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A quantitative analysis of plant community structure in an abandoned rubber plantations on Kho-Hong Hill, southern Thailand

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Abstract

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The present study aimed to characterize plant community structure of rubber plantations abandoned 26 years previously and now a protected area of Prince of Songkla University on the west slope of Kho-Hong Hill. Trees whose girth at breast high were at least 30 cm were recorded from thirty-one plots (10*10 m) which were laid out systematically at every 100 m along three transects. Among native trees, this plant community is dominated by *Schima wallichii* Choisy, *Castanopsis schefferiana* Hance, *Memecylon edule* Roxb., *Diospyros frutescens* Blume, and *Diplospora malaccensis* Hook.f. Trees of the families Myrtaceae, Theaceae, Clusiaceae, Fagaceae, and Rubiaceae, and saplings of Clusiaceae, Myrtaceae, Theaceae, Rubiaceae and Euphorbiaceae were the most common. This plant community was characterized as a late seral stage post-cultivation succession. The basal area of rubber trees was positively significantly related to the species richness of native trees but negatively related to the density of native trees in each plot. Although abandoned rubber plantations create environmental conditions which effectively catalyze forest succession, dense rubber trees could slow succession of native trees by competition for resources. Further ecological, educational and recreational studies are discussed. Zoning this area to be a strict nature reserve and a conservation area is recommended.

Key words : rubber plantation, forest succession, secondary forest, Kho-Hong Hill

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บทคัดย่อ

สาระ บำรุงศรี เอกพงศ์ ศรีเปารยะ และ จรัญ ลีลติวงศ์
โครงสร้างสังคมพืชในพื้นที่สวนยางพาราทิ้งร้างบนเขาคอหงส์ ภาคใต้ของประเทศไทย
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การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อวิเคราะห์โครงสร้างสังคมพืชในพื้นที่สวนยางที่ทิ้งร้างมา 26 ปีบริเวณเชิงเขาคอหงส์ ซึ่งเป็นเขตอนุรักษ์ธรรมชาติของมหาวิทยาลัยสงขลานครินทร์ ทำการวางแปลงขนาด 10x10 เมตร ทุก ๆ ระยะ 100 เมตรตามเส้นแนว 3 เส้น วัดขนาดและจำแนกชนิดต้นไม้ที่มีขนาดเส้นรอบวงที่ระดับอกตั้งแต่ 30 ซม. ขึ้นไป พบว่าไม้พื้นเมืองที่มีค่าดัชนีความสำคัญสูงคือ มังตาน (*Schima wallichii* Choisy) ก่อเขี้ยวหมู (*Castanopsis schefferiana* Hance) พลองเหมือด (*Memecylon edule* Roxb.) พลับกล้วย (*Diospyros frutescens* Blume) เมื่อพิจารณาในระดับวงศ์พบว่า วงศ์ที่เด่นคือ วงศ์ Myrtaceae Theaceae Clusiaceae Fagaceae และ Rubiaceae ขณะที่ลูกไม้ในวงศ์ที่พบมากคือวงศ์ Clusiaceae Myrtaceae Theaceae Rubiaceae และ Euphorbiaceae ป่าทดแทนนี้น่าจะอยู่ในระยะการทดแทนขั้นท้าย ขนาดของพื้นที่หน้าตัดรวมของไม้ยางพารามีความสัมพันธ์ทางบวกกับความหลากชนิดของไม้ประจำถิ่นแต่มีความสัมพันธ์ทางลบกับความหนาแน่นของไม้ประจำถิ่นในแปลงศึกษา ถึงแม้ว่าสวนยางที่ทิ้งร้างจะมีสภาพแวดล้อมที่ช่วยเร่งการฟื้นตัวของป่าตามธรรมชาติ ต้นยางพาราที่หนาแน่นอาจจะลดความเร็วของการฟื้นตัวของไม้ป่าโดยการแก่งแย่งทรัพยากร เนื่องจากมีการใช้พื้นที่นี้เพื่อการศึกษาทางนิเวศวิทยา เป็นแหล่งเรียนรู้และเพื่อสันทนาการ จึงควรแบ่งการใช้พื้นที่เป็นเขตสงวนและเขตอนุรักษ์

ภาควิชาชีววิทยา คณะวิทยาศาสตร์ มหาวิทยาลัยสงขลานครินทร์ อำเภอหาดใหญ่ จังหวัดสงขลา 90112

Throughout the tropics, enormous areas of primary forest have been converted to agricultural land and this phenomenon is a major contributor for biodiversity loss (Bryant *et al*., 1997). In some instances, cultivated land is abandoned and replaced by secondary forest. Although it differs from original forest, this post-cultivation secondary forest supports a number of forest taxa, even when isolated from intact forest. Like other tropical countries, Thailand has lost a large portion of its forest in the last few decades. Fifty three percent of the country's area was covered with forest in 1961, but this had declined to 33.15% in 2000 (Department of National Park, Wildlife and Plant Conservation, 2003). Rubber or 'yang-pa-ra' (*Heavea brasiliensis* Willd. ex A. Juss.) plantations, the major cultivation practice in southern Thailand, replace large tracts of tropical forest. Rubber plantation increased from 1.58 million ha in 1978 to 2.0 million ha in 1992. In that year, 25% of the area of southern Thailand was covered with rubber plantations whereas only 18% was forest (Royal Forest Department, 1993).

Kho-Hong Hill, the largest isolated forest remnant close to the city of Hat Yai, was once covered with tropical forest, however, the majority of the hill area (>50%) is currently covered by rubber plantations. During 1976-1980, Prince of Songkla University bought some rubber plantations, and sixty hectares of them had no further disturbance or cultivation, so that secondary forest became established. This secondary forest is now protected as the university's nature reserve. This protected forest is a catchment for water supply to the university and has become increasingly used for research, education, recreation, and plant conservation. An inventory carried out by Maxwell (1986) indicated relatively high diversity of at least 596 species of vascular plants on this hill. Several undergraduate research projects have been done in the area, mainly on animals such as birds, termites, ants and canopy beetles (Charoensap, 1996; Ratcharote, 1999; Sritangnan, 1999; Wattanasit *et al*., 2005). Further research on forest regeneration, other ecological studies and nature interpretation are planned (Prince of Songkla University, 2002).

However, the area is still lacking a quantitative description of the forest community. It is also important to describe the community structure of abandoned rubber plantations of known age, since it may provide insights into the process of forest recovery. In addition, it is interesting to establish the extent to which a high density of planted rubber trees affects the establishment of native plants. The objectives of the present study are to describe the community structure of the secondary forest in an abandoned rubber plantation, and to determine the relationship between the density of rubber trees and the density and diversity of native plants.

Study area

The present study was carried out in a protected forest of Prince of Songkla University on Kho-Hong Hill (07º 00.4' N, 100º 30.7' E.). This isolated hill lies in a North-South direction and is surrounded by settlements and agricultural land. Most of the study area (60 ha) was an abandoned rubber plantation mixed with a disturbed forest. These plantations had been abandoned since they were bought by the university during 1976-80. The study area is characterized with slight undulating terrain ranging in altitude between 30 and 100 m asl, situated on the western side of the hill. The summit rises to 371 m. Former rubber plantations covered most of the lower elevations and flat areas. The 10 years climate was hot (mean minimum-mean maximum temperatures = 24.1-32.5ºC, average 28.3ºC) and relatively humid (average relative humidity of 72%) with 2,118 mm mean annual rainfall. Generally, there was a three month dry season (February to April) with rainfall less than 100 mm, whereas rain was heavy in October-December (Kho-Hong Meteorically Station, 2004). This tropical climate is classified as tropical wet seasonal according to Walsh (1996). The soil series belonged to the Ranong-Phato Association, subgroup typic paleudults. They are dark brown to brown over yellowish brown, very shallow/ shallow to moderately deep, well drained and have moderate permeability. Soils are poor with moderately low organic matter (Soil Survey Division, 1973). Bedrocks are heavily crushed and weathered carboniferous mudstones (Maxwell, 1986).

Methods

Plots of 0.01 ha (10*10 m) were laid out systematically at every 100 m along three transects (800-1200 m long) in a North-South direction (Figure 1). Transects were 150 m apart. When plots were placed on slopes, their size was adjusted by $x = 10\tan\phi$ where x is the adjusted length, and ϕ is the degree of slope. Trees whose girth at breast high (1.3 m) (GBH) was at least 30 cm were identified and recorded for their GBH. Saplings and shrub (GBH less than 30 cm but greater or equal to 5 cm) were identified and counted in a 4*4 m subplot set at the south-west corner in each plot. Voucher specimens of unknown species were collected for later identification by comparing with specimen in the Prince of Songkla Herbarium. Aspect and location of each plot were also noted.

A number of quantitative attributes were calculated. These were density (D) (total number of tree of species x/total sampling area), frequency (F) (number of plots with species x/ total number of plots), dominance (basal area of species x). The contribution of each species to the forest community in relation to other species was determined as relative density (R_{den}) (density of species x/ density of all species), relative frequency (R_f) (frequency of species x/ sum frequency of all species), relative dominance (R_{do}) (basal area of species x/ basal area of all species). The performance of each species was determined from the sum of relative contributions referred to as the Importance Value Index (IVI) when $IVI = R_{den} + R_f + R_{do}$.

A profile diagram of trees in a selected 10x30 m plot was drawn and the composition and the vertical forest structure were described.

To investigate the possible effect of rubber trees on native trees and saplings, total rubber tree basal area and the number of rubber trees were correlated with the number of native sapling species, the number of native sapling individuals, the number of native tree species and number of

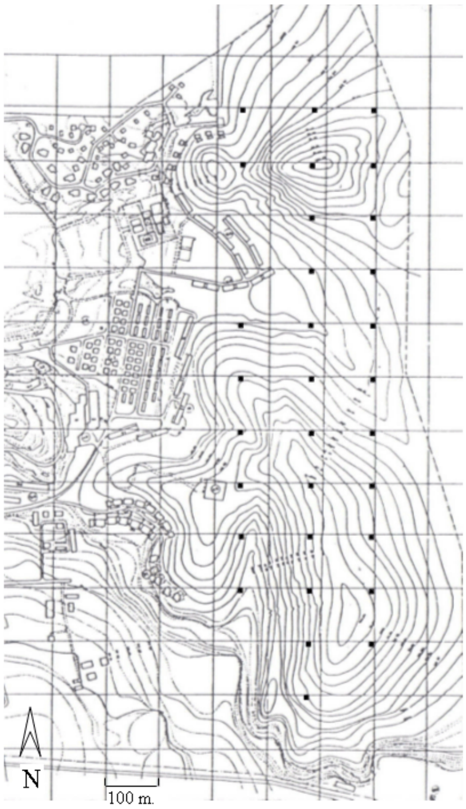

Figure 1. Distribution of sampling plots along thre transects in N-S direction over the protected nature reserve of Prince of Songkla University.

native individual trees in each plot. All statistical analyses were carried out using SPSS (11.0).

Results

Quantitative analysis

Two hundred and thirty seven individuals of 49 tree species with GBH equal or larger than 30 cm were measured in thirty-one 10*10m plots (0.31 ha). In addition, 249 individuals of 52 species of sapling and shrub were found in 31 plots of 4*4 m (0.05 ha). From a total native tree species density of 529 trees/ha, *Schima wallichii* Choisy, *Castanopsis schefferiana* Hance, *Memecylon edule* Roxb. and *Diospyros frutescens* Blume showed the highest density from 35.5-54.8 trees/ha while the density of rubber tree was 235.5 trees/ha. Seventy percent of native species were limited in distribution to only 1 or 2 plots. The four species with highest density and *Diplospora malaccensis* Hook.f. also had the widest distribution among native species and contributed 19-29 % of all plots. The estimated total basal area of all native trees was 11.14 m^2/ha while the basal area of rubber trees is 7.87 m^2/ha. The majority of trees (48%) had GBH between 30 and 39 cm. The GBH of six trees from five species exceeded 100 cm. These were *Albizea splendens* Miq. (200 cm), *Syzygium glaucum* (King) P. Chantaranothai & J.Parn. (160 cm), *Aquilaria malaccensis* Lamk. (157 cm), *Castanopsis schefferiana* Hance (143.5 cm), and rubber tree (128 and 105 cm). Outside the sampled plots, several trees were as large as 300 cm GBH such as *Instia palembanica* Miq., *Sindora echinocalyx* Prain and *Horsfieldia macrocoma* Warb. In terms of summed basal area, *Castanopsis* *schefferiana* Hance, *Schima wallichii* Choisy and *Albizea splendens* Miq. were dominant. In conclusion, *Schima wallichii* Choisy, *Castanopsis schefferiana* Hance, *Diospyros frutescens* Blume, *Memecylon edule* Roxb. and *Diplospora malaccensis* Hook.f. had the highest IVI (30.5, 28.67, 17.57, 17.42 and 14.26, respectively, Table 1).

At the family level of native trees, Myrtaceae (12.1%), Theaceae (11%), Clusiaceae (9.7%), Fagaceae (9.4%), Ebenaceae, Leguminosae and Rubiaceae (5%) had the highest IVI among the 25 families recorded. These families contributed more than 50% of all the IVI among native trees.

From a total sapling and shrub density of 5,020 individuals/ha, *Mesua kunstleri* (King) Kosterm. (806 ind./ha), *Syzygium zeylanicum* (L.) DC. (362 ind./ha), *Syzygium lineatum* (DC.) Merr. & L.M.Perry, *Syzygium cerasiforme* (Blume) Merr. & L.M.Perry, *Schima wallichii* Choisy (282.3 ind./ha) had the highest density. Saplings of rubber trees were also well established (282.3 ind./ha) (Table 2). At the family level, sapling of Clusiaceae (12%) Theaceae (11%), Myrtaceae (9%), Ebenaceae and Fagaceae (9%) and Memecylaceae (7%) dominated the studied area.

Description of the forest community structure based on the profile diagram

Vertical stratification (Figure 2) of the forest was not clearly defined. Three strata probably occured; top layer, middle layer and shrub layer. The top layer was 18-25 m high and was dominated by *Castanopsis schefferiana* Hance, *Schima wallichii* Choisy, *Syzygium glaucum* (King) P. Chantaranothai & J. Parn., *Syzygium claviflorum* (Roxb.) Wall. ex A.M. Cowan & Cowan, *Syzygium lineatum* (DC.) Merr.& L.M.Perry,*Vitex pinnata* L., *Sindora echinocalyx* Prain, *Cynometra ramiflora* L., *Elaeocarpus floribundus* Blume, *Swintonia floribunda* Griff. and *Albizea spendens* Miq.. When present, rubber trees occupied the top layer. The middle layer was between 7-15 m high which was dominated by *Garcinia nigrolineata* Planch. ex. T. Anderson, *Garcinia merguensis* Wight, *Diplospora malaccensis* Hook.f., *Diospyros frutescens* Blume, *Crypteronia paniculata* Blume, *Memecylon edule* Roxb., *Calophyllum calaba* L., *Psydrax nitida* (Craib) K.M. Wong. A number of shrubs including *Mesua kunstleri* (King) Kosterm., *Mallotus oblongifolius* Müll. Arg., *Macaranga lowii* King ex Hook.f., *Ixora javanica* DC., *Greenea corymbosa* (Jack.) K. Schum., *Croton argyratus* Blume, *Memecylon edule* Roxb., *Streblus taxoides* (Heynes) Kurz and *Prunus grisea* (C. Muell.) Kalkman dominated the shrub layer (1-3 m heigh). Seedlings of canopy and subcanopy trees such as *Hopea ferrea* Laness., *Aquilaria malaccensis* Lamk., *Garcinia* spp., *Diospyros* spp., and *Canthium* spp. were common. Woody climbers such as *Spatholobus harmandii* Gagnep., *Linostoma pauciflorum* Griff., *Ancistrocladus tectorius* (Lour.) Merr., and *Artabotrys* sp. were present. Rattan (*Calamus* spp.), *Amomum uliginosum* K.D. Koenig, *Elettariopsis curtisii* Baker, *Etlingera littoralis* (A. Koenig) Giseke, *Phrynium pubinerve* Blume, *Pandanus humilis* Lour., *Molineria latifolia* Herb. ex Kurz, *Licuala spinosa* Thunb., *Homalomena sagittifolia* Jungh. ex Schott and *Alocasia lowii* Hook. were also often found in moist areas along temporary streams. Remnant large trees including *Cynometra malaccensis* L., *Sindora echinocalyx* Prain, *Eleocarpus floribunda* Blume, *Instia palembanica* Miq. were present along the main stream. Creeping bamboo (*Dinochloa scandens* (Blume) Kuntze) was also common, especially along hill-ridges. In tree gaps, seedlings of *Macaranga* spp. were common while a number of early pioneer species such as *Alstonia macrophylla* Wall. ex G. Don, *Mallotus paniculatus* Müell. Arg., *Microcos tomentosa* Sm., *Erythroxylum cuneatum* (Miq.) Kurz, *Peltophorum dasyrachis* (Miq.) Kurz and *Macaranga triloba* (Reinw. ex Blume) Müell. Arg. were present along distinct forest edges. Snags were hardly found.

Although the forest covers a relatively small area (ca. 60 ha), a reconnaissance survey indicated some variations in dominant species in relation to physical microhabitats. On hill-ridges which were characterized by relatively shallow soil over mudrock fragments, *Castanopsis schefferiana* Hance, *Crypteronia paniculata* Blume, *Syzygium*

Table 1. Importance value index of native trees whose girth at breast high at least 30 cm from 31 plots (10*10 m.) in abandoned rubber plantations of Prince of Songkla University.

Scientific names	Vernacular names	Density (tree/ha)	Frequency (m^2/ha)	Basal area	Relative Density	Relative Frequency	Relative Dominance	Importance Value Index
Schima wallichii Choisy	Mangtan	54.84	29.03	1.24	10.37	9.00	11.13	30.50
Castanopsis schefferiana Hance	Kow keuw mu	45.16	19.35	1.57	8.54	6.00	14.13	28.67
Memecylon edule Roxb.	Plong mueat	35.48	19.35	0.54	6.71	6.00	4.86	17.57
Diospyros frutescens Blume	Phlap kluai	35.48	22.58	0.41	6.71	7.00	3.71	17.42
Diplospora malaccensis Hook.f.		22.58	19.35	0.44	4.27	6.00	4.00	14.26
Syzygium glaucum (King) P.Chantaranothai & J.Parn.	Daeng	12.90	6.45	0.95	2.44	2.00	8.52	12.96
Garcinia merguensis Wight	Nuan	25.81	9.68	0.35	4.88	3.00	3.18	11.06
Microcos tomentosa Sm.	Phlapphla	3.23	3.23	1.03	0.61	1.00	9.22	10.83
Albizea splendens Miq.		22.58	12.90	0.28	4.27	4.00	2.48	10.75
Crypteronia paniculatum Blume	Ka aam	16.13	12.90	0.23	3.05	4.00	2.09	9.14
Acronychia pedunculata (L.) Miq.	Ka uam	19.35	9.68	0.27	3.66	3.00	2.44	9.10
Sindora echinocalyx Prain	Ma kha	12.90	6.45	0.37	2.44	2.00	3.37	7.80
Vitex pinnata L.	Tin nok	3.23	3.23	0.63	0.61	1.00	5.68	7.29
Aquilaria malaccensis Lamk.	Mai hom	12.90	9.68	0.16	2.44	3.00	1.42	6.86
Garcinia nigrolineata Planch. ex. T. Anderson	Cha muang	12.90	6.45	0.20	2.44	2.00	1.80	6.24
Syzygium grande (Wight) Walp.	Mao	16.13	3.23	0.17	3.05	1.00	1.55	5.60
Syzygium cerasiforme (Blume) Merr. & L.M.Perry		9.68	6.45	0.13	1.83	2.00	1.19	5.01
Calophyllum calaba L.		9.68	6.45	0.12	1.83	2.00	1.11	4.93
Prunus grisea (C. Muell.) Kalkman	Nuut ton	9.68	6.45	0.08	1.83	2.00	0.69	4.52
Syzygium lineatum (DC.) Merr. & L.M.Perry	Khwaat	6.45	6.45	0.12	1.22	2.00	1.07	4.29
Syzygium zelanicum (L.) DC.	Samet daeng	9.68	3.23	0.13	1.83	1.00	1.14	3.97
Syzygium syzygioides (Miq.) Merr. & L.M.Perry		6.45	6.45	0.08	1.22	2.00	0.70	3.92
Mesua kunstleri (King) Kosterm.	Bunnnak paa	9.68	3.23	0.12	1.83	1.00	1.04	3.87
Hopea ferrea Pierre	Ta khian hin	9.68	3.23	0.11	1.83	1.00	0.98	3.81
Elaeocarpus floribundus Blume	Kaalon	6.45	3.23	0.16	1.22	1.00	1.47	3.69
Unknown 1 (Thymeliaceae)		6.45	6.45	0.05	1.22	2.00	0.46	3.68
Unknown 2		6.45	6.45	0.05	1.22	2.00	0.44	3.66
Cynometra malaccensis L.	Mang khaak	9.68	3.23	0.07	1.83	1.00	0.64	3.47
Chaetocarpus castanocarpus Thwaites	Khee non	3.23	3.23	0.19	0.61	1.00	1.72	3.33
Elaeocarpus petiolatus Wall. ex C. Muell.	Dee nguu	6.45	3.23	0.10	1.22	1.00	0.93	3.15

Table 1. (continued)

Scientific names	Vernacular names	Density (tree/ha)	Frequency (m^2/ha)	Basal area	Relative Density	Relative Frequency	Relative Dominance	Importance Value Index
Diospyros sumatrana Miq.	Lak khoei lak kluea	6.45	3.23	0.07	1.22	1.00	0.59	2.81
Cratoxylum cochinchinense Blume	Tiu kliang	6.45	3.23	0.05	1.22	1.00	0.46	2.68
Knema globularia Warb.	Lueat raet	3.23	3.23	0.10	0.61	1.00	0.89	2.50
Artocarpus elasticus Reinw. ex Blume	Ka ok	3.23	3.23	0.05	0.61	1.00	0.47	2.08
Mallotus paniculatus Müll. Arg.	Soi daao	3.23	3.23	0.05	0.61	1.00	0.47	2.08
Erythroxylum cuneatum (Miq.) Kurz	Krai thong	3.23	3.23	0.05	0.61	1.00	0.41	2.02
Pittosporum ferrugineum Ait.		3.23	3.23	0.04	0.61	1.00	0.37	1.98
Unknown 3		3.23	3.23	0.04	0.61	1.00	0.35	1.96
Swintonia schwenckii Teijsm. & Binn.	Kaan thong	3.23	3.23	0.04	0.61	1.00	0.35	1.96
Diospyros sp. 1		3.23	3.23	0.04	0.61	1.00	0.33	1.94
Morinda elliptica Ridl.	Yo thuean	3.23	3.23	0.04	0.61	1.00	0.32	1.93
Morinda spp.	Yo	3.23	3.23	0.02	0.61	1.00	0.21	1.82
Metadenia trichotoma Bakh.f.	Khamin ton	3.23	3.23	0.03	0.61	1.00	0.30	1.91
Callerya atropurpurea (Wall.) Schot		3.23	3.23	0.03	0.61	1.00	0.30	1.91
Rinorea anguifera Kuntze	Ngoh paa	3.23	3.23	0.02	0.61	1.00	0.22	1.83
Cleistanthus sumatranus Müell. Arg.	Fin daeng	3.23	3.23	0.02	0.61	1.00	0.21	1.82
Garcinia hombroniana Pierre	Waa	3.23	3.23	0.02	0.61	1.00	0.21	1.82
Adinandra integerrima T. Anders. ex Dyer		3.23	3.23	0.02	0.61	1.00	0.21	1.82
Unknown 4		3.23	3.23	0.02	0.61	1.00	0.21	1.82
	Total	529.03	322.58	11.14	100.00	100.00	100.00	300.00

Table 2. Sapling density.

Vernacular names	Scientific names	Density (tree/ha)
บุนนาคป่า	*Mesua kunstleri*	806.45
เสม็ดแดง	*Syzygium zelanicum*	362.90
ยางพารา	*Hevea brasiliensis*	282.26
ขวาด	*Syzygium lineatum*	282.26
ลางนาง	*Syzygium cerasiforme*	282.26
มังตาน	*Schima wallichii*	282.26
จิกนม	*Barringtonia macrostachya*	221.77
พลองเหมือด	*Memecylon edule*	201.61
ตังหน	*Calophyllum calaba*	181.45
ขี้หนอน	*Chaetocarpus castanocarpus*	161.29
โทะ	*Rhodomyrtus tomentosum*	141.13
กะอวม	*Acronychia pedunculata*	120.97
เข็มทอง	*Ixora javanica*	120.97
นวล	*Garcinia merguensis*	100.81
พลับกล้วย	*Diospyros frutescens*	80.65
Tarenna sp.	*Tarenna* sp.	80.65
Memecylon sp. 1		80.65
ตะเคียนหิน	*Hopea ferrea*	80.65
ชะมวง	*Garcinia nigrolineata*	60.48
พลับพลา	*Microcos tomentosa*	60.48
ก้านทอง	*Swingtonia schwenckii*	60.48
Unknown 1	*Thymeliaceae*	60.48
กาลน	*Elaeocarpus floribundus*	60.48
ตะไหล	*Prismatomeris tetrandra*	60.48
ข่อยหนาม	*Streblus ilicifolius*	60.48
พิกุลป่า	*Adinandra integerrima*	60.48
	Mallotus lowii	40.32
มะไฟกา	*Baccaurea parviflora*	40.32
ก่อเขี้ยวหมู	*Castanopsis schefferiana*	40.32
Leguminosae		40.32
ขมิ้นต้น	*Metadina trichotoma*	40.32
มวกกอ	*Olea salicifolia*	40.32
ฝิ่นแดง	*Cleistanthus sumatranus*	20.16
Diplospora sp		20.16
มอกมัน	*Glocidion superbum*	20.16
กาแซะ	*Callerya atropurpurea*	20.16
ส้านใหญ่	*Dillenia obovata*	20.16
กะอาม	*Crypteronia paniculatum*	20.16
กะออก	*Artocarpus elasticus*	20.16
กะทังใบใหญ่	*Litsia grandis*	20.16
Unknown 2		20.16
Unknown 3		20.16
Unknown 6		20.16
กระดูกค่าง	*Aporosa aurea*	20.16

Table 2. (Continued)

Vernacular names	Scientific names	Density (tree/ha)
หาดรุม	*Artocarpus dadah*	20.16
ตีนนก	*Vitex pinnata*	20.16
กาแร้งหิน	*Koilodepas longifolium*	20.16
มะจ้ำก้อง	*Ardisia colorata*	20.16
หว้าหิน	*Syzygium claviflorum*	20.16
Ficus sp		20.16
หาด	*Artocarpus lacucha*	20.16
นูดต้น	*Prunus grisea*	20.16
Tarenna sp.		20.16
total		**5020.16**

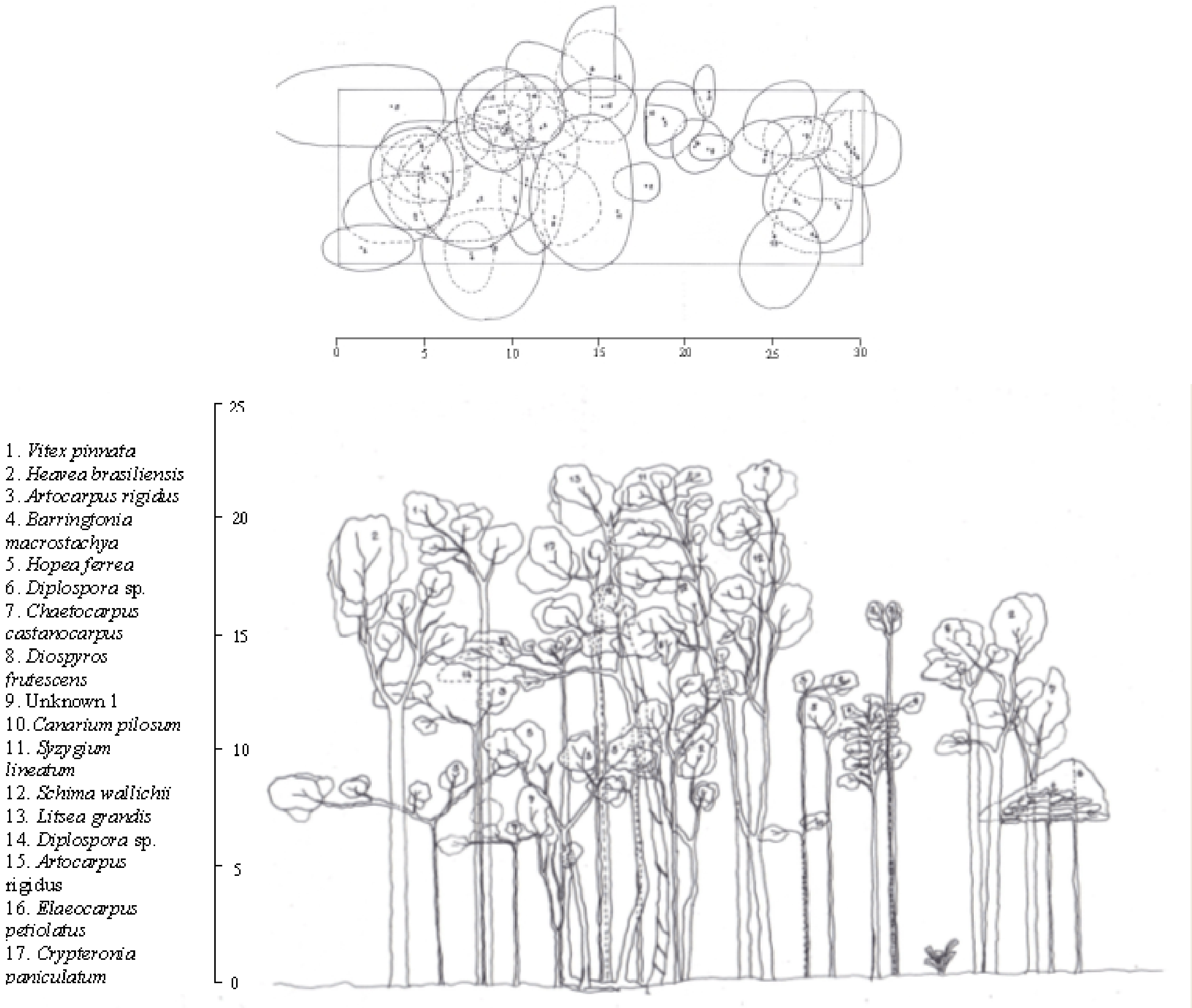

Figure 2. Profile diagram and vertical stratification of trees in a 10*30 m plot.

lineatum (DC.) Merr. & L.M. Perry, *Syzygium glaucum* (King) P.Chantaranothai & J.Parn., *Ixora javanica* DC. dominated. This microhabitat also seems to be more pristine than the others. On slight slopes and relatively flat areas, where more organic matter and sediment accumulated, *Garcinia* spp., *Diospyros* spp., *Memecylon edule* Roxb. and *Artocarpus elasticus* Reinw. ex Blume were common. This community covered most of the study area. In a small area of very shallow soil over rock outcrops (ca. 1 ha), a few plant species such as *Syzygium zeylanicum* (L.) DC., *Schima wallichii* Choisy, *Rhodomyrtus tomentosa* (Aiton) Hassk., *Calophyllum calaba* L. and a parasitic plant, *Dendrotrophe buxifolia* (Blume) Miq., sparsely covered the area, and canopy trees were relatively low (< 8 m.).

Correlation of rubber tree density and community characters of native plants.

Although the density of rubber trees in each plot was not significantly correlated to the number of sapling species ($r = 0.02$, $p = 0.93$), the density of saplings ($r = -0.16$, $p = 0.47$), the number of tree species ($r = 0.03$, $p = 0.91$) or the density of native trees (-0.24, $p = 0.27$) in plots, the basal area of rubber trees was positively significantly correlated to the number of native species ($r = 0.57$, $p = 0.002$, 1 tailed), and partially negatively significantly related to the density of native trees in each plot ($r = -0.75$, $p<0.001$, 1 tailed, controling for number of all trees).

Discussion

In post-cultivation forest succession, floristic composition, structural characters and rate of succession reflect land-use history, soil characteristics and proximity to old-growth forest (Tanthana, 1988; Grau *et al*., 1997; DeWalt *et al*., 2003). Tanthana (1998) compared successional plant communities in different ages (up to 10 years-old) of abandoned rubber plantations at Ton Nga Chang Wildlife Sanctuary, and revealed that native tree density increases with time, although at a longer time scale (50 years) the opposite is true (Grau *et al*., 1997). DeWalt *et al*. (2003) also pointed out that the similarity between secondary forest and old growth forest in tree species composition increases with forest age. Trees of Euphorbiaceae, Moraceae, Lauraceae, Sterculiaceae were dominant, and seedling, sapling and sprouting of Rubiaceae and Euphorbiaceae were the most common in abandoned rubber plantations in a wildlife sanctuary which was 26 km from the study area. The variation in major families between the present study and that of Tanthana (1998) may reflect ecological variation especially proximity to propagule resources and soil conditions. In primary forest of Ton Nga Chang Wildlife Sanctuary, Sawangchote (1998) studied ten 0.1 ha stands and found that trees of Dipterocarpaceae, Euphorbiaceae, Annonaceae, Sapindaceae were the most dominant, respectively. Although soil at Ton Nga Chang and Koh-Hong Hill are both in Ranong-Plato series, soil in the latter may be drier, as it is much shallower, with more weathered mudrock particles and likely more drainage (S. Bumrungsri, pers. obs.). Dominance of *Schima wallichii* Choisy, *Castanopsis schefferiana* Hance, *Syzygium* spp. and *Mesua kunstleri* (King) Kosterm. which are often found in dry habitats, suggests that Kho Hong Hill is drier. *Syzygium* spp. is also well dispersed in coastal sandbars communities in Songkhla Province which normally experience drought conditions during the dry season (Sridith, 2002). Similarly, Maxwell (1986) also pointed out that this forest is drier, and postulated that this was caused by continuous disturbance.

It is suggested that in a tropical moist climate, secondary succession proceeds rapidly with some ecosystem characteristics such as leaf litter mass, soil nutrient processes differing little from values of old growth forest over 40-50 years (Grau *et al*., 1997; DeWalt *et al*., 2003). It would be interesting to compare between the structure of this 26-year-old secondary forest with that of patches of primary forest that are present in military bases. DeWalt *et al*. (2003) found 21% similarity in forest structure between 20 year-old secondary forest and old growth stands in moist neotropical forest on Barro Colorado Island. They also found that it takes at least 70 years for secondary forest to resemble old growth stand structure. However, in the less fertile soils of the Rio Negro Basin of Venezuela, it was suggested to take up to 190 years (Saldarriaga *et al*., 1988).

Grau *et al*. (1997) suggested that pre-abandonment vegetation influences forest composition for several decades. Specifically, forest recovery in former rubber plantations differs from other kinds of cultivation, as farmers normally weed without burning in rubber plantations. Thus, when they were abandoned, rubber plantations still house some plant propagules. Furthermore, several studies have indicated that tree plantations are an effective tool for catalyzing forest succession by overcoming barriers to natural regeneration (review by Parrotta, 2000). This is due to their influence on understorey microclimate, development of litter, humus accumulation and structural complexity of the vegetation. Apart from litter quantity, soil surface microclimate and shading in plantations is also responsible for biomass of the soil fauna which plays a vital role in tropical forest as soil modifiers and nutrient cyclers. Thus, further investigation on how much litter fall and how fast the decomposition rate there is in this 26-year-old abandoned plantation is recommended.

Richards (1996) recognized four stages of post-cultivation succession; invasion, early seral, late seral, and mature. From his description, the present community could be assigned to the late seral stage. In this stage, which is comparable with the building phase of a primary forest gap, the forest becomes mixed with late seral species (long-lived and slow growing pioneers) and primary forest species. *Cryptononia paniculata* (Blume), *Vitex pinnata* L., *Acronychia pedunculata* (L.) Miq., *Artocarpus elasticus* Rienw. Ex Blume are examples of late seral species in this area, whereas species in the genera *Memecylon, Diospyros, Syzygium, Garcinia,* and *Hopea* are often found in primary forest.

Correlation of rubber tree density and community characters of native plants.

The negative correlation between rubber tree biomass and native tree density may be due to the fact that although abandoned rubber plantation create suitable environmental conditions for native tree establishment, rubber trees are likely to be competitors for light and soil water. Although rubber trees probably do not have allelopatric effect on nearby plants (Tanthana, 1998), this negative correlation suggests that, at a certain stage of development, these exotic tropical trees which perform well in the wet tropics can slow succession of native species probably by resource competition. A number of studies indicated negative effects of invasions of exotics on native communities (review by Levine *et al*., 2003), and competition is by far the most common explanation. An empirical study on whether rubber trees have a negative impact on plant community structure and the underlying mechanisms of such impact is needed. At present, rubber trees are well distributed in the study area (70% of plots), and they contributed 30-40% of density and basal area of trees with a diameter larger than 10 cm. Furthermore, rubber saplings are among those which have the highest density, although they accounted for only 5.6 percent of total saplings. Alternatively, the positive correlation between the basal area of rubber trees and the species diversity of native tree was significant. It is possible that in sites where the basal area of rubber trees is larger, the environmental conditions (e.g. microclimate, litter quantity, soil fertility) are also more suitable for the establishment of a number of primary forest species as well.

Further studies and management recommendation

Considering the proximity of the area to a university, this forest provides excellent opportunities for ecological, educational and recreational activities. A GIS map of its boundary and the different habitats on Kho Hong Hill based on updated aerial photographs, together with environmental factors such as soil type and rock parent material should be made. For botanical studies, the flora of Kho Hong Hill should be updated, since Maxwell (1986) carried out his intensive survey of the flora twenty years ago. For further ecological studies, a database and a field guide based on morphological characters of each species are strongly recommended. This is an essential first step and further studies on plant phenology, plant ecology, forest succession, and plant-animal interaction could be undertaken. Permanent plots should be established in representative areas of this forest and intensive studies on forest succession should be carried out. These plots could be specifically research areas for undergraduate and postgraduate studies under the supervision of academic committees.

It is suggested that secondary forest can provide vital resources for nesting, foraging and protection for a number of animal taxa. DeWalt *et al*. (2003) indicated that understory fleshy fruit availability was highest in young secondary forest (20 years old) compared to older secondary and old growth forest. Thus, secondary forest at this age may provide good food resources for wild animals especially generalist frugivore/insectivore birds and mammals. Several species of fruigovorus birds e.g. bulbul (*Pycnonotus* spp.) are common in forest habitats (Charoensap, 1996; S. Bumrungsri, pers. obs.). Several studies have indicated that avian diversity in secondary forest is as high as it is in primary forest, although endemic species are fewer (Estrada *et al*., 1997; Waltert *et al*., 2004). As fauna is also important for forest recovery, an investigation of faunal diversity, population and habitat use is needed, especially for those animals that are pollinators, seed dispersers, and decomposers. This forest patch is actually isolated from nearby patches by current rubber plantations and may suffer from small population effects. Conservation biology-based practices such as restocking of plants and animals, natural corridor establishment and monitoring could be implemented. In addition, environmental education and ecotourism could be potentially applied in this forest, especially for those school students from Hat Yai city. Forest nature trails with information provided could be constructed in different microhabitats including a temporary waterfall (8 m high). However, without any regulations, these activities could possibly upset the area and could disturb ecological studies. Zoning of this protected area to 1.) strict nature reserve (for research only) and 2.) conservation area (education and recreation uses) is recommended. The particularly rich flora along the main stream (Maxwell, 1986) is particularly in need of protection.

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