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Structure diversity in three forest types of north-eastern Thailand (Sakaerat Reserve, Pak Tong Chai)

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The aim of the present study is to provide a basic knowledge in view of a better understanding of the global structure of three tropical forests at the Sakaerat Environmental Research Station (Pak Tong Chai district, Northeastern Thailand): a dry dipterocarp forest (DDF), a dry evergreen forest (DEF) and an intermediate stage (DDFwf), characterized by the absence of fire since 29 years in a pyro-climax. These forest ecosystems were contrasted by the composition and floristic structure, the basal area and the tree density. The species richness increases with the passage from the DDF, the most open environment, to the DDFwf, the most densely wooded. By these tree density and basal area, the DDF (602 trees/ha at DBH ≥ 5 cm, 14.2 m^2/ha) and the DEF (992 trees/ha at DBH ≥ 5 cm, 29.0 m^2/ha) studied belong to the typical tropical ecosytems of south-east Asia. The man-made fires and anarchic forest exploitations are a danger for the stability of these different ecosystems.
Keywords. Thailand, Dipterocarpaceae, forest inventory, forest structure, fire.

Diversité structurale de trois types de forêts du nord-est de la Thaïlande (Réserve de Sakaerat, Pak Tong Chai). L'objectif de la présente étude est de mieux connaître la structure de trois forêts tropicales de la Station forestière de recherche environnementale de Sakaerat (district de Pak Tong Chai, nord-est de la Thaïlande) : une forêt sèche à Dipterocarpaceae (DDF), une forêt dense sèche (DEF) et un stade évolutif intermédiaire entre ces deux forêts (DDFwf), caractérisé par l'absence de feu depuis 29 ans au sein du pyro-climax qu'est la DDF. Ces écosystèmes forestiers ont été différenciés par leur composition et structure floristique, leur surface terrière et la densité des tiges. La richesse spécifique augmente de l'environnement le plus ouvert, la DDF, jusqu'au plus densément boisé, la DDFwf. Par leur densité de tiges et leur surface terrière, la DDF (602 tiges d'un DBH ≥ 5 cm, 14,2 m^2/ha) et la DEF (992 tiges d'un DBH ≥ 5 cm, 29,0 m^2/ha) étudiées s'inscrivent parmi les écosystèmes tropicaux typiques du Sud-est asiatique. Les feux d'origine humaine et les exploitations forestières anarchiques sont particulièrement dangereux pour l'équilibre de ces différents écosystèmes forestiers.
Mots-clés. Thaïlande, Dipterocarpaceae, inventaire forestier, structure forestière, feu.

INTRODUCTION

The total surface of Thai forest areas is decreasing at an alarming rate. These rapid and profound changes endanger the species diversity of Thailand forested ecosystems. If the natural balance of the remaining forest ecosystems is to be maintained and shortages of wood avoided there must be a concerted and timely move towards conservation and protection of Thai natural resources. However, before sustainable management strategies to protect forest biodiversity in Thailand can be developed, the structure, the ecology of the many diverse ecosystems, the phenological behaviour and the reproduction strategies of the dominant tree species must be better understood.

In particular, north-eastern Thailand, the region where this present study took place, presents a range of forest ecosystems observed in tropical dry climates. Studies related to these forest types are scarce, in comparison with studies dealing with the tropical rain forest, although their importance at local and regional tropic levels is obvious. Nevertheless some authors, as for example, Nalamphun *et al.* (1968), Sabhasri *et al.* (1968), Sahunalu *et al.* (1979 and 1995), Bunyavejchewin (1983 and 1986), Kiratiprayoon (1986) and Boonraksa (1989) approached their structure, their composition and their functioning.

The aim of the present study is to provide a basic knowledge in view of a better understanding of the global structure of three tropical forests in north-eastern Thailand: a dry dipterocarp forest (DDF), a dry evergreen forest (DEF) and an intermediate stage (DDFwf: DDF without action of fire). Therefore we have established 1 ha plot in each forest and used the

forest inventory technique, focusing in particular on densities and on basal areas of the constituent species.

MATERIALAND METHODS

Site

The study was carried out at the Sakaerat Environmental Research Station (SERS), which is located on the south-east fringe of the Korat Plateau (lat. 14°31' N, long. 101°55' E) in north-eastern Thailand (**Figure 1**). The area encompasses 81 km² of a reserved forest with two dominant forest types, dry evergreen forest (DEF) and dry dipterocarp forest (DDF). The area has also been designated as a biosphere reserve, because it has suffered little disturbance compared to much of the reserved forest area of the country and has been well protected since the establishment of the station in 1967.

Topography, geology and soil characteristics

The topography of the site is mountainous, with slopes ranging from 10 to 30%. The sedimentary rock in this area is a sandstone formed in the Triassic to Cretaceous periods, classified as the Korat geological group (*Phra wihan* formation). The altitude of the area is 200–800 m above sea level. The soil is generally poor, characterized by rock outcrops and dominated by laterite. Upper soil texture is mostly sandy loam, clay loam and sandy clay loam. Soil thickness varies from 70 to 100 cm.

Climate

The climate is monsoonic (Aw_3) and classified as a "Tropical savanna type" according to Köppen, with annual rainfall between 1100–1300 mm. The year may be divided into three seasons i.e. summer, rainy season period and winter. Most precipitations fall during May–October. The coolest weather occurs in November–February, while the hottest occurs during March–May. Winter season constitutes a cool and dry period while summer is hot and dry. The daily mean temperature is 29.0 °C during the hottest month and 18.5 °C during the coldest one, with an annual mean temperature of 26.0 °C. **Figure 2** shows the climatic diagram of Sakaerat (1982–1992). Annual ground fire

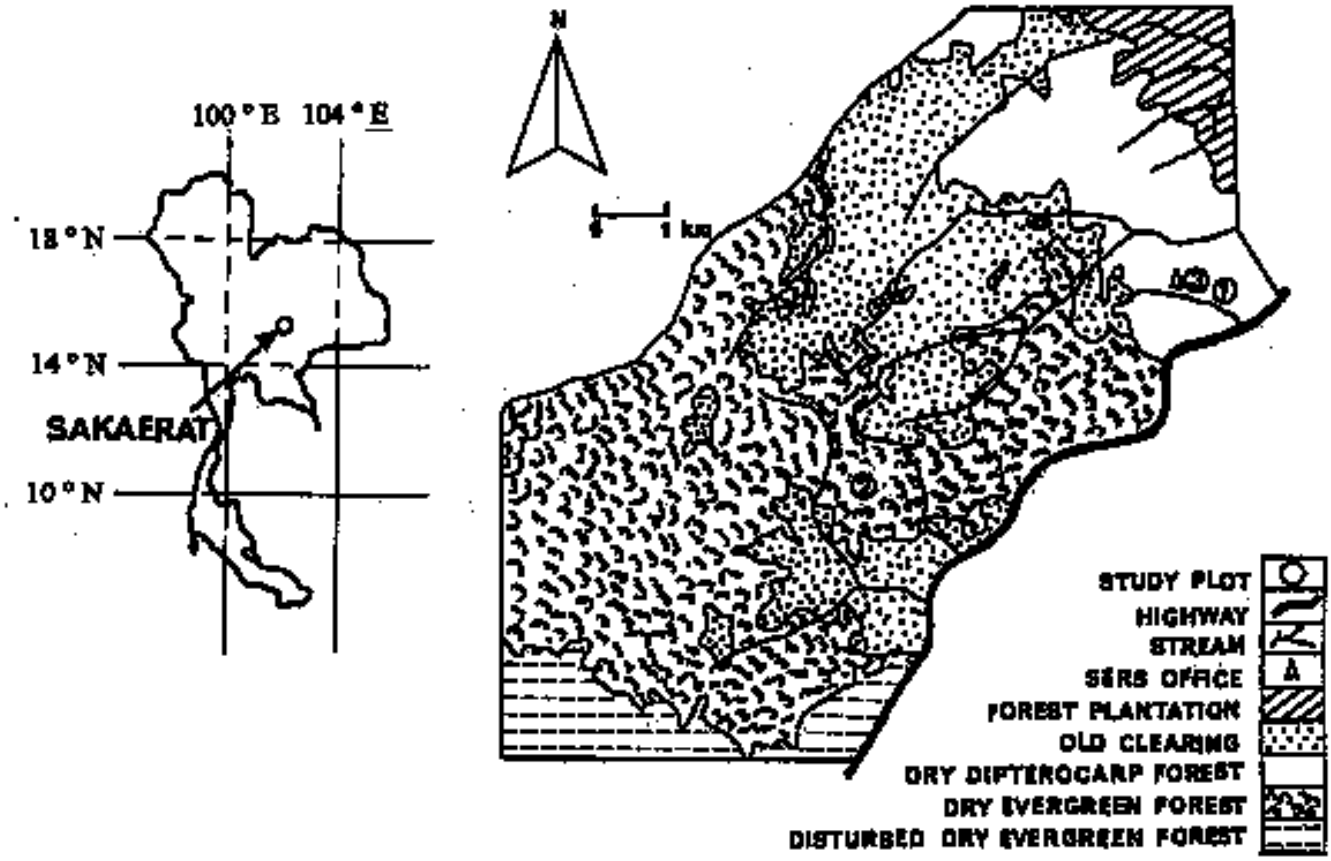

Figure 1. Vegetation map of the Sakaerat Environmental Research Station (SERS) and the location of the three study plots (Sahunalu, Dhanmanonda, 1995) — *Carte de végétation de la Station forestière de recherche environnementale de Sakaerat et localisation des trois parcelles d'étude.*

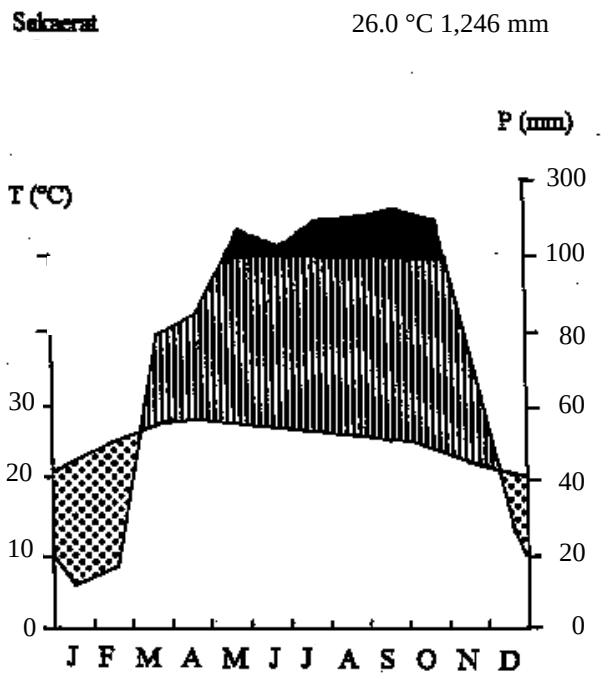

Figure 2. Climatic diagram of Sakaerat (1982–1992) (Sahunalu, Dhanmanonda, 1995) — *Diagramme ombro - thermique de Sakaerat (1982–1992).*

sometimes occurs during the dry season (January –February), especially in the dry dipterocarp forest area and consumes the ground cover of *Arundinaria pusilla*[1] and tree seedlings, but has not been so severe since the area was protected with an extensive network of firelines laid out around the dry dipterocarp forest area of the station.

Vegetation and forest types

Vegetation types of the area are dry evergreen forest (29.5 km² or 36.4%), dry dipterocarp forest (12.2 km² or 15.1%), bamboo forest (1.4 km² or 1.7%), grassland, and an agricultural area (37.9 km² or 46.8%). The dry evergreen forest (DEF) occupies the south-western portion, while the dry dipterocarp forest (DDF) occupies the north-eastern portion of the reserve area, mostly in response to altitude and soil types distribution (Tongyai, 1980). The DDF is a deciduous broad-leaved forest community type occurring on relatively dry sites, and is mainly composed of trees belonging to the Dipterocarpaceae family (Sahunalu, Dhanmanonda, 1995). The DEF is usually referred to as the tropical semi-evergreen rain forest. Tree species in this forest are mainly evergreen, while some shed leaves during the dry season [Bunyavejchewin, 1986].

[1] Complete Latin names are listed in appendix 1.

Plots and collected data

The three study plots of the woody inventory, each 1 ha square, were generally a flat area at 360–535 m above sea level.

Two contrasted plots were just selected, namely a DDF (plot 1) and a DEF (plot 2) type. At last, the choice of the third plot was justified by its particular status: it's a DDF where the fire has been absent since 29 years (DDFWwf). In response to the long absence of fire, its structure and species composition are in evolution.

Each plot was divided into 100, 10 × 10 m quadrats, and all tree with diameter at breast height (DBH) equal to or more than 5 cm were tagged with painted numbers. Circumference measurements were facilitated by the absence of buttresses and grooves.

Stem positions and crown projection area were mapped. Stand profiles were drawn for each randomly selected transect belt of 10 × 30 m.

Detailed analysis gives precise measures of the floristic composition, species density, evolution of the species-area curves, presence, basal area and ecological characteristics.

Species-area curves are a fundamental component of conservation biology and are frequently used to formulate recommendations about species preservation and to predict extinction rates caused by habitat destruction.

Structural characteristics of the three plots were investigated to obtain their basic stand information. The importance value index (IVI), which is the sum of the percentages of relative density, relative frequency and relative dominance, was calculated for each component species of the stands. The relative density (number of individuals of a species versus total number of individuals) and the relative frequency (frequency of the presence of a species in the quadrats compared to the sum of frequencies of all species) were determined from all 10 ×10 m quadrats. The relative dominance was computed from the total basal area at breast height relative to the sum of basal area of all species. Each fraction is expressed in a percentage with a sum of 300 (Mueller-Dombois, Ellenberg, 1974). Furthermore the relative diversity (number of species in a family in comparison with the total diversity observed) is also noted.

RESULTS

Composition and floristic structure

Comparison of the inventories shows wide differences (**Table 1**): 124 woody species were found in the three plots studied, only one of them, *Irvingia oliveri*, was common to all three types. **Table 2** shows that the number of woody species confined in each forest type

Table 1. Evolution of the composition and the basal area (m^2/ha) in the forests: DDF - DDFwf - DEF, n° L= voucher reference, Lamotte collection— *Évolution de la composition et de la surface terrière (m^2/ha) des types forestiers : DDF - DDFwf - DEF.*

N°	Names	DDF	DDFwf	DEF
1	*Quercus kerrii*	0,5342	0	0
2	*Dalbergia dongnaiensis*	0,1314	0	0
3	*Parinari amanense*	0,1285	0	0
4	*Gardenia obtusifolia*	0,0340	0	0
5	Ta noc hoc (n°L1)	0,0091	0	0
6	*Dipterocarpus intricatus*	3,5218	0,5675	0
7	*Shorea obtusa*	3,0094	3,9572	0
8	*Shorea talura*	2,8451	0,0340	0
9	*Pterocarpus macrocarpus*	0,8906	5,3016	0
10	*Sindora siamensis*	0,7517	1,4735	0
11	*Xylia xylocarpa*	0,6268	1,1001	0
12	*Mitragyna brunonis*	0,2368	0,2137	0
13	*Morinda coreia*	0,2305	0,6767	0
14	*Albizia odoratissima*	0,1830	0,7978	0
15	*Shorea siamensis*	0,1588	0,0103	0
16	*Lannea coromandelica*	0,1336	0,7603	0
17	*Bauhinia saccocalyx*	0,1188	0,0805	0
18	*Dalbergia cultrata*	0,1178	0,0265	0
19	*Buchanania latifolia*	0,1086	0,0023	0
20	*Phyllanthus emblica*	0,0756	0,1325	0
21	*Vitex peduncularis*	0,0531	0,2417	0
22	*Petsea membranacea*	0,0417	0,0319	0
23	*Antidesma diandrum*	0,0369	0,1959	0
24	*Ochna integerrima*	0,0328	0,0058	0
25	*Aporusa villosa*	0,0316	0,0414	0
26	*Urena lobata*	0,0273	0,1147	0
27	*Diospyros ehretioides*	0,0168	0,0808	0
28	*Careya sphaeriaca*	0,0140	0,0461	0
29	*Cratoxylum maingayi*	0,0123	2,2378	0
30	Nomsao (n°L2)	0,0046	0,0944	0
31	*Dalbergia nigressens*	0,0042	0,4838	0
32	*Melientha sauvis*	0,0042	0,0020	0
33	*Erythrophleum succirubrum*	0,0035	0,0912	0
34	*Terminalia chebula*	0,0035	0,0110	0
35	*Irvingia oliveri*	0,0108	0,6980	0,0985
36	*Suregata sp.*	0,0058	0	0,1268
37	*Stereospernum neurathum*	0,0050	0	0,1017
38	*Mangifera caloneura*	0	0,5546	0
39	*Gardenia sootepensis*	0	0,5004	0
40	*Canarium subulatum*	0	0,3417	0
41	*Salmalia insignis*	0	0,2757	0
42	*Lagerstroemia sp.1* (n°L36)	0	0,1988	0
43	*Dalbergia oliveri*	0	0,1365	0
44	*Terminalia calamansanai*	0	0,1046	0
45	*Gleditsia sp.*	0	0,0890	0
46	*Sterculia ornata*	0	0,0874	0
47	*Hymenodictyon excelsum*	0	0,0854	0
48	*Lagerstroemia sp.2* (n°L37)	0	0,0726	0
49	*Gmelina asiatica*	0	0,0701	0
50	*Cratoxylum sp.*	0	0,0503	0
51	*Diospyros malabarica*	0	0,0500	0
52	*Polyalthia asteriella*	0	0,0460	0
53	*Litsea glutinosa*	0	0,0446	0
54	*Heterophragma adenophyllum*	0	0,0396	0
55	*Cratoxylum cochinchinensis*	0	0,0382	0
56	*Dalbergia cochinchinensis*	0	0,0300	0
57	*Terminalia tripteroïdes*	0	0,0271	0
58	*Schoutenia hypoleuca*	0	0,0224	0
59	Species 5 (n°L199)	0	0,0202	0
60	*Lagerstroemia loudonii*	0	0,0168	0
61	*Tetrameles nudiflora*	0	0,0165	0
62	*Adina cordifolia*	0	0,0161	0
63	*Diospyros castanea*	0	0,0156	0
64	*Garuga pinnata*	0	0,0147	0
65	*Planchonella sp.*	0	0,0109	0
66	Salao (n°L13)	0	0,0109	0
67	*Gmelina arborea*	0	0,0087	0
68	*Kydia calycina*	0	0,0074	0
69	Mouetdam (n°L3)	0	0,0062	0
70	Takaé (n°L14)	0	0,0055	0
71	*Flacourtia indica*	0	0,0050	0
72	*Zanthoxylum budrunga*	0	0,0050	0
73	*Lagerstroemia sp. 3* (n°L38)	0	0,0035	0
74	*Afzelia xylocarpa*	0	0,0029	0
75	*Ixora sp.*	0	0,0029	0
76	*Adina parvula*	0	0,0020	0
77	*Holoptelea integrifolia*	0	0,0020	0
78	*Randia dasycarpa*	0	0,0020	0
79	Saé Den (n°L15)	0	0,0020	0
80	*Randia wittii*	0	0,1692	0,0890
81	*Croton oblongifolius*	0	0,1134	0,0193
82	*Lagerstroemia duperreana*	0	0,0382	2,2620
83	*Ixora ebarbata*	0	0,0205	0,1913
84	*Celtis timorensis*	0	0,0190	0,0032
85	*Aglaia pirifera*	0	0,0188	0,9531
86	*Walsura trichostemon*	0	0,0128	0,6543
87	*Memecylon caeruleum*	0	0,0084	1,1531
88	*Carallia brachiata*	0	0,0032	0,5439
89	*Meladorum fructicosum*	0	0,0029	0,4255
90	*Diospyros montana*	0	0,0026	0,0127
91	*Hydnocarpus ilicifolius*	0	0,0020	1,3560
92	*Hopea ferrea*	0	0	12,5401
93	*Shorea henryana*	0	0	2,5975
94	Species 1 (n°L4)	0	0	1,0963
95	*Ilex umbellulata*	0	0	0,6903
96	*Parkia speciosa*	0	0	0,5484
97	*Syzygium grande*	0	0	0,5039
98	*Memecylon ovatum*	0	0	0,4915
99	*Grewia paniculata*	0	0	0,4803
100	Dengdon (n°L5)	0	0	0,4476
101	*Peltophorum dasyrachis*	0	0	0,3124
102	*Garcinia cornea*	*0*	*0*	*0,2253*
103	*Dehaasia kerrii*	0	0	0,2224
104	*Xerospermum intermedia*	0	0	0,2044
105	*Ailanthus fauveliane*	0	0	0,1043
106	*Eriobotrya bengalensis*	0	0	0,0968
107	*Chaetocarpus castanocarpus*	0	0	0,0617
108	*Anogeissus acuminata*	0	0	0,0563
109	*Knema globularia*	0	0	0,0509
110	Namkilet (n°L6)	0	0	0,0485
111	*Pterospermum acerifolium*	0	0	0,0483
112	*Linociera microstigma*	0	0	0,0324
113	*Quercus oidocarpa*	0	0	0,0284
114	*Guioa squamosa*	0	0	0,0264
115	*Dialium cochinchinensis*	0	0	0,0210
116	*Cleidion javanicum*	0	0	0,0170
117	*Cinnamomum parthenoxylon*	0	0	0,0122
118	*Garcinia cowa*	0	0	0,0111
119	*Nephelium hypoleucum*	0	0	0,0098
120	*Eugenia aequea*	0	0	0,0086
121	Maypa (n°L191)	0	0	0,0072
122	*Diospyros areolata*	0	0	0,0061
123	Moli (n°L192)	0	0	0,0035
124	Somkoum (n°L7)	0	0	0,0032
TOTAL AREA(m^2/ha)		**14,1547**	**22,9638**	**29,0041**
Total number of species		**37**	**84**	**48**

Table 2. Distribution patterns of woody species in the different forests: DDF - DDFwf - DEF — *Modèles de distribution des espèces forestières au sein des trois écosystèmes : DDF - DDFwf - DEF.*

DDF	DDFwf	DEF	Number of species
abundant	-	-	5
present	rare	-	1
rare	present	-	28
rare	present	rare	1
rare	-	present	2
-	abundant	-	42
-	present	rare	2
-	rare	present	10
-	-	abundant	33
Total			124

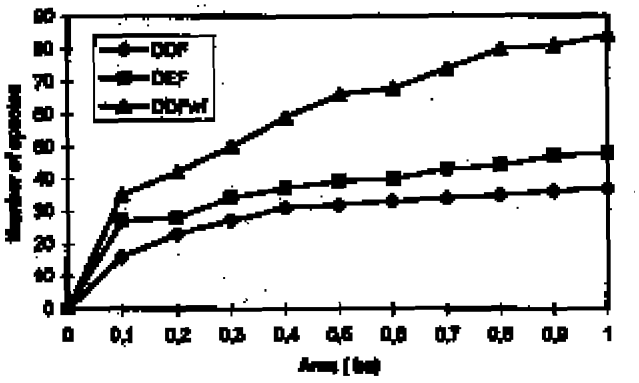

Figure 3. Comparison of species richness (N) according to the area sampled in the different forests: DDF - DDFwf - DEF — *Évolution de la richesse spécifique (N) par rapport à la surface échantillonnée au sein des différentes forêts : DDF - DDFwf - DEF*.

is very variable. Whereas the DEF possesses its own very diversified core (33 spp., 26.61%), the DDF has just five specific species (4.03%) while the DDFwf has 42 specific species (38.87%). However the two last types share a large common core (30 spp., 23.39%) reflecting their same origin.

Figure 3 defines the evolution of the floristic diversity in three vegetation types in terms of the number of species inventoried. These species-area curves indicate that species richness increases with the passage from the DDF, the most open environment, to the DDFwf, the most densely wooded. It's clear that the minimum diversity area is not yet reached in the three plots. The particular richness of the DDFwf needs some further comments. This type harbours a mosaic of ecological groups expressed in three of the main distribution patterns presented in **table 2**. Nevertheless the typical core (42 species) amounts to the largest value. Recordingly, it appears that a lot of dense forest pioneers are well represented here and disappear or become weak in climax stages.

For each type of vegetation, a profile diagram was drawn showing individual position and height; species names were recorded.

The DDF is characterized by the sparsely distributed trees and the crown cover is more or less open on two layers. The upper layer is 11–15 m high, with the dominant species being *Shorea talura, Shorea obtusa* and *Dipterocarpus intricatus*. The lower layer is commonly 4–10 m high, and important species include *Quercus kerrii, Mitragyna brunonis, Xylia xylocarpa, Morinda coreia* and *Lannea coromandelica.* The undergrowth and the forest floor are generally composed of tree saplings, dwarf bamboo-like grass (*Arundinaria pusilla*) and cycads (*Cycas siamensis*). Climbers are present but their occurrence is considered to be unusual (**Figure 4**).

The DEF has a dense, vine-tangled, three-layer canopy. Tree species in this forest are mainly evergreen. The top-storied trees have straight, clear boles and large girth with wide-spreading crowns. The crown canopy is continuous and surimposed owing to the high density of trees. The forest profile is normally composed of trees of small to medium size with straight stems, divided as follows: the upper layer is 23–38 m high and consists of dominant species, such as *Hopea ferrea, Shorea henryana, Irvingia oliveri* and *Lagerstroemia duppereana.* The middle layer is 16–22 m high, the majority of trees being in the small sizes. Their crown canopy is also continuous and superimposed, forming a second canopy. Important species are *Hydnocarpus ilicifolius, Walsura trichostenon, Memecylon caeruleum* and *Aglaia pirifera*. The lower layer, 4–14 m high, is dominated by *Memecylon ovatum, Ixora ebarbata* and *Randia wittii*. The undergrowth and the forest floor are generally composed of seedlings, leafy shrubs and many woody climbers. Penetration is largely impeded (**Figure 5**).

The vertical structure of the third forest type (DDFwf) can be divided into two layers. An upper layer with tree heights of 10–14 m and characteristic tree species such as *Pterocarpus macrocarpus, Sindora siamensis, Shorea obtusa* and *Albizia odoratissima.* A lower layer of 4–9 m height including as dominant tree species *Xylia xylocarpa, Cratoxylum maingayi, Lannea coromandelica* and *Gardenia sootepensis* (**Figure 6**). Very few bamboo-like grasses (*Arundinaria pusilla*) grow under this forest canopy, but many seedlings of woody species and climbers are present.

Presence, density and total basal area

Table 1 shows the total basal area observed in the three plots. At DBH ≥ 5 cm, it reaches 14.16 m²/ha in

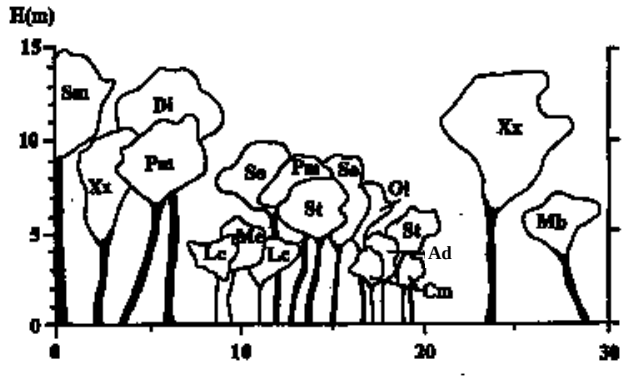

Figure 4. Profile diagram illustrating one strip of the DDF (30 × 10 m) — *Profil vertical illustrant un transect de la DDF (30 × 10 m)*.
Ad: *Antidesma diandrum*, Cm: *Cratoxylum maingayi*, Di: *Dipterocarpus intricatus*, Lc: *Lannea coromandelica*, Mb: *Mitragyna brunonis*, Mc: *Morinda coreia*, Oi: *Ochna integerrima*, Pm: *Pterocarpus macrocarpus*, Sm: *Sindora maritima*, So: *Shorea obtusa*, Xx: *Xylia xylocarpa*.

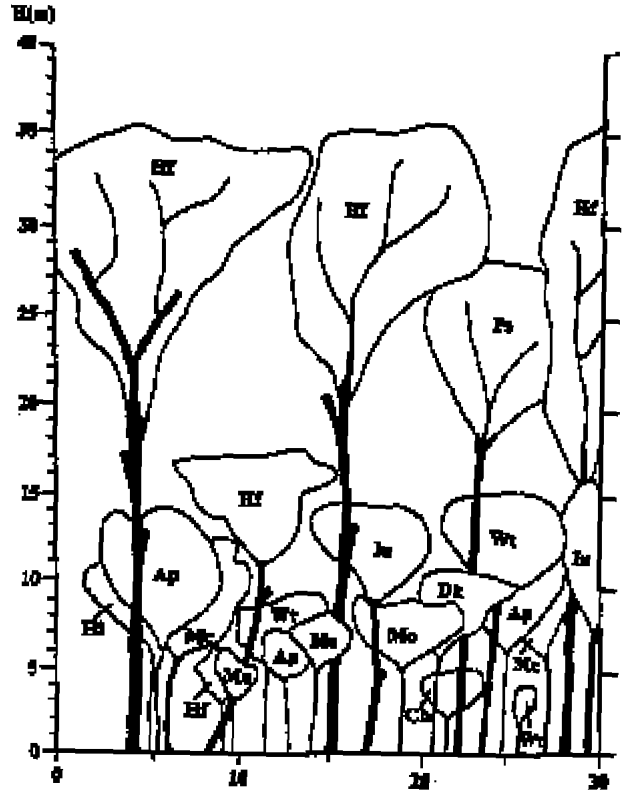

Figure 5. Profile diagram illustrating one strip of the DEF (30 × 10 m) — *Profil vertical illustrant un transect de la DEF (30 × 10 m).*
Ap: *Aglaia pirifera*, Cb: *Carallia brachiata*, Dk: *Dehaasia kerii*, Hf: *Hopea ferrea*, Hi: *Hydnocarpus ilicifolius*, Iu: *Ilex umbellulata*, Mc: *Memecylon caeruleum*, Mo: *Memecylon ovatum*, Ps: *Parkia speciosa*, Wt: *Walsura trichostemon*.

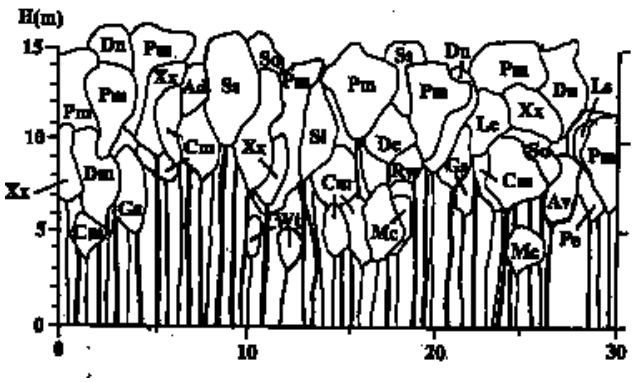

Figure 6. Profile diagram illustrating one strip of the DDFwf (30 × 10 m) — *Profil vertical illustrant un transect de la DDFwf (30 × 10 m).*
Ad: *Antidesma diandrum*, Av: *Apurosa villosa*, Cm: *Cratoxylum maingayi*, Dc: *Dalbergia cultrata*, Dm: *Diospyros malabarica*, Dn: *Dalbergia nigressens*, Gs: *Gleditsia sp.*, Lc: *Lannea coromandelica*, Ls: *Lagerstroemia sp.*, Mc: *Memecylon caeruleum*, Pe: *Phyllantus emblica*, Pm: *Pterocarpus macrocarpus*, Rw: *Randia witii*, Si: *Salmalia insignis*, So: *Shorea obtusa*, Ss: *Sindora siamensis*, Wt: *Walsura trichostemon*, Xx: *Xylia xylocarpa*

the DDF, 22.96 m²/ha in the DDFwf and 29.00 m²/ha in the DEF, with a number of tree species of 37, 84 and 48, respectively. If all stems over 5 cm in DBH are taken into consideration, the density is highest in DDFwf, being 1,769 stems/ha, in DEF: 992 stems/ha and in DDF: 602 stems/ha; thus respectively a ratio of 3.24, 1.65 and 1. The number of trees diminishes along the gradient from the most wooded environment (DDFwf) to the most open one (DDF). It should be noted that the total number of trees, in other studies published to date, appears to vary very widely in tropical forests as a result of differences in vegetation type, site, spatial distribution pattern and stage of development. Lastly, another source of variation consists in the height of the trees and the minimal DBH value taken into consideration by various authors (Malaisse, 1982). **Appendix 2** gathers several data related to tropical forest ecosystems of South-east Asia. Stem densities (≥ 4.5 cm in DBH) are comprised between 731 and 1,154 ha for south Asian dry evergreen forests. Whereas basal area values range from 27.5 to 32.2 m²/ha.

Floristic and phytomass structure

The floristic and phytomass structure of a stand can simultaneously be expressed by the species-dominance curve, which represents the contribution of each species to the stand basal area. The species are plotted in decreasing order of their contribution to total basal area (Brunig, Klinge, 1976). The species-dominance of the three biotopes are shown in **figure 7**.

Once more, DDFwf possesses a particular position with a curve showing the flattest trend, thus suggesting that competitive exclusion is weak and that random distribution of ecological niches prevails.

Importance value index (IVI)

Species composition of the three forests together with their importance value indices (IVI) for the 10 most important families are listed in **tables 3, 4 and 5**.

In the DDF, a large number of species belong to the Dipterocarpaceae.

The dominant families were the Dipterocarpaceae in the DDF and in the DEF although species are not the same, and the Fabaceae in the DDFwf. The IVI for each of the dominant families was 155.4, 85.0 and 66.5, respectively. It should be noted that, at present stage of evolution, the Clusiaceae family is important in the intermediate stage (DDFwf) but these species are only undergrowth species, with a low diameter.

DISCUSSION

This study revealed the importance of the forest dynamics in dry forests of Thailand. The DDF and the DEF are two very different ecosystems while existing in similar climatic regions. Fire is a principal factor controlling the DDF and is believed to be the most important factor for maintaining the forest structure and species composition. Stott (1988a; 1988b) qualified the Dipterocarp forests as being strongly adapted, phenologically, physionomically and physiologically, to the dry season burns which so characterize their environment. Sabhasri *et al.* (1968) recognized the DDF as a pyro-climax forest because, if it is well protected from fire, tree species belonging to more mesic forest types will invade the DDF. Thus the DDFwf plot is an intermediate stage in the succession bringing about a new steady state, the DEF. The very high number of species in DDFwf may be explained by the coexistence of pioneer species from DEF, characteristic species of this transitional state and, lastly few typical species of the DDF which are destined to finally disappear.

The analysis of species-area curves shows that preserved areas against the effect of fire must be higher than 1 ha to maintain the specific diversity. Generally the DEF and the DDF lands must be preserved in pockets and areas similar to the SERS. These two forest types should be allowed to be exploited under a selective harvesting scheme which would take out only those individual trees which have reached specific sizes, thus establishing a natural continuance of harvesting according to the principle of maximum sustained yields.

This study revealed also a need for controlling ground fires within dry dipterocarp forests which are adjacent to dry evergreen forests. Such fires destroyed both seedlings and saplings as borders of more dense patches which support the expansion of the boundaries of the DEF. The ground fire control would also assist in the re-establishment and strengthening of existant DDF within the SERS. However, the majority of the fires are man-made deliberate or accidental burns,

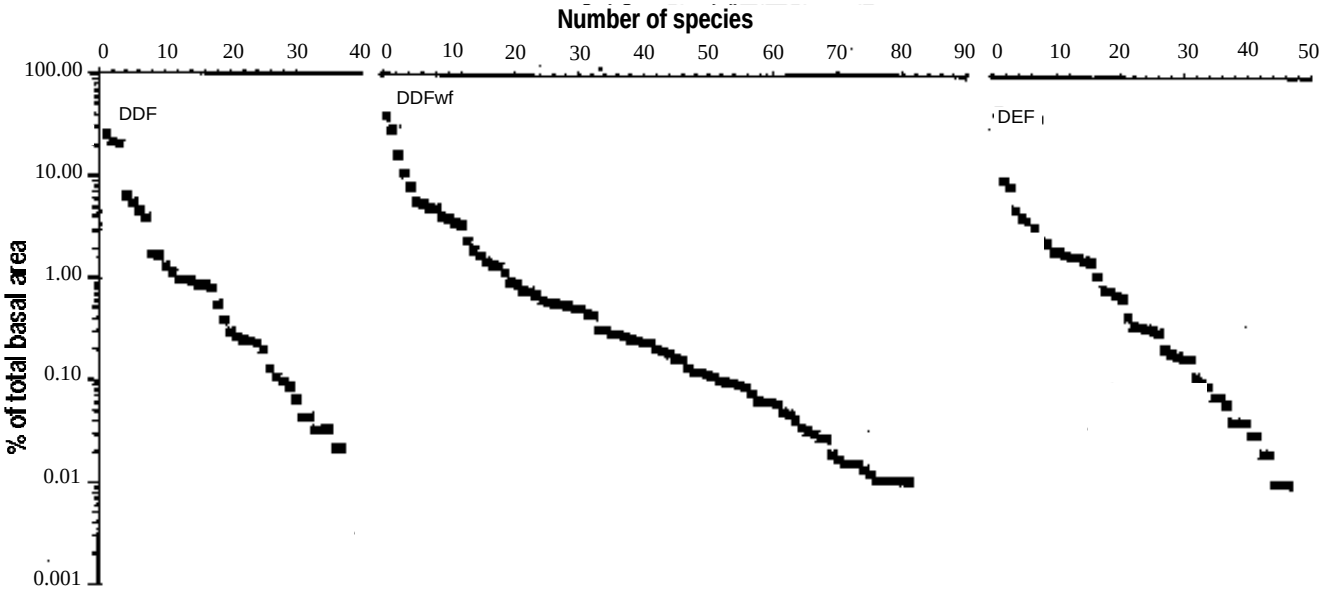

Figure 7. Dominance – diversity curves for the three types of vegetation: DDF – DDFwf – DEF — *Courbes illustrant la dominance et la diversité pour les trois types de végétation : DDF – DDFwf – DEF*.

Table 3. Importance value index (IVI) for the 10 ecologically most important families of the DDF in SERS — *Indice d'importance familiale (IVI) pour les 10 familles les plus importantes écologiquement de la DDF au SERS.*

N°	Family	Number of species	Number of stems	Basal area (m^2)	Relative frequence	Relative diversity	Relative density	Relative dominance	IVI
1	*Dipterocarpaceae*	4	302	9,5351	37,84	10,81	50,17	67,36	155,4
2	*Fabaceae*	4	67	1,1440	13,28	10,81	11,13	8,08	32,5
3	*Mimosaceae*	2	60	0,8098	13,03	5,41	9,97	5,72	28,7
4	*Rubiaceae*	3	49	0,5013	10,53	8,11	8,14	3,54	22,2
5	*Caesalpinaceae*	3	28	0,8741	5,26	8,11	4,65	6,18	16,1
6	*Anacardiaceae*	2	26	0,2421	5,01	5,41	4,32	1,71	11,0
7	*Fagaceae*	1	21	0,5342	3,76	2,70	3,49	3,77	11,0
8	*Euphorbiaceae*	3	18	0,1442	4,01	8,11	2,99	1,02	8,0
9	*Verbenaceae*	1	4	0,0531	1,00	2,70	0,66	0,38	2,0
10	*Chrysobalanaceae*	1	3	0,1285	0,50	2,70	0,50	0,91	1,9
11	Remaining families	13	24	0,1835	5,76	35,14	3,99	1,33	11,1
	Total	37	602	14,1545	100,00	100,00	100,00	100,00	300,0

Table 4. Importance value index (IVI) for the 10 ecologically most important families of the DDFwf in SERS — *Indice d'importance familiale (IVI) pour les 10 familles les plus importantes écologiquement de la DDFwf au SERS*.

N°	Family	Number of species	Number of stems	Basal area (m^2)	Relative frequence	Relative diversity	Relative density	Relative dominance	IVI
1	*Fabaceae*	6	388	6,0675	18,14	7,14	21,93	26,42	66,5
2	*Clusiaceae*	3	326	2,3263	8,53	3,57	18,43	10,13	37,1
3	*Rubiaceae*	10	189	1,6890	13,99	11,90	10,68	7,35	32,0
4	*Dipterocarpaceae*	4	87	4,5690	6,78	4,76	4,92	19,90	31,6
5	*Mimosaceae*	3	187	1,9008	11,37	3,57	10,57	8,28	30,2
6	*Caesalpinaceae*	3	82	1,6452	5,90	3,57	4,64	7,16	17,7
7	*Anacardiaceae*	3	121	1,3172	3,50	3,57	6,84	5,74	16,1
8	*Euphorbiaceae*	3	57	0,2873	7,10	3,57	3,22	1,25	11,6
9	*Lythraceae*	5	26	0,3299	1,86	5,95	1,47	1,44	4,8
10	*Ebenaceae*	4	26	0,1490	2,40	4,76	1,47	0,65	4,5
11	Remaining families	40	280	2,6825	20,44	47,62	15,83	11,68	47,9
	Total	84	1769	22,9638	100,00	100,00	100,00	100,00	300,0

Table 5. Importance value index (IVI) for the 10 ecologically most important families of the DEF in SERS — *Indice d'importance familiale (IVI) pour les 10 familles les plus importantes écologiquement de la DEF au SERS*.

N°	Family	Number of species	Number of stems	Basal area (m^2)	Relative frequence	Relative diversity	Relative density	Relative dominance	IVI
1	*Dipterocarpaceae*	2	179	15,1377	14,81	4,17	18,04	52,19	85,0
2	*Meliaceae*	2	174	1,6074	15,98	4,17	17,54	5,54	39,1
3	*Memecylaceae*	2	148	1,6446	14,37	4,17	14,92	5,67	35,0
4	*Flacourtiaceae*	1	99	1,3560	9,53	2,08	9,98	4,68	24,2
5	unknown	1	40	1,0963	4,99	2,08	4,03	3,78	12,8
6	*Lythraceae*	1	11	2,2620	1,61	2,08	1,11	7,80	10,5
7	*Rubiaceae*	2	47	0,2802	4,40	4,17	4,74	0,97	10,1
8	*Aquifoliaceae*	1	32	0,6903	4,11	2,08	3,23	2,38	9,7
9	*Rhizophoraceae*	1	33	0,5439	3,81	2,08	3,33	1,88	9,0
10	*Clusiaceae*	2	29	0,2364	3,37	4,17	2,92	0,82	7,1
11	Remaining families	33	200	4,1493	23,02	68,75	20,16	14,31	57,5
	Total	48	992	29,0041	100,00	100,00	100,00	100,00	300,0

although natural fires do occur, particularly on dry ridges. The main fuel for the fires is provided by the leaves shed during the early part of the dry season and the groundcover of grasses, pygmy bamboos (*Arundinaria pusilla*), sedges, herbs, seedlings and small shrubs, particularly when the grasses have dried out, later in the season. Such ground fires appeared to be difficult to control where human economic and social activities continued to be evident notably, in areas adjacent to the reserve. Indeed, deforestation, in general, has been caused by shifting cultivation and log poaching which has developed into one of the gravest factors in the socio-economic security of the peoples of Thailand. Also to prevent further exploitation, the restoration and protection of these forest types in Thailand are urgently needed.

Bibliography

Boonraksa W. (1989). *Distribution pattern, gap formation and turnover time in dry evergreen forest at Sakaerat*. Thesis, Kasetsart Univ., Bangkok, 98 p. (in Thai, abstract in English)

Brunig EF., Klinge H. (1976). Comparison of the phytomass structure of equatorial “Rain Forest” in Central Amazonas, Brazil, and in Sarawak, Borneo. *Gard. Bull.* (Singapore), **39**, p. 81–101.

Bunyavejchewin S. (1983). Canopy structure of the dry dipterocarp forest of Thailand. *Thai For. Bull. Bot.* **14**, p. 1–93.

Bunyavejchewin S. (1986). Ecological studies of tropical semi-evergreen rain forest at Sakaerat, Nakhon Ratchasima, Northeast Thailand : 1. Vegetation patterns. *Nat. Hist. Bull. Siam Soc.* **34** (1), p. 35–57.

Kajornsrichon S. (1988). *Some ecological characteristics of natural pine stands at Ban Wat Chan Royal Project, Amphoe Mae Cham, Cahngwat Chiang Mai*. M. Sci. Thesis, Kasetsart University, Bangkok, 171 p. (in Thai)

Kiratiprayoon S. (1986). *Comparative study on the structure of the rattan bearing tropical rain forest*. M. Sci. Thesis, Kasetsart University, Bangkok.

Malaisse F. (1982). Comparison of the woody structure in a regressive zambezian succession: dry evergreen forest - open forest - wooded savanna (Luiswishi, Shaba, Zaïre). *Geo-Eco-Trop* **6** (4), p. 309–350.

Nalamphun A., Santisuk T., Smitinand T., Chaiyandand C. (1968). *Inventory of one hectare (100m × 100m plot) centred on forest tower, ASRCT. Sakaerat Experiment Station (Amphoe Pak Thong Chai, Changwat Nakhon Ratchasima)*. Report n°3. Bangkok: ASRCT, 13 p.

Mueller-Dombois D., Ellenberg H. (1974). *Aims and Methods of Vegetation Ecology.* New-York: John Wiley & Sons.

Ogawa H., Yoda K., Kira T. (1961). A preliminary survey of the vegetation in Thailand. *Nat. Life Southeast Asia* **1**, p. 22–157.

Ogawa H., Yoda K., Ogino K., Kira T. (1965). Comparative ecological studies on three main types of forest vegetation in Thailand. II. Plant biomass. *Nat. Life Southeast Asia* **4**, p. 49–80.

Proctor J., Anderson JM., Chai P., Vallack HW. (1983). Ecological studies in four contrasting lowland rain forests in Gunung Mulu National Park, Sarawak. I. Forest environment, structure and floristics. *J. Ecol.* **71** (1), p. 237–260.

Sabhasri P., Boonmittee A., Khemnark C., Aksornkoae S. (1968). *Structure and floristic composition of forest vegetation at Sakaerat, Pak Thong Chai, Nakorn Ratchasima: I. Variation of floristic composition along transect through dry evergreen and dry dipterocarp forest.* Bangkok: ASRCT, 18 p.

Sahunalu P., Dhanmanonda P., Puriyakorn B., Jamroenprucksa M., Suwannapinunt W., Prachaiyo B. (1979). Comparative strutural characteristics of three forest types at Namprom Basin, Chaiyaphoom Province (Th.). *For. Res. Bull.* **63**, p. 25–33 (in Thai, abstract in English)

Sahunalu P., Dhanmanonda P. (1995). Structure and dynamics of dry dipterocarp forest, Sakaerat, northeastern Thailand. *In* Box EO., Peet RK., Masuzawa T., Yamada I., Fujiwara K., Maycock PF. (eds), *Vegetation science in forestry: global perspective based on forest ecosystems of East and Southeast Asia.* Dordrecht, Netherland : Kluwer Academic Publishers, p. 465–494.

Stott P. (1988a). Savanna forest and seasonal fire in South-East Asia. *Plants today* (Nov-Dec), p. 196–200.

Stott P. (1988b). The forest as a phoenix: towards a biogeography of fire in mainland Southeast Asia. *Geogr. J.* **154** (3), p. 337–350.

Tongyai MLP. (1980). *The Sakaerat Environmental Research Station: Its role as a knowledge base for the determination of forest lands conservation policies for establishing maximum sustained yields on forest resources.* NRC/ KU/ TISTR, submitted to UNESCO/ MAB. Programme, Bangkok, 230 p.

Vannaprasert M. (1985). *Structural characteristics and gap size distribution of the hill evergreen forest at Doi Pui, Chiang Mai*. M. Sci. Thesis, Kasetsart University, Bangkok. (in Thai)

Visaratana T. (1983). *Structural characteristics and canopy gap regeneration of the dry evergreen forest at Sakaerat Environmental Research Station*. M. Sci. Thesis, Kasetsart University, Bangkok. (in Thai)

Visaratana T., Pitprecha K., Kiratiprayoon S., Kampan T., Higuchi K. (1986). Structural characteristics and species composition of dry dipterocarp forest (*Dipterocarpus tuberculatus Roxb.* Community type) at Salak Phra Wildlife Sanctuary. Technical paper n°10, Forest Ecology Section, RFD. (in Thai)

(21 ref.)

Appendix 1. List of different species observed in the three forests — *Liste des différentes espèces observées au sein des trois forêts.*

Family	Latin name	Vernacularname
Anacardiaceae	*Buchanania latifolia* Roxb.	Mamouang
Anacardiaceae	*Mangifera caloneura* Kurz.	Mamouang Pa
Anarcardiaceae	*Lannea coromandelica* Merr.	Couks
Annonaceae	*Meladorum fructicosum* Lour.	Lamdouan
Annonaceae	*Polyalthia asteriella* Ridl.	Yang Daun
Aquifoliaceae	*Ilex umbellulata* Loes.	Naonaé
Bignoniaceae	*Stereospernum neuranthum* Kurz.	Kay Saé
Bignoniaceae	*Heterophragma adenophyllum* Benth.	Kayhankan
Bombacaceae	*Bombax insigne* Pierre	Nioupa
Burseraceae	*Canarium subulatum* Guillaum.	Makockun
Burseraceae	*Garuga pinnata* Roxb.	Takam
Caesalpinaceae	*Bauhinia saccocalyx* Pierre	Siopa
Caesalpinaceae	*Erythrophleum succirubrum* Gagnep	Pansad
Caesalpinaceae	*Sindora siamensis* Teysmann ex Miquel	Makatè
Caesalpinaceae	*Peltophorum dasyrachis* Kurz.	Allaang
Caesalpinaceae	*Dialium cochinchinensis* Pierre	Nangdam
Celastraceae	*Suregata* sp.	Katongpahiabad
Chrysobalanaceae	*Parinari amanense* Hance	Kapoc
Clusiaceae	*Cratoxylum cochinchinensis* Pierre	Tao Kao
Clusiaceae	*Cratoxylum maingayi* Dyer	Tao Deng
Clusiaceae	*Cratoxylum* sp.	Tao Pio
Clusiaceae	*Garcinia cornea* Roxb.	Pahoua
Clusiaceae	*Garcinia cowa* Roxb.	Sommong
Combretaceae	*Anogeissus acuminata* Wall.	Takien No
Combretaceae	*Terminalia calamansanai* Rolfe.	*Sacouni*
Combretaceae	*Terminalia chebula* Retz.	Samoy Taé
Combretaceae	*Terminalia triptera* Stapf	Namkaé
Dipterocarpaceae	*Dipterocarpus intricatus* Dyer	Hieng
Dipterocarpaceae	*Hopea ferrea* Pierre	Takien Hin
Dipterocarpaceae	*Shorea henryana* Pierre	Kiem Kanong
Dipterocarpaceae	*Shorea obtusa* Wall.	Teng
Dipterocarpaceae	*Shorea siamensis* Miq.	Rang
Dipterocarpaceae	*Shorea talura* Roxb.	Payom
Ebenaceae	*Diospyros areolata* King & Gamble	Pap
Ebenaceae	*Diospyros castanea* Fletcher	Takopanon
Ebenaceae	*Diospyros ehretioides* Wall. ex G.Don	Taptaoton
Ebenaceae	*Diospyros malabarica* Kostel.	Takosouan
Ebenaceae	*Diospyros montana* Roxb.	Tanfayipi
Euphorbiaceae	*Chaetocarpus castanocarpus* Thw.	Sampao
Euphorbiaceae	*Croton oblongifolius* Roxb.	Paohia Hé
Euphorbiaceae	*Aporusa villosa* H.Bn.	Mouetlaud
Euphorbiaceae	*Phyllanthus emblica* L.	Makanpom
Euphorbiaceae	*Antidesma diandrum* Roth.	Kaomao
Euphorbiaceae	*Cleidion javanicum* Pl.	Dymi
Fabaceae	*Gleditsia* sp.	Samad
Fabaceae	*Dalbergia cochinchinensis* Pierre	Payoumg
Fabaceae	*Dalbergia cultrata* Grah. ex Benth.	Getdam
Fabaceae	*Dalbergia dongnaiensis* Pierre	Kapiikaokouai
Fabaceae	*Dalbergia nigressens* Kurz.	Tchen Nouang
Fabaceae	*Dalbergia oliveri* Gamble ex Prain	Chintchan
Fabaceae	*Pterocarpus macrocarpus* Kurz.	Pradu
Fabaceae	*Quercus kerrii* Craib.	Kor Paè
Fabaceae	*Quercus oidocarpa* Korth.	Kor Louet
Flacourtiaceae	*Flacourtia indica* Merr.	Tacop
Flacourtiaceae	*Hydnocarpus ilicifolius* King	Kabaokak
Ixonanthaceae	*Irvingia oliveri* Pierre	Krabok
Lauraceae	*Cinnamomum parthenoxylon* Kurz.	Tchouang
Lauraceae	*Dehaasia kerrii* Kosterm.	Sihaibaiyai
Lauraceae	*Litsea glutinosa* Pierre	Miman
Lauraceae	*Petsea membranacea* Roxb.	Yet
Lecythidaceae	*Careya sphaeriaca* Roxb.	Kadon
Lythraceae	*Lagerstroemia duperreana* Pierre	Tabag Prukbang
Lythraceae	*Lagerstroemia loudonii* Teijsm.	Hintenin
Lythraceae	*Lagerstroemia* sp.1 (n°L36)	Tabag
Lythraceae	*Lagerstroemia* sp.2 (n°L37)	Sélabayleg
Lythraceae	*Lagerstroemia* sp.3 (n°L38)	Sélaprukbang
Malvaceae	*Kydia calycina* Roxb.	Lihangman
Malvaceae	*Urena lobata* L.	Nanuang
Meliaceae	*Aglaia pirifera* Hance	Kankao
Meliaceae	*Walsura trichostemon* Miq.	Katleen
Memecylaceae	*Memecylon caeruleum* Jack.	Pongbayleg
Memecylaceae	*Memecylon ovatum* JE.Smith	Pongbayai
Mimosaceae	*Parkia speciosa* Hassk.	Krating Dong
Mimosaceae	*Afzelia xylocarpa* Craib.	Makamong
Mimosaceae	*Albizia odoratissima* Benth.	Kankimoid
Mimosaceae	*Xylia xylocarpa* Taubert	Daeng
Myristiaceae	*Knema globularia* Warb.	Loudlet
Myrtaceae	*Eugenia aequea* Burm. F.	Chompopa
Myrtaceae	*Syzygium grande* Wight	Houadong
Ochnaceae	*Ochna integerrima* Merr.	Katchè
Oleaceae	*Linociera microstigma* Gagnep.	Kadongden
Opiliaceae	*Melientha sauvis* Pierre	Pac One
Rhizophoraceae	*Carallia brachiata* Merr.	Kiem Kanong Hé
Rosaceae	*Eriobotrya bengalensis* Hook.	Takaonam
Rubiaceae	*Adina cordifolia* Hook.	Kwouaho
Rubiaceae	*Adina parvula* Geddes.	Komin
Rubiaceae	*Gardenia obtusifolia* Roxb.	Kamoknioy
Rubiaceae	*Gardenia sootepensis* Hutch.	Kamokluang
Rubiaceae	*Ixora ebarbata* Craib.	Kimkao
Rubiaceae	*Ixora* sp.	Kim
Rubiaceae	*Mitragyna brunonis* Craib.	Katom
Rubiaceae	*Morinda coreia* Ham.	Hyopa
Rubiaceae	*Randia dasycarpa* Roxb.	Namlowiang
Rubiaceae	*Randia wittii* Craib.	Mamoo
Rubiaceae	*Hymenodictyon excelsum* Wall.	Oulog
Rutaceae	*Zanthoxylum budrunga* Kurz.	Mahen
Sapindaceae	*Guioa squamosa* Radlk.	Moken
Sapindaceae	*Xerospermum intermedium* Radlk.	Kor Hia
Sapindaceae	*Nephelium hypoleucum* Kurz.	Kor Len
Sapotaceae	*Planchonella* sp.	Tansien
Simaroubaceae	*Ailanthus fauveliana* Pierre	Langkao
Sterculiaceae	*Pterospermum acerifolium* Willd.	Kananping
Sterculiaceae	*Sterculia ornata* Wall.	Podaeng
Tetramelaceae	*Tetrameles nudiflora* R. Br.	Sompong
Tiliaceae	*Grewia paniculata* Roxb.	Papa
Tiliaceae	*Schoutenia hypoleuca* Pierre	Daeng Saké
Ulmaceae	*Celtis timorensis* Span.	Tchetkonpalouang
Ulmaceae	*Holoptelea integrifolia* Pl.	Katchao
Verbenaceae	*Gmelina arborea* Roxb.	Soho
Verbenaceae	*Gmelina asiatica* L.	Songméo
Verbenaceae	*Vitex peduncularis* Wall.	Kasanpic

Appendix 2. Comparison of tropical forest ecosystems of south-east Asia regarding basal area and tree density — *Comparaison de la densité de tiges et de la surface terrière des écosystèmes forestiers d'Asie du Sud-Est.*

Forest ecosystem	**Locality** (country)	**Restrictions of size**	**Basal area** (m^2/ha)	**Tree density** (n° tree/ha)	**References**
Tropical Rain Forest (*Shorea* spp.)	Gunung Mulu (Sarawak)	> 1 m in height	61.8		Proctor *et al.* (1983)
Tropical Rain Forest (*Calophyllum* sp.)	Gunung Mulu (Sarawak)	> 1 m in height	50.9		Proctor *et al* .(1983)
Tropical Rain Forest (*Hopea* sp.)	Gunung Mulu (Sarawak)	> 1 m in height	42.1		Proctor *et al.* (1983)
Tropical Rain Forest	Khao-Chong (Thailand)	DBH > 4.5 cm	38.3		Ogawa *et al.* (1965)
Tropical Rain Forest (*Bhesa* sp.)	Gunung Mulu (Sarawak)	> 1 m in height	36.3		Proctor *et al.* (1983)
Tropical Rain Forest	South Thailand	DBH > 4.5 cm		818–1540	Kiratiprayoon (1986)
Evergreen Gallery Forest	Mae Hoi River (Thailand)	DBH > 4.5 cm	82.8	16200	Ogawa *et al.* (1961)
Hill Evergreen Forest	Doi Pui (Thailand)	DBH > 4.5 cm		726	Vannaprasert (1985)
Monsoon Forest	Ping Kong (Thailand)	DBH > 4.5 cm	36.2		Ogawa *et al.* (1965)
DEF	Sakaerat (Thailand)	DBH > 4.5 cm		731	Visaratana (1983)
DEF	Sakaerat (Thailand)	DBH ≥ 5 cm	29.0	992	This study
DEF	Namphrom Basin (Thailand)	DBH > 4.5 cm	27.5	1088	Sahunalu *et al.* (1979)
DEF	Sakaerat (Thailand)	DBH > 4.5 cm		1140	Nalamphun *et al.* (1968)
DEF	Sakaerat (Thailand)	DBH > 4.5 cm	32.2	1154	Bunyavejchewin (1986)
Mixed Deciduous Forest	Tak (Thailand)	DBH > 4.5 cm	19.1	1340	Ogawa *et al.* (1961)
Mixed Deciduous Forest	Prom Basin (Thailand)	DBH > 4.5 cm		253	Sahunalu *et al.* (1979)
Teak Forest	North Thailand	DBH > 4.5 cm		262-395	Bunyavejchewin (1983)
DDF	Sakaerat (Thailand)	DBH ≥ 5 cm	14.2	602	This study
DDF	Sakaerat (Thailand)	DBH > 4.5 cm	7.91-13.95	554-733	Sahunalu *et al.* (1995)
DDF	Ban Mae Hoi (Thailand)	DBH > 4.5 cm	15.3	1576	Ogawa *et al.* (1961)
DDF	Ping Kong (Thailand)	DBH > 4.5 cm	17.4		Ogawa *et al.* (1965)
DDF	Namphrom Basin (Thailand)	DBH > 4.5 cm	23.7	938	Sahunalu *et al.* (1979)
DDF	Salak Phra (Thailand)	DBH > 4.5 cm		554-789	Visaratana *et al.* (1986)
Pine Forest	Amphoe Mae Cham (Th.)	DBH > 4.5 cm		145-280	Kajornsrichon (1988)
Temperate Evergreen Forest	Doi Inthanon (Thailand)	DBH > 4.5 cm	52.1	2933	Ogawa *et al.* (1961)

DBH = diameter at breast height.