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ANALYSIS OF THE TROPICAL DRY DECIDUOUS FOREST OF THAILAND, I. CHARACTERISTICS OF THE DOMINANCE-TYPES

by

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ABSTRACT

This study was designed to determine the characteristics of the dominance-types of the tropical dry deciduous forest of Thailand. Quantitative data for trees bigger than 10 cm dbh and environmental characteristics were collected in 40 forest stands located in northern, northeastern, and western Thailand. An agglomerative cluster analysis was used to classify stands into dominance-types based on the importance value 300 (CURTIS & MCINTOSH, 1951) of the tree species which occur in at least 10 percent of the total number of stands. Two dominance-types are the *Tectona grandis* type, and the *Lagerstroemia calyculata* type. The *Tectona grandis* type can be divided into two sub-types based on the importance value of the dominant species : *Tectona grandis* – *Xylia kerrii* sub-type, and *Tectona grandis* – *Xylia kerrii* – *Terminalia mucronata* sub-type. The *Tectona grandis* – *Xylia kerrii* sub-type is composed of taller and bigger trees than the other types. It also occupies the best sites of the tropical dry deciduous forest.

INTRODUCTION

Tropical dry deciduous forest, called "tall deciduous forest" (OGAWA *et al.*, 1961) or "mixed deciduous forest" (ROYAL FOREST DEPARTMENT, 1962) occurs naturally only on the mainland of Southeast Asia : Vietnam, Laos, Cambodia, Thailand, Burma, and India. This forest type is composed of medium-to-tall trees which remain almost leafless during the dry season, and has a closed to slightly open canopy. This forest type contains a large number of deciduous species; however certain species are predominant. Teak (*Tectona grandis* Linn.f.), occurs exclusively in this forest type and is one of the characteristic species, but it is not found in every stand. Teak occurs naturally in two distinct regions of Southeast Asia : one includes most of Peninsular India, the other includes Burma, Thailand, and a small area of northwestern Laos (KADAMBI, 1972). The tropical dry deciduous forest is found where there is a monsoon climate with a marked dry period of 5 to 6 months and where the total rainfall ranges from 1,000 to 1,500 mm per year.

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In Thailand, the tropical dry deciduous forest occurs throughout the country except in the peninsular, central, and eastern regions. It covers about 20 percent of the total forest area of the country (NEAL, 1967), where the elevation is 150–650 m above mean sea level. Although there have been many studies in this forest type, especially in teak forest, very few have been made of forest structure (OGAWA *et al.*, 1965).

This study aims to determine the dominance-types of the tropical dry deciduous forest of Thailand, and to determine topography and soil properties of these dominance-types. Canopy structure and vegetation-environment relationships will be the subject of a later paper, and are not considered here.

The data of this study come from Annual Reports No. 1 and 2 of Biotrop Research Project No. TFR-1 B/C and some unpublished data which were prepared by S. Sukwong and his collaborators.

GENERAL DESCRIPTION OF THE STUDY AREA

Forty stands of the tropical dry deciduous forest were located in northern, northeastern, and western Thailand (Fig. 1). Sample stands were positioned between 14° to 20 N latitude and 97° 30′ to 105° E longitude.

Climate. The climate of the northern, northeastern, and western Thailand is monsoon. Climate diagrams for these areas (Fig. 2) based on 25-year records (1951-1975; METEOROLOGICAL DEPARTMENT, 1977), are representative of weather conditions in the study area. Mean annual rainfall ranges from 1,000 to 2,000 mm per year but is generally less than 1,500 mm. August and September are the wettest months, and December to February the driest. Mean temperature ranges from 19° to 24° C.

Geology and Soil. Rocks in northeastern Thailand (Korat Plateau) are mainly arenaceous rocks (clastic sediments of sand grain size) which are either sub-horizontal or very gently folded. The rocks exposed in the northern and western parts of the country comprise clastic sediments from clays to sandstones and limestones; some of these rocks are more or less metamorphosed and show evidence of intense folding. Igneous rocks are relatively rare in the northeastern part but very common in the folded regions (MOORMANN & ROJANASOONTHON, 1972).

Five great soil groups under the tropical dry deciduous forest are differentiated by MOORMANN & ROJANASOONTHON (1972) : rendzinas, brown forest soil, red-brown earths, red-yellow podzolic soil, and reddish-brown lateritic soil.

Soils of the undulating and rolling areas are rendzinas and brown forest soils, which are formed on calcareous materials. A typical rendzinas shows a black to very dark brown surface layer. The brown forest soil has brownish B horizon. Both soils

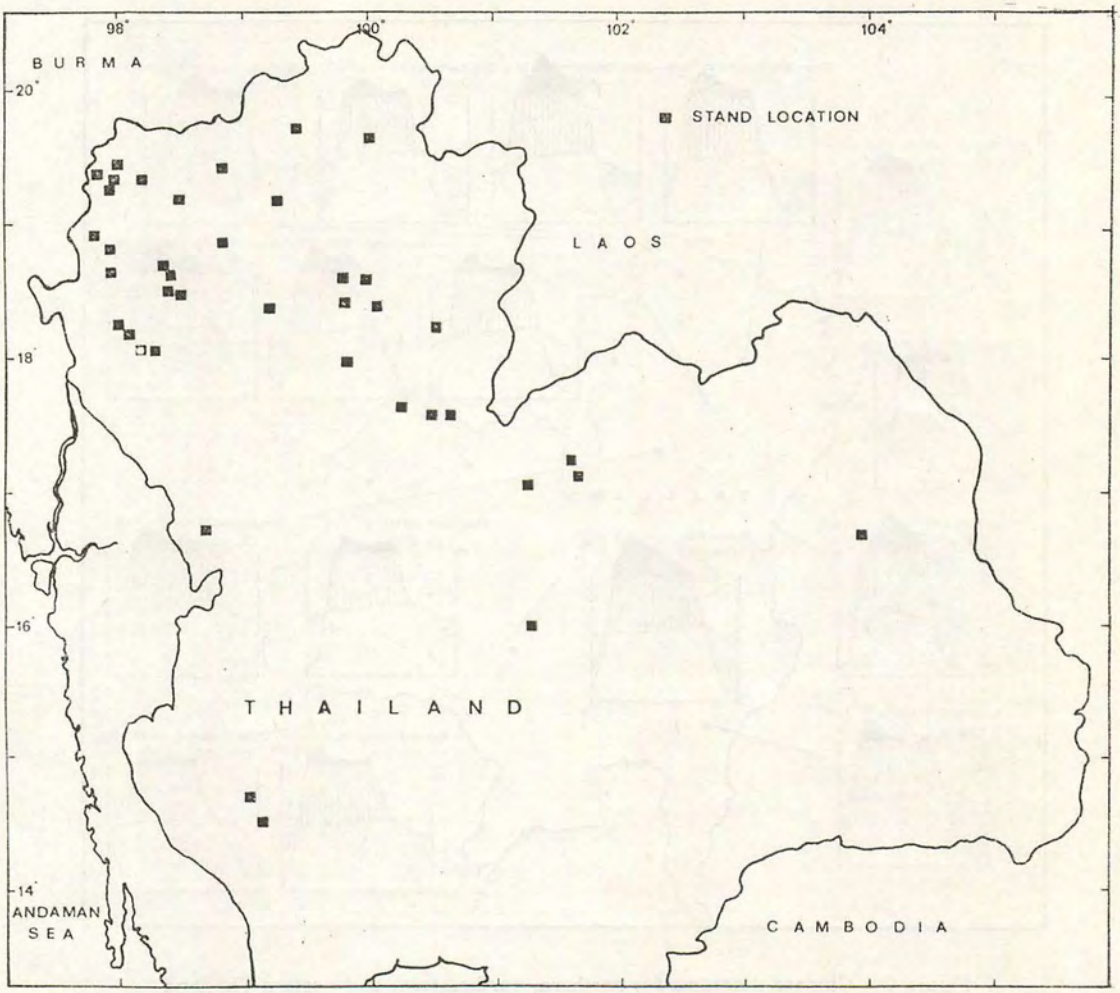

Figure 1. Locations of sample stands.

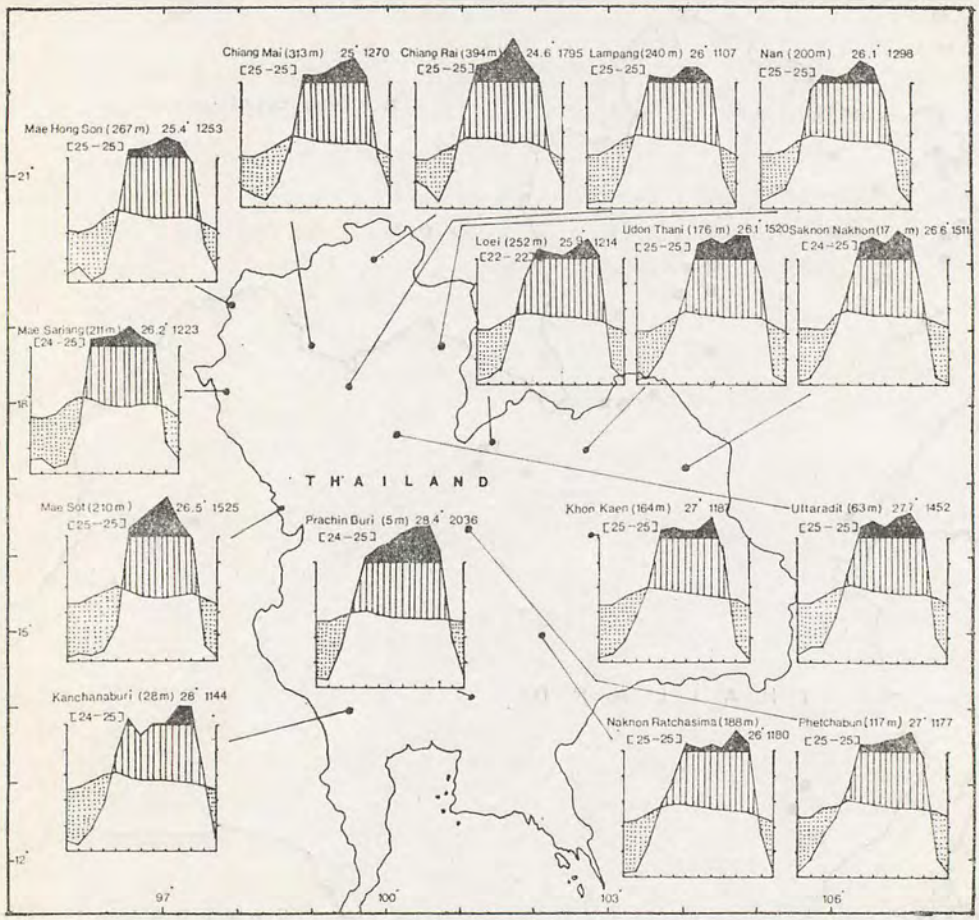

Figure 2. Climate diagrams for northern, northeastern, and western Thailand (Source : Meteorological Department, Ministry of Communications, Thailand, 1977).

have a clayey to loamy texture. Red brown earths have formed on the undulating and gently rolling terrain, but may also be close to or on steep limestone crags. They have clayey texture throughout the profile, and a dark red to dark reddish-brown subsurface layer. Reddish brown lateritics also have clayey texture but they are of limited extent on old alluvium where the rocks of the adjacent catchment areas are basic. Red-yellow podzolic soils, of loamy texture, are in mountainous or hilly areas, and occur extensively on old alluvial terraces which occur in the northern part of the Korat Plateau and in the elongate valleys of the northern and western parts of the country.

METHODS

Field Methods. The 40 sample stands were chosen where there had been little or no apparent disturbance, and were relatively homogeneous in species composition and distribution. Twenty quadrats, each 10 × 10 m, were established within each stand. The total number of trees greater than 10 cm dbh of each species was recorded and their basal area was computed. Tree density, frequency, and basal area were transformed to relative density, relative frequency, and relative basal area. An importance value 300 (the sum of relative density, relative frequency, and relative basal area) of each tree species in each stand was computed. The average stand height was calculated by summing tallest tree height in each quadrat and dividing by the number of quadrats.

Three soil pits were dug within each stand and the soil profile was described. For soil analyses, soil samples were collected from each pit at 0–5, 10–15, 20–25, and 45–50 cm depth. The other data collected for each stand included elevation, percent slope, soil drainage characteristics, and topographic and land form characteristics.

Laboratory Methods. Bulk soil density was determined by weighing a sample of known volume after oven drying at 105°C for 48 hours. Soil particle density was determined by the pycnometer method. Soil texture was determined by using the hydrometer method (BOUYOUCOS, 1951, 1953). Soil pH was determined by a pH meter after by 1 : 1 soil-water suspension. Organic matter content was determined by using the Walkley and Black Rapid Titration Method. Exchangeable potassium and sodium were determined by flame photometry. Exchangeable calcium and magnesium were determined by using the atomic absorbtion spectrophotometer (JACKSON, 1967). Available phosphorus was extracted by the Bray's II procedure (ALEXANDER & ROBERTSON, 1970). Cation exchange capacity was determined by using neutral normal ammonium acetate extraction (TISDALE & NELSON, 1969).

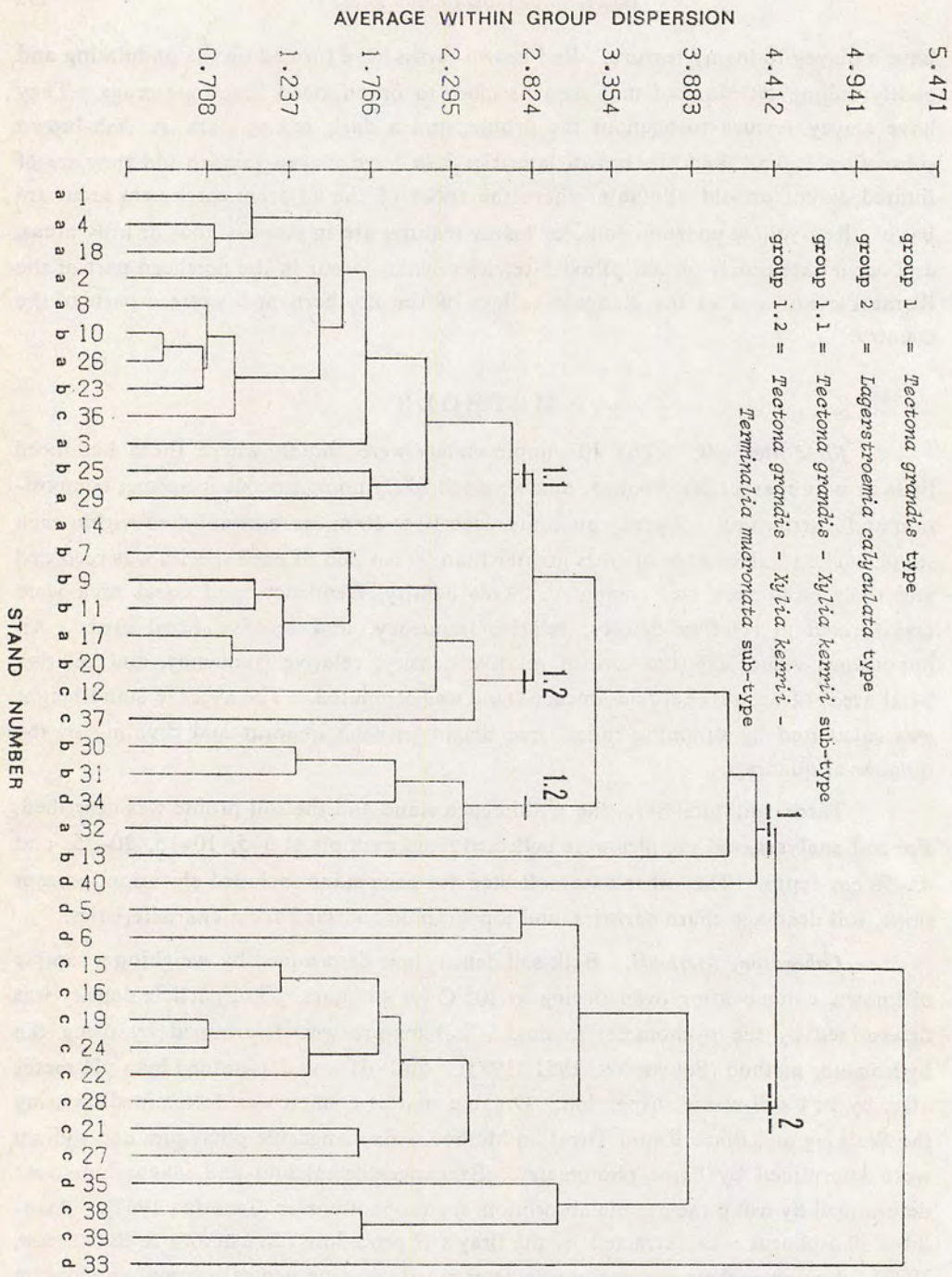

Figure 3. Dendrogram formed by the agglomerative cluster analysis of the tropical dry deciduous forest. a, *Tectona grandis–Xylia kerrii* sub-type; b, *Tectona grandis–Xylia kerrii–Terminalia mucronata* sub-type; c, *Lagerstroemia calyculata* type; d, unidentified.

Synthesis of Data. The agglomerative cluster analysis computing programme (GOLDSTEIN & GRIGAL, 1971) incorporating a method of minimum within-group sum of squares (ORLOCI, 1967) was used to classify sample stands into groups based on importance values of the tree species which occurred in at least 10 percent of the total number of sample stands. The individual stands were compared to one another and a pair was fused into a group if its within-group sum of squares was less than that produced by the fusion of any other ungrouped combination. That pair became a new group and the programme continued until all stands were joined.

RESULTS

The dendrogram for 40 stands is shown in Fig. 3. Average within-group dispersion can be viewed as the floristic dissimilarity between stands and clusters. I recognized two groups at the 4.40 level. The groups may be summarized by dominant tree species as follows: Group 1, *Tectona grandis* type; Group 2, *Lagerstroemia calyculata* type. Average density, average basal area, average stand height, and number of species of the two dominance-types are summarized in Table 1.

The *Tectona grandis* type is dominated by *Tectona grandis* Linn. f., and *Xylia kerrii* Craib is the secondary dominant species. This type occupies elevations ranging from 150 to 650 m, and occurs on level to moderate slopes of medium soil texture–sandy loam and sandy clay loam. The average stand height and basal area cover are 26.8 m and 38.4 m^2 per ha. The average tree density is 325 trees per ha.

The tree layer is composed of three strata. The upper canopy consists of the two dominant species ranging from 25 to 30 m high though some trees reach 40 m in deep well-drained soil. Other common species of the upper stratum are *Pterocarpus macrocarpus* Kurz, and *Terminalia mucronata* Craib et Hutch, and occasionally *Spondias pinnata* Kurz, *Bombax anceps* Pierre, *Anogeissus accuminata* Wall., *Terminalia tomentosa* Wight & Arn., *T. bellerica* Roxb., *Dillenia parviflora* Griff, *Lagerstroemia calyculata* Kurz, *L. collettii* Craib, *Schleichera oleosa* Merr., *Dalbergia* spp., etc. The middle stratum is 10 to 20 m high, composed of upper stratum tree species and mixed with *Vitex* spp., *Lepisanthes siamensis* Radlk., *Mitragyna brunosis* Craib, and *Grewia paniculata* Roxb. These species usually fill in the gaps of the upper canopy and provide a continuous crown cover. The lower stratum consists of pole-sized trees of the species mentioned above. Other associated species are *Morinda coreia* Ham., *Colona fragrocarpa* Craib, *Holarrhena antidysenterica* Wall., and *Phyllanthus emblica* Linn. This stratum ranges from 5 to 10 m high.

A shrub layer consists of two major bamboo species—*Oxytenanthera albociliata* Munro and *Dendrocalamus strictus* Nees. The other bamboo, *Bambusa tulda* Roxb., is clustered. The 2 to 5–m saplings of the tree layer species are evenly distributed. Ground cover is rather open. Dominant grasses are *Arundinella hispida* Hack.,

Table 1. Average and standard deviation of stand height, basal area cover, density, and number of species in the tropical dry deciduous forest.

Dominance-type	Height (m)	Basal area (m^2/ha)	Density (trees/ha)	No. of species per 0.2 ha
Tectona grandis type	26.79 ± 4.06	38.38 ± 10.53	325.71 ± 123.49	17.62 ± 6.57
Tectona grandis–Xylia kerrii sub-type	28.25 ± 3.78	42.45 ± 10.97	262.27 ± 67.17	15.09 ± 6.86
Tectona grandis–Xylia kerrii–Terminalia mucronata sub-type	25.19 ± 3.91	33.90 ± 8.38	395.50 ± 136.19	20.40 ± 5.21
Lagerstroemia calyculata type	24.40 ± 4.14	33.12 ± 14.30	360.38 ± 118.36	23.15 ± 7.17

Heteropogon triticeus Beauv., *Imperata cylindrica* Beauv., and *Eupatorium odoratum* Linn. Seedlings of the tree species are scattered. *Butea superba* Roxb. commonly climbs to the top of the trees. Orchids, *Dendrobium* spp., *Vanda* spp., and *Platycerium* spp., are found on large limbs and tree trunks.

The *Tectona grandis* type can be divided into two sub-types. The *Tectona grandis–Xylia kerrii* sub-type is dominated by the two major species. This type may range from 150 to 650 m above mean sea level but is usually found between 380 to 500 m. Soil of this sub-type is deep sandy clay loam. This sub-type has a structure and species composition similar to the *Tectona grandis* type. Average stand height and average basal area cover are 28.3 m and 42.5 m^2 per ha; average density is 262 trees per ha.

The other sub-type, the *Tectona grandis–Xylia kerrii–Terminalia mucronata* sub-type, is dominated by *Tectona grandis* Linn. f *Terminalia mucronata* Craib et Hutch and *Xylia kerrii* Craib are secondary dominants but *Xylia kerrii* Craib occurs infrequently in some sample stands. Structure and floristic composition are similar to those of the *Tectona grandis–Xylia kerrii* sub-type. Trees in this sub-type are shorter and smaller than those of the previous sub-type. The average stand height, average basal area, and average density are 25.2 m, 33.9 m^2 per ha, and 396 trees per ha respectively. The most common soil texture in this sub-type is sandy loam and the soil is usually slightly shallower than in the *Tectona grandis–Xylia kerrii* sub-type.

2. The *Lagerstroemia calyculata* type is commonly dominated by *Lagerstroemia calyculata* Kurz. *Tectona grandis* Linn. f. may occur in this type. This type occurs at elevations of 150 to 550 m but usually occupies elevations lower than 400 m. Trees are shorter and smaller than those of the *Tectona grandis* type. The average stand height and average basal area are 24.4 m and 33.1 m^2 per ha. Soils under this type are sandy loam, sandy clay loam, and clay loam.

The tree layer is usually divided into upper and lower strata; however, some stands also have a middle stratum. The upper stratum is 20 to 30 m high and is dominated by *Lagerstroemia calyculata* Kurz. Other common species are the same as in the *Tectona grandis* type. The middle and lower strata are composed of small trees of upper stratum species, with heights of 10–20 m and 5–10 m, respectively.

The shrub layer is dominated by the bamboo *Oxytenanthera albociliata* Munro. *Dendrocalamus strictus* Nees and *Bambusa tulda* Roxb. are occasionally found. Saplings of the tree layer are scattered. Ground cover is not dense and consists of the upper-canopy species seedlings with a scattering of bamboo seedlings. Dominant grasses and herbs are *Arundinella hispida* Hack., *Eupatorium odoratum* Linn., etc.

Table 2. Means, ± standard deviation, and ranges (numbers within parentheses) for soil properties (0–15 cm depth) and topographic features of the tropical dry deciduous forest.

Soil properties and topographic features	Tegr*	Tegr-Xyke**	Tegr-Xyke-Temu***	Laca****
Bulk density (g/cc)	1.16 ± 0.14 (0.83 - 1.37)	1.16 ± 0.15 (0.92 - 1.34)	1.17 ± 0.15 (0.83 - 1.37)	1.26 ± 0.16 (0 95 - 1.54)
Particle density (g/cc)	1.977 ± 0.093 (1.765 - 2.138)	1.990 ± 0.079 (1.853 - 2.138)	1.962 ± 0.109 (1.765 - 2.092)	1.956 ± 0.089 (1.819 - 2.124)
Silt + clay (%)	51.787 ± 9.435 (32.17 - 63.19)	52.804 ± 9.286 (32.17 - 63.19)	50.668 ± 9.967 (40.54 - 62.31)	47.935 ± 14.866 (26.79 - 68.80)
pH	5.70 ± 0.66 (4.90 - 7.65)	5.88 ± 0.74 (5.00 - 7.65)	5.50 ± 0.54 (4.90 - 6.55)	5.33 ± 0.41 (4.55 - 5.90)
Cation exchange capacity (meq/100 g)	21.33 ± 7.49 (7.82 - 33.84)	23.17 ± 7.29 (7.82 - 33.84)	19.30 ± 7.54 (8.58 - 29.62)	18.32 ± 5.78 (9.51 - 26.36)
Organic matter (%)	3.81 ± 0.99 (1.93 - 5.52)	4.10 ± 1.08 (1.93 - 5.52)	3.50 ± 0.83 (2.60 - 4.94)	3.48 ± 0.89 (2.54 - 5.67)
Total nitrogen (%)	0 147 ± 0.045 (0.092 - 0.250)	0.156 ± 0.043 (0.099 - 0.239)	0.138 ± 0.047 (0.092 - 0.250)	0.130 ± 0.040 (0.081 - 0.200)
Available phosphorus (ppm)	14.00 ± 17.12 (2.90 - 67.00)	11.47 ± 18.59 (2.90 - 67.00)	16.78 ± 15.84 (3.45 - 52.50)	9.11 ± 14.20 (2.10 - 55.50)
Exchangeable cation (meq/100 g)				
potassium	0.49 ± 0.17 (0.22 - 0.98)	0.52 ± 0.21 (0.26 - 0.98)	0.45 ± 0.13 (0.22 - 0.60)	0.45 ± 0.19 (0.18 - 0.72)
calcium	10.49 ± 9.59 (3.06 - 47.00)	13.08 ± 12.05 (4.30 - 47.00)	7.65 ± 5.09 (3.06 - 17.75)	6.01 ± 3.47 (1.91 - 11.30)
magnesium	4.64 ± 3.46 (1.06 - 12.83)	4.66 ± 3.89 (1.06 - 12.83)	4.63 ± 3.12 (1.77 - 11.74)	4.47 ± 3.98 (0.93 - 12.60)
sodium	0.54 ± 0.18 (0.27 - 0.91)	0.54 ± 0.21 (0.27 - 0.91)	0.55 ± 0.15 (0.32 - 0.77)	0.52 ± 0.22 (0.10 - 0.98)
Depth of root penetration (cm)	57.71 ± 11.74 (32.0 - 80.0)	61.18 ± 7.80 (50 0 - 73.0)	53.90 ± 14.42 (32.0 - 80.0)	68 69 ± 19.31 (50.0 - 95.0)
Elevation (m)	407.86 ± 129.65 (180 - 640)	429.55 ± 120.43 (180 - 640)	384.00 ± 141.53 (190 - 595)	371.54 ± 118.38 (190 - 540)
Slope (%)	20.90 ± 17.01 (0 - 60)	20.73 ± 17.77 (0 - 60)	21.10 ± 17.77 (4 - 60)	17.62 ± 15.55 (0 - 55)

* *Tectona grandis* type

** *Tectona grandis–Xylia kerrii* sub-type.

*** *Tectona grandis–Xylia kerrii–Terminalia mucronata* sub-type.

**** *Lagerstroemia calyculata* type

Table 3. Number of trees in each diameter class of the dominance-types of the tropical dry deciduous forest. Numbers within parentheses give the percentage within each size class.

Dominance-types	No. of stands*	D.B.H (cm)																
		10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–110	110–120	120–130	130–140	140–150	150–160	160–170	170–180
Tectona grandis type	21	415 (30.38)	292 (21.38)	244 (17.86)	174 (12.74)	110 (8.05)	73 (5.34)	29 (2.12)	11 (0.80)	7 (0.51)	3 (0.22)	2 (0.15)	2 (0.15)	1 (0.07)	1 (0.07)	–	1 (0.07)	1 (0.07)
Tectona grandis–Xylia kerrii sub-type	11	144 (25.44)	88 (15.30)	89 (15.48)	86 (14.96)	76 (13.22)	49 (8.52)	20 (3.48)	10 (1.74)	5 (0.87)	–	2 (0.35)	2 (0.35)	1 (0.17)	1 (0.17)	–	1 (0.17)	1 (0.17)
Tectona grandis–Xylia kerrii–Terminalia mucronata sub-type	10	271 (34.26)	204 (25.79)	155 (19.60)	88 (11.13)	34 (4.30)	24 (3.03)	9 (1.14)	1 (0.13)	2 (0.25)	3 (0.38)	–	–	–	–	–	–	–
Lagerstroemia calyculata type	13	371 (39.59)	213 (22.73)	159 (16.97)	88 (9.39)	41 (4.38)	32 (3.42)	15 (1.60)	5 (0.53)	5 (0.53)	3 (0.32)	2 (0.21)	1 (0.11)	1 (0.11)	–	1 (0.11)	–	–

*0.2 hectare.

Figure 4. *Tectona grandis* forest type.

Figure 5. *Lagerstroemia calyculata* forest type, Huai Kha Khaeng Wildlife Sanctuary, Uthaithani Prov.

Butea superba Roxb., *Jasminum coarctatum* Roxb. and *Dioscorea hispida* Dennst. are the common climbers. Many orchids are included in this type–*Cymbidium* spp., *Vanda* spp., *Dendrobium* spp., and *Platycerium* spp.

There were 6 stands unclassified due to logging effects, which are deleted from this analysis.

Means and ranges of the soil properties (0–15 cm depth) and topographic features of the dominance-types of the tropical dry deciduous forest are summarized in Table 2. Organic matter, an expression of biomass production, and the other soil nutrients (especially exchangeable calcium) of the *Tectona grandis–Xylia kerrii* sub-type are higher than in the other types. Soils under this sub-type are only slightly acid while the *Lagerstroemia calyculata* type has a lower pH.

Table 1 shows that the *Tectona grandis–Xylia kerrii* sub-type has the highest average stand height and average basal area cover, 28.3 m and 42.5 m^2 per ha, respectively. The second highest average stand height and basal area are in the *Tectona grandis–Xylia kerrii–Terminalia mucronata* sub-type, and the *Lagerstroemia calyculata* type has the lowest average stand height and basal area cover.

Generally, the height of the upper canopy indicates the quality of the site (SPURR & BARNES, 1980). Average stand height from Table 1 shows that the *Tectona grandis–Xylia kerrii* sub-type occupies the best sites of the tropical dry deciduous forest while the *Lagerstroemia calyculata* type occurs on slightly poorer sites. Basal area cover is used as an estimate of dominance by the Wisconsin School (MUELLER–DOMBOIS & ELLENBERG, 1974). It shows the same trends as average stand height.

The distributions of tree sizes in each dominance-type are summarized in Table 3. The *Tectona grandis–Xylia kerrii* sub-type has 44.2 percent of trees larger than 40 cm while the others have only about 20 percent. The *Tectona grandis–Xylia kerrii –Terminalia mucronata* sub-type and the *Lagerstroemia calyculata* type are composed of trees similar in size, but they average smaller than those of the *Tectona grandis–Xylia kerrii* sub-type.

CONCLUSIONS

The 40 stands studied in the tropical dry deciduous forest of northern, northeastern, and western Thailand contain 138 identified tree species and 13 unidentified species. The vertical structure usually consists of three layers: the upper canopy, shrub layer, and ground cover. The upper canopy generally consists of two to three strata. Two species may dominate the upper conopy of the sample stands–*Tectona grandis* Linn. f. and *Lagerstroemia calyculata* Kurz. Two other species, *Xylia kerrii*

Craib and *Terminalia mucronata* Craib et Hutch, are secondary dominants. The tropical dry deciduous forest can be divided into two dominance-types: the *Tectona grandis* type and the *Lagerstroemia calyculata* type. The *Tectona grandis* type may be divided into two sub-types, based on the importance value of the dominant species: a *Tectona grandis–Xylia kerrii* sub-type, and a *Tectona grandis–Xylia kerrii–Terminalia mucronata* sub-type. The *Tectona grandis–Xylia kerrii* sub-type occupies the best sites of the tropical dry deciduous forest.

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