DENDROLOGICAL COMPOSITION AND FOREST STRUCTURE IN NAM BAI CAT TIEN NATIONAL PARK, VIETNAM.

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INTRODUCTION

This article is based on a study, made in the framework of WWF Project WWF VN0007 "Remote Sensing of Natural Habitats in Protected Areas in Vietnam". The goal of this study was to make an evaluation of the composition, structure and state of degradation of the forest in Nam Bai Cat Tien National Park.

1. NAM BAI CAT TIEN NATIONAL PARK

Nam Bai Cat Tien National Park is located in the Dong Nai province, approximately 130 km north-east of Saigon. The park has a total surface of 37.900 ha. In the east and southeast, the Dong Nai-river forms the natural border of the reserve. The forest-exploitation enterprises of Vinh-An and La-Ngá border the park in the west and in the south-west.

In 1975 the forest on both sides of the river was allocated to a former army brigade. They founded the village of Ta Lai on the eastbank and cut the forest on that side of the river. The forest on the other side of the river, was used by the villagers to provide them with fuelwood and construction-wood.
In 1988 the forest was classified as 'special forest', and preparations were made to create a national park (outlining the borders, construction of guard-posts,..).
In the south-east of the reserve, a village was built and conducting measures were made for the Stiêng, an ethnic minority which executed shifting cultivation inside the park.

The east of the park is located in the Dong Nai-river plain; in the west a few hills occur. The altitude of the park varies mostly between 100 and 300 m above sea level. The highest summit is only 375 m high. During the monsoon, large areas of the park are flooded. This is mainly the area under 130 m altitude.
The soil mainly consists of deep fertile red basalt-soils with stony outcrops. In the east and the south this soil is covered with different layers of sediments from the Dong Nai river and its secundary streams This dark-brown alluvium covers all

areas thad are periodically flooded and is also very fertile.
The area is submitted to a typical tropical monsoon climate. The temperature varies between 24 and 29 °C, with an average of 26.2 °C. The precipitation is characterised by a wet and a dry season. The dry season runs from november to march. The total annual precipitation amounts to 2345 mm. The relative humidity varies between 70 and 88 percent.

87 % of the surface of the park is still covered with the original vegetation. Large areas of this original vegetation though are strongly degraded by shifting cultivation and logging. The remaining 13 % are covered with agriculture and infrastructure.

Faunistically Nam Bai Cat Tien is very rich : inside the park, a total of 59 mammal species occur, including douc (*Pygatrix nemaeus*), black gibbon (*Hylobates concolor*), tiger (*Panthera tigris corbetti*) and gaur (*Bos gaurus*). Just north of the park a small population of the extremely rare Javan rhino (*Rhinoceros sondiacus*) survives. About 250 bird species have been recorded including white-winged wood-duck (*Cairina scutulana*), Siamese fireback (*Lophura diardi*) and Germain's peacock-pheasant (*Polyplectron germaini*). A list of 40 reptiles and 16 fish species was also recorded. The park forms an important key for the survival of these species in the wild.

About 11,000 people live around the national park. Inside the reserve itself there are about 170 people, of which 140 are Stiêng. In this figure the staff of the park is not included. 42 % of the population is younger than 17; no-one is older than 55. This young fast-growing population can cause problems in the future of insufficient measures are taken to involve them in the conservation of nature.
The staff of the park consists of about 100 people, of which 80 guards. They occupy the 12 guardposts and execute inspections inside the park. The park is due to be opened for tourism. For this purpose the staff will be expanded.

The whole park is surrounded by a buffer-zone of 1 km. Activities in this zone are restricted. In the east this zone is covered with agriculture land, where the main crops are rice, mais, sugarcane and beans. In the west, the buffer-zone is covered by the forests of three forest-enterprises. In there forests, these enterprises execute two different management systems : selective logging and plantation of *Eucalyptus* sp., *Acacia auriculiformis* and *Tectona grandis*. The bamboo is also periodically harvested. Since 1988 no more trees may be cut inside the bufferzone, without the permission of the park-management.

2. FIELD SURVEY METHODS

2.1. Preliminary studies

Prior to the field work some research was done to find and appropriate sampling method for vegetation inventory in the reserve. Two aspects were considered important here: (1) the size of the sample plots, and (2) location and number of sample plots.

In addition, some practical restrictions had to be taken into account :

- Because of safety reasons and climatic circumstances (monsoon season) it was not allowed to spend the night in the forest.

- During our stay in the national park, there was an epidemic outbreak of a dangerous strain of *Plasmodium falciparum* (malaria). Therefore the fieldwork had to be completed in the shortest time possible.

- As it was monsoon season, large parts of the park were flooded and inaccessible.

Therefore it was impossible to systematically cover the area with sample plots, nor to work with sample plot sizes of 1 ha, that are commonly used in forest studies (Lamprecht, 1969; Finol, 1971; Förster, 1973; Rollet, 1979; Reitsma, 1988; Lamprecht, 1989; Heany and Proctor, 1990). The data would also be used for profile diagrams, for which much smaller sizes are recommended (25x200 ft = 7.6x61 m = 463.6 m^2).

Taking the above mentioned considerations into account, a stratified sampling method was selected with plot sizes of 20 x 50 m, which is more than sufficient for the profile diagrams and practically feasable in the field.
Hereby the area to be surveyed is divided in a number of vegetation classes and for each class a number of sample plots is made. This method requires preliminary information on the vegetation of the study area. For this study we could use the following sources of information :

1. Satellite image LANDSAT 5 TM frame 124/52, dated 30/12/1990.

2. Topographical maps on scale 1/50.000. These maps contain data on topography, river network, villages and some information on forested/non-forested areas.

3. Two 'Forest Resource maps', scale 1/25000, made by F.I.P.I. (Forest Inventory and Planning Institute), and based on arial photography. They both have the same classification. Some classes of non-forest vegetation are determined

such as settlement areas, plantations, grassland, shrubland and lakes. The forest vegetation is divided in regenerating forest, rich, medium and poor forest, and bamboo-stands.

These detailed forest resource maps were overlaid on the satellite images. Zones in which classifications in both maps matched and fitted into the Landsat image were selected for positioning of the sample plots.

2.2. Division in vegetation classes

For the choice of the vegetation classes that were to be selected for this study, the existing vegetation maps and the classifications of the vegetation of Vietnam and Cambodia made by Trung (1966), Rollet (1972) and Schmid (1974) were taken into account.
According to Trung (1966), the natural forest vegetation in the area belongs to the closed deciduous tropical forest (forêt fermée décidue subhumide tropicale). This vegetation is characterized by a strong domination in the upper story by *Lagerstroemia angustifolia,* mixed with *Dipterocarpaceae, Datiscaceae* en *Leguminosae.*
This vegetation type was described by Rollet (1972) as 'forêt dense décidue' and by Schmid (1974) as 'forêt caducifolié sur terres brunes'. In this study it will be called 'Lagerstroemia forest'. Next to this dominating forest type, 2 other natural forest types could be distinguished :

- gallery forest
- Dipterocarp-dominated stands

Dipterocarpaceae have the property of occuring gregariously in the forest. In this case, they replace the *Lagerstroemia*-dominated forest, mostly on the lower and wetter sites (Rollet, 1972; Schmid, 1974).

The forest vegetation in the study area is strongly degraded by overexploitation by the villagers in the east and the forest exploitation company in the west, as well as by the shifting cultivation practiced by the Stiêng-people.

Three types of degraded forest could be distinguished :

- pure bamboo stands
- bamboo mixed with trees
- young regenerating forest stands without bamboo

The non-forest vegetation includes all low vegetation, swamp areas and lakes, agriculture, plantations and infrastructure.

To obtain a general idea of the location of the different vegetation classes, a vegetation map was made, using the available satellite image (see under 3).

2.3. Practical execution of the field work

Due to the practical problems mentioned above, it was not possible to make large number of samples. The purpose of the study however was not to produce a detailed vegetation map, but, within a restricted time frame, to obtain a general assessment of the different vegetation types, especially forest types and their state of degradation. In total, 12 sample plots, 9 observation plots and one line transect were made.

Observation plots

When the positioning of a sampling plot was impossible (inside the swamp or across the river) or not necessary (description of agriculture land), only an observation was made. Hereby, data on physiography (location, hight, slope,...), soil and vegetation were recorded on a tally sheet. For the vegetation, all dominant species were recorded together with data on understorey, herbaceous layer and natural regeneration. This way, a general view on the vegetation and its potential development were obtained.

Sample plots

In addition to the general information, recorded on the tally sheet as outlined above, more data were collected in the 20 x 50 plots. For all trees over 8 cm DBH, the following data were recorded: species, diameter, heigt and branch-free bole length, location of the tree inside the plot and size of the crown. For tree species with strongly tapering bole (such as *Lagerstroemia angustifolia*) as a rule of the thumb, the obtained diameter was reduced by 25 %.

The data on position and crown size were immediately drawn on a horizontal projection of the plot on scale 1/200.The horizontal projection of the crown was also drawn on this paper.

For bamboo, every cluster was located on the horizontal projection. For every plant, the number of stems as well as the average diameter and top height of the poles was recorded.

For all sample plots forest profiles were made according to the rules for profiles in the tropics made by Lamprecht (1958) : minimum width of 10 m (here it is 20 m), vertical as well as horizontal projections and only trees with minimum DBH of 10 cm are included in the plot. The most important forest profiles are presented in

Appendix 2.

Line transect

A line-transect was marked off to describe a gallery forest. Hereby, the method suggested by Mackinnon (1981) was followed : over a distance of 500 m, the height, diameter and species of every tree with diameter > 8 cm within 5 m on both sides of a trajectory was recorded. The transect was divided in blocks of 10 x 20 m. Thus it was possible to make a species-area-curve of the transect.

3. VEGETATION MAPPING FROM SATELLITE DATA

The location in the field of the non-forest vegetation classes was possible using the existing maps. However, a proper forest vegetation classification was not possible using the available map data. The 'resource maps' made by F.I.P.I. divide the forest into very broad production classes. For example, no difference was made between *Lagerstroemia*-forest and *Dipterocarpus*-dominated stands. Therefore remote sensing was applied as a tool to obtain a reasonably up-to-date forest vegetation class map.

3.1. Method

A classification of the Landsat TM satellite image was conducted using the Dragon Image Processing System. The technique of supervised classification using the maximum likelihood algorithm was adopted. Two combinations of spectral bands were used : TM band 2, 3, 4 and 5 and TM 2, 5, 6 and NDVI. For a detailed description of the applied method, the reader is referred to De Cauwer (1993).

The classes 'gallery forest' and 'plantation' were not taken into account in the supervised classification as their spectral signature differed only slightly from the *Dipterocarpus*-forest. Furthermore their surface is very limited and the location in the field is known.

3.2. Discussion of the results

The classification accuracy (Kappa values) of the final map was assessed for both methods :

TM 2, TM 3, TM 4 en TM 5 : 0.68
TM 2, NDVI, TM 5 en TM 6 : 0.74

De Cauwer (1993) was able to increase this accuracy through a number of correction procedures to a Kappa-value of 0.82. To obtain this result however the class '*Dipterocarpus*-forest' was not considered. As this forest type is essential to the vegetation description, in the present work, the somewhat less accurate classifications were retained.

Surface percentages for the different classes of both classifications for the complete image (not only the national park) as well as the results of De Cauwer (1994) (considering only the surface of the park) are listed in Table 1.

Table 1 : Image class statistics (% of complete image) for image 1 (column 1), 2 (column 2), and the results obtained by De Cauwer (1994) (column 3).

Class	1	2	3
agriculture	**3.93**	**5.61**	**0.7**
swamp	**4.82**	**4.02**	**4.5**
water	**1.01**	**1.01**	**0.8**
low vegetation	**4.46**	**2.47**	**2.95**
paddy fields	**9.99**	**12.57**	**0.7**
pure bamboo	**18.32**	**21.71**	**30.4**
mixed bamboo	**33.11**	**21.35**	**18.9**
secundary forest	**10.50**	**12.80**	**23.3**
primary forest	**7.9**	**11.70**	**17.7**
Dipterocarp forest	**5.89**	**6.7**	-
Total forest	**75.72**	**74.26**	**90.3**

From these numbers following conclusions can be drawn :

1. Within the park, the forest-index is over 90 %. Outside, the forest index is explicitly lower

2. Pure bamboo stands and mixed bamboo with trees cover about 2/3 of the forest in the park.

3. About 80% of the forest inside the park is in a degraded state, since only the primary forest, occupying 15 to 20 % of the forested area can be considered as mainly unaffected. The *Dipterocarpus*-forest is also strongly degraded because of the great economic value of its timber. *Dipterocarpus*-dominated stands occupy

about 10 % of the forest inside the park.

Considering the spatial distribution of the different classes following conclusions can be made :

1. The eastern part of the forest complex is a patchwork of primary and secundary forest.

2. Here and there this patchwork is replaced by *Dipterocarpus*-dominated stands, especially in the lower areas and around the swamps. This corresponds with the results of Rollet (1972) and Schmid (1974) who also situated this forest type lose to swamps and in lower areas featuring wetter soils.

3. In the east it is remarkable that 'bamboo mixed with trees' occurs only sporadically. Bamboo is restricted to pure stands in the hilly areas along the big swamp, in the extreme north-east and the south-east of the reserve.

4. The west of the park however, where red basalts occur instead of alluvial soils, is completely dominated by degraded forest mixed with bamboo. Primary forest and Dipterocarp-forest are sporadic and degraded forests without bamboo are also rare.

In summary, it can be stated that the west of the park is dominated completely by bamboo, while as the east is marked by a mosaic of more and less degraded forest where the position of bamboo is only marginal.

4. DESCRIPTION OF THE VEGETATION CLASSES

A list of all plant species that were determined during the field work is provided in Appendix 1. For scientific names the following sources were used : Ho (1970), Chinh *et al.* (1981), Whitmore and Ng (1972), Mabberly (1990) and Jansen *et al.* (1991). Still it was not possible to find all species in literature, as botanical information on Indochina is rare. Systematics according to Cronquist (in Mabberly 1990) are used in this list.

4.1. Non-forest vegetation

Agriculture

Agriculture occupies only 1 % of the surface of the park and is located around the

headquarters, south of the eastern forest complex and at the Stiêng-village. The crops consist mainly of rice, vegetables and fruit, all for personal consumption.

Plantation of *Acacia auriculiformis*

The surface of plantations inside the park is only 61 ha and is situated in the extreme south-east of the park. The tree-species planted here are *Acacia auriculiformis*, and sporadically *Eucalyptus camaldulensis*. All trees were planted in 1986 (approximately 2200 trees per ha).
The top height of the trees was 13 m and diameters varied between 7 and 28 cm with an average of 13 cm. The basal area reached 32.2 m^2.

The shrub and herb layer consisted of the following species : *Claoxylon polos, Caetaria* sp., *Hediotis* sp., *Eupatorium odoratum, Grewia annamensis, Selaginella* sp., *Colona evecta, Curcuma xanthorrhiza* and *Acacia vielana*.

***Imperata cylindrica* and other low vegetation**

The agricultural zone south of the eastern forest complex is bordered to the north by an extensive area of *Imperata cylindrica* and *Cyperus*-species. To the north this plain is bordered by a shrub vegetation, dominated by *Grewia bulot*, which forms a transition towards the *Dipterocarpaceae*-forest. This vegetation of *Imperata cylindrica* has no botanical value but forms a favourite hunting ground for tiger.

Swamp area

A vast swamp area dominates the central north of the park. Some smaller swamps also occur in the eastern forest complex. During the dry season the big swamp consists of some permanent lakes, intermitted with vast swamp vegetation complexes. During the rainy season, this area changes into one big lake. Vegetation on the lake shore consists mainly of bamboo species, supplemented with the following tree species : *Lagerstroemia hexaptera, Strychnos thorelii, Barringtonia longipes, Careya sphaerica, Dipterocarpus alatus, Crateva religiosa, Xanthophyllum colubrinum, Harpullia* sp., *Antidesma bunius*.

Many of the trees standing in the water showed low vitality and were covered with epiphytical ferns, especially *Drinaria quercifolia*. Herb vegetation consists mainly of *Cyperaceae*. Non-woody species that could be determined were include *Carex helecarpa, Carex indica, Cyperus digitatus and Thysanolaena maxima*. Vast areas of the swamp were covered with *Eichhornia crassipes*.

The smaller swamps within the forest complexes were characterised by a vegetation of *Carex helecarpa, Oxytenanthera stockessii, Ischaemum rugosum* and *Alocasia macrorrhizos*. Other herbs and lower vegetation consisted of *Caryota urens, Korthalsia*

laciniosa, Calamus dioicus, Eragrostis tenella and *Similax* sp. Woody vegetation surrounding these small swamps consists mainly of *Barringtonia acutangula, Anogeissus acuminata, Eugenia nigrans* and *Pandanus* sp. In and around these small swamps stands of *Livistona saribus* do occur, with an understory of *Bambusa spinosa, Calamus tetradactylus, Carex indica, Areca triandra* and *Licuala spinosa.*
An observed stand of *Livistona saribus,* had a stem-number of 140 trees per hectare. The average diameter was 40 cm and the length of the branch-free bole varied between 0.8 and 3.2 m.

4.2. Forest vegetation

In the forest vegetation several forest types were distinguished :

- typical forest with *Lagerstroemia* : plot 1, 4, 6 and observation 7.
- young and regenerating forest : plot 2, 5 and 12
- pure bamboo-stands : plot 9 and 10
- bamboo mixed with trees : plot 3 and 8 and observation 9
- *Dipterocarpus*-stands : plot 7 and 11 and observation 1
- gallery forest : line-transect and observation 3

Using the collected data it was possible to obtain a view on the dendrological and structural properties of the forest vegetation of Nam Bai Cat Tien.

4.2.1. Data on the complete forest vegetation

4.2.1.1. Dendrological composition

For the 12 sample plots together, covering a total area of 1.2 ha, 576 trees, with a diameter of over 8 cm, belonging to 106 species were recorded. This means 88 species per ha. If one considers a minimum diameter of 10 cm, which is a more common value in literature, one arrives at 93 species, which means 78 species per ha.These numbers can be compared with those mentioned in literature (it was not possible to find data on comparable forests in South-East Asia) :

Tropical rainforest in Sarawak (Proctor *et al.* 1983) : 225
Tropical rainforest in Malaya (Whitmore 1983) : 170
Deciduous rainforest (Lamprecht 1972) : 60
Deciduous rainforest in Venezuela (Förster 1973) : 85

From the comparison above the following one can conclude that the species richness in Nam Bai Cat Tien can be considered as normal for this forest type. The result is much lower than for the evergreen rainforests of Southeast Asia but is comparable to deciduous tropical forests in South America.

In the line transect of the gallery forest, covering an area of 0.5 ha, 13 species were registered, of which 7 did not occur in the sample plots. The complete list of tree species, found in the plots and the transect is presented in Appendix 1a. This species list features 38 families. The most important ones are listed in Table 2.

Table 2 : Abundant families in Nam Cat Tien

Family	No. of species	No. of trees
Lythraceae	4	81
Dipterocarpaceae	8	77
Datiscaceae	1	65
Ebenaceae	3	41
Sapindaceae	7	37
Moraceae	6	24
Myrtaceae	5	24
Combretaceae	3	28

A directive list of the most important tree species of Nam Bai Cat Tien, based on numbers of individuals and basal surface, is given below :

Lagerstroemia angustifolia
Sindora siamensis
Dipterocarpus costatus
Harpullia sp.
Shorea obtusa
Melanorrhoea laccifera
Diospyros crumenata
Castanopsis hyptrix
Macaranga tanarius
Afzelia xylocarpa
Lagerstroemia hexaptera
Anogeissus acuminata
Dipterocarpus turbinatus
Xerospermum laoticum
Tetrameles nudiflora
Ficus hispida
Erismanthus sinensis
Vitex pinnata
Lagerstroemia calyculata
Terminalia calamansanai
Dipterocarpus alatus
Nephelium melliferum
Shorea thorelii
Syzigium polyalthum
Diospyros rubra
Pouteria barauense
Xylia xylocarpa

A commonly used, be it a more directive measure for diversity is the mix-quotient of Jentsch (Lamprecht, 1969; Förster, 1973; Lamprecht, 1989). This coefficient is the ratio of the number of species and the number of individuals. Our data yield a value of 1 : 5.434 (including the gallery forest this becomes 1 : 5.646).
According to Lamprecht (1969) this factor varies for tropical forest types between 1:5 and 1:10. We can conclude that the forest in Nam Bai Cat Tien has a high species diversity. This might be due to the mosaic of forest types caused by human disturbances.

An interesting method to relate species richness to the sampled surface is the Species-Area Curve (Paijmans, 1971; Mackinnon, 1981; Heaney and Proctor, 1990)

(figure 1a). Using this curve one can easily verify whether the sampled area was large enough to estimate the species richness of the area. The sampled area is large enough when a rise of the surface with 10 % no longer results an increase of the species richness of 10 % (Cain 1938 cited in Cain and Castro de Oliveira 1959). In the present case this decision is difficult to make. The curve in Figure 1a is drawn in a chronological sequence. There is an obvious levelling off at the bamboo-dominated forest type and the *Dipterocarpus*-stands and a sudden rise at the last plot. Another sequence of plots would probably have given a totally different image. This is caused by the strong diversity in forest types.

A graph which, in our case, may give better results is the cumulative species curve, (figure 1b) as also used by Verbist (1990). Here, the number of species is related to the number of registered trees. The influence of the sequence of the plots is not so important as the share of a plot is related to its stem number.

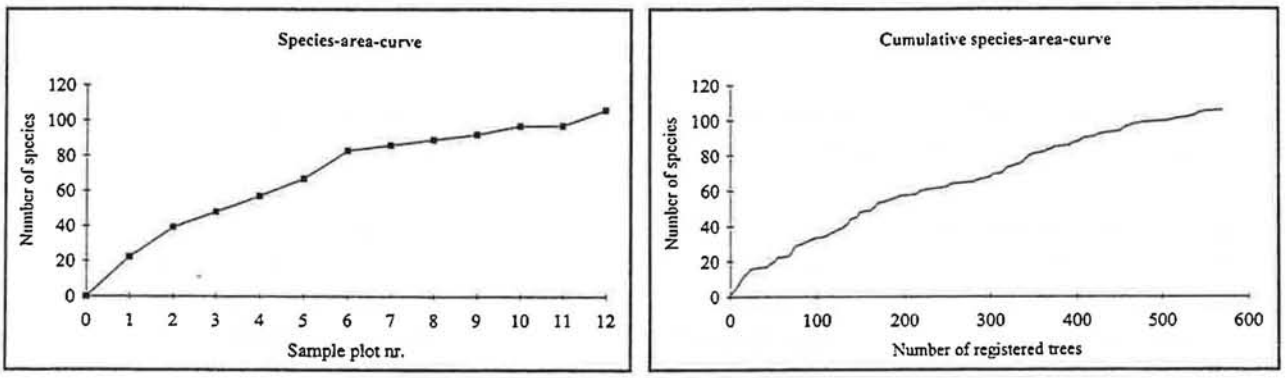

Figure 1 : Two different ways to characterise forest diversity
1a : Species-area curve for the 12 sample plots (chronological sequence); 1b : Cumulative species curve for the 12 sample plots (chronological sequence).

A last method of illustrating the diversity of a forest is by using the absolute frequencies. The absolute frequency of a species is the ratio of the number of plots where this species occurs to the total number of plots. Then the species can be classified in 5 frequency-classes (Class I = absolute frequency 1 - 20 %, Class II = 21 - 40 %, etc.). Using these classes, one can construct a frequency diagram (Figure 2), that illustrates the homogenity of the vegetation (Lamprecht, 1989; Bogaert et al., 1992). From this figure one can conclude once again that the species composition is very heterogenous. More than 3/4 of the species occurs only in 1 or 2 of the 12 plots. Only one species occurs in 8 of the 12 plots : *Lagerstroemia angustifolia*. This strong heterogenity is partly due to the diversity of forest types but may also be caused by the limited size of the plots.

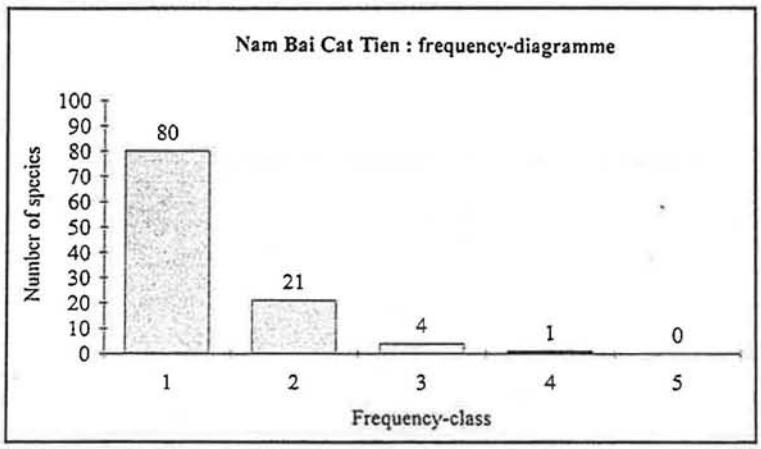

Figure 2 : Frequency diagram for the 12 sample plots.

4.2.1.2. Structural description

A discussion on the structure of the forest, using average values for all sample plots is not very significant due to the strong heterogenity of the forest. Average values would conceal the proper characteristics of the different forest types. Furthermore the sampled area per forest type is not related to its relative surface. Therefore Table 3 is confined to the most important dendrometrical parameters for the different forest types. A more detailed discussion is provided below in the analysis of the different forest types.

In order to obtain an overview of the general structure and stability of the forest, a diameter distribution graph for the 12 sample plots was produced (Figure 3).

Omitting the first column containing the trees between 8 and 10 cm diameter, one can conclude that the forest shows a balanced all-aged distribution. The distribution of stem numbers for the different classes seems quite normal and in line with other tropical deciduous forests. These differ from evergreen forests by having a lower global stem number, underrepresentation of smaller diameters and a higher stem-number in the heavy diameter-classes. (Lamprecht 1989).

For a more objective examination of the results though, a comparison with literature is useful. Borota (1991) produced theoretical diameter distributions for the different forest types in Laos. One of the considered forest types was comparable to the forest in Nam Bai Cat Tien. His results are compared with the results for Nam Bai Cat Tien in Table 4.

Table 3 : Dendrometrical data for the 12 sample plots (N = stems/ ha; D = average diameter; H = average height; G = basal surface; S = number of species).

Forest type	plot no.	N	D(cm)	H(m)	G (m^2/ha)	S d>8	S d>10
Lagerstroemia-forest	1	660	29,4	19,4	113,1	22	19
Young forest	2	690	20,9	15,1	47,4	23	21
Bamboo mixed	3	170	22,5	14,5	10,9	10	9
Lagerstroemia-forest	4	490	33,4	20,3	80,4	19	17
Young forest	5	930	20,9	18,4	41,2	18	14
Lagerstroemia-forest	6	670	29,9	16,7	94,4	23	20
Dipterocarpus-forest	7	230	37,3	27,3	33,6	8	7
Bamboo mixed	8	130	46,5	15,3	16,7	8	8
Pure bamboo	9	110	17,1	9,76	4,15	8	7
Pure bamboo	10	250	15,1	10,82	5,8	10	9
Dipterocarpus-forest	11	220	40,5	25,3	29,8	4	4
Young forest	12	560	22,9	16,2	44,9	29	23
Average values	--	**428,3**	**28,75**	**17,17**	**45,9875**	**106**	**93**

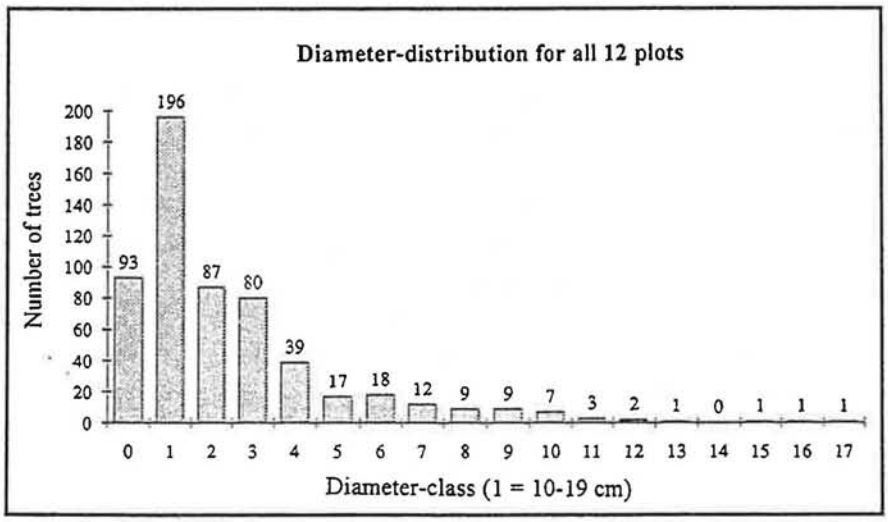

Figure 3 : Diameter distribution for the 12 sample plots.

Table 4 : Theoretical diameter distribution for Laotian deciduous forests (Borota 1991) compared with data recorded in Nam Bai Cat Tien.

	BOROTA (1991)	Nam Bai Cat Tien
Class 2	142	87
Class 3	60	80
Class 4	32	39
Class 5	20	17
Class 6	15	18
Class 7	8	12
Class 8	5	9
Class 9	3	9
Class 10 and more	3	16

Even for a 'normal' deciduous forest Nam Bai Cat Tien shows an obvious underestimation of the smaller diameters. Medium diameters are quite normal, but the very large diameters are still overrepresented. These results are contradictory to the fact that a vast part of the forest is in a regenerating stage, where smaller diameters should be abundant. This might indicate that the natural regeneration is more difficult than can be expected.

4.2.1.3. Conclusion

The forest in Nam Bai Cat Tien, occupying more than 90 % of the park surface is a rich and diverse forest. It consists of three forest types, forming a more or less disturbed patchwork. The diversity and forest composition is quite normal with a strong dominance of *Lagerstroemia angustifolia*. The global forest structure shows an underrepresentation of the smaller diameters, which is not normal considering the fact that 80 % of the forest is in a regenerating state.

4.2.2. *Lagerstroemia* - forest

According to Trung (1966) this forest type is characteristic for the climatic area to which Nam Bai Cat Tien belongs. It is described as 'forêt fermée décidue subhumide tropicale'.
According to Trung, the vegetation is dominated here by *Lagerstroemia angustifolia*, mixed with Dipterocarps (*Dipterocarpus dyeri* and *Dipterocarpus turbinatus*), *Datiscaceae* (*Tetrameles nudiflora*) and *Leguminosae* (*Afzelia xylocarpa, Sindora* sp., *Dalbergia* sp., *Pterocarpus* sp. and *Peltophorum* sp.).

Schmid (1974) describes the forest along the Dong Nai river as 'Forêt caducifoliée sur terres brunes'. The upper-canopy is 35 to 45 m high and consists almost

exclusively of deciduous species. Evergreen species (especially Dipterocarps : *Dipterocarpus intricatus, D. turbinatus* and *Hopea odorata*) can occur on spots with a higher groundwater level. The *Lythraceae* with *Lagerstroemia angustifolia* and some less common species are dominating the forest. *Leguminosae* (like *Pterocarpus* sp. en *Afzelia xylocarpa*) are well represented, especially on young soils. *Combretaceae* (with *Anogeissus acuminata* and *Terminalia* sp.) are also common.
The understory consists of evergreens (such as *Macaranga* sp., *Cleistanthus* sp.) and deciduous species (*Polyalthia* sp., *Gelonium* sp., *Vitex* spp.).

Rollet (1972) describes a similar type of forest in Cambodia and calls it 'forêt dense décidue'. The vegetation is dominated by a few gregarious species, mainly *Lagerstroemia* spp. and *Xylia xylocarpa*. Other species commonly recorded are *Sindora* spp., *Haldina cordifolia, Vitex spp., Anogeissus pierrei, Grewia paniculata, Terminalia nigrovenulosa, Eugenia* spp. and *Pterospermum* spp. According to Rollet (1972) there are many transition forms between this forest type and the other two forest types of the area, namely the closed evergreen forest and the open forest. This author states that the spatial distribution of these three main types is not static but dynamic : the transition of one forest type to another is possible, both spontaneously and antropogenically. In addition, Rollet suggests that forests dominated by many large *Lagerstroemia*-trees are not stable, but will evolve quickly towards stands without *Lagerstroemia*.

The *Lagerstroemia* forest was studied in sample plots 1, 4 and 6. Plot 1 is located in the east, plot 4 in the north and plot 6 in the west of the park.

4.2.2.1. Dendrological composition

As can be deduced from the profiles in appendix 2, three canopy storeys can be distinguished : a close upperstorey, a fragmented, open middle storey and a species-rich understorey.

The upperstory in the three sample plots is dominated by *Lagerstroemia angustifolia*. The top height varies between 32 and 38 m. Other species recorded in the upperstory are *Dipterocarpus turbinatus, Xerospermum laoticum, Stereospermum cylindricum, Eugenia cochinchinensis, Anthocephalus chinensis, Terminalia calamansanai* and *Pterospermum megalocarpum*.

The middle storey consists of trees of 20 to 27 m heigh. It is very diverse in species composition :

Plot 1 : *Diospyros rubra, Diospyros hasseltii, Eugenia cochinchinensis, Shorea thorelii, Heritiera javanica, Pterospermum diversifolium, Grewia* sp. and *Vitex pedunculari*

Plot 4 : *Lagerstroemia angustifolia, Garcinia fragaroides* and *Melanorrhoea laccifera*

Plot 6 : *Nephelium melliferum, Schoutenia hypoleuca, Anthocephalus chinensis, Toona sinensis, Lagerstroemia angustifolia, Lagerstroemia speciosa, Walsura robusta, Wrightia sikkimensis, Dipterocarpus alatus, Dipterocarpus dyeri* and *Palaquium annamensis*

The understorey consists of all trees under 20 m. Here also the species diversity is very high. In the understorey of plot 1, 4 an 6, respectively 11, 16 and 16 species were recorded. The most common ones are :

plot 1 : *Diospyros rubra, Erismanthus sinensis, Pouteria barauensis, Syzigium polyanthum*

plot 4 : *Vitex pinnata, Erismanthus sinensis, Diospyros crumenata*

plot 6 : *Pouteria barauensis, Diospyros rubra, Diospyros hasseltii, Schoutenia hypoleuca*

Dominance en abundancy

The importance of the different species can be illustrated by the relative abundancy and relative dominance. The relative abundancy is the ratio of the number of individuals of one species to the total stem number. The relative dominance is the vegetation cover of one species in relation to the total forest cover. This vegetation cover is the sum of all crown projections. As there is a linear correlation between crown projection and basal area, this last parameter is used as it is much easier to measure. The results of both calculations are given for plot 6 in Figure 4.
Species of the upperstorey are always dominant, even if only one individual occurs, as dominance is related to the square of the diameter. That is why abundancy can yield a completely different image than dominance : small trees have the same weight here as big trees. For plot 6 it is obvious that Lagerstroemia angustifolia is strongly dominant. The relative abundancy of the species is not so important. Many species are present but not one is explicitly more abundant than the others. Graphs for plot 1 and plot 4 yeald the same results.

Diversity

To assess the diversity of the 3 sample plots separately and of the forest type itself, the absolute species richness, the mix-quo^_tient of Jentsch (Table 5) and the cumulative species curves will be determined.

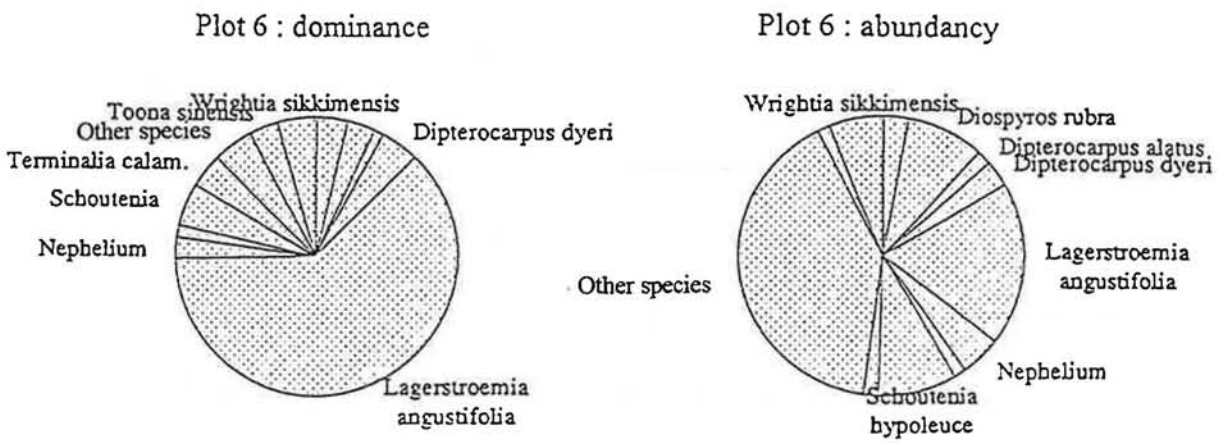

Figure 4 : Relative dominance and abundancy for sample plot 6 (*Lagerstroemia*-forest);

Table 5 : Species diversity in the *Lagerstroemia*-forest.

	number of species	MQ of Jentsch
plot 1	22	1 : 3
plot 4	19	1 : 2.6
plot 6	23	1 : 2.9
average for the 3 plots	**21**	**1 : 2.8**

The number of species is distinctively higher than the average value for the 12 plots (= 15 tree species per plot of 0.1 ha). The mix-quotient of Jentsch gives an extremely low value : 1:2.8 (compared to the average value of 1:5.4 which was already quite low). The *Lagerstroemia*-forest can thus be considered as a very heterogenous and diverse forest.

If only the upperstorey is considered, one may find very divergent results. The species diversity in the upperstorey is randomly distributed : on some spots many species are intermixed while on other spots the upperstorey consists only of *Lagerstroemia angustifolia*. The sample plots are too small to obtain a good overview on the degree of mixture by using the mix-quotient.

The cumulative species curves for the 3 plots are presented in Figure 5. The curves show no levelling off. This means that the real species richness for this forest type is distinctively higher than the one found in the sample plots.

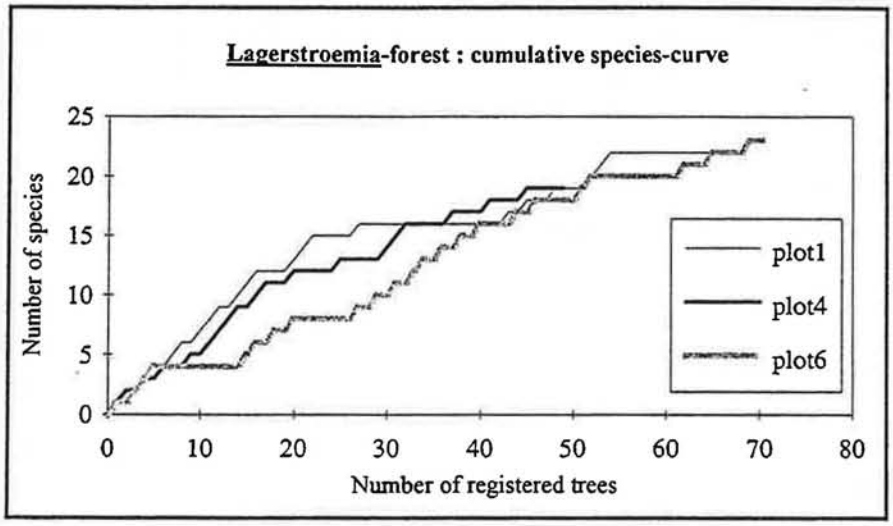

Figure 5 : Cumulative species curves for the 3 plots of *Lagerstroemia*-forest

Shrub and herb vegetation

The most important shrubs and herbs found in the *Lagerstroemia*-forest are listed below :

Psychotria serpens
Tadehagi triquetrum
Costus speciosus
Pinanga quadrijuga
Actephila excelsa
Cyperus sp.
Ixora sp.
Excoecaria agallocha
Ophiopogon sp.
Psychotria sp.
Eugenia sp.
Ziziphus oenoplia
Caryota urens
Globba sp.
Carex indica
Ardisia sp.
Mimosa sp.
Tabernaemonthana sp.
Talangium sp.
Similax sp.
Vernonia sp.
Curculigo sp.
Glycosmis cochinchinensis
Calamus viminalis
Licuala spinosa
Commelina diffusa
Ancistrocladus sp.
Entada sp.
Adenanthera sp.
Amomum sp.
Mallotus apelta
Boehmeria sp.
Derris sp.

Floristically we can describe the *Lagerstroemia*-forest as follows : an upperstorey dominated by *Lagerstroemia angustifolia;* the middle and understorey however have a high species richness and diversity.

4.2.2.2. Structural description of the *Lagerstroemia*-forest

The strong dominance of *Lagerstroemia* is also reflected by the diameter distribution. Figure 6 describes the diameter distribution of the 3 plots taken together. The lower part of every bar illustrates the share of *Lagerstoemia angustifolia.*

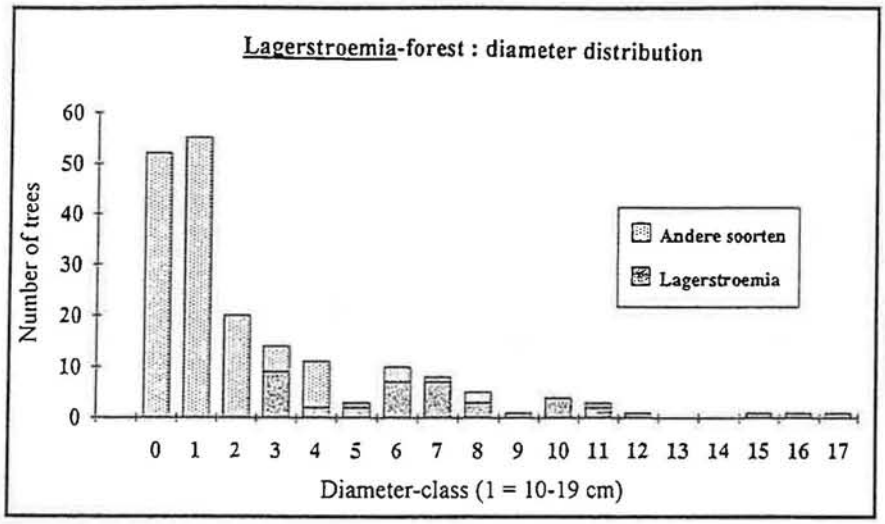

Figure 6 : Diameter distribution of the 3 plots in the *Lagerstroemia*-forest.

Although the curve shows a gap at diameter class 5 it appears to be well-balanced : a large number of trees occurs in the small diameter-classes. However when only *Lagerstroemia* is considered, it is striking that no trees occur in classes 0, 1 and 2. On the other hand the large and very large diameter classes are almost completely occupied by this species. The natural regeneration in the *Lagerstroemia*-forest consists mainly of *Dipterocarpus, Diospyros, Pterospermum, Garcinia, Melanorrhoea* and *Hopea,* but no *Lagerstroemia.*

Thus one can conclude that the *Lagerstroemia*-dominated forest stands are not stable formations, but a transition towards deciduous forest without *Lagerstroemia* : the over-aged trees will slowly disappear and be replaced by other species of the deciduous forest that do regenerate, as stated by Rollet (1972).

Three other parameters that draw the attention are the average stem number/ha (N), the basal area (G) and the average diameter (D).

Table 6 : Dendrometrical characteristics of the *Lagerstroemia* forest.

	N	G (m^2/ha)	D
plot 1 :	660	113,1	29,4
plot 4 :	490	80,4	33,4
plot 6 :	670	94,4	29,9
average value for the 3 plots :	606	96,0	30.9

A comparison of the data of Table 6 with literature :

	N/ha	G (m^2/ha)	D
Evergreen rainforest, Indonesia (Whitten 1982)	-	16-42	-
Evergreen rainforest, Sarawak (Bruenig 1983)	420-920	27-73	-
Evergreen rainforest, Sarawak (Proctor 1983)	615-780	28-57	20.5-24.5
Deciduous tropical forest, Venezuela (Lamprecht 1989)	280-333	28-29	-
Deciduous tropical forest, Taiwan (Hsieh 1989)	-	28-92	-

The stem number of our forest is quite normal and the average diameter is somewhat higher than normal, due to the abundance of very large diameters. What is striking however is the extreme high value of the basal area. In no other natural forest type similar values were found. Only Hsieh (1989) in Taiwan found a comparable value in a forest that was very similar to the one in Nam Bai Cat Tien. This is caused by the odd concentration of very high diameters.

4.2.2.3.Conclusion

One can conclude that the *Lagerstroemia*-forest is a very diverse and highly stocked forest with an overwhelming dominance of *Lagerstroemia angustifolia*. The natural regeneration is quite fluent but is not representable for the present forest composition. This composition is not stable but will change drastically in the future. This is a normal evolution in this forest type with strong dominance of one hardly reproducing longlived pioneer-species (Rollet 1972).

4.2.3. Young regenerating forest formations without bamboo

Young forest stands were studied in plots number 2, 5 and 12. Sample plots 2 and 12 are located in the east of the eastern forest complex and plot 5 is located in the center of this complex. These young forests are all to be considered as natural regenaration after shifting cultivation.

4.2.3.1. Dendrological composition of the young forest

From studying the profiles (Appendix 2) one can derive the following conclusions:

1. Contrary to the *Lagerstroemia*-forest, the young forest is very heterogenous : the sample plots are strongly different in structure as well as in species composition.

2. Plot 2 is characterised by a diverse mixed young forest-vegetation, with a few old trees that were saved from cutting during shifting cultivation. The massive regeneration of *Shorea obtusa* is very obvious.

3. In plot 5 there are no old trees. The forest is completely dominated by a gregareous regeneration of *Tetrameles nudiflora* that constitutes the upperstorey . An understorey is relatively rare, except in the gaps of the *Tetrameles* canopy, where a diverse regeneration occurs.

4. Plot 12 is to be considered as on older stage of plot 2 : the distinction between left-over trees and the strongly developed regeneration is already hard to make. *Lagerstroemia angustifolia* is also quite common. This stand is to be considered as a transition stage towards the *Lagerstroemia*-forest.

The upperstorey of the young regenerating forests has a height of 25 m, 30 m and 30 to 35 m respectively and consists entirely of light demanding species :

plot 2	plot 5	plot 12
Nephelium melliferum	*Tetrameles nudiflora*	*Nephelium melliferum*
Haldina cordifolia	*Scaphium lychnophorum*	*Michelia sp.*
Cinnamomum iners	*Ficus sp.*	*Lagerstroemia angustifolia*
Lagerstroemia angustifolia		*Schoutenia hypoleuca*
Terminalia calamansanai		*Cinnamomum iners*
Elaeocarpus dongnaiensis		*Pterospermum diversifolium*

The left-over trees consist of the following species : *Sindora siamensis, Afzelia xylocarpa, Dipterocarpus turbinatus, Dipterocarpus intricatus, Lagerstroemia angustifolia.*

The species composition of the understorey is very diverse. Under the canopy of the pioneerspecies, shadow-tolerant and typical understorey species develop : *Diospyros crumenata, Diospyros rubra, Vitex pinnata, Randia acuminata* and *Xylia xylocarpa*. In the canopy gaps typical light-demanding species grow : *Nephelium melliferum, Ficus sp., Shorea obtusa, Zollingeria dongnaiensis, Sterculia cochinchinensis, Macaranga denticulata, Eugenia nigrans* and *Scaphium lychnophorum.*

In plot 2 and 5 *Lagerstroemia* angustifolia occurs only sporadically in the regeneration. In plot 12 however, the species is well represented.

Dominance and abundancy

Dominant and abundant species of the young forest are also very diverse : The most abundant species are normally the left-over trees of the former forest vegetation : *Afzelia xylocarpa, Sindora siamensis* and *Lagerstroemia angustifolia* .
In young forests, a few gregariously regenerating species are very abundant (*Shorea obtusa, Diospyros crumenata, Tetrameles nudiflora*). In further evolved young forests like in plot 12 regeneration is more complex and no more species are explicitely dominant.

Diversity

To judge the diversity of the young forest, the same parameters and techniques will be used as for the *Lagerstroemia*-forest :

	number of species	MQ of Jentsch
plot 2	23	1 : 3
plot 5	18	1 : 5.2
plot 12	29	1 : 2
average for the 3 plots	23.3	1 : 3.4

The species diversity per plot is higher than in the *Lagerstroemia*-forest . This is logical as the structure of the young forest is even more heterogenous than the mature forest. The mix-quotient of Jentsch has again an extremely low value.
The values for the dominance-concentration of Simpson are resp. 0.18; 0.64 and 0.29. These values confirm what was already apparent from the profiles : plot 2 and 12 have a very heterogenous upperstory, whereas plot 5 is strongly dominated by *Tetrameles nudiflora.*

The cumulative species curves for the 3 plots are shown in Figure 7.

While for the Lagerstroemia-forest the curves were very similar, here they are very different. This is quite logical as the plots comprise a very diverse forest type. The *Tetrameles*-forest is definitely less diverse in species than the other 2 plots. One can observe that the *Tetrameles* curve shows a clear levelling off. So the real species diversity is quite similar to the diversity found from the plot. This is not the case for the other 2 curves : here the real species diversity is much higher than the calculated value.

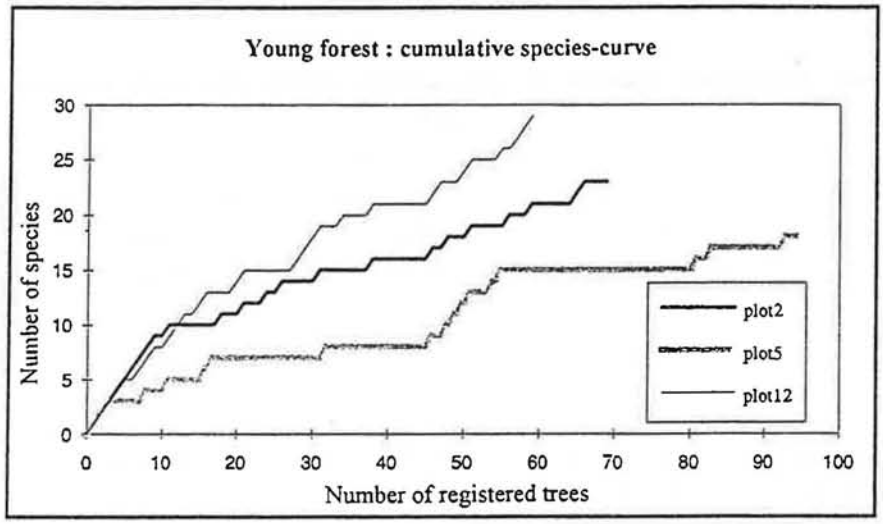

Figure 7 : Cumulative species curves for the 3 plots in young forest.

Shrub and herb vegetation

The shrub and herb vegetation found in the young forest consists mainly of the following species :

Adenanthera sp.
Allophylus sp.
Calamus pratiacanthus
Calamus dioicus
Curculigo sp.
Pueraria sp.
Physostigma sp.
Psychotria sp.
Hoya sp.
Hediotis amicans
Litsea sp.
Costus sp.
Actephila excelsa
Alocasia evrardii
Ardisia sp.
Similax sp.
Amomum xanthioides
Ixora sp.
Derris sp.
Ancistrocladus cochichinensis
Antirhea sp.

Other common families are : *Orchidaceae, Commelinaceae, Simarubaceae* and *Moraceae.*

Floristically the young forest is very heterogenous. Upperstory as well as understory can be rich in species and very diverse. Still the possibility exists that one species occurs abundantly, in the upperstory (*Tetrameles nudiflora*) as well as in the understory (*Shorea obtusa*) and thus dominates the present or future forest stand.

4.2.3.2. Structural description of the young forest

Figure 8 illustrates the diameter distribution of the 3 plots.

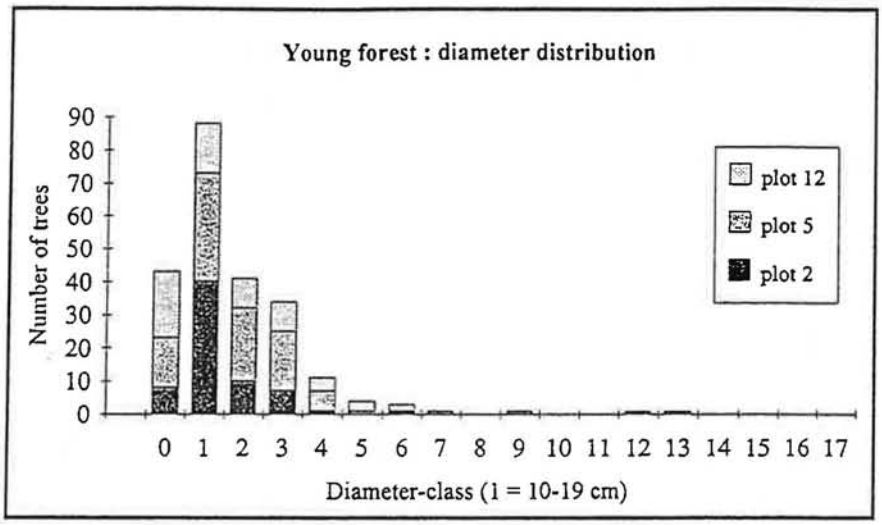

Figure 8 : Diameter distribution for the three plots in young forest.

When not considering class 0 (= diameter 8 - 10 cm), the graph shows an ideal all-aged curve. The regeneration is not hampered in its development. The clearcut field originating from shifting cultivation regenerates spontaneously towards a secundary forest of short-lived light-demanding species (*Tetrameles, Nephelium,...*) and evolves smoothly towards the *Lagerstroemia*-forest. In plot 2 there is a massive regeneration of *Shorea obtusa* : on a surface of 25 m², 28 seedlings with an average height of 1 m were observed. Also in the other plots a well developed regeneration was noticed. The species composition was dependent on the extent of the canopy cover : When no canopy cover was present, the regeneration consisted of pioneer species, especially *Sterculia spp., Tetrameles nudiflora, Nephelium melliferum, Hediotis sp.* Under canopy, species of the *Lagerstroemia*-forest (excl. *Lagerstroemia* sp..) were abundant : *Diospyros spp., Melanorrhoea laccifera, Hopea sp., Pterospermum diversifolium, Xylia xylocarpa.*

Other dendrometrical parameters

Comparing the data from Table 7 with those obtained in the *Lagerstroemia*-forest as well as with those from literature one can conclude that : (1) The stem number is slightly higer than in the *Lagerstroemia*-forest; (2) The average diameter and the basal area are much lower: this is to be expected as the forest consists here mainly of young trees, occupying a smaller surface. The results are in line with those reported in literature.

Table 7 : Dendrometrical parameters in the young forest.

	stem number/ha	basal area (m^2/ha)	average DBH
plot 2	690	47,4	20,9
plot 5	930	41,2	20,9
plot 12	590	44,9	22,9
average for the 3 plots	**737**	**44,5**	**21,6**
Lagerstroemia-forest:	606	96,0	30,9

4.2.3.3. Conclusion

On the alluvial soils in the east of the park, a secundary forest develops spontaneously after shifting cultivation. The regeneration occurs very smoothly : in a first stage especially fast-growing light-demanding species; in a second phase the shadow-tolerant species appear. The forest evolves towards a climax vegetation, be it not allways dominated by *Lagerstroemia angustifolia* : this is the case in plot 12, but not in the others.

4.2.4. Bamboo-dominated stands

4.2.4.1. Dendrological composition of the bamboo-dominated stands

Contrary to the situation on alluvial soils after shifting cultivation, there is no spontaneous forest regrowth along the rivers and on plains and hilly terrain where the red basalt-soils dominate. Here, after shifting cultivation or logging, the overcut patches are rapidly overgrown with bamboo. Thus the spontaneous development of secundary forest is hindered.
These bamboo-dominated stands can be distinghuished into two types. The 'bamboo stands' are characterised by an overwhelming dominance by *Bambusa* species. The tree vegetation is very scarce in species as well as in biomass. The basal area reaches a mere 5 m^2/ha. This forest type is illustrated in the profiles of plot 9 and 10. The most important species are : *Macaranga tanarius, Ficus* spp., *Parinari anamensis* and *Hydnocarpus anthelmintica.* The calculation of relative abundancies, dominances and other parameters makes no sense here. 'Bamboo mixed with trees' is to be considered as a variant of the former type with some large trees still occuring. These are mostly left over after shifting cultivati^_on or after exploitation. This forest type is shown in profiles 3 and 8.

In plot 3 the tree vegetation is completely dominated by *Lagerstroemia calyculata* and *Tetrameles nudiflora.* In plot 8 the tree vegetation consists of overaged trees such as

Shorea thorelii, Dipterocarpus costatus, Lithocarpus sp., *Melanorrhoea laccifera* and *Castanopsis hystrix*. The scarce regeneration consists of *Semecarpus annamensis, Calophyllum thorelii* and *Walsura robusta*.
In hilly terrain the hillsides are mostly pure bamboo stands while the summits are covered with mixed stands of bamboo with left over trees. These trees belong mainly to the following species : *Dalbergia mammosa, Dipterocarpus intricatus, Nephelium melliferum, Haldina cordifolia, Buchanania arborescens, Parinari anamensis* and *Shorea* spp.

Shrub and herb vegetation

The most important herbs and shrubs occuring under the bamboo-dominated stands are :

Ixora sp.	*Adenanthera sp.*	*Randia spinosa*
Albizzia sp.	*Careya sp.*	*Litsea garciae*
Grewia sp.	*Wendlandia sp.*	*Carex sp.*
Saccharum sp.	*Acacia sp.*	*Eupatorium odoratum*
Goniothalamus sp.	*Ammomum xanthioides*	*Stemona pierrei*
Calamus plathiacanthus	*Piper acalaucacia*	*Muntingia calabura*
Mallotus philippensis	*Donax cannaeformis*	*Piper lolot*

4.2.4.2. Structural description

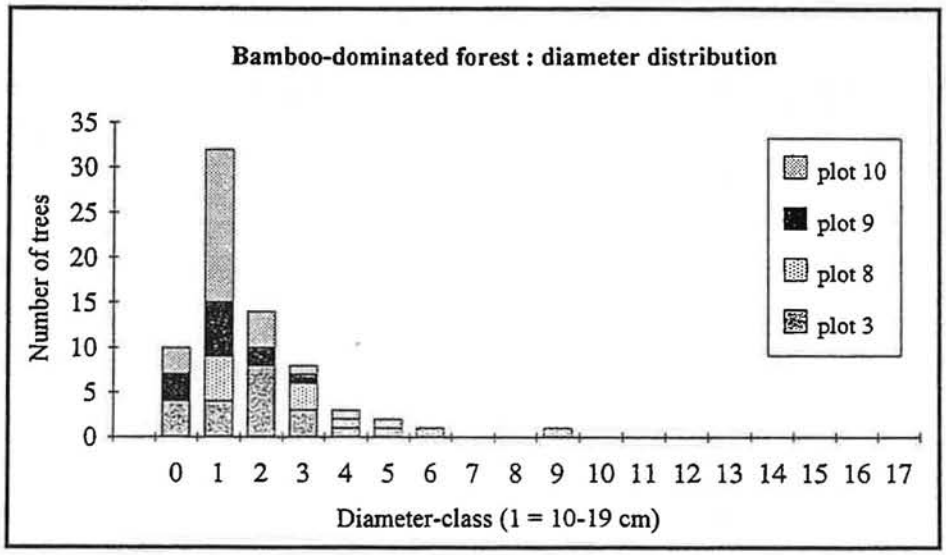

Figure 9 : Diameter distribution in bamboo-dominated stands

At a first glance on figure 9, the diameter-distribution appears quite normal, but

on closer scrutiny it becomes apparent that all diameter classes are definitely underrepresented. If the results from the young forest vegetation are extrapolated, one we would arrive at a stem number of 120 in class 1. In reality there are only 26 trees. The natural regeneration under a bamboo canopy is clearly very difficult and the development of a secundary forest vegetation is doubtful. The natural regeneration in the sample plots was scarce or absent and consisted of a limited number of species :

- Plot 3 : no regeneration
- Plot 8 : scarce regeneration (200 seedlings/ha) of *Dipterocarpus* spp., *Melanorrhoea laccifera, Garcinia fragaroides* and *Calophyllum thorelii.*
- Plot 9 : scarce regeneration (<100 seedlings/ha) of *Gonocaryum subrostratum, Semecarpus annamensis, Ficus* spp. and *Pterospermum diversifolium.*
- Plot 10 : scarce regeneration of *Macaranga tanarius* and *Hydnocarpus anthelmintica.*

The bamboo vegetation features two predominant species : *Bambusa spinosa* and *Bambusa procera.* A quantitative assessment of the bamboo vegetation is presented in Table 8.

Table 8 : Dendrometrical parameters of bamboo vegetation in Nam Bai Cat Tien

A = soil cover (%) by the bamboo canopy H = average top height of the plant (m)
D = average diameter of the stakes (cm) N = number of bamboo plants/ha
n = average number of stakes per plant
V = a raw estimation of the volume of bamboo (m3/ha)

as $V = \frac{D^2 \times pi}{4} \times H \times N \times n \times R$ (with R = reduction-factor, here taken at 0.7)

	A	N	n	H	D	V
plot 3	0,8	130	22	15	8	187.3
plot 8	0,7	60	70	12	5	74.5
plot 9	0,9	170	25	10	5	52.0
plot 10	0,8	80	35	13	8	199.7

4.2.4.3. Conclusion

The bamboo vegetation is very young and vital. This is mainly due to the fact that until recently bamboo was cut and harvested every 4 years. This type of exploitation results in high yields and is still applied in the buffer zone and outside the park. The stakes can be used for light constructions and paper pulp. The disadvantage of this practice is that bamboo never arrives at the gregarious stage of flowering and dying, and therefore the scarce tree vegetation has no chance to

develop.
Since 1992, the bamboo exploitation inside the reserve is prohibited. Hence there will be an opportunity for the bamboo to complete a normal life cycle with flowering and die-off after about 15 years. At this point the natural forest may have a reasonable opportunity to regenerate. Once the trees have grown the bamboo is unlikely to reappear as a dominant element due to its strong light-demanding character. The question as to why bamboo vegetation did not develop in the disturbed forests on alluvial soils cannot be answered.

4.2.5. Dipterocarp forest

4.2.5.1. Dendrological composition

Next to the type forest, dominated by *Lagerstroemia angustifolia*, and its degraded forms, two other natural forest types can be distinguished in the reserve : the gallery forest, discussed in the following section, and the *Dipterocarpus*-forest. The latter type is characterised by a strong dominance of *Dipterocarpaceae*, especially *Dipterocarpus costatus* and covers about 10 % of the surface of the park. As could be derived from the remote sensing data, this forest type occurs mainly where sufficient water is available during the whole year : on low-lying terrain, along brooks and along the greater and smaller swamps. This corresponds with the reports of Rollet (1972) and Schmid (1974).

The *Dipterocarpus*-forest was studied in sample plot 7 and 11. Plot 7 is located in the west of the national park; plot 11 (together with observation plot 1) is situated south of the eastern forest complex.

The *Dipterocarpus*-forest is generally in a bad state. This is apparent from the profiles of the two plots : the upperstory is very open and the understory is fragmented or is absent. The canopy cover is a mere 50 to 60 percent. This degradation is caused by overexploitation in the past : there is a strong demand for timber of Dipterocarp species. It is assumed that during each cutting operation large volumes were taken out. This could be deduced from measurements in plot 7 which was subject to a recent cutting, as was evident from fresh stumps. About 30 trees per hectare were cut, covering about half of the basal area : before cutting the basal area amounted to 63,1 m^2/ha, and this was reduced to 33,6 m^2/ha after cutting. These heavy cuts not only have implications for the structure, but also for the species composition of the forest : the *Dipterocarpaceae* are systematically harvested.

The species composition in these heavily disturbed forests is very limited : in plot 7 there are only 8 species; in plot 11 there are only 4. In plot 7 the upperstorey consists of 3 species : *Dipterocarpus costatus, Shorea thorelii* and *Lagerstroemia angustifolia*. In plot 11 the upperstorey consists of only one species namely *Dipterocarpus*

costatus. Under- and middle-storey consist of the following species :

plot 7 : *Callicarpa* sp., *Diospyros rubra, Homalium fagifolium, Mitragyna diversifolia* and *Semecarpus annamensis.*

plot 11 : *Walsura robusta, Eugenia cochinchinensis* and *Parinari anamensis.*

In both plots there is also some bamboo, but it has no predominant position.

Natural homogeneous stands of *Dipterocarpaceae* are not exceptional, due to their gregarious character. In this case however the limited species composition is caused by overexploitation in the past, and a management by the exploitation company that was aimed on obtaining homogeneous Dipterocarp stands.

Shrub and herb vegetation

The most important shrub and herb species of the Dipterocarp-dominated forest are given below :

Grewia bulot	Desmodium sp.	Breynia fruticosa
Costus sp.	Imperata cylindrica	Cyperus sp.
Similax sp.	Drynaria quercifolia	Careya sphaerica
Mimosa sp.	Musa sp.	Phyllanthus reticulatus
Leea crispa	Wrightia sp.	Gonocaryum subrostratum
Sterculia hypochra	Sterculia viscida	Sterculia helicterus
Buettneria aspera	Commelina sp.	Croton caudatus

4.2.5.2. Structural description

The diameter distribution (figure 10) doesn't reflect a normal forest structure but is rather Gaussian. This is due to the abundancy of the Dipterocarpaceae as well as Lagerstroemia angustifolia. For these species an asymmetric Gauss curve of the diameter distribution is a normal phenomenon (Rollet 1979).

This has some important implications towards the stability of the stand. As one could already derive from the profiles, the natural regeneration is limited. In plot 7 however a replanting was done by the exploitation company, using *Dipterocarpus costatus* at a density of 400 plants per ha.
It is quite remarkable that the natural regeneration is so difficult as the canopy is strongly fragmented and bamboo is only marginal. A possible explanation is that the exploitation was too recent to create a massive regeneration. Other dendrome-

trical parameters are given in table 9.

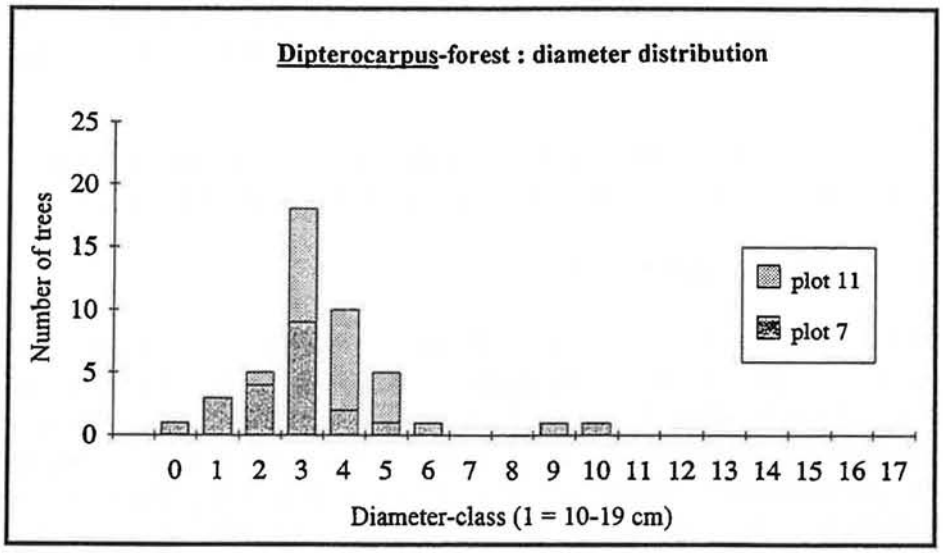

Figure 10 : Diameter distribution for the two plots in the *Dipterocarpaceae*-dominated forest.

The stem number and average diameter differ strongly from what is normal in *Dipterocarpus*-forest : Brünig (1983) and Proctor *et al.* (1983) found resp. 420-920 and 615-780 trees per hectare and an average diameter of 20.5 to 24.5. The basal area is quite in line with what is common.
These unusual results are due to the unstable structure of the *Dipterocarpus*-stands caused by overexploitation in the past. Further research should decide in what extent this forest type can recover from the damage caused in the past.

Table 9 : Structural parameters of the Dipterocarp-dominated forest.

	stem number/ha	G (m^2/ha)	D (cm)
plot 7	230	33,6	37.3
plot 11	220	29,8	40.5

4.2.6. Gallery forest

Gallery forests, together with the swamp forests, belong to the azonal forest types. The term 'gallery forest' or 'corridor forest' is given to the narrow forest strips along rivers. They clearly differ from the adjoining forests as they are always well provided with water, even in the dry season. Globally they have a taller canopy, higher stocking, larger volume and a larger share of evergreen species (Lamprecht 1989).

This forest type was studied in a line transect and in an observation plot. Both are located along the Dong Nai river, close to the park headquarters.

4.2.6.1. Dendrological composition

The gallery forest is mostly in a degraded state. In the transect only 61 trees, belonging to 13 species were recorded in an area of 0.5 ha. The canopy cover reached only 65 percent and the top height was between 26 and 28 m.
The upper storey consisted of *Dipterocarpus alatus* and *Anogeissus acuminata*, mixed with *Dalbergia mammosa, Harpullia* sp., *Vitex pinnata* and *Lagerstroemia angustifolia*. In the understorey the following species were recorded : *Eugenia cochinchinensis, Syzygium polyanthum, Ficus glomerata, Ficus hispida, Litsea garciae, Bombax ceiba, Lagerstroemia ovalifolia, Crateva religiosa* and *Cinnamomum iners*. In the understorey there is a strong natural presence of bamboo. In the transect 112 bamboo plants per hectare were recorded. The bamboo plants have a top height of 9 to 16 m. There is an average of 28 stakes per plant with a diameter varying between 3 and 8 cm.

In the observation plot, which is in a less degraded stage, the following species were recorded : *Dipterocarpus alatus, Dipterocarpus baudii, Anogeissus acuminata, Dalbergia mammosa, Haldina cordifolia, Xylia xylocarpa, Pterospermum diversifolium, Afzelia xylocarpa, Sindora siamensis and Anthocephalus chinensis.*

The dominance and abundancy in stem number als well as in basal area of two species is prevalent: *Dipterocarpus alatus* and *Anogeissus acuminata*. Both species are typical for gallery forests; they do not occur anywhere else in the plots.

Numerous species in this forest type provide valuable timber (*Dipterocarpus, Dalbergia, Xylia, Afzelia, Sindora*) and the forests are easily accessible along the rivers. Where a high degree of diversity and strong mixture of species is to be expected in a gallery forest, only 14 species in an area of 0.5 ha were recorded. This is a very low number if we compare with the *Lagerstroemia*-forest where about 20 species were registered on a 0.1 ha plot. The mix-quotient of Jentsch is 1 : 4.35 which is also a higher value than in the *Lagerstroemia*-forest. Important species of the shrub and herb vegetation along the rivers are given below :

Calamus polyacanthus	*Urena lobata*	*Hibiscus sagittifolius*
Ficus hirta	*Clerodendrum intermedia*	*Caryota urens*
Sterculia hypochra	*Ammomum sp.*	*Acanthopanax armatus*
Imperata cylindrica	*Eupatorium odoratum*	*Mimosa sp.*
Pueraria thomsonii		

4.2.6.2. Structural description

The diameter distribution in figure 11 shows an uncommon curve. There are strikingly low stem numbers in the small and medium diameter classes and the stem number is rather constant from diameter class 2 onwards. Both phenomena are caused by the presence of bamboo and especially by the strong extent of human disturbance.

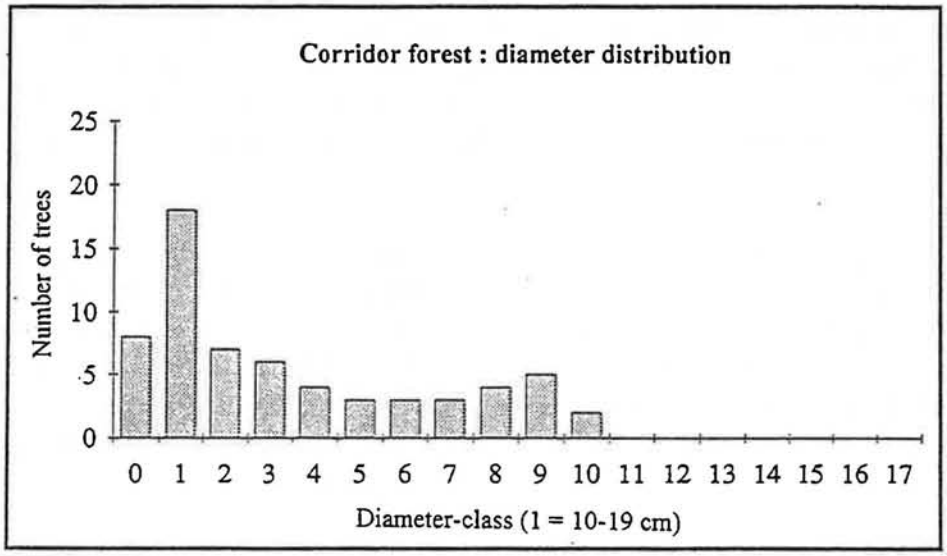

Figure 11 : Diameter distribution in the line transect in the gallery forest.

Considering other dendrometrical parameters one can conclude the same. The stem number (122 stems/ha) and basal area (22,4 m^2/ha) are both much to low, because of overlogging in the past. The average diameter on the other hand is quite normal (D = 36.6).

4.2.6.3. Conclusion

The dominance and abundancy in stem number als well as in basal area of *Diptero-*

carpus alatus and *Anogeissus acuminata* is striking. Both species are typical for gallery forests; they do not occur anywhere else in the plots. As numerous species in this forest type provide valuable timber, it is seriously damaged and overlogged. This is also illustrated by the diameter-distribution and the other dendrometrical parameters.

5. GENERAL CONCLUSION

The forest vegetation in Nam Bai Cat Tien national park is generally very disturbed : although 90 % of the park surface is covered with forest, only 15 to 20 % is in a primary condition.
This primary forest belongs to the closed deciduous forest described by Trung (1966), Rollet (1972) and Schmid (1974). It is characterised by an upperstorey which is completely dominated by *Lagerstroemia angustifolia*. The under- and middle storey are rich in species and consist of deciduous as well as evergreen species. This primary forest is in good condition concerning species composition as well as forest structure, be it that the very large diameters are overrepresented. This is reflected by the dendrometrical parameters : extremely high values were found for the basal area, averaging 96 m^2/ha.

About 70 % of the forest consists of degraded forms of the *Lagerstroemia*-forest, originating from shifting cultivation and overexploitation. These degraded formations can be divided into two types : on the one hand there are young regenerating stands without bamboo, and on the other hand there are degraded stands dominated by bamboo. The western part of the park is almost completely dominated by this bamboo vegetation, while the east is characterised by a patchwork of primary and secundary forest where bamboo is only marginal.

The young forests without bamboo are generally rich in species and have a good forest structure. The natural regeneration is normal and the forest evolves spontaneously towards a climax vegetation like the *Lagerstroemia*-forest or towards a transition forest type, with dominance of light-demanding species like *Tetrameles nudiflora* or *Shorea obtusa*.
The stands dominated by bamboo vegetation however are in a critical condition. The tree vegetation is very poor in species and has a low stem number and basal area. Due to the dominating bamboo canopy, natural regeneration is very difficult. The bamboo on the other hand is vital and strong as it was until recently regulary cut. Now that there is a global ban on bamboo cutting inside the park the bamboo should complete its normal life cycle and die-off. It is expected that at that time the regeneration of the tree vegetation gets a fair chance.

Next to the *Lagerstroemia*-forest and its degraded forms, there are two more forest types inside the park, covering about 10 % of the surface : the gallery forest and the *Dipterocarpus*-forest. These two forest types are also heavily degraded due to overexploitation, as the tree species occurring here are much sought after.

Although the forest in Nam Bai Cat Tien is generally in a bad shape, the national park is still regarded a protected area of international importance. This is mainly due to the fact that the park encompasses an unbroken forest complex that is large enough to host a large number of animal species, of which some are very rare. The large swamp in the north of the National Park also has a high biological value. This biological value of the forest can still increase if the forest vegetation can recover from the previous disturbances. In this process, bamboo constitutes the biggest obstacle for the natural regeneration of the forest. An important topic of research in Nam Bai Cat Tien is the monitoring of the natural evolution of the bamboo and the natural regeneration in the bamboo-dominated spots now that the bamboo cutting is prohibited.

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Appendix 1

Appendix 1a : registered tree-species in the 12 sample-plots and the line-transect

Species + author	Family (Subfamily)
Acacia vielana	Leguminosae (Mimosoidae)
Acronychia pedunculata (L.) Miquel	Rutaceae
Afzelia xylocarpa (Kurz) Craib.	Leguminosae (Caesalpinoideae)
Aglaia sp. Lour.	Meliaceae (Melioideae)
Allospondias lakonensis (Pierre) Stapf.	Anacardiaceae
Allophylus cobbe (L.) Raeuschel	Sapindaceae
Anogeissus acuminata (DC) Guillemin & Perrottet	Combretaceae
Anthocephalus chinensis (Lam.)Walp.	Rubiaceae
Aphanamixis polystachya (Wallich)R.Parker	Meliaceae (Melioideae)
Baccaurea ramiflora Lour.	Euphorbiacee
Bambusa procera A.Chev.& A.Cam.	Gramineae
Bambusa spinosa Roxb.	Gramineae
Bombax ceiba L.	Bombacaceae
Buchanania arborescens (Blume)Blume	Anacardiaceae
Callicarpa sp. L.	Verbenaceae
Callicarpa poilanei	Verbenaceae
Calophyllum saigonense Pierre	Guttiferae
Calophyllum soulattri Burm.f.	Guttiferae
Calophyllum thorelii Pierre	Guttiferae
Canarium subulatum Guill.	Burseraceae
Carralia brachiata (Lour.) Merrill	Rhizophoraceae
Castanopsis hystrix A.DC.	Fagaceae
Cinnamomum cambodjanum H.Lec.	Lauraceae
Cinnamomum iners Reinw.	Lauraceae
Crateva religiosa Forster f.	Capparidaceae
Cycas siamensis Miquel	Cycadaceae
Dalbergia mammosa Pierre	Leguminosae (Papilionoideae)
Diospyros crumenata Thw.	Ebenaceae
Diospyros hasseltii Zoll.	Ebenaceae
Diospyros rubra H.Lec.	Ebenaceae
Dipterocarpus alatus Roxb.	Dipterocarpaceae
Dipterocarpus costatus Gaertner f.	Dipterocarpaceae
Dipterocarpus dyeri Pierre	Dipterocarpaceae
Dipterocarpus intricatus Dyer	Dipterocarpaceae
Dipterocarpus turbinatus Gaertner f.	Dipterocarpaceae
Dolichodendron rhedii Seem.	Bignoniaceae
Elaeocarpus dongnaiensis Pierre	Elaeocarpaceae

Species + author	Family (Subfamily)
Erismanthus sinensis Oliv.	Euphorbiaceae
Eugenia chanlos Gagnep	Myrtaceae
Eugenia cochinchinensis Gagnep in Lec.	Myrtaceae
Eugenia nigrans Gagnep	Myrtaceae
Ficus hirta Vahl	Moraceae
Ficus hispida L.	Moraceae
Ficus lacor Buch.-Ham.	Moraceae
Ficus sikkim	Moraceae
Ficus racemosa L.	Moraceae
Ficus sp. L.	Moraceae
Flacourtia rukam Zoll.& Moritzi	Flacourtiaceae
Garcinia fragaroides	Guttiferae
Garcinia merguensis Wight	Guttiferae
Gonocaryum sp. Miq.	Icacinaceae
Grewia paniculata Roxb. ex DC.	Tiliaceae
Haldina cordifolia (Roxb.) Ridsd.	Rubiaceae
Harpullia sp. Roxb.	Sapindaceae
Heritiera javanica (Blume) Kosterm.	Sterculiaceae
Homalium fagifolium	Flacourtiaceae
Hopea ferrea Lanessan	Dipterocarpaceae
Horsfieldia amygdalina Warb.	Myristicaceae
Hydnocarpus anthelmintica Pierre	Flacourtiaceae
Hydnocarpus ilicifolia King	Flacourtiaceae
Lagerstroemia calyculata Kurz	Lythraceae
Lagerstroemia cochinchinensis Pierre in Gagn.	Lythraceae
Lagerstroemia hexaptera Miquel	Lythraceae
Lagerstroemia speciosa (L.) Pers.	Lythraceae
Lithocarpus sp. Blume	Fagaceae
Litsea garciae Vidal	Lauraceae
Macaranga denticulata Muell.Arg.	Euphorbiaceae
Macaranga tanarius (L.)Muell.Arg.	Euphorbiaceae
Madhuca sp. J.Gmelin.	Sapotaceae
Melanorrhoea laccifera Pierre	Anacardiaceae
Michelia sp. L.	Magnoliaceae
Micromelum falcatum Blume	Rutaceae
Mitragyna diversifolia Havil.	Rubiaceae
Muntingia calabura L.	Flacourtiaceae
Nephelium melliferum Gagnep	Sapindaceae

Species + author	Family (Subfamily)
Otophora amphifolia Pierre	Sapindaceae
Palaquium annamensis	Sapotaceae
Parinari anamensis Hance	Chrysobalanaceae
Polyalthia cerasoides Benth.& Hook	Annonaceae
Pouteria barauensis	Sapotaceae
Pouteria sp. Aublet.	Sapotaceae
Pterospermum diversifolium Blume	Sterculiaceae
Pterospermum megalocarpum Tardieu	Sterculiaceae
Randia acouminata (acuminatissima Merr.)	Rubiaceae
Scaphium lychnophorum (Hance.) Kost.	Sterculiaceae
Schoutenia hypoleuca	Tiliaceae
Semecarpus annamensis Tard.	Anacardiaceae
Shorea obtusa Wallich	Dipterocarpaceae
Shorea thorelii Pierre	Dipterocarpaceae
Sterculia cochinchinensis Pierre	Sterculiaceae
Sterculia parvifolia Wall.	Sterculiaceae
Sterculia stigmarata	Sterculiaceae
Stereospermum cylindricum Pierre	Bignoniaceae
Sindora siamensis Teysm. ex Miquel	Leguminosae (Caesalpinoideae)
Syzygium oblatum (Roxb.) A.M. & J.M. Corva	Myrtaceae
Syzygium polyanthum (Wight) Walp.	Myrtaceae
Terminalia bellirica (Gaertner) Roxb.	Combretaceae
Terminalia calamansanai (Blanco) Rolfe	Combretaceae
Tetrameles nudiflora R.Br.	Datiscaceae
Toona sinensis (A.Juss.) M. Roemer	Meliaceae (Swietenioideae)
Turpinia montana (Blume)Kurz	Staphyleaceae
Vitex peduncularis Wallich	Verbenaceae
Vitex pinnata L.	Verbenaceae
Vitex trifolia L.	Verbenaceae
Walsura cochinchinensis Harms.	Meliaceae (Melioideae)
Walsura robusta Roxb.	Meliaceae (Melioideae)
Wrightia sikkimensis Gamble	Apocynaceae
Xanthophyllum flavescens Roxb.	Xanthophyllaceae
Xerospermum laoticum Gagnep	Sapindaceae
Xerospermum poilanei	Sapindaceae
Xylia xylocarpa (Roxb.) Thaub.	Leguminosae (Mimosoideae)
Xylopia vielana Pierre	Annonaceae
Zollingeria dongnaiensis Pierre	Sapindaceae

Appendix 1b : tree-species not included in the sample plots and herbactous plants

Species + author	Family (Subfamily)
Acanthopanax armatus	
Actephila excelsa (Dalz.) Muell.Arg.	Euphorbiaceae
Adenanthera sp. L.	Leguminosae (Mimosoideae)
Alocasia macrorrhizos (L.) G. don f.	Araceae (Lasioideae)
Alocasia evrardi Gagnep	Araceae (Lasioideae)
Ammomum sp.(rhizomea)	Zingiberaceae
Ammomum xanthioides Wallich ex Baker	Zingiberaceae
Ancistrocladus cochinchinensis Gagnep	Ancistrocladaceae
Anisoptera glabra Kurz	Dipterocarpaceae
Antirhea sp. Comm. ex Juss.	Rubiaceae
Anthocephalus chinensis (Lam.)Walp.	Rubiaceae
Antidesma bunius (L.)Sprengel	Euphorbiaceae
Ardisia sp. Sw.	Myrsinaceae
Areca triandra Roxb.	Palmae
Barringtonia acutangula (L.)Gaertner	Lecythidaceae
Barringtonia longipes Gagnep	Lecythidaceae
Boehmeria sp. Jacq.	Urticaceae
Buchnera aspera	Scrophulariaceae
Breynia fruticosa (L.)Benth.	Euphorbiaceae
Caetaria sp.	
Calamus dioicus	Palmae
Calamus polyacanthus	Palmae
Calamus pratiacanthus	Palmae
Calamus tetradactylus Hance	Palmae
Calamus viminalis Willd.	Palmae
Carex helecarpa	Cyperaceae
Carex indica L.	Cyperaceae
Careya sphaerica Roxb.	Lecythidaceae
Caryota urens L.	Palmae
Claoxylon indicum (Reinw. ex Blume)Hassk.	Euphorbiaceae
Claoxylon polos	Euphorbiaceae
Clerodendrum intermedia	Verbenaceae
Colona evecta (Pierre)Gagnep	Tiliaceae
Commelina sp. L.	Commelinaceae
Commelina diffusa Burm.f.	Commelinaceae
Convolvulus sp. L.	Convolvulaceae

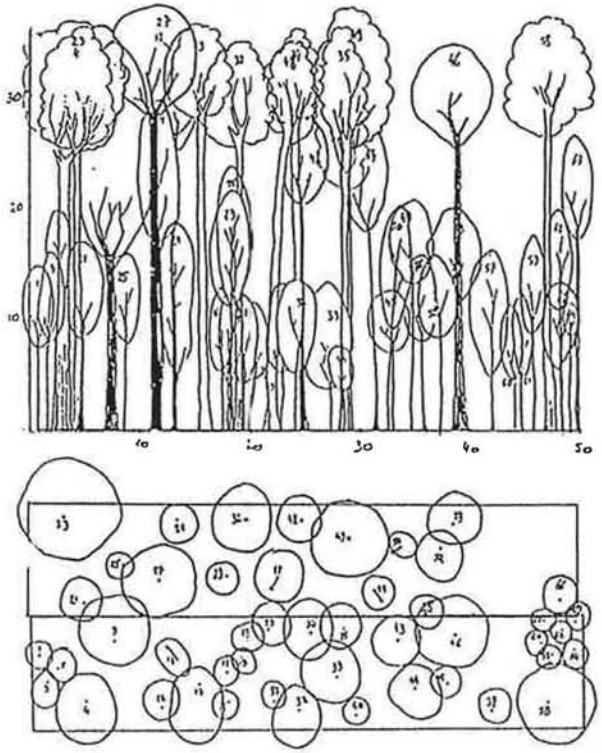
Species + author	Family (Subfamily)
Costus sp. L.	Zingiberaceae
Costus speciosus (Koenig)Smith	Zingiberaceae
Crateva religiosa Forster f.	Capparidaceae
Cratoxylum cochinchinense (Lour.)Blume	Guttiferae
Croton caudatus Geiseler	Euphorbiaceae
Curcuma xanthorrhiza Roxb.	Zingiberaceae
Curculigo sp. Gaertner	Liliaceae
Cyperus sp. L.	Cyperaceae
Cyperus digitatus Roxb.	Cyperaceae
Dalbergia cochinchinensis Pierre	Leguminosae (Papilionoideae)
Derris sp. Lour.	Leguminosae (Papilionoideae)
Desmodium sp. Desv.	Leguminosae (Papilionoideae)
Diospyros eriantha Champ.	Ebenaceae
Dipterocarpus baudii Korth.	Dipterocarpaceae
Donax cannaeformis (G.Forster)K.Schumann	Marantaceae
Drynaria quercifolia (L.)J.Smith	Polypodiaceae
Entada sp. Adans.	Leguminosae (Mimosoideae)
Eichhornia crassipes	
Eragrostis tenella (L.)Beauv. ex Roem. & Sch.	Gramineae
Eupatorium odoratu L.	Compositae
Excoecaria agallocha L.	Euphorbiaceae
Globba sp. L.	Zingiberaceae
Glycosmis cochinchinensis (Lour.)Pierre	Rutaceae
Gonocaryum subrostratum Pierre	Icacinaceae
Goniothalamus sp. (Blume)Hook.f. & Thomson	Annonaceae
Grewia bulot	Tiliaceae
Grewia annamensis	Tiliaceae
Hedyotis sp. L.	Rubiaceae
Hedyotis amicans	Rubiaceae
Hibiscus sagittifolius Kurz	Malvaceae
Hoya sp. R.Br.	Asclepiadaceae
Imperata cylindrica (L.)Räusch.	Gramineae
Ischaemum rugosum Salisb.	Gramineae
Ixora sp. L.	Rubiaceae
Korthalsia laciniosa (Griffith)Martins	Palmae

Species + author	Family (Subfamily)
Leea crispa	Leeaceae
Licuala spinosa Thunberg	Palmae
Livistona saribus (Lour.)Merrill. ex Chevalier	Palmae
Mallotus apelta (Lour.)Muell.Arg.	Euphorbiaceae
Mallotus philippensis (Lam.)Muell.Arg.	Euphorbiaceae
Mimosa sp. L.	Leguminosae (Mimosoideae)
Musa sp. L.	Musaceae
Ophiopogon sp. Ker-Gawler.	Liliaceae
Ormosia sp.	
Oxytenanthera stockessii Murro	Gramineae
Pandanus sp. Parkinson	Pandanaceae
Phyllanthus reticulatus Poiret	Euphorbiaceae
Physostigma sp. Balf.	Leguminosae (Mimosoideae)
Pinanga quadrijuga Gagnep	Palmae
Piper acalaucacia	Piperaceae
Piper lolot C.DC.	Piperaceae
Psichotria sp. L.	Rubiaceae
Pueraria thomsonii	Leguminosae (Mimosoideae)
Psychotria sp. L.	Rubiaceae
Psychotria serpens L.	Rubiaceae
Randia spinosa	Rubiaceae
Saccharum sp. L.	Gramineae
Selaginella sp. Pal.	Selaginellaceae
Similax sp. L.	Similacaceae
Stemona pierrei Lour.	Stemonaceae
Sterculia hypochra Pierre	Sterculiaceae
Sterculia viscida	Sterculiaceae
Sterculia helicterus	Sterculiaceae
Strychnos thorelii Pierre ex Dop.	Loganiaceae (Strychneae)
Symphyla amicans	Rubiaceae
Tabernaemontana L.	Apocynaceae
Tadehagi triquetrum (L.)Ohashi	Leguminosae (Mimosoideae)
Talinum sp.	Portulacaceae
Thysanolaena maxima (Roxb.)Kuntze	Gramineae
Urena lobata L.	Malvaceae
Vernonia sp. Schreber.	Compositae
Wendlandia sp. Bartling ex DC.	Rubiaceae
Xanthophyllum colubrinum Gagnep	Xanthophyllaceae
Ziziphus oenoplia (L.)Miller	Rhamnaceae

Appendix 2 : forest profiles

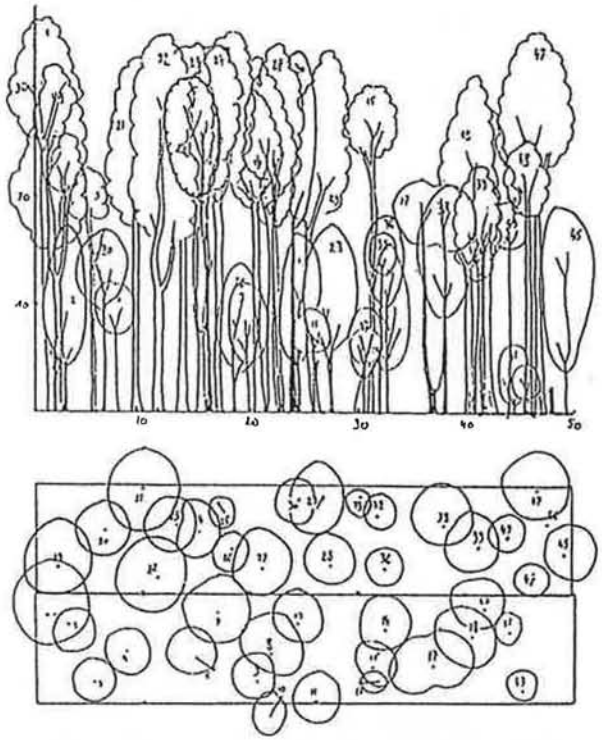
Forest profiles for Lagerstroemia-forest

Plot 1



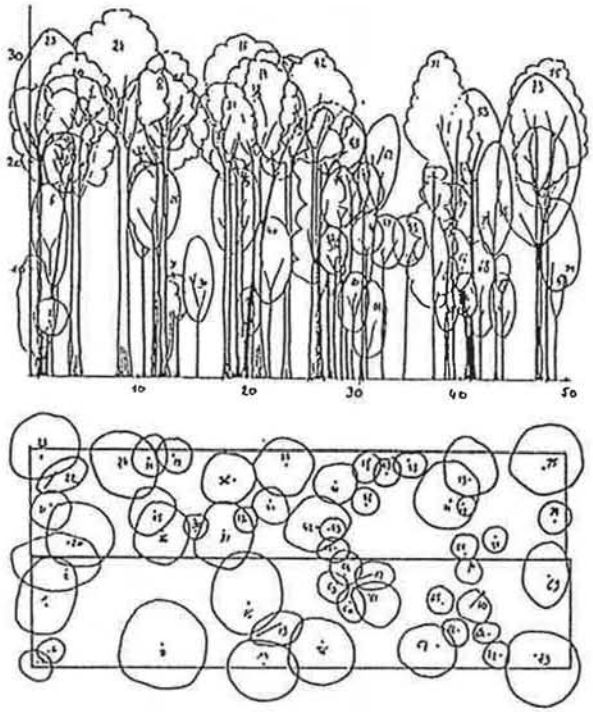
Tree species of plot 1:
Lagerstroemia angustifolia (4, 13, 23, 32, 24, 35, 47, 49, 58); Diospyros rubra (2, 3, 5, 26, 59); Diospyros horsfieldii (15); Cinnamomum cambodianum (8, 33); Cycas siamensis (45); Dipterocarpus turbinatus (46, 27); Erismanthus sinensis (17, 24, 66, 57, 38); Eugenia cochinchinensis (25, 29, 37, 44); Grewia sp. (21, 50); Melanorrhoea laccifera (52, 55); Palaquium annamense (1); Pterospermum diversifolium (54); Shorea thorelii (43, 63); Stereospermum cylindricum (12); Heritiera javanica (48); Vitex peduncularis (53); Zollingeria dongnaiensis (14); Syzigium polyanthum (16, 39, 40, 62, 64)

Plot 4



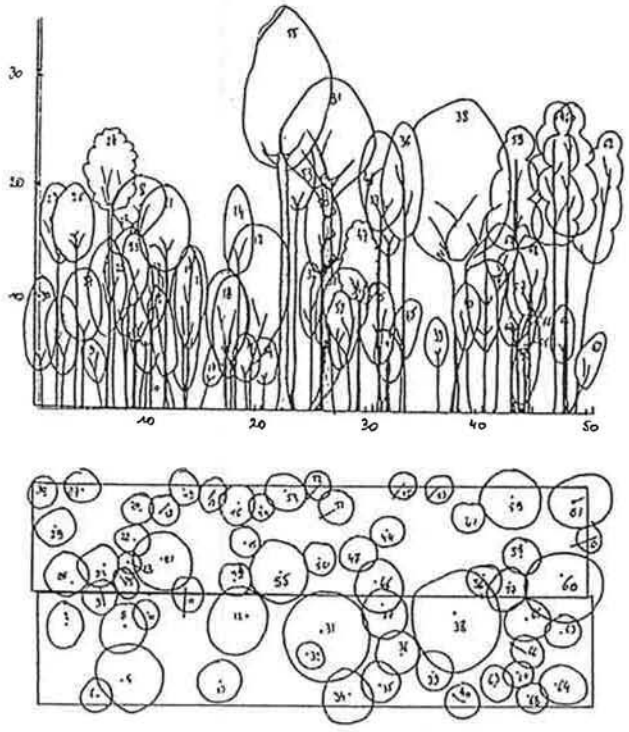
Tree species of plot 4 :
Lagerstroemia angustifolia (1, 3, 5, 7, 8, 10, 15, 18, 19, 21, 22,23, 24, 27, 29, 36, 39, 40, 47, 48); Diospyros crumenata (20); Aphanamixis polystachia (14); Baccaurea ramiflora (16); Castanopsis hystrix (2); Erismanthus sinensis (33); Eugenia cochinchinensis (30); Garcinia fragaoides (17, 45, 49); Melanorrhoea laccifera (38); Nephelium melliferum (32); Palaquium annamense (11); Vitex pinnata (4, 26, 28); Walsura cochinchinensis (9); Syzigium polyanthum (13)

Plot 6



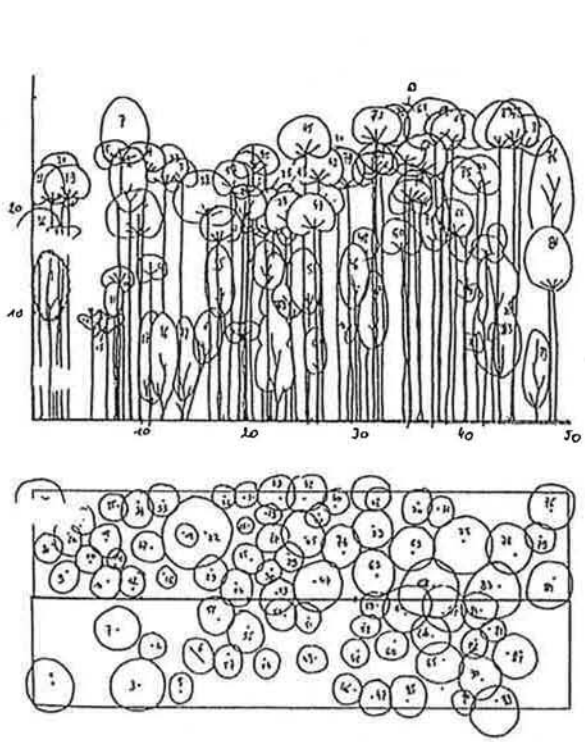
Tree species of plot 6 :
Lagerstroemia angustifolia (1, 2, 8, 14, 16, 20, 24, 26, 31, 36, 38, 42, 44, 48, 51, 75); Anthocephalus chinensis (19; 70); Carralia brachiata (66); Diospyros rubra (32, 33, 65, 68, 71, 72,); Diospyros horsfieldii (40, 52); Dipterocarpus dyeri (43, 53); Dipterocarpus alatus (41); Garcinia merguensis (54); Homalium fagifolium (74);Nephelium melliferum (39, 56, 67); Palaquium annamense (55); Pterospermum megalocarpum (23); Schoutenia hypoleuce (30, 60, 61, 62, 63, 64); Semecarpus annamensis (47); Terminalia calamansanai (73); Toona sinensis (69); Turpinia montana (6); Walsura robusta (5, 25); Wrightia sikkimensis (21, 2, 45)

Plot 2



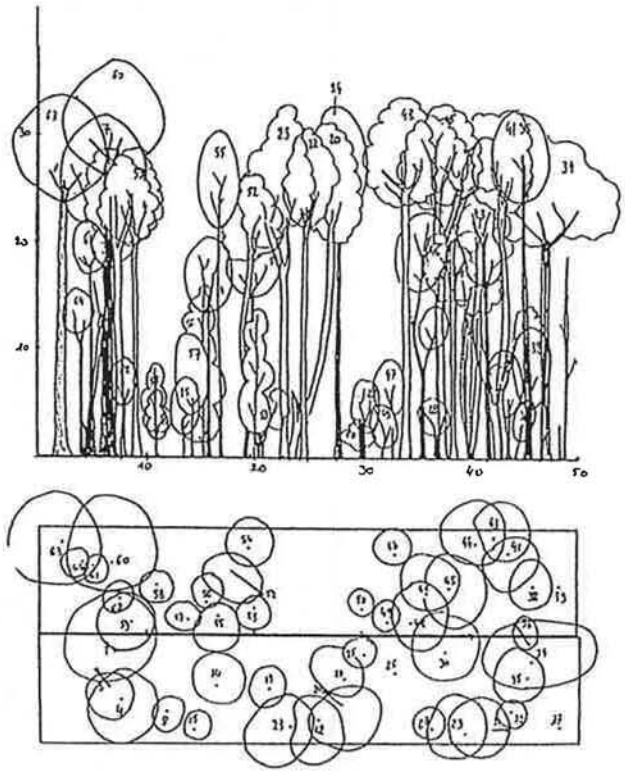
Tree species of plot 2:
Lagerstroemia angustifolia (24, 47); Diospyros crumenata (110, 14, 22, 23, 25, 29, 50, 63, 67, 68, 69); Cinnamomum iners (46); Buchanania arborescens (5); Haldina cordifolia (26, 53); Elacocarpus dongnaiensis (8); Erismanthus sinensis (2); Eugenia nigrans (6, 19); Macaranga denticulata (56); Nephelium melliferum (59, 60, 61, 64); Afzelia xylocarpa (38); Pterospermum diversifolium (66); Pouteria barauensis (9, 15); Shorea obtusa (27, 30, 34, 35, 36, 39, 40, 41, 43, 45, 52, 54, 57, 58, 62, 43, 63); Sterculia cochinchinensis (11); Sindora siamensis (31); Terminalia bellirica (21); Terminalia calamansanai (18, 20, 37, 55); Vitex pinnata (65); Xylia xylocarpa (51); Zollingeria dongnaiensis (12, 13, 16)

Plot 5



Tree species of plot 5 :
Tetrameles nudiflora (3, 4, 5, 6, 7, 9, 10, 14, 15, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 33, 34, 35, 36, 39, 40, 41, 42, 44, 45, 56, 57, 59, 60, 61, 63, 65, 66, 67, 68, 69, 70, 72, 73, 74, 78, 81, 84, 85, 86, 87, 89, 90, 91, 92, 95) Lagerstroemia angustifolia (1); ; Calophyllum saigonensis (49); Ficus sp. (55, 71, 75, 76); Hydnocarpus ilicifolium (53); Madhuca sp.(16, 38); Nephelium melliferum (51, 52); Polyalthia cerasoides (17, 18); Randia acuminata (83); Scaphium lychnophorum 11, 12, 43, 47, 58); Sterculia stigmarata (79);Terminalia calamansanai (54); Xanthophyllum flavescens (48); Xylia xylocarpa (46)

Plot 12

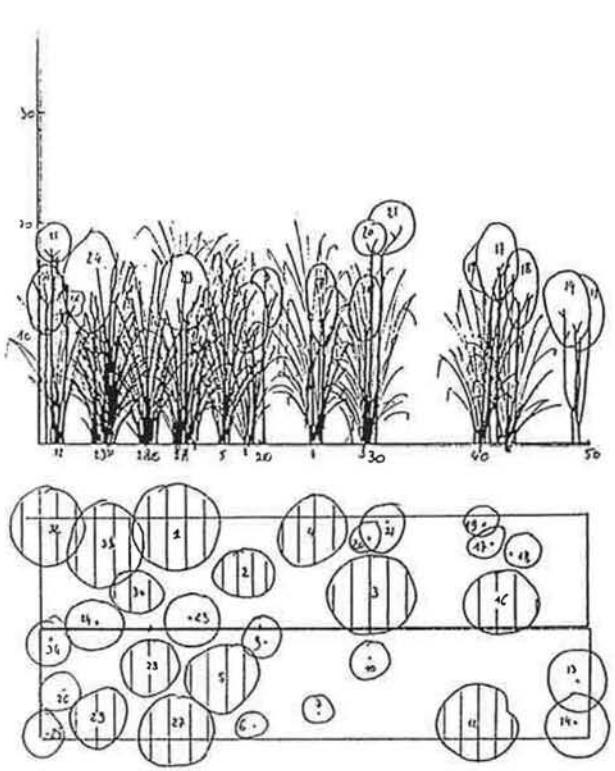


Tree species of plot 12 :
Lagerstroemia angustifolia (4, 20, 22, 23, 29, 30, 31, 41, 44, 45, 48, 52, 59); Acronychia pedunculata (32); Aglaia sp. (64); Calophyllum thorelii (50); Cinnamomum iners (55); Diospyros crumenata (19, 36, 47); Diospyros rubra (57); Dipterocarpus intricatus (60); Dipterocarpus turbinatus (63); Homalium fagifolium (54); Hydnocarpus anthelmintica (21); Michelia sp. (35); Micromelum falcatum (25); Nephelium melliferum (8, 53, 56); Afzelia xylocarpa (34); Polyaltia sp. (15); Pterospermum diversifolium (3); Schoutenia hypoleuce (24); Shorea thorelii (7, 61); Terminalia calamansanai (36); Xerospermum loaticum Xylia xylocarpa (14, 43); Xylopia vielana (28, 49)

forest profiles

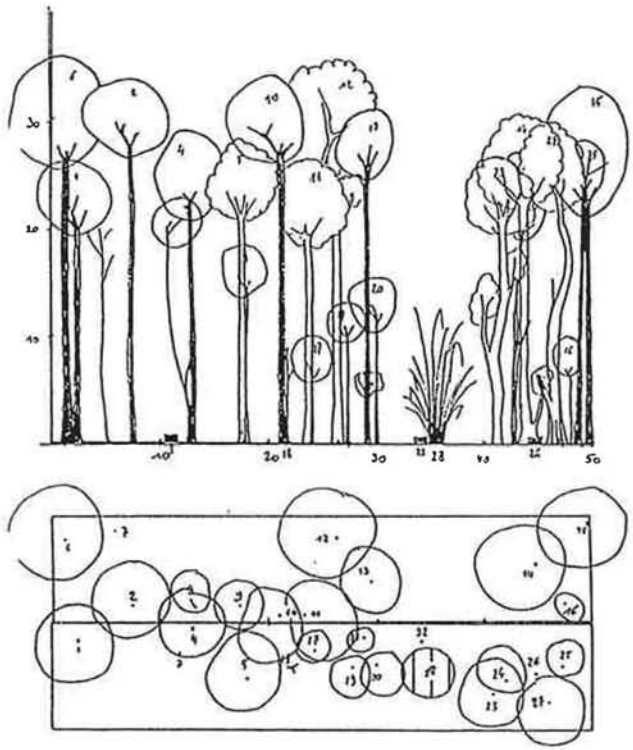
Forest profiles for bamboo and Dipterocarpus-stands

Plot 3 : bamboo-dominated stand



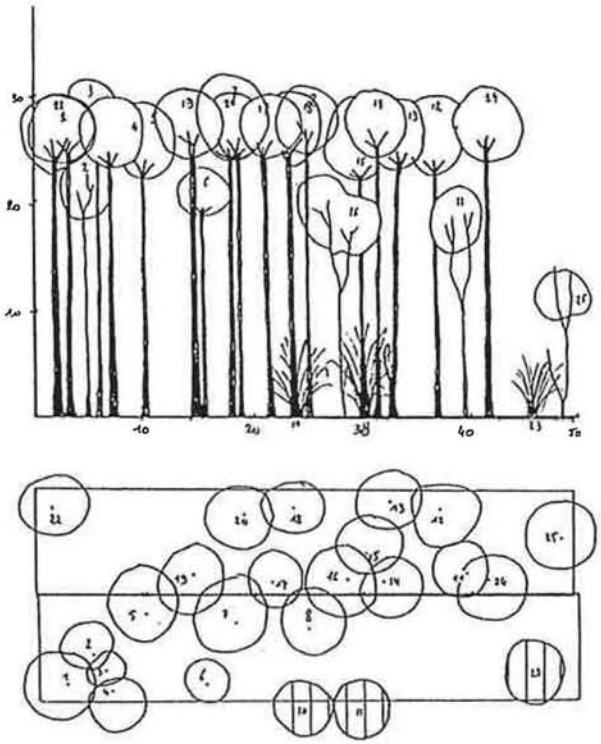
Tree species of plot 3:
Bambusa spinosa (1, 2, 3, 4, 5, 7, 12, 16, 27, 28, 29, 30, 31, 32); Lagerstroemia calyculata (9, 13, 14, 17, 19); Acacia vielana (7); Calophyllum saigonense (18); Castanopsis hystrix (6); Eugenia chanlos (10); Flacourtia rukam (24); Hydnocarpus anthelmintica (20, 21); Tetrameles nudiflora (23, 25, 26, 34)

Plot 7 : Dipterocarpus stand



Tree species of plot 7 :
Dipterocarpus costatus (1, 2, 6, 7, 8, 10, 13, 21, 24, 25); Lagerstroemia angustifolia (5, 11, 12, 14, 22, 26); Callicarpa sp.(20); Diospyros rubra (16); Dipterocarpus intricatus (3); Mitragyna diversifolia (23); Semecarpus annamensis (9); Shorea thorelii (4, 15, 18, 19); Bambusa spinosa (28)

Plot 11 : Dipterocarpus stand



Tree species of plot 11 :
Dipterocarpus costatus (1, 3, 5, 6, 7, 8, 12, 13, 14, 15, 17, 18, 19, 20, 22, 24, 26); Bambusa spinosa (9, 10, 21, 23); Eugenia cochinchinensis (2); Parinari annamensis (11, 25); Walsura robusta (16)