and the fifth 300 m from the fourth. Transects no. 1, 4 and 5 were located on the level land, no. 2 on the slope, and no. 3 on the bottom of a depression. In each transect, 10 sampling points were established at 15 m intervals. Four trees (diameter greater than 10 cm) and four saplings (diameter of 2—10 cm) at each sampling point were identified and their diameters were measured. Herbs and seedlings were sampled in each point with a 1 x 1 m plot and the coverage of each species was

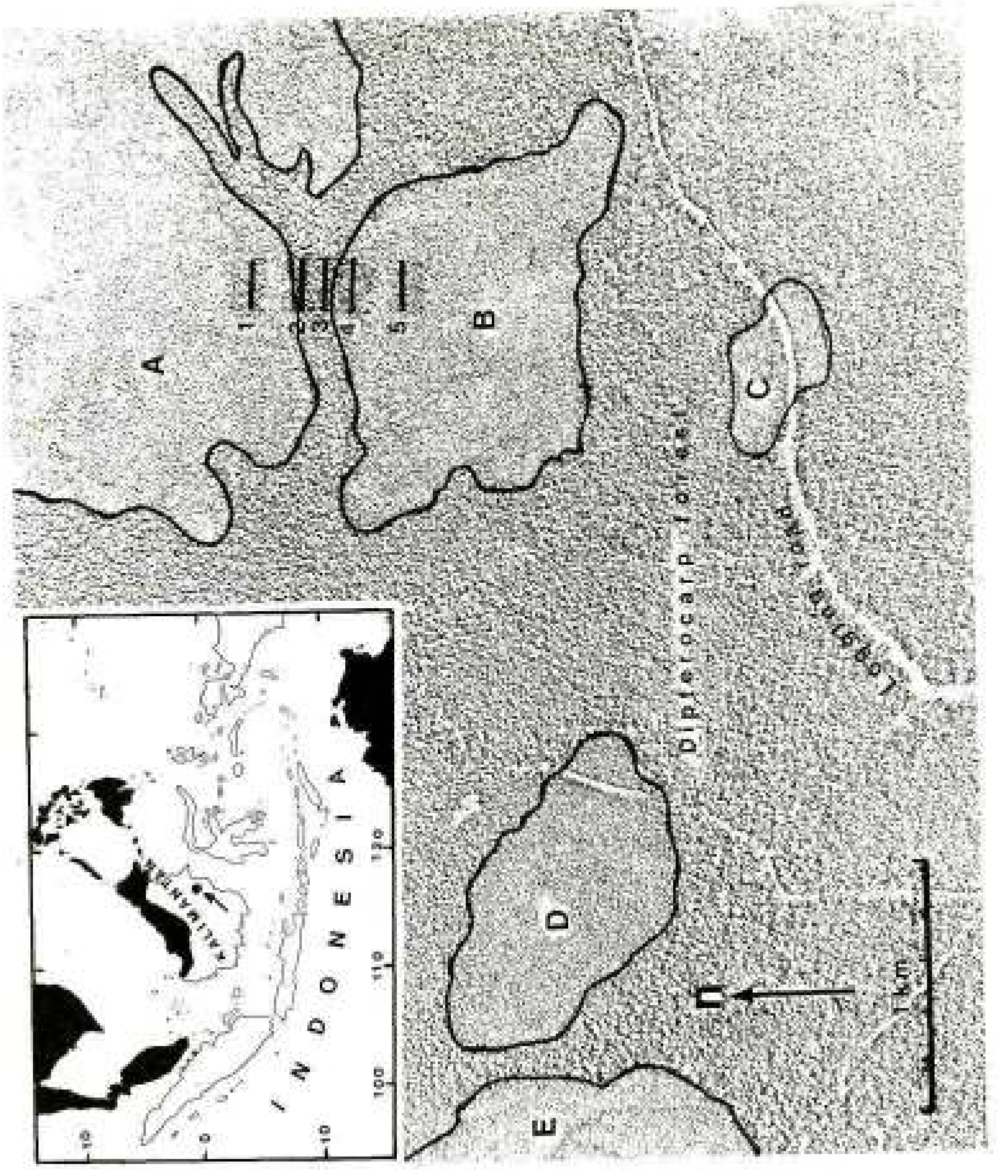


FIG. 1. A man showing the locations of the Kerangas forest forming islands (A-E) within the lowland dipterocarp forest matrix at Sebulu, Bast Kalimantan. The *iLuves (V-5)* show the sample numbers and the sampling sites. The map was reproduced from an aerial photograph supplied by the Directorate of Forest Planning, Directorate-General of Forestry, Bogor.

estimated. Surface soil samples to a depth of 10 cm was collected from each point and the composite sample for each transect was analysed by the Soil Research Institute, Bogor. Voucher specimens are deposited at the Herbarium Bogoriense, Bogor.

RESULTS

Eighty four species of trees, shrubs and herbs were recorded in the samples, and together with specimens collected from outside the samples the number of species was 136. These do not include the epiphytes which were common in the area, such as *Hydnophytum* spp., *Myrmecodia* spp., *Dischidia* spp., and *Dendrophtoe* spp.

Floristically the forest investigated may be differentiated into three communities, i.e. *Cratoxylum glaucum - Dactylocladus stenostachys, Eugenia palembaniea-Ilex hypoglauca*, and *Shorea ovalis-Eugenia acuminatissimct* communities. They are named after the species having the highest importance values. The importance value is the sum of relative frequency, relative density and relative dominance (Curtis and Gottam 1962).

The dominant species in the *Cratoxylum-Dactylocladus* communitiy were *Cratoxylum glaucum* and *Dactylocladus stenostachys*, whose importance values were 81.04 and 50.01, respectively. Other prominent tree species were *Cornbretocarpus rotundatus, Tristania obovata, Ilex hypoglauca* and *Tetractomia obovata;* each of them had the importance value greater than 10.

In Table 1 the species group 2 represents species that were restricted to this community. It can be seen also that trees with diameters greater than 10 cm are only 12 species. The sapling group consists of saplings, treelets and shrubs; these were *Dacrydium elatum, Tetractomia obovata, Antidesma puncticulosa* and *Baccaurea brdcteata.* It is interesting to note that *Dacrydium elatum* occurred in the island B as small trees and so far was not seen in the island A. In the sapling group *Cratoxylum glaucum* was still the prevalent species, followed by *Tristania obovata*, but *Dactylocladus stenostachys* was here less important. As a whole *Cratoxylum glaucum* and *Dactylocladus stenostachys* were the most widely distributed species with high value of dominance. *Tristania obovata* occurred less frequently in the middle of the community, but it became dominant and often formed a pure concentric stand at the edge of the community next to the tall dipterocarp forest, and this occurred also on the island C.

Trees and shrubs occurring in this community are dwarf and have sclerophyllous leaves. The largest diameter was less than 30 cm (Table 2),

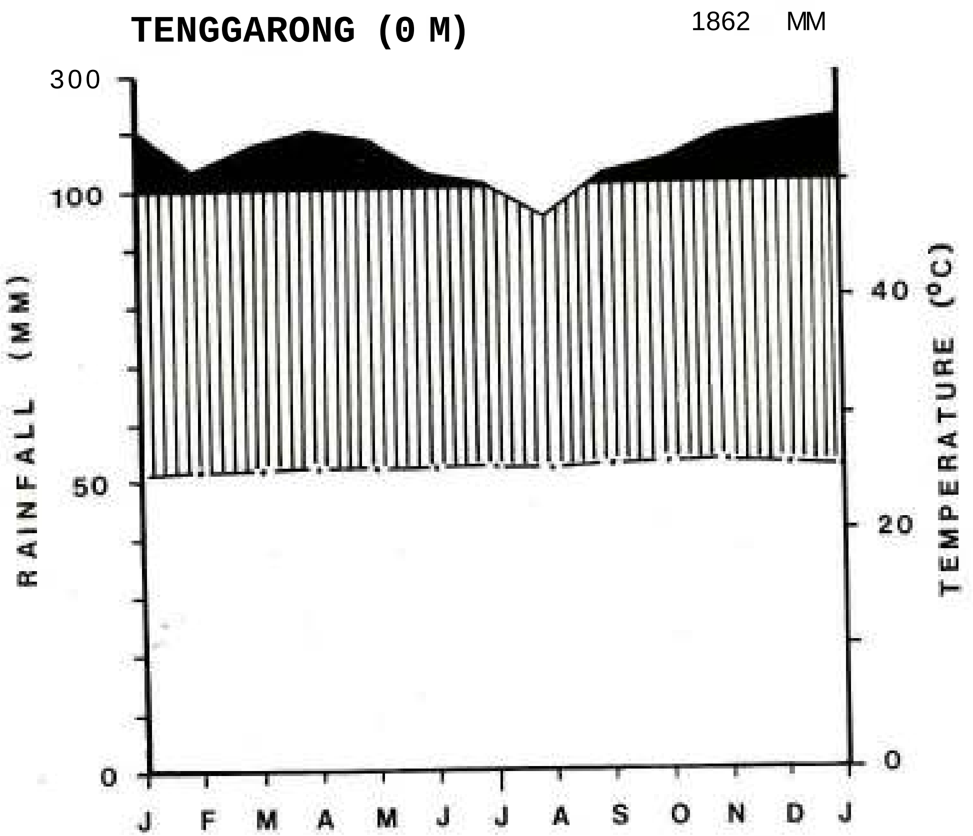


FIG. 2. The climate diagram of the nearest rainfall station at Tenggarong, located at sea level, along the Mahakam River, North-west of Samarinda. The mean annual rainfall is 1862 mm. The rainfall data were taken from Berlage (1949) and the temperature data were obtained by extrapolation.

and the maximum height was 14 m. Trees with diameters greater than 20 cm were scattered and formed the emergents, such as *Shorea balangeran* and *Cratoxylum glaucum.* The tree crowns were thin and the canopy was discontinuous (Fig. 3). The density of trees was 549 trees/ha and the average basal area was 10.73 sq.m/ha. The density of saplings and shrubs was 1900 plants/ha with the basal area of 4.1 sq. m/ha.

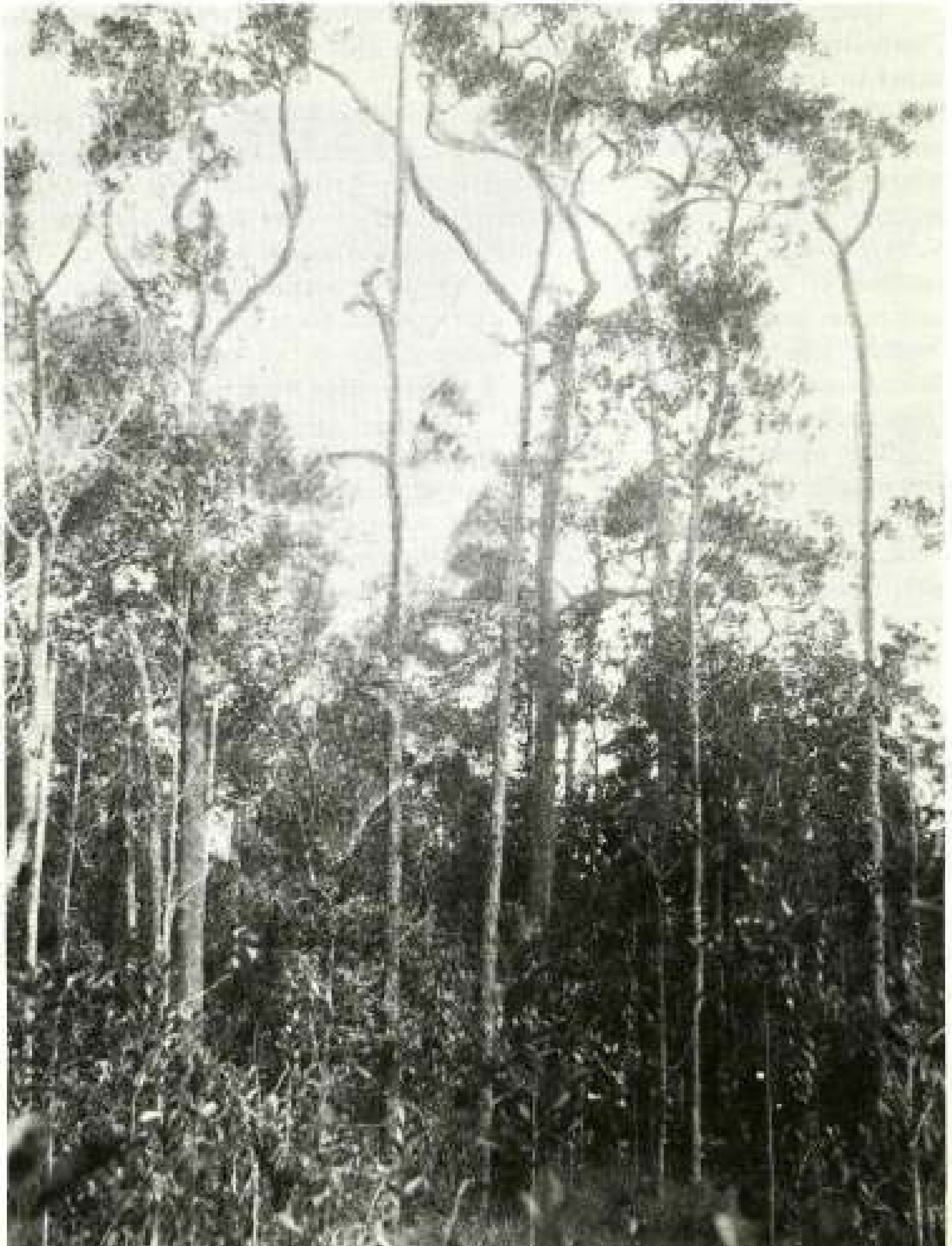
The population structure (Table 2) shows that all the important species were well represented in the sapling stage (diameter class 2—9.9 cm), but less so in the higher diameter classes. These species may be included under the category of "frequent producers" (Knight 1975). However, in the seedling stage they were poorly represented (Table 5). Only *Tristania obovata* and *Cratoxylum glaucum* were present, but with

low frequency and coverage, while *Dactylocladus stenostachys* and *Combretocarpus rolundatus* were absent. This situation could be attributed to the inadequacy of sampling.

Tricostularia undulata was the dominant and the most frequent species (Table 5) in the herb and seedling layer. It occurred on exposed sandstone and peaty substrate, particularly in unshaded places. Other common species (frequency greater than 30%) were *Nepenthes gracilis, N. rafflesiana, Antidesnia puncticulatum* and *Aporusa microsphaera.* The seedling of *Tristania tvhiteana* was common also, although it occurred only occasionally in the tree layer and was not recorded in the transects. Outside the plots it was also observed the occasional occurrence of *Burmannia disticha, Calamus* sp., *Dendrotrophe varians* and *Nepenthes reinwardtiana.*

The ground under the *Cratoxylum-Dactylocladus* community was peaty soils overlying white sandstone and in many places it was bare and exposed sandstone. The peaty soil was covered by litter of 1—2 cm thick. The humus layer, whose thickness ranged from 5 to 15 cm, was soft, spongy, moist, and brownish black in colour, and was strewn by the mass of living, fine roots. Underlying this was a 5—15 cm thick black to grey layer of moist silty sand, intergrading with the white compacted sand beneath. Occasionally at the depth of 10—15 cm, charcoal was noted, indicating the occurrence of fire in the community in the past. During rainy seasons the soil was extremely wet to swampy, discharging black to dark brown water. Stagnant water filled up depressions and in such places pneumatophores often developed (Fig. 4). This indicates that water remained stagnant in such places for some time. The soil was very acid and low in nutrient content (Table 6).

The *Eugenia-Ilex* community is represented by sample no. 2 located on the slope. It is a transition between the *Cratoxylum-Dactylocladus* and the *Shorea-Eugenia* communities. *Eugenia palembanica* and *Ilex hypoglauca,* whose importance values were 92.77 and 58.62 respectively, were the dominant trees in this community. Other prominent trees were *Cotylelobium malayanum, Eugenia cymosa, Intsia palembanica, Dactylocladus stenostachys, Tristania obovata* and *Calophyllum soulattri.* The latter four species and *Ilex hypoglauca* were also important components of the *Cratoxylum-Dactylocladus* community (Table 1, species group 3). In the sapling group the dominant trees were not represented or less important, and *Calophyllum soulattri, Barringtonia sumatrana, Pygeum parviflorum,* and *Shorea teysmanniana* were prominent (Table 3) and appear to be reproducing well.



PIG. 3. A view of the *Cratoxyliim-Dactyloeladus* community. The trees are *Cratoxylum glaucum, Dactylocladus stenostachys* and *Combretocarpus rottmdatus.* On the foreground are young plants of T'*etractomia obovata* and behind them are *Tricostularia undulata* covering the ground.

FIG. 4. Stagnant water in a depression in the *Cratoxylunu-Dactylocladus* community, with pneumatophores in the center and ground cover around it consisting of *Tricostularia undulata, Nepenthes gracilis* and seedlings of *Tetractomia obovata*

Table 1. The average importance values of trees and saplings (including treelets and shrubs) in *Cratoxylum-Dactylocladus* (CD), *Eugenia-Ilex* (El), and *Shorea-Eugenia* (SE) communities

Species	CD		El		SE	
	Trees	Sapling	Trees	Sapling	Trees	Sapling
Species group 1						
Syzyffium claviflorum	15.19	5.80	3.58	—	—	67.06
Horsfieldia subglobosa	—	4:0-2	—	4.37	6.74	—
Cratoxylum formosum	—	11.76	—	—	12.64	12.81
Sterculia sp.	—	2.29	—	—	—	5.97
Species group 2						
Combretocarpus rotundatus	45.31	16.43	—	—	—	—
Litsea crassifolia	7.59	12.50	—	—	—	—
Shorea balangeran	3.28	4.73	—	—	—	—
Myrsyne hasseltii	2.33	6.56	—	—	—	—
Eugenia cerina	10.67	—	—	—	—	—
Tetractomia obovata	—	35.36	—	—	—	—
Daorydium elatum	—	16.23	—	—	—	—
Antidesma puncticulatum	—	7.56	—	—	—	—
Species group 3-	-					
Cratoxylum glaucum	81.04	48.73	5.29	—	—	—
Dactyloeladus stenostaehys	50.01	13.3-6	11.3'9-	—	—	—
Tristania obovata	36.69	47.36	10.48	—	—	—
Calophyllum soulattri	9.0-3	26,13	10.67	61.07	—	—
Palaquium ridleyi	2.22	—	7.14	—	—	—
Ilex hypoglauca	re.00	37.47	58.62	9.12	—	—
Baccaurea bracteata	—	9.36	7.45	17.18	—	—
Species group 4						
Eugenia cymosa	—	—	17.15	—	—	—
Intsia palembanica	—	—	12.30'	—	—	—
Cotylelobium malayanum	—	—	31.71	—	—	—
Shorea teysmanniana	—	—	—	27.83	—	—
Eugenia jamboloides	—	—	—	8.63	—	—
Garcinia rostrata	—	—	—	8.36	—	—
Garcinia bancana	—	—	—	7.45'	—	—
Timonius flavescens	—	—	—	6,65	—	—
Eugenia cuprea	—	—	—	6.30	—	—
Species group 5						
Eugenia palembanica	—	—	92.77	8.10	23.80'	—
Litsea sp.	—	—	—	8.0'2	6.34	—
Calophyllum pulcherimum	—	—	—	6.30	12.96	—
Pygeum parviflorum	—	—	—	39.14	—	30.96
Barringtonia sumatrana	—	—	—	55.20	—	22.30
Baccaurea puberula	—	—	—	10.53	—	5.97
Ixora steno-ghulla	—	—	—	10.01	—	12,46-;

Table 1. (Continued)

Species	CD Trees	CD Sapling	El Trees	El Sapling	SE Trees	SE Sapling
Species group 6						
Shorea ovalis	—	—	—	—	37.42	—
Eugenia acuminatissima	—	—	—	—	21.27	—
Rhodamnia cinerea	—	—	—	—	15.50	—
Xylopia altissima	—	—	—	—	15.22	—
Eugenia sp.	—	—	—	—	14.32	—
Xanthophyllum sp.	—	—	—	—	11.92	—
Pternandra galeata	—	—	—	—	11.72	—
Laplacea ovalis	—	—	—	—	11.37	—
Parinari sp.	—	—	—	—	10.44	—
Mastixia rostrata	—	—	—	—	8.35	—
Vatica umbonata	—	—	—	—	8.19	—
Polyalthia sp.	—	—	—	—	7.16	—
Lithocarpus datystachyus	—	—	—	—	6,14	—
Polyalthia lateriflora	—	—	—	—	5.65	—
Sindora gadelupa	—	—	—	—	5.65	—
Endiandra sp.	—	—	—	—	5.58	6.68
Lithocarpus sundaicus	—	—	—	—	6.35	5.63
Baccaurea sp.	—	—	—	—	6.15	8.69
Memecylon edule	—	—	—	—	5.73	6.49
Aporosa microsphaera	—	—	—	—	—	33.06
Fordia coriacea	—	—	—	—	—	23.67
Aporosa nitida	—	—	—	—	—	6.84
Strombosia javanica	—	—	—	—	—	6.66
Dialium indum	—	—	—	—	—	6.49
Cryptocanja densiflora	—	—	—	—	—	6.16
Sterculia macropoda	—	—	—	—	—	5.93
Knema laurina	—	—	—	—	—	5.59

Table 2. Density (plants/ha) of tree species in *Cratoxylum-Dactylocladiis* community according to diameter classes

Species	Diameter class (cm)		
	2 — 9.9	10 — 19.9	20—29.9
Cratoxylum glaucum	538	146	9
Tristania obovata	511	64	—
Combretocarpus rotundatus	161	23	27
Dactyloeladus stenostaehys	108	151	—
Tetractomia obovata	484	5	—
Ilex hypoglauca	323	5	5
Others	1103	67	14

Trees were bigger and taller than those in the *Cratoxylum-Dactylocladus* community. The largest tree with diameter more than 40 cm was represented by *Cotylelobium makiyanum* (Table 3). The density trees was 722 trees/ha with the total basal area of 24.43 sq. m/ha, and the density of sapling group was 2890 plants/ha with the basal area of 4.23 sq. m/ha. The tree crowns were thick and the canopy was continuous.

Table 3. Density (plants/ha) of tree species in *Eugenia-Ilex* community according to diameter classes.

Species	Diameter class (cm)				
	2-9.9	10-19.9	20-29.9	30-39.9	40-49.9
Eugenia palembanica	—	54	126	IS	—
Ilex hypoglauca	91	199	18	—	—
Cotylelobium malayanum	—	18	—	18	18
Tristania obovata	—	91	36	18	—
Eugenia cymosa	—	18	18	—	—
Cratoxylum glaucum	—	—	18	—	—
Daetylocladus stenostachys	—	—	36	—	—
Baccaurea bracteata	181	18	—	—	—
Calophyllum soulattri	785	18	—	—	—
Intsia palembanica	91	18	—	—	—
Barringtonia sumatrana	543	—	—	—	—
Pygeum parviflorum	453	—	—	—	—
Shorea teysmanniana	364	—	—	—	—
Others	1024	271	54	—	—

In the herb and seedling layer, *Ixora stenophylla* and *Eugenia cuprea* were the dominant and the most common species while others were present with low cover and frequency (Table 5). In general the ground cover was sparse.

The soil under this community comprised of litter layer of 1—2 cm thick, beneath which was the humus layer of 3—8 cm thick, ramified by abundant living fine roots. Underlying the humus layer was black to grey, friable sandy soil with thickness of **14—25** cm. **The white, hard,** compacted sand occurred as the parent material underneath. **The** surface soil to the depth of 10 cm was very sandy and acid and was very low in nutrient contents (Table 6).

The *Shorea-Eugenia* community occurred on the depression between kerangas forest on the islands **A and B and is represented by sample no. 3 (Fig. 1).** *Shorea ovalis* and *Eugenia acuminatissima* **are here designated as the** dominant species **as they have the highest importance values.**

Other important species, which respectively has importance value greater than 10, were *Eugenia palembanica, Calophyllum pulcherimum* and species listed in species group 6 (Table 1). This community intergrades with both the *Cratoxylum-Dactyllocladus* and *Eugenia-Ilex* communities.

In the sapling and shrub layer, the important species were *Aporusa microsphaera, Pygeum parviflorum* and *Barringtonia sumatrana.* Tables 1 and 4 show also that the dominant and other important trees were not represented in the sapling stage. *Shorea ovalis,* in fact, occurred in the sample only as seedlings and trees with diameters greater than 50 cm (Tables 4 and 5).

This community is more complex than the *Cratoxylum-Dactylocladus* and *Eugenia-Ilex* communities. It resembles more the surrounding normal dipterocarp forest than the kerangas forest. Outside the sample, tall and big dipterocarp species, such as *Shorea lamellata, S. teysmanniana S. bracteolata, S. laevis* and *S. leprosula,* were present. The biggest tree recorded was *Shorea ovalis,* whose diameter reached 110 cm and height of more than 30 m.

Table 4 shows the size class distribution of trees and it appears that *Syzygium claviflorum, Litsea* sp., *Endiandra* sp., *Lithocarpus sundaicus Memecylon edide* and *Diospyros puncticulosa* were "frequent producers".

Table 4. Density (plants/ha) of tree species in *Shorea-Eugenia* community according to diameter classes

Species	Diameter class (cm)					
	2-9.9	10-19.9	20-29.9	30-39.9	40-50'	>50
Syzygium claviflorum	578	11	—	—	—	—
Litsea sp.	.217	11	—	—	—	—
Endiandra sp.	72	23	—	—	—	—
Lithocarpus sundaicus	72	23	—	—	—	—
Memecylon edule	72:	11	—	—	—	—
Diospyros puncticulosa	145	23	—	—	—	—
Eugenia palembanica	—	11	—i	23	—	—
Eugenia acuminatissima	—	46	11	—	—	—
Rhodamnia cinerea	—	23	11	—	—	—
Xylopia altissima	—	23	—	11	-r-	—
Xanthophyllum sp.	—	—	11,	11	—	—
Baccaurea bracteata	72	—	—	11	—	—
Shorea ovalis	—	—	—	—	—	11
Others	2395	,240	33'	44	22	11

In the seedling layer the important trees were poorly represented. Here the seedling and herb layer consisted mainly of seedlings **of other tree** species, except for *Shorea ovalis* and very few herbs (Table 5). The ground cover in this community was very sparse.

Table 5. Average percentage of cover (C) and frequency (F) of seedlings and herbs in *Cratoxylum-Dactylocladus* (CD), *Eugenia-Ilex* (El) and *Shorea-Eugenia* (SE) communities.

Species	CD		El		SE	
	C	F	C	P	C	F
Tricostularia undulata	36.67	66.67	—	—	—	—
Antidesma puncticulatum	7.17	46.67	—	—	—	—
Tristania whiteana	5.57	46.67	•—	—	—	—
Nepenthes gradlis	2.63	40.00	—	—	—	—
Aporusa viicrosphaera	5.30-	30.00	—	—	—	—
Nepenthes rafflesiana	4.07	30.00	—	—	—	—
Eugenia sp.	8.90	26.70	—	—	—	—
Tristania obovata	2.40	23.30	—	—	—	—
Bromhaedia finlaysoniana	1.10	20.00	—	—	—	—
Tetractomia obovata	3.00	20.00	—	—	—	—
Trichospermum canaliculatum	1.70	13.33	—	—	—	—
Myrsine hasseltii	0.27	r0.00	0.50	10.00	—	—
Xavnthophyllivm sp.	0.37	10.00	0.10	10.00	—	—
Calophyllum soulattri	0.70	10.00	—	—	—	—
Baccaurea bracteata	1.00	10.00	—	—	—	—
Xyris borneensis	0.07	6.67	—	—	—	—
Timonius flavescens	1.13	6.67	2.50	10. OO	—	—
Ilex hypoglauca	2.67	6.67	—	—	—	—
Diospyros puncticulosa	0.03	3.33	—	—	—	—
Gomphaea serrata	0.03	3.33'	—	—	—	—
Bulbophyllum sp.	0.13	3.33	—	—	—	—
Pygeum parviflorum	0.03>	3.33	0.50	r0.00	—	—
Cryptocarya sp.	0.03	3.33	—	—	—	—
Dacrydium datum	0.83	3.33	—	—	—	—
Sterculia sp.	0.17	3.33	—	—	—	—
Cratoxylum glaucum	0.1.7	3.33	—	—	—	—
Lauraceae	0.07	3.33	—	—	—	—
Ixora stenophylla	—	—	10.4	90.00	6.0	40.00
Eugenia cuprea	—	—	16.8	80.00	—	—
Urophyllum glabrum	—	—	10.00	20.00'	—	—
Calophyllum pulcherimum ,	—	—	3.00	20.00	—	—
Garcinia bancana	—	—	3.00	20,00	—	—
Shorea teysmannianq.	—	—	1.00	20.00	—	—

Table 5. (Continued).

Gaertnera vaginans	—	—	1.00	20.00	—	—
Medinilla cuspidata	—	—	22.50	r0.00	—	—
Pternandra galeata	—	—	0.50	10.00	—	—
Barringtonia sumatrana	—	—	0.50	10.00	—	—
Oxymitra grandifolia	—	—	0.10	10,00	—	—
Pandanus sp.	—	—	—	—	8.50	40.00
Syzygium claviflorum	—	—	—	—	1.60	30.00
Baccaurea sumatrana	—	—	—	—	2.60	40.00
Sohima wallichii	—	—	—	—	2.50	10.00
Erycibe borneensis	—	—	—	—	1.00	10,00
Pentace polyantha	—	—	—	—	0.50	**10.00**
Shorea bracteolata	—	—	—	—	0.50	10.00
Shorea ovalis	—	—	—	—	0.50	1O.00
Sindora gadelupa	—	—	—	—	0.50	10.00
Boea macrophylla	—	—	—	—	O'IO	10.00

The *Shorea-Eugenia* community occurred on a somewhat swampy soil, with litter layer of about 1 cm thick, overlying brownish black humus layer of about 5 cm thick. Living fine roots were abundant in this humus layer. Beneath this was the layer of dark grey sandy clay silt, whose thickness was about 8 cm, overlying light grey compacted sandy clay silt. The surface soil to the depth of 10 cm was very acid and low in nutrient contents, although the nitrogen, phosphorous and potassium contents were higher than those in soils of the *Cratoxylum-Dactylocladus* and *Eugenia-Ilex* communities (Table 6).

Table 6. Chemical and physical properties of soils to the depth of 10 cm.

	Community		
	Cratoxylum-Dactylocladus	*Eugenia-Ilex*	*Shorea-Eugenia*
Sand (%)	40'.7	64	15
Silt (%)	54.7	33	60
Clay (%)	44.6	3	16
pH (in H_2O)	3.4	3.6	3.6
C (mg/100 g)	8.19	6.52	**7.16**
N (mg/lOO g)	0.40	0.28	**0.51**
C/N	23	23	14
P_2O_5 (mg/100 g) •	**19.5**	30	46
K_2O (mg/100 g)	8	9/	19
Lime requirement at pH 6.5 (g $CaCO_3$ per 100 g soil)	2.18	1.52	1.52

DISCUSSION

The kerangas forest does not occur exclusively in Borneo. Kartawinata (1976) in his review shows that it is found also in Sumatra, Celebes, and Irian Jaya (West New Guinea) at the altitude up to 2400 m, but it is absent in Java and Nusa Tenggara (Lesser Sunda Islands). He notes that previous studies of kerangas forest are mainly concerned with floristic records based on visual observations during botanical and soil explorations. The present studies gives a descriptive account based on objective assessment, although I have to admit that the inadequacy of sampling produces results that may not reflect the true picture of the forest investigated. Nevertheless, the present data will be of value in providing a brief and objective description of the structure and composition of the kerangas forest, hitherto little known in Indonesia. Further detailed studies are, therefore, needed to understand better, not only the structure and composition but also the functioning of this type of forest ecosystem.

Among the three communities identified in the present study, only the *Cratoxylum-Dactylocladus* community can be considered the true kerangas forest. The *Shorea-Eugenia* community, on the other hand, is more appropriate to be considered a variant of the lowland dipterocarp forest occurring on swampy habitat, on account of its structure, species composition and soil, in particular the textural properties. The *Eugenia-Ilex* community may be regarded as a transition between the two.

The *Cratoxylum-Dactylocladus* community is a type of kerangas forest occurring on other "islands" (C, D and E) in Sebulu area, although they may be somewhat different in floristic composition. In the "island" C, for instance, *Tristania obovata* and *Calophyllum soulattri* were observed to be the most prominent tree species. Other kerangas forests found elsewhere in Indonesia, so far recorded (Kartawinata 1976), and many of those occurring in Sarawak (Brunig 1965) are similar in habitat, structure and to a certain extent in floristic composition to the *Cratoxylum-Dactylocladus* community. This community is also similar floristically to the forest occurring on white sand island, recorded by Dilmy (1965) to occur in the middle of the peat swamp forest, in particular in the presence of such species as *Tristania obovata, Dacrydium elatum, Shorea balangeran, Dactylocladus stenostachys* and *Cratoxylum glaucum.*

The presence of charcoal in the soil at the depth of 15 cm indicates the occurrence of fire in the past. However, there was no indication of recent burning in the area. It is difficult to say that the kerangas forest

at Sebulu is of secondary origin. Typical species of secondary kerangas forest, such as *Ploiarium alternifolium, Dillenia suffruticosa, Dicranopteris linearis, Fagraea fragrans, Rhodomyrtus tomentosa* and *Vitex pubescens* (Browne. 1952; Whitmore 1975), were absent.

The soil in the *Cratoxylum-Dactylocladus* and *Eugenia-Ilex* communities is very acid, and is poorer in nutrient contents compared to that in the *Shorea-Eugenia* community. It is also different from the soil under dipterocarp forest occurring at Beloro (Tinal & Palinewen 1974), about 10 km west of the study area, which is comparable to the soil under the dipterocarp forest surrounding the *Cratoxylum-Dactylocladus* community. The properties of soil under this community is also comparable to those of kerangas soils at Bangka, Padang Luwai (Hardon 1937) and Sarawak (Richards 1965). These soils are considered the poorest in terms of nutrient contents compared to latosols and other soils (Hardon 1937; Mohr and Baren 1954; Richards 1965).

Considering that the timber volume in the kerangas forest is comparatively very much smaller than that in the lowland dipterocarp forest, the kerangas forest is at present of no commercial value, except for the local supply of timber, poles and fuel. Should this forest be exploited, ecological considerations have to be taken into account in its exploitation, otherwise it will be a disaster. Kerangas forest is easily degraded by felling and burning and the rate of secondary succession is very slow (Whitmore 1975). The possibility of replanting such degraded sites to re-establish productive forest is slight (Mitchell 1963). It is reported, however, that it might be still possible to re-establish clear-felled and burnt kerangas with *Casuarina nobilis* (Whitmore 1975), *Agathis* spp., *Araucaria cunninghamii, Dryobalanops fusca* and *Shorea albida* (Brunig 1969).

In view of the above account and the facts that the need for land outside Java and Bali is not critical to the effect that it is necessary to utilize unproductive land, such as kerangas forest, it is deemed more rational to keep all kerangas forests in their natural state. Utilization can be directed towards such aspects as education, research and recreation. I have suggested (Kartawinata 1975b) that all kerangas forests should be converted into conservation areas.

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