Stand Structure and Species Composition in the Long-term Dynamic Plots of Sakaerat Deciduous Dipterocarp Forest, Northeastern Thailand

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ABSTRACT

Stand structure and species composition were analyzed in 4 stands, each 1 ha square plot established for the long-term forest dynamic studies in Sakaerat deciduous dipterocarp forest (SDDF) in 1894. All 4 stands exhibit their stand structural organization as being open and less crown overlapping among the canopy tree species. The stands are identified as having considerable large canopy gap. The forest canopy is stratified into 2 layers in stand 1 and 3; and 3 layers in stand 2 and 4 in this forest type. The stands are dominated by tree species belonging to Dipterocarpaceae family and being co-occurrence with several tree species in other families. Stand density of trees (DBH $\geq$ 4.5 cm) in the 4 stands varies from 555 to 823 trees.ha^{-1}. Species composition ranges from 32 to 37 species, average tree height from 7.48 to 12.08 m, total basal area from 14.52 to19.11 m2.ha-1. Species diversity as determined by Shannon-Weiner's index varies from 1.980 to 2.732. These stand parameters are recorded and used as the baseline information for future long-term study on their dynamics. The different 4 stands are classified basing on the highest and the next following importance value index (IVI) of the leading two co-occurring tree species as 4 association types: (1) *Shorea roxburghii-Quercus kerrii*, (2) *Shorea obtusa-Shorea siamensis*, (3) *Shorea obtusa-Pterocarpus macrocarpus* and (4) *Shorea siamensis-Shorea roxburghii* association types in stands1, 2, 3, and 4 respectively.

Keywords: Deciduous dipterocarp forest, Sakaerat, Species composition, Structural analysis.

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INTRODUCTION

Deciduous dipterocarp forest (Santisuk, 1988) or dry dipterocarp forest (RFD, 1962; Smitinand, 1977) or dipterocarp savanna forest (Ogawa *et al*., 1961), hereafter abbreviated as DDF, is one of the important forest community types in Thailand. It is also found widely distributed in the mainland Southeast Asian countries, covering eastern region of India, central Myanmar, Thailand, Laos and Vietnam (Sukwong, 1974). It is called "forêt claires" by French-speaking botanists. This forest type occurs in seasonal climate with a distinct dry season (Stott, 1976, 1984, 1990). The origin of these forests was discussed by many authors (Rollet, 1953; Boulbet, 1982; Blasco, 1983; Stott, 1986, 1988, 1990). However, Boulbet (1982) considered dipterocarp "forêt claires" in northern Thailand to have an edaphic origin, as they are found on poor soil. This forest type is believed to be extended by human influences and maintained through regular burning (Stott, 1990). It is assumed that the "forêt claires" covered a more extensive area in the drier climate of the last glaciation (Stott, 1990). "Forêt claires" of Laos were fully described by Vidal (1960).

In more general terms, this forest type is classified under the tropical dry forests (Holdridge, 1967) in which it is received less attention than the wet and moist forest types (Murphy and Lugo, 1986). It is also considered as the world most endangered tropical ecosystems (Trejo and Dirzo, 2000). Recently it has been given more and more interest in this dry forest type (e.g. Gentry, 1982, 1988, 1995; Janzen, 1988), but detail study on this significant forest type is still very scarce.

In Thailand this forest type covers an extensive area in northern, northeastern, eastern and western regions of the country. Early record of its area cover was about 47 % of the total forest area (Neal, 1967). Latest statistical record indicated that it covered about 20.55 % of total forest area (RFD, 2000). Recent severe disturbance of all forest types in this country has created the scattering fragmental forest area at present and often found the existing patches on the hilly and steep slope topography. Some areas are managed as the protected areas such as catchment's protection and developmental units, wildlife sanctuaries and national parks. Many fragmental parts and secondary types also still patchily distribute throughout the country.

Studies on the forest dynamics have emerged from the fact that all forest types are undergone everlasting change in every level of the community organization; individual, population

and the whole plant community. Theoretically, any plant community is in a stage of dynamic equilibrium in all stage of life being counterbalanced by growth, death and recruitment. There are several forest dynamic studies undertaken in the tropical region such as in southern America (Crow, 1980; Lieberman and Lieberman, 1987; Hubbell and Foster, 1990; Rankin-de-Merona *et al*., 1990), Africa (Swain *et al.,* 1987 a; Okali and Ola-Adams, 1987) and in Asia (Manokaran and Kochummen, 1987; Whitmore, 1989). However, all these studies are in the ever-wet tropical forests where the tropical evergreen or tropical rain forests are prominent. In the areas of alternate wet and dry or seasonal and arid climatic conditions, particularly under the monsoon climate as in Thailand however, there is very little substantial evidence of a long-term study in almost all forest types, except those undertaken in a seasonal evergreen forest in Sakaerat area (Bunyavejchewin, 1999), or seasonal evergreen rain forest (Santisuk, 1988) hereafter abbreviated as SSERF. Past studies on DDF in Thailand were always focused on the short-term, in small plots and mainly on some aspects, emphasizing only in forms of descriptive and qualitative rather than a more quantitative one. Dynamics of the DDF covering the changes in structural features, species composition and diversity, developmental stages in tree life history such as recruitment, death, growth and regeneration are all necessary to be monitored periodically for a long-term period and in a considerable large-scale and permanent plot.

Ecological investigation on DDF in Thailand was initiated in 1958 and reported subsequently by Ogawa *et al*. (1961). Their studies included the detail structure, biomass production, organic matter accumulation and turn over of this forest type. In 1965, a series of ecological study comparatively on the three main types of forest vegetations in Thailand were published (Ogawa *et al*., 1965 a, b). These latter studies had also included structural analyses, species composition and biomass production of the DDF in some specific areas. Ogino *et al*. (1967) reported the primary productivities of the Thai tropical forests including the DDF as a part of their studies. Later studies carried out by other investigators (e.g., Robbins and Smitinand, 1960; Kutintara, 1975; Sukwong *et al*., 1976, 1977) did not deal with the long-term dynamics of this forest type. In 1984 the long-term dynamics of DDF was initiated (Sahunalu and Dhanmanonda, 1995), particularly in the Sakaer-at Environmental Research Station (SERS) which is considered to be the first long-term

study in a large scale permanent plot in this country.

Sakaerat deciduous dipterocarp forest (hereafter abbreviated as SDDF) was selected as an ideal focal location based on the assumption that this forest area might be the last remaining tract, least disturbed and probably relevant to the primary forest condition. This assumption is based on the fact that the area is small and under a strictly control since the establishment of the station in 1967 and free from anthropogenic disturbances since then. This area is also considered to be the last forest fringe and a representative DDF of the northeastern region of the country. On the other hand, this forest tract has been designated as one of the Biosphere Reserves of the country in 1978. It is therefore considered to be the most reliable area for the long-term study in the large-scale permanent plot than in other areas. This paper forms part of a series of reports in relation to the forest dynamic studies in which the stand structural variations and species composition are dealt with and demonstrated in order to clarify the initial status of stands under studies prior to the full report on the long-term investigation. Other aspects will be dealt with and reported subsequently.

MATERIALS AND METHODS

Permanent plot establishment and field tree census

Sakaerat deciduous dipterocarp forest (SDDF) was delineated in the SERS (latitude 14° 31´ N, longitude 101° 55´E). Due to the very heterogeneous forest community in this area, 4 stands, each 1 ha square plot (100x100 m²) were selected, being altogether 4 ha and equivalent to 0.327 % of the total DDF area cover (1,222.24 ha) in SERS. Climatic as well as soil conditions of the area were fully described by Sahunalu and Dahanmanonda (1995), Bunyavejchewin (1999) and Sahunalu *et al*. (1993, 1994).

Locations of these 4 permanent plots are justified as to represent the variations of the whole community and studied stand positions were also described by Sahunalu and Dhanmanonda (1995). At four corners, the middle side and center points, 9 durable posts made of cement pipe were installed in each stand for demarcating the permanent boundary of the study plots. Each plot subdividing into 100 (10x10 m² quadrat) contagious grids was marked by the wooden posts.

Diameter at breast height (DBH) of all perennial plant individuals (DBH $\geq$ 4.5 cm) was measured to the nearest 1 cm by diameter tape. Paint mark was drawn at the DBH measuring

point and aluminum numbering tags were attached to the trunks. Species of all individuals were identified in the field and subsequently confirmed at the Bangkok Herbarium of the RFD from the specimen collection. All plant nomenclatures were referred to the well known works of Smitinand (1980, 2001). In the first year census, stem position and crown projection diagram of all individuals (DBH $\geq$ 4.5 cm) were mapped and sketched. Total stem height (H) and height to the lowest living branch (Hb) were measured by using Haga hypsometer and measuring pole for facilitating in profile diagram drawing and stratifying in structural analysis procedure. Repeat tree censuses were carried out at approximately one year interval. These databases facilitated for further assessment of growth and recruitment rates of individuals reaching to the fixed DBH of 4.5 cm in the current year elapse. Number of tree death was counted and species identified in the current census for mortality rate assessment of both stand and individual species levels.

Vertical stand structural analysis

Vertical structure, a stratification of trees in the 4 stands, was investigated using Ogawa's crown-depth and H-H_b diagram analysis method (Ogawa *et al*., 1965a) in the sample transects by alternately subdividing each stand into a rectangular shaped belt of either 10x100 m^2 or 20x100 m^2 and a square shaped sample plot of 100x100 m^2.

Species composition and their attributes

Tree species composition classified into the taxonomic group by family, genera and the status in each canopy layer was identified. The stratification of tree species in the 4 stands was investigated only at the first year study. The fundamental stand and species parameters were investigated using the conventional attributes such as stand density, dominance and frequency of occurrence together with their relative values. Basal area at breast height derived from $\pi D^2/4$, where D is measured DBH (cm), was used as the dominance parameter. Species importance value index (IVI) was determined by adopting the method of Curtis and McIntosh (1951) as the summation of relative density, relative frequency and relative dominance, (%).

RESULTS AND DISCUSSION

Structure of SDDF

Stand characteristics

Stand characteristic and initial stand condition on the onset of the dynamics study in SDDF is summarized in Table 1. In these 4 stands, stand density of tree individuals (DBH $\geq$ 4.5 cm) ranges from 555 to 823 trees.ha^{-1} and number of species ranges from 32 to 37 species. These include some very few lianas and

Table 1 Stand characteristics of SDDF in 1984

Stand parameters	Stand				
	1	2	3	4	Mean
1. Plot size (ha)	1	1	1	1	1
2. Altitude (masl)	284	360	362	365	342.5
3. Aspect	N	N	N	N	-
4. Slope	Gentle	Gentle	Gentle	Gentle	-
5. Stand density (trees.ha^{-1})	555	663	823	707	687
6. Number of species	36	34	32	37	35
7. Total basal area (m^2.ha^{-1})	14.52	19.11	15.46	18.60	16.9225
8. Average height (m)	7.95	12.08	7.48	10.25	9.44
9. Shannon-Wiener's H*	2.732	2.197	1.980	2.465	2.344

* Shannon-Weiner's index of species diversity (Shannon and Weaver, 1949)

unidentified shrub species. The occurrence of lianas in DDF is not so frequent since this plant life form is rather common and abundant in close forests such as in seasonal evergreen rain forest (SERF), mixed deciduous (MDF) and tropical evergreen rain forests (TRF). Density and species number of these 4 stands are not comparable to the dipterocarp savanna forest in northwestern Thailand investigated by Ogawa *et al*. (1961) but the physiognomy of both forests are relatively similar, being an open canopy with scattered trees and less abundant tree species as compared to other forest types.

Density of trees in SDDF is relatively high and greater in number of species than in the Pingkong deciduous savanna forest community in northern Thailand and that in Namphrom basin in the northeast (Ogawa *et al*., 1965; Sahunalu *et al*., 1979). Both number of species and stand density are found to be within the lower range of most tropical dry forests summarized by Murphy and Lugo (1986).

Species diversity evaluated by Shannon-Wiener's index (Shannon and Weaver, 1949) is relatively low in stand 3 where stand density is highest. This primarily owes to the number of species in this stand is lower than in other 3 stands. Basal area of trees in stand 3 is also considerably low, partly due to the existing of dense small trees even though the medium sized trees are as similarly abundant as in other 3 stands. Basal area in stand 2 is greater than in stand 4, due clearly to the more abundance of some large and emergent trees.

Stand structure

Vertical structuring of forest was first observed visually to identify its canopy stratification by using profile diagram investigation following Richards's method (Richards, 1952). Stratification of trees in this forest is obviously composed of 2-3 layers of the canopy arrangement, showing their dominant and co-dominant tree species respectively in forms of vertical layering and the relatively small crown overlapping. Vertical structuring by using profile diagram alone (Richards, 1952) seems to be insufficient to describe the stratification quantitatively for the SDDF, especially by using the narrow belt-transect strip of the forest. Although recently developed methods are available (Latham *et al*., 1998; Baker and Wilson, 2000) but the stratification of this open canopy forest using Ogawa's method (Ogawa *et al*., 1965 a) is found to be simple and sufficient for discriminating the layering of this forest type. Adopting Ogawa's method in a larger belt of 20x100 m^2 as well as in the whole 1 ha (100x100 m^2) plot in the same stand found that Ogawa's method is proved to be more preferable in stratification analysis of the SDDF, since the

canopy layering is less complex. The stratification difference among each stand is observed but 2 layers of the canopy are classified clearly in stands 1 and 3 and 3 layers in stands 2 and 4 (Figure 1). Major and minor species composition

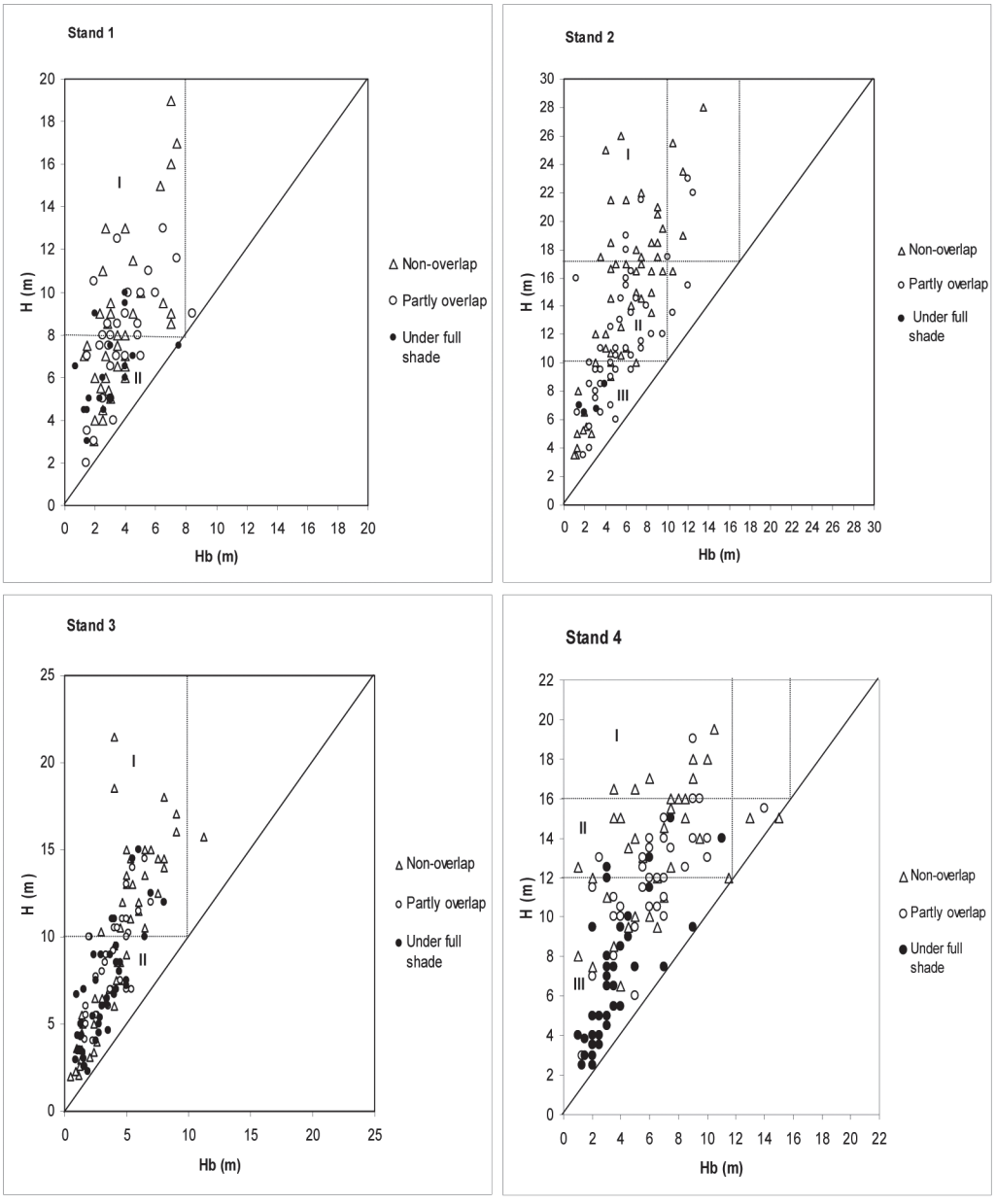

Figure 1 H-Hb diagram for determining stand stratification following Ogawa *et al.* (1965)'s method. The scattered points were from an arbitrarily selected transect of 20x100 m^2 quadrat in each stand. Horizontal dash lines indicate the discriminated layers in each stand by layering vertically as I, II and III from upper to lower lines respectively. Three different points indicate three canopy overlapping types.

of each layer in each stand are however, obviously different. Three canopy layers were found in other stand of similar forest type such as in the Namphrom DDF where the same method was applied (Sahunalu *et al*., 1979). Other forest types usually had more than 3 layers (Ogawa *et al*., 1965), where they are relatively true closed forest types.

In this study, the 4 stands have trees without crown interference by the neighboring tree elements for 45, 47, 50 and 54% of total tree individuals in stands 4, 2, 1 and 3 respectively. The status of each tree species in the corresponding canopy layers or stratification in the 4 stands are shown in Table 2. These dominant trees in the upper canopy layer are composed of 16, 15, 17 and 18 species respectively, calculated total basal area at breast height being 8.66, 13.95, 7.91 and 9.77$m^2.ha^{-1}$ respectively. Partly light receiving tree species are however, sometimes under the full light regime and crown might be interfered by the neighboring trees periodically and composed of 23, 24, 28 and 35% of total individuals in stands 1, 3, 4 and 2 respectively. Other tree species are less important in terms of the layering contribution but maintain their status as the suppressed trees by co-occurring with the other undergrowths and some species may be under the stage of regeneration, being in forms of saplings and seedlings of the canopy tree species.

Species composition

Species composition and their taxonomic identification by families and genera are demonstrated in Table 2. In these 4 stands, there are 18 species common in all stands, 13 species are in some single stand, 7 species are in only 2 stands and 18 species are common in 3 stands. These stands are composed of total 24 families of trees (excluding lianas) and mostly have 18 to 19 families, being largest in stands 1 and 2 and fewest in stands 3 and 4. Thirteen families are identified and commonly found in all 4 stands (Table 2). Other families are found in some stands only.

There are total 42 genera of trees (DBH ≥4.5 cm) in this forest type (Table 2) in which 29, 30, 28 and 30 genera are found in the 4 stands respectively. Only 19 genera present commonly in all 4 stands, other genera are found only in one, two or three stands. At species level, there are 18 common tree species in all 4 stands and only 13 species in some single stands, 7 species in only 2 stands and 18 species in 3 stands. The most dominant tree families are Dipterocarpaceae (3-4 species), Rubiaceae (3-5 species), Euphorbiaceae (1-4 species), Caesalpinoideae (2-3 species), Papilionoideae (2-4 species) and

Table 2 Species composition and their status in stand stratification in the 4 stands of SDDF in 1984.

Species	Family[1]	Status in stand stratification[2]			
		Stand			
		1	2	3	4
Albizia odoratissima (L.f.) Benth.	Mimosoideae (L)	g	g	d	f
Antiaris toxicaria Lesch.	Moraceae	NE	NE	NE	c
Antidesma ghaesembila Gaerth.	Euphorbiaceae	NE	NE	B	c
Antidesma laurifolium Airy Shaw	Euphorbiaceae	b	NE	NE	NE
Aporosa villosa (Wall. ex Lindl.) Baill.	Euphorbiaceae	c	c	d	c
Artocarpus lacucha Roxb.	Moraceae	NE	NE	b	NE
Bauhinia saccocalyx Pierre	Caesalpinoideae (L)	d	d	NE	f
Bauhinia sp.	Caesalpinoideae (L)	NE	NE	d	NE
Bombax insigne Wall.	Bombaceae	b	NE	NE	NE
Buchanania lanzan Spreng.	Anacardiaceae	c	c	NE	NE
Canarium subulatum Guillaumin	Burseraceae	b	b	b	f
Careya sphaerica Roxb.	Lecythidaceae	c	c	b	c
Cratoxylum formosum (Jack) Dyer	Guttiferae	NE	NE	NE	f
Dalbergia assamica Benth.	Papilionoideae (L)	NE	NE	NE	c
Dalbergia cultrata Graham ex Benth.	Papilionoideae (L)	e	e	NE	c
Dalbergia nigrescens Kurz	Papilionoideae (L)	NE	NE	d	NE
Dalbergia oliveri Gamble	Papilionoideae (L)	NE	NE	d	f
Dillenia obovata (Blume) Hoogland	Dilleniaceae	c	c	b	c
Diospyros ehretioides Wall. ex G. Don	Ebenaceae	f	f	b	c
Diospyros mollis Griff.	Ebenaceae	NE	NE	NE	f
Diospyros oblonga Wall. ex G. Don	Ebenaceae	NE	NE	a	NE
Dipterocarpus intricatus Dyer	Dipterocarpaceae	g	g	d	g
Erythrophleum succirubrum Gagnep.	Caesalpinoideae (L)	c	c	d	NE
Gardinia sootepensis Hutch.	Rubiaceae	c	c	b	f
Irvingia malayana Oliv. ex A.W. Benn.	Irvingiaceae	c	c	b	f
Ixora ebarbata Craib	Rubiaceae	NE	NE	NE	NE
Kydia calycina Roxb.	Malvaceae	c	c	NE	NE
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	c	c	NE	NE
Lithocarpus polystachyus (Wall ex A.DC.) Rehder	Fagaceae	d	d	NE	f
Mangifera caloneura Kurz	Anacardiaceae	d	d	b	NE
Mitragyna rotundifolia (Roxb.) Kuntze	Rubiaceae	f	f	d	f
Morinda coreia Ham.	Rubiaceae	f	f	b	f
Nauclea officinalis (Pierre ex Pit.) Merr. & Chum	Rubiaceae	NE	NE	NE	f
Nauclea orientalis (L.) L.	Rubiaceae	NE	NE	NE	f
Parinari anamense Hance	Chrysobalanaceae	f	f	d	f
Phyllanthus emblica L.	Euphorbiaceae	NE	NE	a	c
Premna pyramidata Wall. ex Schauer	Labiatae	NE	NE	NE	b
Pterocarpus macrocarpus Kurz	Papilionoideae (L)	g	g	d	f

Table 2 Cont.

Species	Family[1]	Status in stand stratification[2]			
		Stand			
		1	2	3	4
Quercus kerrii Craib	Fagaceae	f	f	d	f
Rothmannia wittii (Craib) Bremek.	Rubiaceae	b	b	NE	NE
Semecarpus reticulata Lecomte	Anacardiaceae	NE	NE	d	NE
Shorea obtusa Wall. ex Blume	Dipterocarpaceae	g	g	d	c
Shorea roxburghii G.Don	Dipterocarpaceae	d	g	d	g
Shorea siamensis Miq.	Dipterocarpaceae	d	g	NE	g
Sindora siamensis Teijsm. & Miq.	Caesalpinoidae (L)	d	g	d	f
Unidentified	-	g	g	d	c
Unidentified (Liana)	-	NE	NE	NE	NE
Vaccinum sprengelii (G.Don) Sleumer	Ericaceae	c	c	NE	NE
Vitex canescens Kurz	Labiatae	c	c	NE	NE
Vitex peduncularis Wall. ex Schauer	Labiatae	c	c	b	f
Xylia xylocarpa var. *kerrii* (Craib & Hutch.) I.C. Nielsen	Mimosoideae (L)	f	f	d	f

[1] (L) = Legume tree group

[2] Presence of their species in the corresponding layers in each stand stratification: a=layer 1 only, b=layer 2 only, c=layer 3 only, d=layer 1 and 2, e=layer 1 and 3, f=layer 2 and 3, g=layer 1, 2 and 3. NE = Non-existing.

Mimosaceae (2 species). There are also some families in this forest type that has few species and sporadically grown such as Bombaceae, Moraceae, Guttifereae, Dilleniaceae, Irvingiaceae, Malvaceae, Combretaceae, Burseraceae, Chrysobalanaceae, Ericaceae, Myrtaceae and Celastraceae. It is therefore obvious that the most dominant and its associated co-dominant tree species are different among the 4 stands, suggesting that this forest type is extremely heterogeneous in terms of species composition even within a small area as in SDDF.

Few studies in various Thai forests have included the identification of floristic family, making it impossible to detect the similarity and difference among the forest types. A study in Sakaerat seasonal evergreen rain forest (Sahunalu, 2002), hereafter abbreviated as SSERF, found 30 families of trees and 13 families of lianas (DBH $\geq$ 4.5 cm), comprising of 49 genera of trees, 13 genera of lianas and 57 species of trees, 15 species of lianas. Only 2 tree species *(Hopea ferrea and Shorea henryana)* belong to Dipterocarpaceae family in the SSERF, making the contrast differences in the physiognomy between DDF and SERF clearly. All these Dipterocarpaceae tree species in SDDF are entirely the deciduous trees as opposed to the evergreen Dipterocarpaceae that are generally found in the wetter lowland dipterocarp forest in some equatorial regions in Southeast Asia (Smitinand *et al*., 1980). In tropical forest type, there are only 4 significant and exceptional evergreen Dipterocarpaceae tree species (Suntisuk, 1988).

There are no published numerical taxonomic classification of the tropical dry forest in Southeast Asia but Gillespie *et al*. (2000) summarized the floristic diversity in 0.1 ha sample plots from lowland neotropical dry forests sites gathering from various sources, being ranged from 19 to 46 families and 34 to 121 species. It is likely that the SDDF ranks as one of the species-poor forests among the world tropical dry forest communities.

Species IVI of the dominant and other component trees are different among the 4 stands (Table 3). Thus, the 4 stands are considered to represent some association types of the DDF of the area. Considering the species IVI that indicate the successful establishment of trees in occupying the habitat, especially those having highest IVI and the followers among the first two component species in each stand are therefore classified as *Shorea roxburghii-Quercus kerrii, Shorea obtusa-Shorea siamensis, Shorea obtusa - Pterocarpus macrocarpus* and *Shorea siamensis-Shorea roxburghii*

Table 3 Importance value index (IVI) of the component species in the 4 stands of SDDF in 1984.

Species	IVI (%)[1]			
	Stand			
	1	2	3	4
Albizia odoratissima (L.f.) Benth	0.97	5.13	4.88	4.96
Antiaris toxicaria Lesch.	0.97	NE	NE	0.40
Antidesma ghaesembila Gaerth.	0.50	NE	NE	NE
Antidesma laurifolium Airy Shaw	0.94	NE	0.45	1.23
Aporosa villosa (Wall.ex Lindl.) Baill.	4.07	0.45	0.46	3.31
Artocarpus lacucha Roxb.	NE	NE	0.44	NE
Bauhinia saccocalyx Pierre	NE	3.87	NE	1.42
Bauhinia sp.	0.70	NE	2.96	NE
Bombax insigne Wall.	1.01	NE	NE	NE
Buchanania lanzan Spreng.	NE	0.45	NE	NE
Canarium subulatum Guillaumin	NE	0.57	0.46	0.91
Careya sphaerica Roxb.	2.69	0.47	3.97	1.60
Cratoxylum formosum (Jack) Dyer	0.45	NE	NE	2.34
Dalbergia assamica Benth.	NE	NE	NE	0.57
Dalbergia cultrata Graham ex Benth.	7.35	1.98	NE	7.52
Dalbergia nigrescens Kurz	NE	NE	2.95	NE
Dalbergia oliveri Gamble	1.26	NE	2.28	3.02
Dillenia obovata (Blume) Hoogland	13.66	1.00	0.96	0.04
Diospyros ehretioides Wall. ex G. Don	4.42	1.02	2.71	0.47
Diospyros mollis Griff.	0.56	NE	NE	0.47
Diospyros oblonga Wall. ex G. Don	NE	NE	1.98	NE
Dipterocarpus intricatus Dyer	39.97	6.36	19.30	9.39
Erythrophleum succirubrum Gagnep.	NE	1.04	1.46	NE
Gardinia sootepensis Hutch.	0.46	4.50	2.35	6.10
Irvingia malyana Oliv. ex A.W.Benn.	1.99	2.53	1.05	1.59
Ixora ebarbata Craib	1.99	NE	NE	NE
Kydia calycina Roxb.	0.68	0.46	NE	NE
Lannea coromandelica (Houtt.) Merr.	2.93	1.11	NE	NE
Lithocarpus polystachyus (Wall ex A.DC.) Rehder	NE	0.94	NE	3.79
Mangifera caloneura Kurz	5.71	14.60	0.93	NE
Mitragyna rotundifolia (Roxb.) Kuntze	14.89	4.82	8.06	8.38
Morinda coreia Ham.	4.09	6.82	8.38	9.78
Nauclea officinalis (Pierre ex Pit.) Merr. & Chum	NE	NE	NE	1.59
Nauclea orientalis (L.) L.	NE	NE	NE	0.42
Parinari anamense Hance	NE	0.65	2.03	1.72
Phyllanthus emblica L.	0.48	NE	0.53	1.19
Premna pyramidata Wall. ex Schauer	NE	NE	NE	0.45
Pterocarpus macrocarpus Kurz	33.50	28.52	37.89	21.12
Quercus kerrii Craib	42.74	7.94	2.14	24.41
Rothmannia wittii (Craib) Bremek.	NE	1.38	NE	NE
Semecarpus reticulata Lecomte	NE	NE	1.52	NE
Shorea obtusa Wall. ex Blume	23.69	123.65	157.03	0.99

Table 3 Cont.

Species	IVI (%)[1]			
	Stand			
	1	2	3	4
Shorea roxburghii G.Don	46.01	4.06	7.81	73.74
Shorea siamensis Miq.	6.37	50.30	NE	80.74
Sindora siamensis Teijsm. & Miq.	8.16	4.73	11.35	10.85
Siphonodon celastraneus Griff.	NE	NE	0.91	NE
Stereospermum neuranthum Kurz	0.61	0.50	3.57	1.24
Syzygium cumini (L.) Skeels	NE	NE	NE	0.60
Terminalia chebula Retz. var. *chebula*	0.93	0.47	NE	0.40
Unidentified	1.06	3.04	0.46	1.34
Unidentified (Liana)	0.94	NE	NE	NE
Vaccinum sprengelii (G.Don) Sleumer	NE	0.68	NE	NE
Vitex canescens Kurz	NE	0.46	NE	NE
Vitex peduncularis Wall. ex Schauer	8.94	1.36	0.95	3.56
Xylia xylocarpa var. *kerrii* (Craib & Hutch.) I.C. Nielsen	15.74	14.18	7.80	8.18

[1] NE = Non-existing

association types in stands 1, 2, 3 and 4 respectively. Kutintara (1975) classified 6 association types of the DDF in the northwest Thailand; however, Ogawa et al. (1961) classified this forest type into 3 association types while Sukwong (1974) added another one more association type into these earlier classifications.

Classification of the association type for the SDDF is considered to be slightly different from that proposed by Sukwong (1974) and Kutintara (1975) as their original works included the relatively highland DDF type into the classification; such as Pine-dipterocarp association type. In highland DDF type, it is always found *Pinus kesiya* and *P. merkusii*, the two native pine species co-occurring with those tree species belonging to Dipterocarpaceae family. SDDF is grown on the relatively low, undulating hill under the slightly arid climate and shallow soils where these two native pine species are absolutely absent. Moreover, other two more important tree species, *D. tuberculatus* or *D. obtusifolius* are not frequently found in the Sakaerat area. SDDF is in fact, primarily composed of the most dominant trees belonging to genus *Shorea* of the Dipterocarpaceae family. The entire area of SDDF may belong to the association type 1 in Ogawa *et al*. (1961)'s classification, e.g. *Shorea obtusa-Shorea siamensis* association type. The co-occurrence of the dominant and co-dominant tree species and formation of various association types as found in these stands may be different among stands in the same area within the same location as in present case. One dominant tree species in one particular stand may grow as a co-dominant in other stand in different location such as *S. siamensis and S. roxburghii* in SDDF. However, *P. macrocarpus*, one of the most valuable commercial tree species belonging to Papilionoideae family (one of legume tree species) is not only grown as a co-dominant tree species of *S. obtusa* in stand 3 but also being one of the most important tree species as being the 3rd and 4th ranking tree elements in terms of its IVI in all 4 stands (Table 3). Although *M. rotundifolia, S. roxburghii, Q. kerrii, D. intricatus* and *Sindora siamensis* are found in all 4 stands but they have the relatively high IVI only in some stands in SDDF. Whilst M. *caloneura* is found to be among the top five species having high IVI in stands 2 and 3 in this area (Table 3).

CONCLUSION

SDDF exhibits the structural organization of the stand as being open and less crown overlapping among the canopy tree

species. The stands are identified as having considerable large canopy gap. The forest canopy is stratified into 2-3 layers for the 4 stands in this site. The stands are dominated by the tree species belonging to Dipterocarpaceae family and being co-occurrence with several tree species in other families. Stand density of trees (DBH ≥ 4.5 cm) in the 4 stands ranges between 555-823 trees.ha^{-1}. Species composition ranges between 32-37 species, average tree height between 7.48-12.08 m and total basal area between 14.52-19.11 m^2.ha^{-1}. Shannon-Weiner's index of species diversity (H) is calculated as 1.980-2.732. These stand parameters are clearly shown the large variations in stand structure and species composition. All data recorded initially in 1984 will be used as the baseline information for a future long-term study on their dynamics. The 4 stands are recognized as 4 association types by using two leading tree species having correspondingly highest and the next high IVI as: (1) *Shorea roxburghii-Quercus kerrii*, (2) *Shorea obtusa-Shorea siamensis*, (3) *Shorea obtusa-Pterocarpus macrocarpus* and (4) *Shorea siamensis-Shorea roxburghii* association types in stands 1, 2, 3, and 4 respectively.

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