CHAPTER II

LITERATURE REVIEW

GENERAL INFORMATION OF DOI PHU KHA

Location

Doi Phu Kha is located in Nan province, lines along most of the eastern part of northern Thailand adjoining to the Laos' border (Fig. 2). According to a royal decree, on 17 June 1999, Doi Phu Kha and surrounding areas were established as a national park (The Government Gazette, 1999). Doi Phu Kha National Park is aimed to conserve and restore forests in the following areas: Doi Phu Kha forest, Pha Daeng forest, eastward of the southern part of Nan river forest, Nam Waar forest and Mae Charim forest. The area covers approximately 1,704 km^2 (170,400 hectares or 1,065,000 Rai) in eight administrative districts: Bo Kluea, Chalerm Pra Kiat, Chiang Klang, Mae Charim, Pua, Santisuk, Tha Wang Pha and Thung Chang (Fig. 3). It is shown in topographic map scale 1: 50,000: sheets 5146I, 5246IV, 5147I, 5147II, 5247III and 5247IV.

The park headquarters is located in Phu Kha subdistrict, Pua district, ca. 1,300 m above sea level and about 80 km north of the centre of Nan City. The coordinate is QB 191240 and on topographic map scale 1: 50,000: sheet 5247III. To access the park headquarters from Nan, one can take the highway 1080 (Muang – Pua road) about 60 km until Pua City and turn right along highway 1256 (Pua – Bo Kluea road) at Km. 25 (Fig. 10). The highest peak of the highway 1256 is 1,684 m a.s.l. at Km. 33+675. There are visitor center, guesthouses and camping areas for visitors around the park headquarters. The park has nine forest ranger stations scattered through the area.

Geography

Doi Phu Kha National Park has a geographical position between 18° 40′ – 19° 30′ north latitudes and 100° 55′ – 101° 10′ east longitudes. The topographical feature mainly consists of mountainous ranges and valleys oriented in a north to south direction, part of the Luang Pra Bang mountainous range, which actually lies in the eastern part of northern Thailand and the western part of northern Laos. The mountainous areas account for about three-fourths of the whole region, while the remaining one-fourth can be classified as plains and valleys. The elevation is between 500-1,980 m above the sea level (Figs. 4, 9). There are several peaks in Doi Phu Kha National Park, namely Doi Phu Kha (1,980 m), Doi Dong Yaa Wai (1,939 m) (Fig. 16),

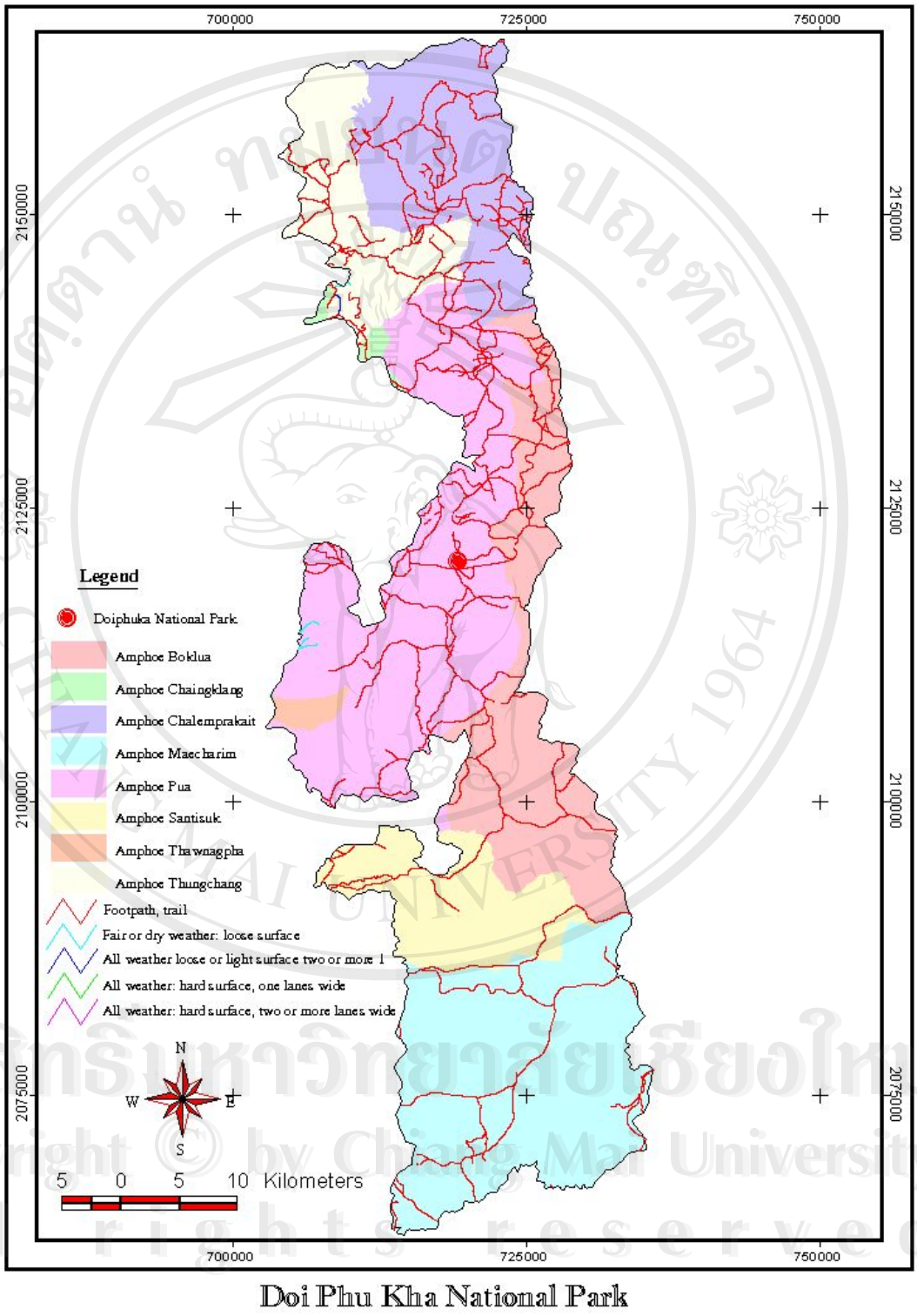
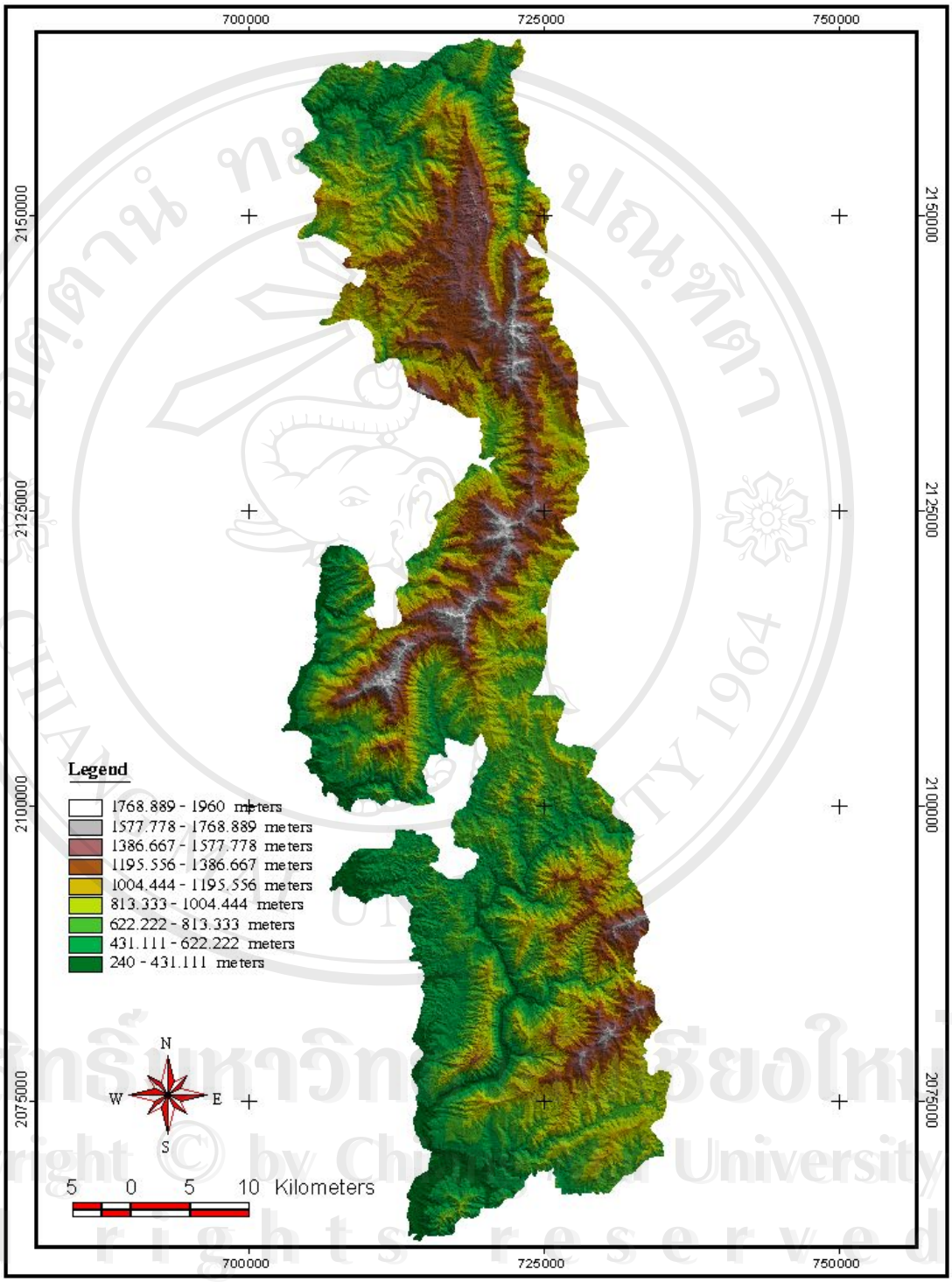


Figure 3. Map of Doi Phu Kha National Park.



Topography of Doi Phu National Park

Figure 4. Topography of Doi Phu Kha National Park.

Doi Phu Wae (1,837 m) (Figs. 17-19), Doi Khun Nam Nan (1,812 m) Doi Phu Sam Liam (1,348 m), Doi Phu Huat (1,342 m) (Fig. 15), Doi Phu Faa (1,248 m) and Doi Mon Phe Tai (1,085 m).

The area represents by primary forests, secondary forests and disturbed areas (Fig. 23), forest plantations, orchards (Fig. 26), highland shifting cultivation fields (Figs. 24, 25) and villages. However, some parts of the forests still remain valuable and are considered as watershed areas originating important rivers and tributaries. The Nan river, which is one of the four main rivers that join and form Chao Phraya, the main river of central Thailand, also originates here. There are several caves in the park but not easy to access. After establishment as a park, the nature trails to some caves such as Tham Pha Kong in Pua district and Tham Pha Khaw in Bo Kluea district were constructed. Some caves also have maritime fossil especially in northern part of the park such as Tham Pha Daeng and Tham Pha Pheng in Chiang Klang district. Waterfalls are distributed moderately through the park, and also not easy to access, notably are Namtog Thon Tong in Pua district (Fig. 13), Namtog Wiang Peian in Chalerm Pra Kiat district (Fig. 14) and Namtog Phu Faa in Mae Charim district.

Geology

The main bedrock in Doi Phu Kha National Park originated in the Jurassic period approximately 205-140 million years ago. It basically consists of shale, sandstone and siltstone, while in the higher elevation, ca. 1,300 m above sea level upward, belonging to Pra Wihan (white to light brown quartz sandstone, siltstone and shale) and Sau Khua (reddish brown siltstone, mudstone, sandstone and shale) formations. Limestone is also found in scattered outcrops. The northern part, however, in Chalerm Pra Kiat district (Doi Phu Wae) has rugged limestone massive hills up to ca.1,837 m in elevation from Permian period approximately 290-245 million years ago (Hess & Koch, 1975). The landscape typically consists of crack stone, sinkholes and vertical cliffs.

Soils

The mountainous areas in northern Thailand are generally dominated by two great soil groups: the red-yellow to red-brown podzolic soils and the reddish brown lateritic soils.

The red-yellow podzolic soils are developed from a wide range of parent materials including weakly acidic to acidic rocks and older alluvial sediments, which are not strongly leached. The soils possess clayey subsurface horizons and loamy textured surface horizons. Generally, soils of this group are stony and shallow but vary with the type of parent rock, climatic and topographic conditions. Soils in the drier climate are usually shallower and stonier than those in the more mesic environments on similar parent materials. Mottled clay often appears in the subsoil.

The reddish brown lateritic soils are derived from intermediately acidic to basic rocks. Texture of surface soils is loamy or sandy and clay is evident throughout the profile. Subsurface soil colours range from dark red to dark reddish brown. Mottled clay, with or without laterite, may be found in the deeper zone.

In valleys, the soils near the rivers are old alluvium, red-yellow podzolic soils, poorly drained and clayey, with high to moderate fertility. Red-yellow podzolic soils on residuum and colluvium, formed from acidic rocks, and of low fertility are occasionally found along the foothills (Smitinand et al., 1978; Santisuk, 1988).

Climate

The climate in northern Thailand is influenced by the alternating monsoon: the south-west monsoon, originates in the Indian Ocean and brings warm moist air masses to the region, which is the main source of precipitation, during May to September and the north-east monsoon, from the Pacific Ocean and NE Asia and bring cool dry air to the region, during November to February.

At Doi Phu Kha National Park, there are three distinct seasons influenced by the monsoon climate. The meteorological records from Nan City (18° 47′ north latitude and 100° 47′ east longitude, ca. 200 m a.s.l.) (Table 1; Figs. 5, 8) and Tha Wang Pha (19° 06′ north latitude and 100° 48′ east longitude, ca. 235 m a.s.l.) (Table 2; Figs. 6, 8) stations for the lowland area and from the park headquarters (19° 13′ north latitude and 101° 05′ east longitude, ca. 1,300 m a.s.l.) (Table 3, Figs. 7, 8) for the highland area are available which can be roughly used to indicate approximate rainfall and temperature in the national park.

The rainy season is from May to mid-October, with the peak of rainfall in August. The annual rainfall averages around 1,277.85 mm in Nan City, 1,423.13 mm in Tha Wang Pha and 2,048.09 mm in park headquarters stations.

The cool dry season is from mid-October to February, the temperature at park headquarters can drop at night as low as 5°C (observed by the author in December 1998).

The hot dry season is from late February to May, the highest temperature is in April.

The average mean temperature ranges from 25.20°-25.88°C (min. 20.21°-20.57° - max. 31.99°-33.04°C) in the lowland area stations and about 20.88°C (min. 16.24° - max 25.54°C) in the highland area station.

In fact, average temperatures decrease about 0.6°C per 100 m increasing in elevation. The actual temperatures on the mountains from the park headquarters (ca. 1,300 m a.s.l.) up to the summit (ca. 1,980 m) should be considerably less than those readings from three meteorological stations while the rainfall is higher.

Phytogeography

Thailand is located in the centre of mainland Southeast Asia, between 5° 27′ – 20° 17′ north latitudes and 97° 21′ – 105° 37′ east longitudes. It has a total area of about 515,000 km^2, almost equal to France or Texas State, USA. The country is bounded by the following countries: on the north by Shan State, Myanmar (Burma) and northern Laos; on the northeast and east by Laos and Cambodia (Kampuchea), respectively; on the west by Myanmar; and on the southernmost by Malaysia. Its long coastlines are flanked on the southeast and eastern side of the Peninsular by the Gulf of Thailand; and on the western side of the Peninsular by the Andaman Sea (Fig. 1).

Because of the geographical position, Thailand does not have unique floristic elements since the majority of plant species in the country are closely related to the species in neighboring countries. Thus, flora of Thailand is mainly influenced by three major floristic elements: Indo-Burmese element (E Himalayan element) from NE India, Nepal, Bhutan, Sikkim, Bangladesh and Myanmar; Indo-Chinese element from S China, Laos, Vietnam and Cambodia; and Malaysian element from Malaysia and Indonesia.

In northern Thailand, as well as Doi Phu Kha National Park, the flora is presumably more influenced by Indo-Burmese element and Indo-Chinese element. Malaysian element has considerably less influence due to the geographical position.

There are several families or genera belonging to Indo-Burmese element or Indo-Chinese element having shown their southernmost limit distribution within northern or northeastern Thailand. Families are, for example, Bretschneideraceae, Helwingiaceae and Podoaceae. Genera are, for example, *Anisadenia* Wall. ex Meissn. (Linaceae), *Boenninghausenia* Reich. ex Meissn. (Rutaceae), *Cautleya* Hook.f. (Zingiberaceae), *Choerospondias* B.L. Burtt & A.W. Hill (Anacardiaceae), *Colquhounia* Wall. (Lamiaceae), *Dactylicapnos* Wall. (Fumariaceae), *Docynia* Decne. (Rosaceae), *Hovenia* Thunb. (Rhamnaceae), *Leucosceptrum* Sm. (Lamiaceae), *Luculia* Sweet (Rubiaceae), *Neohymenopogon* Bennet (Rubiaceae), *Reinwardtia* Dumort. (Linaceae), *Silvianthus* Hook.f. (Carlemanniaceae or Caprifoliaceae), *Sladenia* Kurz (Sladeniaceae or Theaceae), *Stauntonia* DC. (Lardizabalaceae), *Streptolirion* Edgew. (Commelinaceae), *Sycopsis* Oliv. (Hamamelidaceae) and *Trachycarpus* H. Wendl. (Arecaceae).

Fauna

The number of wild animals in Doi Phu Kha has become scarce due to loss of habitats through human activities such as hunting. There are previous records that Doi Phu Kha has been home of wildlife such as wild boar, Asiatic black bear, serow, mountain goat, binturong, civet, porcupine, pangolin, leopard, fishing cat, monkey, gibbon, snake, jungle fowl, bat, etc.

There are over 200 species of birds known to be in the park, including kite, eagle, king fisher, warbler, woodpecker, bulbul and pita. Rare birds such as Rufous-throated Fulvetta and Clamorous Reed-Warbler are also found.

People and Activities

The people who live in Doi Phu Kha National Park and surrounding areas are highland Thais and hill tribe minorities. Both groups have settled here before the establishment of the national park.

Thai people settled below 700 m above sea level. Upland rice, maize and ginger are their main agricultural crops. Non-timber forest products such as bamboo shoots, honey, pulp from the mulberry tree and rattan provide supporting income. According to Hilltribe Welfare Division (1998), the number of highland Thais in 1997 was 3,884 persons who reside in the park and surrounding areas, which defined in 2 districts (Bo Kluea and Mae Charim), 4 subdistricts, 17 villages and 740 households (Table 4).

Hill tribe minorities comprise of 3 groups: Hmong or Meo, Lau (Lawa) or H'tin (official name by government) and Khamu. They reside at an elevation between 600-1,300 m.

Hmong, belongs to the Meo-Yao branch of the Austro-Thai linguistic family, is one of the most spread out minority groups, scattered throughout S China in Kweichow, Hunan, Szechwan, Kwangxi and Yunnan provinces. In Thailand, Hmong settlement is concentrated in north and upper part of northeastern regions, in thirteen provinces: Chiang Mai, Chiang Rai, Mae Hong Son, Lampang, Phrae, Nan, Phayao, Tak, Kamphaeng Phet, Sukhothai, Phitsanulok, Phetchabun and Loei. The number of Hmong people in 1995 was approximately 124, 211, the second largest group after Karen and made up 17.88 % of all hill tribes in the country (Technical Service Club, 1995). They migrated from Laos to Nan about a century ago. According to Hilltribe Welfare Division (1998), the number of Hmong in 1997 was 7,619 persons who reside in the park and surrounding areas, which defined in 4 districts (Thung Chang, Bo Kluea, Santisuk and Mae Charim), 6 subdistricts, 17 villages and 858 households (Table 4). Litchi plantations and cabbage fields are their main cash crops. While, rice and maize are their main subsistence crops. The expansion of agriculture into deep forests is a response from the demand from lowland people. The rapid increase of the Hmong population is also the cause of forest destruction because each family must have their own land. Polygamy is allowed for Hmong family.

H'tin (Lua), belongs to the Mon-Khmer branch of the Austro-Asiatic linguistic family, is migratory swidden farmers in the northern Thailand-Laos border area. From available reports it appears that H'tin have lived in Thailand for a very long time (Technical Service Club, 1995). In Thailand, H'tin settlement is mostly concentrated in Nan and with very few scattered (about 1,300 persons) in Chiang Mai, Mae Hong Son, Phetchabun and Loei. The number of H'tin people in 1997 was approximately 38,823 (Hilltribe Welfare Division, 1998), and made up about 4.5 % of

all hill tribes in the country. According to Hilltribe Welfare Division (1998), the number of H'tin in 1997 was 28,808 persons who reside in the park and surrounding areas, which defined in 7 districts (Chalerm Pra Kiat, Thung Chang, Chiang Klang, Pua, Bo Kluea, Santisuk and Mae Charim), 15 subdistricts, 114 villages and 5,079 households (Table 4). Upland rice fields using shifting cultivation method are the major forms of livelihood. The fallow period is about 3-6 years. Cutting and burning strongly effect the forest situation. Other cultivated plants include cucumber, ginger and Zanthoxylum, which are planted for sale. Non-timber forest products such as broom grass, herbs, mushroom and wild banana flower are collected for increasing their income. H'tin is animist and monogamous. They have their own regulations to protect the holy (special) forest according to the belief that their ancestor still reside there. They do not cut or disturb that forest due to respectfulness and fearfulness of spirits (the appearing of abnormal or unexpected events). The holy forest has become one of the *in situ* conservation areas locally protected by them. It is also effective in indirectly conserving the forest even though it is a small percentage of the whole area.

Khamu, also belongs to the Mon-Khmer branch of the Austro-Asiatic linguistic family, lives along mountainous area of northern Thailand-Laos border area. They first migrated from Laos to Nan about a century ago as labourers and worked either in the teak forests or in similarly isolated places. In Thailand, Khamu settlement is mostly concentrated in Nan and with scattered (about 3,000 persons) in Chiang Rai, Lampang, Sukhothai and Uthai Thani. The number of Khamu people in 1997 was approximately 13,674 (Hilltribe Welfare Division, 1998), one of the smallest groups in northern Thailand and made up about 1.5 % of all hill tribes in the country. According to Hilltribe Welfare Division (1998), the number of Khamu in 1997 was 6,511 persons who reside in the park and surrounding areas, which defined in 3 districts (Chalerm Pra Kiat, Thung Chang and Bo Kluea), 7 subdistricts, 22 villages and 1,193 households (Table 4). The major form of livelihood is similar to H'tin supplemented by hunting and hireling. Khamu is also animist.

Selective logging is actively done by both highland Thais and hill tribe minorities for housing construction, fuel and miscellaneous activities. Cattle are commonly set free for grazing. Native pastures used as grazing lands may lead to overgrazing in the future. Since the establishment of the national park, fixing-field farming policy for the national park management program seems to be positively benefiting for the forest regeneration.

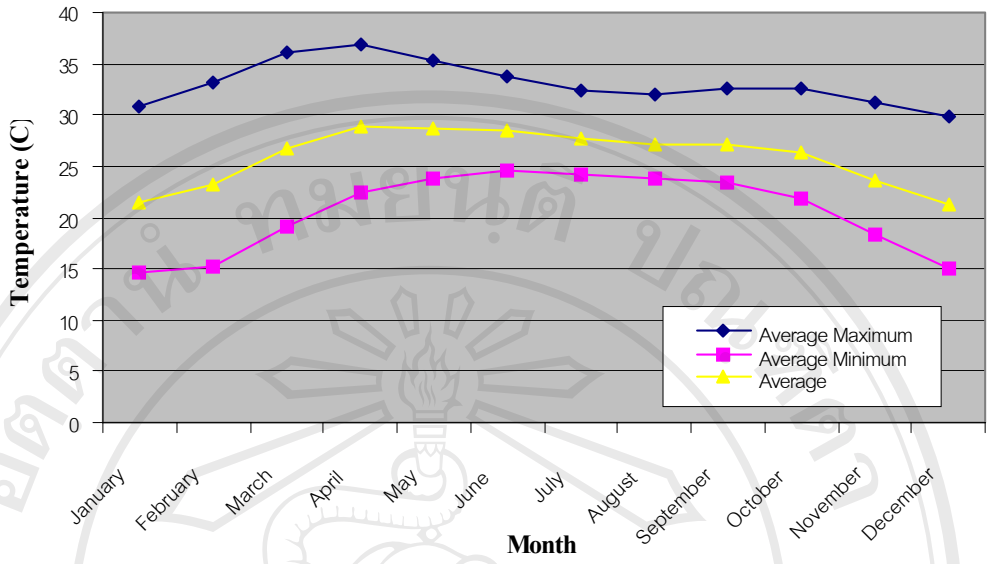


Figure 5. Climatological data of Nan City (200 m a.s.l.). Average of 13 years (1991-2003).

Table 1. Climatological data of Nan City (200 m a.s.l.).

Average of 13 years (1991-2003).

Month	Temperature (C)			Average
	Average Maximum	Average Minimum	Average	Rainfall (mm)
January	30.78	14.63	21.44	4.90
February	33.12	15.24	23.13	12.40
March	36.11	19.18	26.64	54.04
April	36.93	22.49	28.89	76.92
May	35.27	23.90	28.73	172.44
June	33.69	24.51	28.43	125.03
July	32.44	24.26	27.72	208.03
August	31.98	23.83	27.19	318.28
September	32.61	23.49	27.10	206.91
October	32.52	21.92	26.26	65.80
November	31.13	18.36	23.70	21.64
December	29.90	15.05	21.30	11.46
	33.04	**20.57**	**25.88**	**1,277.85**

Source: Northern Meteorological Center (Unpubl. data).

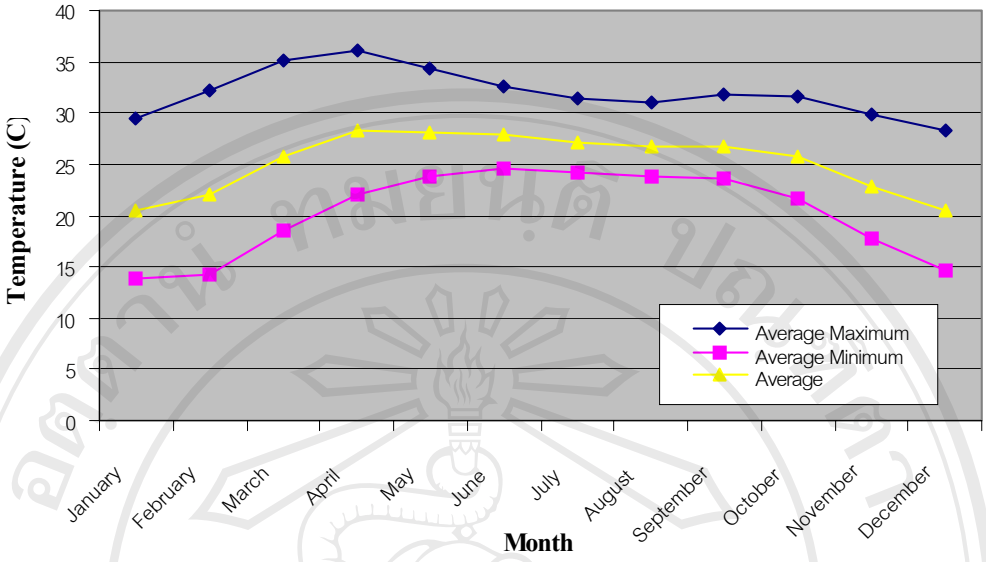


Figure 6. Climatological data of Tha Wang Pha (235 m a.s.l.). Average of 13 years (1991-2003).

Table 2. Climatological data of Tha Wang Pha (235 m a.s.l.). Average of 13 years (1991-2003).

Month	Temperature (C)			Average Rainfall (mm)
	Average Maximum	Average Minimum	Average	
January	29.48	13.88	20.47	4.86
February	32.20	14.15	22.03	8.24
March	35.15	18.46	25.83	49.54
April	36.10	22.09	28.23	81.17
May	34.30	23.80	28.17	185.60
June	32.64	24.50	27.87	189.22
July	31.39	24.16	27.19	269.93
August	31.04	23.86	26.82	312.24
September	31.85	23.53	26.76	207.50
October	31.53	21.63	25.67	76.19
November	29.83	17.81	22.90	26.25
December	28.38	14.67	20.47	12.39
	31.99	**20.21**	**25.20**	**1,423.13**

Source: Northern Meteorological Center (Unpubl. data).

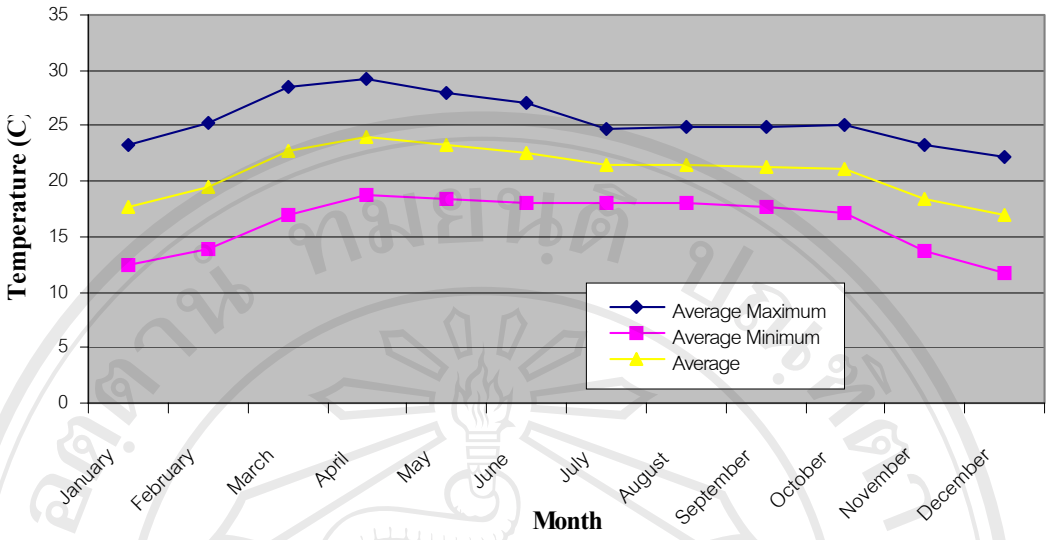


Figure 7. Climatological data of Doi Phu Kha National Park (1,300 m a.s.l.). Average of 6 years (1997-2002).

Table 3. Climatological data of Doi Phu Kha National Park (1,300 m a.s.l.). Average of 6 years (1997-2002).

Month	Temperature (C)			Average Rainfall (mm)
	Average Maximum	Average Minimum	Average	
January	23.22	12.42	17.75	9.58
February	25.26	13.81	19.53	2.25
March	28.49	16.99	22.74	68.52
April	29.25	18.74	23.99	112.96
May	28.01	18.38	23.19	149.06
June	27.01	18.12	22.57	204.83
July	24.80	18.08	21.44	507.88
August	24.96	18.05	21.51	499.73
September	24.87	17.73	21.30	336.08
October	25.01	17.14	21.08	115.86
November	23.29	13.69	18.49	34.68
December	22.26	11.67	16.97	6.66
	25.54	**16.24**	**20.88**	**2,048.09**

Source: Doi Phu Kha National Park.

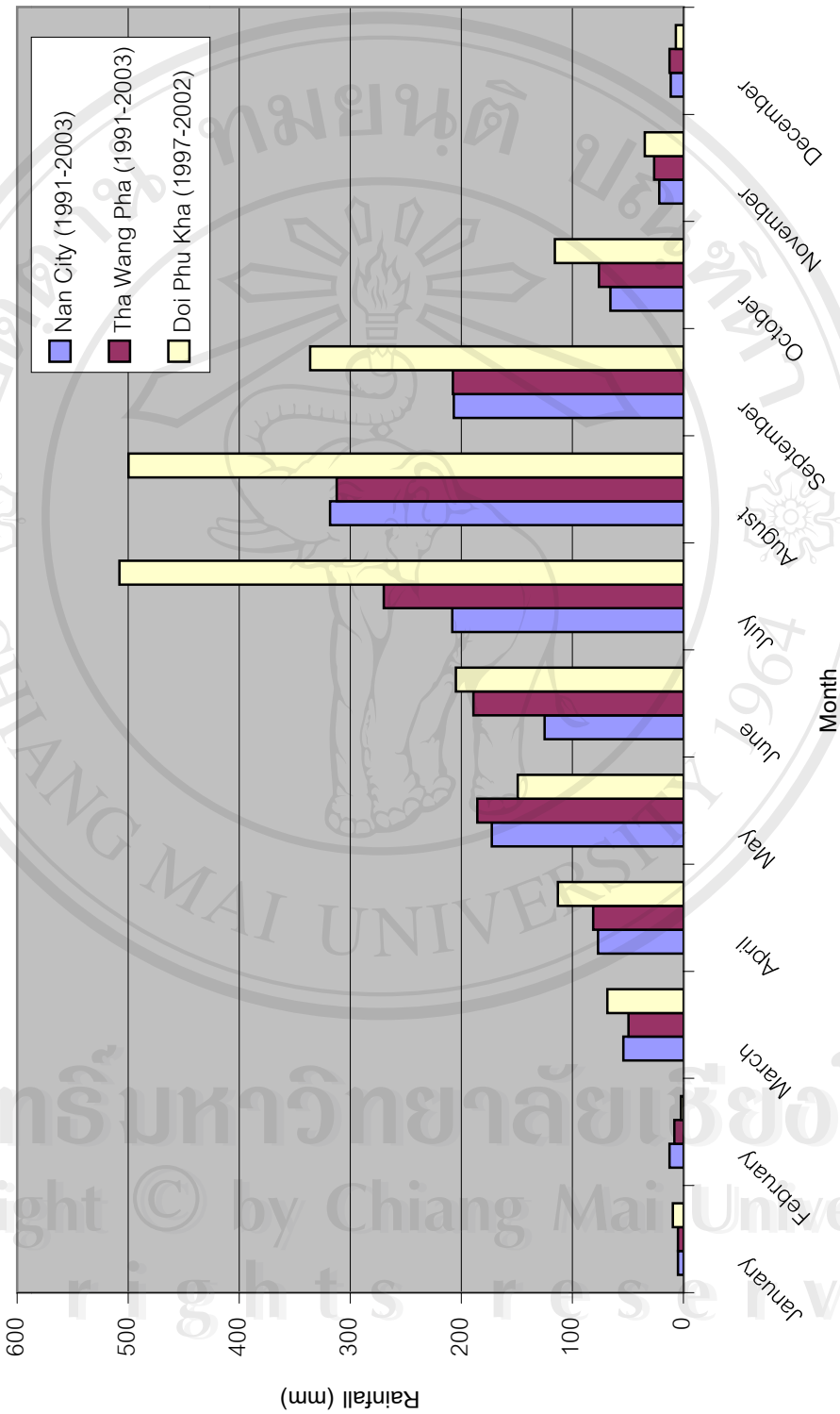


Figure 8. Average rainfall (mm) of three stations.

Table 4. Population in Doi Phu Kha National Park and surrounding areas.

District	Subdistrict	H'tin			Khamu			Hmong			Highland Thai		
		Villages	Households	Persons	Villages	Households	Persons	Villages	Households	Persons	Villages	Households	Persons
Chalerm Pra Kiat	Huay Klon	5	340	1,612	1	33	204	-	-	-	-	-	-
	Khun Nan	23	1,013	6,289	8	477	2,678	-	-	-	-	-	-
Thung Chang	Pond	5	375	1,755	2	260	1,371	-	-	-	-	-	-
	Ngob	2	109	603	2	146	611	-	-	-	-	-	-
	Lae	1	37	144	2	64	316	3	194	1,947	-	-	-
	Thung Chang	1	76	294	1	11	45	8	326	3,189	-	-	-
Chiang Klang	Phaya Kaeo	2	256	1,156	-	-	-	-	-	-	-	-	-
Pua	Phu Kha	22	863	4,560	-	-	-	-	-	-	-	-	-
Bo Kluea	Bo Kluea Nuea	21	523	3,322	6	202	1,286	1	12	50	6	219	1,165
	Dong Phaya	7	202	1,515	-	-	-	-	-	-	-	-	-
	Bo Kluea Tai	14	381	2,233	-	-	-	-	-	-	2	19	291
	Phu Faa	6	437	2,482	-	-	-	-	-	-	-	-	-
Tha Wang Pha		-	-	-	-	-	-	-	-	-	-	-	-
Santisuk	Pong	2	273	1,825	-	-	-	2	121	867	-	-	-
Mae Charim	Mae Charim	1	82	425	-	-	-	1	57	337	2	88	434
	Nam Pang	2	112	593	-	-	-	2	148	1,229	7	414	1,994
Total		**114**	**5,079**	**28,808**	**22**	**1,193**	**6,511**	**17**	**858**	**7,619**	**17**	**740**	**3,884**

Source: Hilltribe Welfare Division (1998).

VEGETATION OF NORTHERN THAILAND

There have been quite a number of publications concerning the account of the vegetation of Thailand since the forests of Thailand have been studied taxonomically. Beginning with Dr. C.C. Hosseus in 1904, who made the first botanical exploration of northern Thailand (Jacobs, 1962; Tips, 2001). He published the results based on his collecting trip as the article, entitled "Beiträge zur Flora des Doi Suthäp, unter vergleichender Berüchsichtigung einiger anderer Höhenzüge Nordsiams" (Contributions to the flora of Doi Suthep with special reference to comparison with a few other mountain ranges of northern Siam) (Hosseus, 1908). This work was also considered as the first publication about the forest vegetation of Thailand. Subsequently, Dr. A.F.G. Kerr sketched the vegetation of Chiang Mai (Kerr, 1911). Since that time, the classification of vegetation of Thailand has been improved continuously by various botanists, including those of Credner (1935), Ogawa et al. (1961), Royal Forest Department (1962), Williams (1965), Neal (1967), Smitinand (1989), Nanakorn (1996, 1997, Undated) and Maxwell (2001). There were also the studies emphasizing on vegetation of northern Thailand, including those of Smitinand et al. (1978), Santisuk (1988) and Pooma & Barford (2001). Some floristic studies in certain localities in northern Thailand also mentioned their vegetation type in each studies area such as Doi Suthep-Pui National Park, Chiang Mai (Maxwell & Elliott, 2001), Doi Chiang Dao, Chiang Mai (Smitinand, 1966; Maxwell, 1992b, 1998a; Santisuk, 1998b; Nanakorn, 1998), Doi Inthanon National Park, Chiang Mai (Robbins & Smitinand, 1966), Doi Kuhn Tan National Park, Lamphun-Lampang (Maxwell et al., 1995) and Jae Sawn National Park, Lampang (Maxwell et al., 1997).

The basic criterion for classification of vegetation of Thailand in published works is the presence or absence of the leaves of the tree component in each area particularly in dry season in response to the amount of soil moisture. Thus, there are only two fundamental vegetation types namely deciduous forest and evergreen forest. Both forest types had been classified into various subtypes mainly based on the two paramount factors: elevation and species composition (floristic component) such as dominant or remarkable species occurring e.g. members of Dipterocarpaceae, Fagaceae and Pinaceae, teak and bamboo. The other environmental factors such as geology, topography, climate, land use, etc. are also considered significant for classification.

A short description of the classification of vegetation of northern Thailand by Smitinand et al. (1978), Santisuk (1988), Maxwell (2001) and Pooma & Barford (2001) is reviewed as follows:

Smitinand et al. (1978) classified the forest types of northern Thailand into two main categories: evergreen and deciduous, with further subtypes associated with differences in altitude, soil, rainfall and land use. Details of the species distribution within the forest subtypes are listed. Modifications and special subtypes, economic value, and noxious species in each forest are also mentioned. A short description of each forest type is given below.

Evergreen forest consists of:

1. Lower montane (moist evergreen) forest

Location: Higher parts of western ranges of northern Thailand at elevation above 1,000 m.

Soil types: Red granitic or brown-black calcareous.

Annual rainfall: 1,500-2,000 mm, high humidity in undisturbed forest.

Structure: Two-storied, dense.

Floristics: Dominant upper story tree species is composed of members of Fagaceae, i.e. oaks (*Quercus*) and false chestnuts (*Lithocarpus*, *Castanopsis*), and Lauraceae, e.g. *Cinnamomum* and *Neolitsea*, birch (*Betula alnoides* Buch-Ham. ex G. Don) and other evergreen species. Shrubs and epiphytes including mosses, liverworts and lichens are abundant. Herbaceous species form a rich ground flora. Lianes are relatively infrequent. Several genera of bamboos and palms are also found. Ferns and orchids are also rich represent.

Modifications and special subtypes: Undisturbed primary forest type – portions with closed canopy; High altitude boggy areas – sphagnums; Open exposed summits and ridges – sparse vegetation resembling subalpine forest, containing temperate zone genera; Areas disturbed by man – several false chestnuts (*Castanopsis*) species and birch (*Betula alnoides* Buch-Ham. ex G. Don) become dominant.

2. Coniferous forest

Location: Steep slopes and exposed ridges; elevation varies, this is an edaphic type, which usually occupies areas subject to extensive erosion and leaching.

Soil types: Grayish sandy or brownish gravelly, sometimes lateritic.

Annual rainfall: 1,000-1,500 mm.

Structure: Three-storied, open.

Floristics: Dominant upper story tree species is composed of pines: *Pinus kesiya* Royle ex Gord. and *P. merkusii* Jungh. & de Vriese. Middle story is formed of oaks and false chestnuts, together with other evergreen species. At lower elevations middle story contains dipterocarps including *Dipterocarpus* and *Shorea*. Lower story is formed of small trees and tall shrubs. Ground flora is varied and mainly composed of tall grasses and a variety of herbaceous species.

3. Dry evergreen forest

Location: Scattered in depressions of the peneplain (300 m) and in humid valleys of low hill ranges (500-1,000 m) or forming galleries along streams and rivulets.

Soil types: Granitic or calcareous loam.

Annual rainfall: 1,000-2,000 mm.

Structure: Three-storied.

Floristics: Dominant upper story tree species is composed of a number of dipterocarps such as *Anisoptera costata* Korth., *Dipterocarpus alatus* Roxb. ex G. Don, *D. costatus* C.F. Gaertn., *D. turbinatus* C.F. Gaertn., *Hopea*

odorata Roxb., and other species. There are scattered palms and sparsely growing bamboos. Lianes are abundant. Epiphytic orchids and ferns occur sporadically. Strangulating figs are frequent. The dense undergrowth is composed of members of Zingiberaceae, ferns and a number of other plants.

Notes: Except in valleys between low ranges of hills, dry evergreen forests are remnants of extensive luxuriant forest, which once covered the peneplain and has now been largely cleared for agriculture.

Deciduous forest consists of:

4. Moist mixed deciduous forest

Location: Above lowlands up to the elevation approximately 600 m.

Soil types: Granitic or calcareous loam.

Annual rainfall: 1,000-1,500 mm.

Structure: Three-storied.

Floristics: Dominant upper story tree species is composed of teak (*Tectona grandis* L.f.), *Lagerstroemia tomentosa* C. Presl, many species of legumes such as *Afzelia xylocarpa* (Kurz) Craib, *Albizia chinensis* (Osb.) Merr., *A. lebbeck* (L.) Benth., *Dalbergia cultrata* Graham ex Benth., *D. oliveri* Gamble, *Pterocarpus macrocarpus* Kurz, *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C. Nielsen, and many other species such as *Bombax anceps* Pierre, *Chukrasia tabularis* A. Juss., *Terminalia bellerica* (Gaertn.) Roxb. A few palms are scattered through this forest. Shrubs of several genera also occur. Lianes are scattered. Bamboos are abundant. Epiphytes including orchids, ferns and other species are less abundant. Ground flora is composed of members of Zingiberaceae and other species.

Notes: Teak and other valuable timber species are taken from this forest type.

5. Dry mixed deciduous forest

Location: Scattered in higher and lower elevations.

Soil types: Colluvial, sandy loam or lateritic.

Annual rainfall: 600-1,000 mm.

Structure: Two-storied.

Floristics: Dominant upper story tree species is composed of teak (*Tectona grandis* L.f.), *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C. Nielsen, and several other species such as *Lagerstroemia balansae* Koehne, *L. calyculata* Kurz, *L. macrocarpa* Wall., *Spondias pinnata* (L.f.) Kurz. Bamboos are scattered. Epiphytes including orchids, ferns and other species are frequent. Ground flora is similar to that of the Moist mixed deciduous forest, but species of *Crotalaria*, *Desmodium* and several other genera are also prominent.

Modifications and special subtypes: Along ridges between 300-500 m, the forests are more open due to high evaporation, excessive exposure, extensive surface erosion and much leaching of the soil; under these conditions xerophytic species are found such as *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb., *Shorea obtusa* Wall. ex Bl. and *S. siamensis* Miq.

Notes: Ground flora subject to annual ground fires.

6. Dry deciduous dipterocarp forest

Location: On undulating peneplain and ridges at elevation between 300-1,000 m.

Soil types: Sandy or lateritic.

Annual rainfall: Under 1,000 mm.

Structure: Two-storied, open upper story and low shrubby lower story.

Floristics: Dominant upper story tree species (ca. 20-25 m high, but only ca. 15-20 m in arid places) is composed of *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb., *Gluta usitata* (Wall.) Ding Hou, *Shorea obtusa* Wall. ex Bl. and *S. siamensis* Miq, and other species. Epiphytes including orchids, ferns and other species are common. Ground flora consists largely of tuberous and rootstock-bearing species, because of the selective effects of fire, and includes small bamboos, as well as members of herbaceous genera and others.

Modifications and special subtypes: Where the forest floor is subject to inundation during the rainy season and the soil is podzolic, the annual plant community consists of *Eriocaulon*, *Habenaria*, *Spathoglottis* and *Drosera*.

Notes: Forest subject to extreme leaching and erosion as well as annual burning. These conditions create a climax type of vegetation in which dipterocarps and other fire-resistant species prevail.

Santisuk (1988) classified the vegetation of northern Thailand into nine forest types, also within two basic categories: evergreen and deciduous.

The major criterion for his account is moisture (between xeric and mesic) and elevation (between lowland and montane zone). Floristic components and other environmental factors such as edaphic and anthropogenic are also used for supporting his system. He also proposed that the vegetation could be divided into lowland zone and montane zone by altitudinal line at approximately 1,000 m above sea level that supported by the floristic disparity of these two ecological zones. The transition between lower montane forest and upper montane forest lies at approximately 1,800 m above sea level. Intimate mixtures of different components frequently occur along the junctions of the principal vegetation types resulting in the formation of a transition boundary. Floristic components in each forest type are listed. A short description of each forest type is given below.

Evergreen forest consists of:

1. Seasonal rain forest

Location: Sheltered moist valleys of low hill ranges up to the elevation approximately 900 m, gentle to moderate moist slopes, along mountain ravines, moist foothills or depressions of the peneplain.

Soil types: Granitic or calcareous loam.

Structure: Three-storied, rarely with emergent trees (ca. 35-40 m high).

Floristics: Dominant upper story tree species (ca. 22-35 m high) is composed of *Anisoptera costata* Korth., *Dipterocarpus alatus* Roxb. ex G.

Don, *D. costatus* C.F. Gaertn., *D. turbinatus* C.F. Gaertn., *Hopea odorata* Roxb., and many other species e.g. in Anacardiaceae, Euphorbiaceae, Fabaceae (Leguminosae), Flacourtiaceae, Meliaceae and Moraceae. Middle story (ca. 10-22 m high) consists of members of Fabaceae, Lauraceae, Meliaceae, Sapindaceae and others. Lower story (less than 10 m high) consists of members of Araliaceae, Bignoniaceae, Clusiaceae, Euphorbiaceae, Lauraceae, Moraceae, Myristicaceae and others. Shrubs are well represented by members of Acanthaceae, Capparaceae, Euphorbiaceae, Rubiaceae, Urticaceae and others. Palms are more frequent in moister places or along the watercourses. Bamboos are uncommon and considered as secondary colonizers since they are found mostly in the gaps of the forest or along the forest margins where light can penetrate to the forest floor. Lianes are abundant. Epiphytic orchids and ferns occur occasionally. Herbaceous flora includes a number of species of Araceae and Zingiberaceae.

Notes: Seasonal rain forest is heavily subjected to shifting cultivation practiced by lowland Thai dwellers due to its favourable edaphic condition.

2. Lower montane rain forest

Location: Moist valley slopes and valley basins at elevation between 1,000-1,800 m.

Soil types: Red granitic or brown-black calcareous, with conspicuous accumulation of orgamic matters.

Annual rainfall: 1,300-2,000 mm or more, constant high humidity.

Structure: Three-storied, dense.

Floristics: Dominant upper story tree species (ca. 25-35 m high) is composed of members of Fagaceae, Lauraceae, Magnoliaceae and Theaceae. Epiphytic orchids and ferns are more abundant. Herbaceous species form a rich ground flora. Undergrowth and lianes are rather poor. Tall large bamboos are almost absent.

Notes: Lower montane rain forest is heavily subjected to shifting cultivation traditionally practiced by hill tribes and, in recent decades, by lowland Thai dwellers. As a consequence, secondary growths, woodlands, savannas and man-made grasslands representing various destruction stages are common in the mountains of the North.

3. Lower montane oak forest

Location: Secondary growth on mountainous areas at elevation between (700-)1,000-2,200 m.

Structure: Very variable, depending on the extent of disturbance.

Floristics: Dominant tree species is composed of members of Fagaceae, Betulaceae, Proteaceae and Theaceae. Epiphytic orchids and ferns are also common. Lianes are sparsely represented. Grasses are poorly developed. Herbaceous flora includes a number of species of Asteraceae, Gentianaceae, Lamiaceae and Liliaceae.

Notes: Lower montane oak forest represents heavily disturbed various succession stages of the primary montane vegetation caused by shifting cultivation.

4. Lower montane pine-oak forest

Location: Typically on ridges and moderate to steep slopes at elevation between (700-)1,000-1,400(-1,700) m.

Soil types: Red to yellow granitic

Structure: Similar to lower montane oak forest, but differs from it by the inclusion of a native, emergent, three-needled pine, *Pinus kesiya* Royle ex Gord.

Floristics: Similar to lower montane oak forest.

Notes: Lower montane pine-oak forest may be considered as a severe destruction stage of lower montane oak forest which is regularly or periodically interfered with by biotic (burning, cutting, grazing) or edaphic (e.g. soil erosion) factors. Regular or periodical burning in dry season (January-February) is a common phenomenon in this forest as fire can readily sweep over the forest floor, where dry needle leaves are thickly accumulated.

5. Upper montane rain forest

Location: Peaks of the mountains at elevation between (1,800-)2,000-2,565 m.

Soil types: moist, rich in orgamic matter and humus.

Structure: Single-storied, tall and dense.

Floristics: Dominant tree species (ca. 16-22 m high) is composed of members of Aceraceae, Fagaceae, Lauraceae, Magnoliaceae and Theaceae. Epiphytic orchids are numerous. Large woody lianes are absent, but common herbaceous vines still occur. Herbs are also commonly found along the forest margins.

Notes: It can be distinguished floristically from lower montane rain forest by gradual disappearance of the species of Fagaceae and Magnoliaceae, which commonly encountered in lower montane rain forest.

6. Upper montane scrub

Location: Along the crests of exposed, barren summit areas of the limestone massive in Chiang Dao district, Chiang Mai province at elevation between 1,900-2,175 m.

Floristics: Only prominent palm trees, *Trachycarpus oreophilus* Gibbons & Spanner, now endemic to northern Thailand are found scattered along the crests and ridge tops. Dominant species are herbaceous plants and low shrubs, many of which are temperate genera or species, thriving in the mossy cracks or crevices of limestone rocks.

Deciduous forest consists of:

7. Tropical mixed deciduous forest

Location: On peneplains, along foothills and lower and middle slopes at elevation below 800 m.

Soil types: both acidic and basic soil groups, but usually reaching its best development on the soil derived from limestones and the fertile alluvium, more xeric phase may be expected on shallower soils, sandy loam, colluvium to laterite.

Structure: Very variable from mesic (three-storied) to xeric (not distinctly two-storied) phases.

Floristics: Mixed with almost all deciduous tree species without any single species dominance. Notable are the families Fabaceae (*Albizia*, *Cassia*, *Dalbergia*, *Millettia*, *Xylia*), Lamiaceae (*Premna*, *Tectona*, *Vitex*), Combretaceae (*Anogeissus*, *Terminalia*) and Lythraceae (*Lagerstroemia*). Upper story is vary from mesic (ca. 20-30 m high) to xeric (12-20 m high). Middle story and lower story of mesic phase is 10-20 m high and less than 10 m high, respectively. The undergrowths are abundant including shrubs and bamboos, of which are influenced by periodic fires which result in the replacement of evergreen shrubs by tufted grasses and these are abundant, where the canopy is open. Palms and rattans are very rare, the latters are confined to the ravines. Lianes are abundant. Bamboos are abundant. Epiphytes including orchids, ferns and other species are more frequent at higher elevations. Ground flora is composed of members of Zingiberaceae, Commelinaceae, Rubiaceae and Orchidaceae. Grasses and sedges are commonly found.

Notes: Tropical mixed deciduous forest is devoid of the floristic associations of the deciduous dipterocarps: *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb., *Shorea obtusa* Wall. ex Bl. and *S. siamensis* Miq. Deciduous trees change tones to varying degree in November-December and continue to drop their leaves unitil January-February, when the menace of forest fire is quite serious.

8. Deciduous dipterocarp forest

Location: On the slopes of foothills, on hill sides, along the ridges, and running up slopes to elevation approximately 600-800 m.

Soil types: Acidic, shallow, gravelly to sandy, or lateritic with levels of stoniness.

Structure: Two-three-storied, usually dominated by two or three of deciduous dipterocarp species, with open canopy and a conspicuous layer of graminoid (including dwarf bamboos) undergrowth.

Floristics: Most characteristic trees are deciduous dipterocarps: *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb, *Shorea obtusa* Wall. ex Bl. and *S. siamensis* Miq., in association with *Gluta usitata* (Wall.) Ding Hou, several legumes such as *Dalbergia cana* Graham ex Kurz, *D. cultrata* Graham ex Benth., *Pterocarpus macrocarpus* Kurz, *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C. Nielsen and other species such as *Canarium subulatum* Guill., *Haldina cordifolia* (Roxb.) Ridsd., *Mitragyna hirsuta* Havil., *M. rotundifolia* (Roxb.) Kuntze. Upper story consists of medium-sized trees (seldom over 18 m high, 25-35 m high in mesic sites) of deciduous dipterocarp species and a few other associates. Middle story and lower story are hardly distinguishable from one another. Shrub layer includes numerous seedlings and saplings of the dominant canopy tree species. Grasses are common everywhere. Climbers (represented by legumes, *Argyreia*, *Dioscorea*, *Smilax* and *Lygodium*) and epiphytes (represented by

orchids, ferns, *Dischidia* and *Hoya*) are rare. Ground flora consists largely of tuberous and rootstock-bearing species.

Notes: This is the most xeric type of the natural vegetation of northern Thailand. The soils are subject to annual burning, slope erosion and extreme leaching. Deciduous dipterocarp forest is entirely absent from limestone hills except *Shorea siamensis* Miq.

9. Pine-deciduous dipterocarp forest

Location: Extensively developed on the plateau-like rolling hills at elevation between (500-)800-1,200(-1,300) m.

Soil types: Grayish sandy, brownish gravelly or lateritic with varying degrees of stoniness.

Structure: Three-storied, with open canopy and a conspicuous layer of graminoid undergrowth.

Floristics: Upper story tree species or emergent (25-30(-40) m high) is composed of the majority of *Pinus merkusii* Jungh. & de Vriese and sporadic *P. kesiya* Royle ex Gord. Middle story or main canopy consists of deciduous dipterocarps: *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb, *Shorea obtusa* Wall. ex Bl. and the other common associates: *Gluta usitata* (Wall.) Ding Hou, *Anneslea fragrans* Wall., *Schima wallichii* (DC.) Korth., *Engelhardia spicata* Bl., oaks and false chestnuts. Lower story is formed of small trees. Dominant trees are the same as middle story, among which *Tristaniopsis burmanica* (Griff.) P.G. Wilson & J.T. Waterh. var. *rufescens* (Hance) J. Parn. & N. Lughadha, *Dillenia aurea* Sm., *Aporosa villosa* (Wall. ex Lindl.) Baill. and *Symplocos racemosa* Roxb. are common associates. Shrub layer includes seedlings and saplings of pines and deciduous dipterocarp species. Grasses are common everywhere. The dwarf palm, *Phoenix acaulis* Roxb., is highly characteristic of the forest. Bamboos are absent. Climbers (represented by legumes, *Aristolochia*, *Clematis* and *Smilax*) are uncommon. Epiphytes (represented by orchids, ferns and lichens) are abundant. Ground flora consists of many temperate genera and species.

J.F. Maxwell has recently summarized forest classification in Thailand from various works and presented his forest classification scheme (Table 5) in a re-assessment of the forest types of Thailand (Maxwell, 2001). His system originally developed for use in northern Thailand was expanded to include all the country.

The salient parameters for his system are seasonality, vegetational structure, floristic composition and elevation. He recognized that seasonality occurred throughout Thailand. His scheme also links with the developmental state (primary, secondary or tertiary) of the vegetation. His classification, excluding aquatic and beach vegetation, can be broadly divided into three main forest types: evergreen forest, deciduous forest and mixed evergreen + deciduous forest. For the presence of dominant species in any types of forest, the name of that species plus the name of main forest type had been applied as the name of forest subtype. For example, as a name of deciduous forest with abundance of bamboo, he named it deciduous forest

with bamboo, while notable pine in primary evergreen forest, is primary evergreen forest with pine, and dominance of members of Dipterocarpaceae and Fagaceae association in deciduous forest, is deciduous dipterocarp – oak forest, etc.

Pooma & Barfod (2001) described the vegetation of northern Thailand. The account is based on Santisuk (1988) and information extracted from Anderson (1993), Poffenberger (1999) and Schmidt-Vogt (1999). They also classified the vegetation within two basic categories: evergreen and deciduous and mentioned that the forest types described have mostly been studied in the western and southern parts of northern Thailand and especially on Doi Inthanon and Doi Suthep, Chiang Mai. Some areas in the eastern part remain poorly explored, in particular to areas near the Laotian border in Nan and in Uttaradit and Phrae provinces. To make a detailed description of the variation of the floristic composition and structural characteristics of the forest in northern Thailand it is important that additional vegetation studies are conducted in those areas.

Evergreen forest consists of

1. Seasonal rain forest

The forest is as described by Santisuk (1988) and also known under the name "Dry evergreen forest" in Smitinand et al. (1978). There are further mentioned that *Dipterocarpus costatus* C.F. Gaertn. and *D. turbinatus* C.F. Gaertn. are common at elevation between 500-900 m, whereas *Anisoptera costata* Korth., *Dipterocarpus alatus* Roxb. ex G. Don and *Hopea odorata* Roxb. are more abundant at lower altitude and towards the south of distributional ranges of seasonal rain forest.

2. Lower montane evergreen forest

The forest is known under the names "Lower montain rain forest in case of primary vegetation and Lower montane oak forest in case of secondary vegetation" in Santisuk (1988).

3. Upper montane evergreen forest

The forest is as described by Santisuk (1988) under the name "Upper montane rain forest".

4. Montane scrub

The forest has been termed for sub-alpine vegetation occurring on limestone at altitudes between 1,900-2,200 m and also known under the name "Upper montane scrub" in Santisuk (1988).

Deciduous forest consists of

5. Mixed deciduous forest

The forest is as described by Santisuk (1988) under the name “Tropical mixed deciduous forest”. There are further mentioned that based on human impact and terrain characteristics two subtypes are sometimes recognised: forest dominated by teak and forest dominated by bamboo. The dominance of teak reflects richer soil types and an environment with moderate rainfall and moist, and well drained soils (mesic). The dominance of bamboo is related to various human activities such as logging and shifting cultivation (xeric).

6. Dry deciduous dipterocarp forest

The forest is as described by Smitinand et al. (1978) and Santisuk (1988). But there are mentioned that in some areas, the two native pines: *Pinus merkusii* Jungh. & de Vriese and *P. kesiya* Royle ex Gord. are mixed. This association should be considered a transition between the deciduous dipterocarp forest in the lowland and the montane forest. *P. kesiya* Royle ex Gord. is usually dominant in the lower montane evergreen forest. Almost pure stands of the two native pines are distributed around 1,000-1,400 m on exposed ridges and steep slopes on which soils are excessively eroded and too xeric to support the growth of other broad-leaved trees. Here they are often referred to as montane evergreen forest rather than deciduous forest.

Table 6 compares the classification of vegetation/forest types of northern Thailand by Smitinand et al. (1978), Santisuk (1988), Maxwell (2001) and Pooma & Barford (2001).

Table 5. Vegetation/Forest Types in Thailand by Maxwell (2001).

Forest Type		Primary Growth	Secondary/Degraded Growth (da/sg)	Tertiary Growth (da/sg)	Elevation (m)
Seasonal (Monsoonal)	Almost ever-wet (rain forest)	evergreen (egf)	evergreen scrub	bamboo thickets, grassland, cultivated areas, plantations	sea level-ca. 1,800
	Distinctly Seasonal	evergreen (egf)	evergreen+bamboo (eg/bb), deciduous dipterocarp-oak (dof)	bamboo thickets, grassland cultivated areas	sea level-ca. 1,000-ca.2,565*
		deciduous with bamboo (bb/df)	bamboo thickets, grassland, deciduous dipterocarp-oak (dof)	cultivated areas	sea level-ca. 850
		mixed evergreen+deciduous (mxf)	bamboo+mixed evergreen+ deciduous scrub, deciduous dipterocarp-oak (dof)	bamboo thickets, grassland cultivated areas	sea level-ca. 1,000
		evergreen+pine (eg/pine), deciduous dipterocarp-oak with pine (do/pine)	deciduous dipterocarp-oak (dof)	grassland, cultivated areas	ca. 60-ca. 1,800
Aquatic	Saline	mangrove	no vegetation, mangrove scrub	no vegetation	sea level-ca. 25
	Fresh	lakes, ponds, swamps, marshes, rivers, etc.	scrub, grassland, cultivated areas	scrub, grassland, cultivated areas	sea level-ca. 2,550
Beach		beach vegetation	scrub, grassland	grassland, cultivated areas	sea level

* In peninsular and central Thailand egf can be found starting at or near sea level,

but in northern Thailand, where the dry season is longer and more severe, it starts at ca. 1,000 m.

Table 6. Comparison of the classification of vegetation/forest types of northern Thailand by four authors.

Smitinand et al. (1978)	Santisuk (1988)	Maxwell (2001)	Pooma & Barford (2001)
Lower montane (moist evergreen)	Lower montane rain Lower montane oak Upper montane rain Upper montane scrub	Primary evergreen seasonal	Lower montane evergreen Upper montane evergreen Montane scrub
Coniferous	Lower montane pine-oak Pine-deciduous dipterocarp	Primary evergreen seasonal with pine Deciduous dipterocarp-oak seasonal with pine	Lower montane evergreen Dry deciduous dipterocarp
Dry evergreen	Seasonal rain	Mixed evergreen+deciduous seasonal	Seasonal rain
Moist mixed deciduous	Tropical mixed deciduous	Deciduous seasonal with bamboo	Mixed deciduous
Dry mixed deciduous	Tropical mixed deciduous	Deciduous seasonal with bamboo	Mixed deciduous
Dry deciduous dipterocarp	Deciduous dipterocarp	Deciduous dipterocarp-oak seasonal	Dry deciduous dipterocarp

HISTORICAL BACKGROUND OF BOTANICAL WORKS IN NORTHERN THAILAND

Botanical history of the exploration and collection of vascular plants of northern Thailand is presented. The data had been obtained from various sources of information available including those of Jacobs (1962) and Smitinand (1989). The following paragraphs list the botanical collection from the first visit until up to present as much as possible.

C.C. Hosseus (1878-1950), a German botanist, is the first to collect plants in northern Thailand. He collected mostly in northern Thailand between 1904-1905 and wrote several publications on his expeditions. The collection is about 830 numbers and deposited at Munich Museum (M). Duplicates of the herbarium specimens are placed at Kew (K) and in some other herbaria in Europe.

A.F.G. Kerr (1877-1942), originally an Irish medical doctor in the service of the Royal Thai Government who later became the Government botanist and worked in Thailand (Siam) between 1902-1932, made large botanical collection all over Thailand, mostly between 1908-1932. His collection is over 20,000 numbers, of which more than half was collected from the north. The complete set is deposited at Kew (K) and British Museum (BM). A number of duplicates are distributed to herbaria in Europe such as Aberdeen (ABD), Edinburgh (E), Dublin (TCD) and Paris (P). The collection in the Department of Agriculture, Bangkok (BK) was intended to be the complete second set, but the early numbers were lost. Up to 1962, our knowledge on the Flora of Thailand was mainly based on Kerr's collection, which formed the materials for the Florae Siamensis Enumeratio I-III (1925-1962).

H.B.G. Garrett (1871-1959), a British citizen who came to Thailand in 1896 and served as a forest officer under the Royal Thai Government, collected exclusively in northern Thailand especially the areas at high altitude between ca. 1909-1959. His exploration included Doi Angka (Doi Inthanon) 10 times between 1910-1939, Doi Chiang Dao 12 times between 1939-1957 and Doi Suthep 13 times between 1909-1958. His collection is over 1,500 numbers of which most are deposited at British Museum (BM), Kew (K), Rijksherbarium, Leiden (L) and Forest Herbarium, Bangkok (BKF).

Phraya Wanapruk Phicharn or Vanpruk (Thongkam Sawetsira) (1879-), a Thai forest officer, collected about 1,200 numbers mainly in northern and peninsular Thailand between 1912-1920. His collection is deposited at Forest Herbarium, Bangkok (BKF), with duplicates in Kew (K).

Phraya Winit Wanandorn (Toh Komes) (1896-1955), a Thai forest officer, collected about 1,923 numbers mainly in northern Thailand between 1913-1930. His collection is deposited at Forest Herbarium, Bangkok (BKF), with duplicates in British Museum (BM) and Kew (K).

J.F. Rock (1884-), an Austrian botanist, sinologist and explorer, made three collecting trips in northern Thailand between 1919-1921 including on Doi Suthep, Doi Chiang Dao, vicinity of Chiang Rai and along the Me Ping river between Chiang Mai and Raheng. His collection is at least 1,912 numbers, which mostly are deposited at the U.S. National Herbarium, Washington DC. (US). Many of his plant specimens have also been revised and cited in the Florae Siamensis Enumeratio.

Put Paisurin (1877-), a Thai privately employed to collect plants for Dr. Kerr, collected all over Thailand between 1926-1931. His collecting number ran to 4,548 numbers as shown in his field books, in which 1,000 numbers were collected from the north (Jacobs, 1962). His collection is deposited at British Museum (BM) and Kew (K). He also collected for the Forest Herbarium (BKF) between 1933-1936, with a total number of about 500 (Smitinand, 1989).

B. Hayata, a Japanese botanist, collected in northern Thailand. His collection is about 1,000 numbers of which are deposited at Tokyo (TI).

G. Seidenfaden (1908-2001), a Danish botanical student, collected in Chanthaburi and Surat Thani over a period of two months between 1934-1935. The collection is about 550 numbers. Later, he became a diplomat and was posted the Danish Minister Plenipotentiary, and eventually became the Danish Ambassador residing in Bankok. During his diplomatic career in Thailand, he devoted his spare time to the study of the orchids of Thailand, with the collaboration of Tem Smitinand. A series of collecting trips were made during 1955-1973 in various parts of Thailand. The spirit collection and collection of living orchids, totalling over 9,000 numbers, are kept in Copenhagen (C).

Khid Suvarnasuddhi, a Thai forest officer, collected about 1,000 numbers mainly in northern Thailand between 1936-1942. His collection is deposited at Forest Herbarium, Bangkok (BKF), with some duplicates in Kew (K) and Paris (P).

Tem Smitinand (1920-1995), a Thai forest botanist, collected extensively all over Thailand between 1947-1994. His collection is over 12,000 numbers and deposited at Forest Herbarium, Bangkok (BKF), with duplicates in main European and American herbaria. In 1966, He made the checklist of Doi Chiangdao vascular plants based on the expedition by various botanists including by himself since 1904 to November 1962. A total of 570 species were recorded including 64 endemic and 3 new record species (Smitinand, 1966). It should be mentioned that during 1947-1977, he also organized a group of Thai collectors to botanically explore various parts of Thailand, namely:

Dee Bunpheng (ca. 1,600 no.),
Din Nakkan (ca. 1,200 no.),
Chit Nuphakdee (ca. 800 no.),
Ploenchit Suvarnakoset (ca. 1,800 no.),
Bunnak Sangkhachand (ca. 3,000 no.),
Bunchu Nimanong (ca. 1,000 no.),
Sanan Phengnaren (ca. 1,000 no.),

Damrongsak Praphat (ca. 1,200 no.),
Sanoh Phengnaren (ca. 800 no.),
Sanan Thaworn (ca. 1,300 no.),
Sinchai Phusomsaeng (ca. 1,000 no.) and
Khanthachai Bunchai (ca. 2,000 no.) (Smitinand, 1989).

L. Williams, an American botanist, came to investigate the latex-bearing trees of Thailand in 1950. He made a three-month trip in northern, southeastern and peninsular Thailand, accompanied by T. Smitinand. The collection of 500 numbers is deposited at Forest Herbarium, Bangkok (BKF) (Smitinand, 1989).

The Thai - Danish botanical studies commenced in 1957, and two eminent Danish botanists, Prof. Kai Gram and Dr. C. Syrach Larsen, came to investigate the possibility of conducting scientific research in Thailand and to prepare for the forthcoming expeditions. During the period of January-March, they travelled to northern and peninsular Thailand, collecting about 400 herbarium speciemens and deposited at Copenhagen (C).

The actual Thai - Danish botanical expeditions started from 1958 and ended in 1968. Danish botanists engaged in these expeditions were Thorvald Soerensen, Kai Larsen, Bertel Hansen and E. Warncke. During the ten-year period, they carried out eight expeditions in collarboration with Thai botanists from Forest Herbarium (BKF). They made extensive excurions in Thailand with the total collecting number amounting to some 30,000.

It is worthwhile to mention in details that in 1965, K. Larsen and others made a botanical expedition in Thailand. This is the collaboration between Thai and Danish botanists as a result of the starting point of the Flora of Thailand project, which commenced since 1965. The purposes of this expedition are

1. To collect supplementary material of those groups, which are supposed to be treated first in the Flora
2. To visit some areas where few or no collection has been made before
3. To start cytotaxonomical studies on Thai bryophytes.

The northern region was investigated as follows:
19-26 July, Thung Salaeng Luang, Phitsanulok, 468 numbers were recorded
27-29 July, Phu Mieng Mountain, Uttaradit, 182 numbers were recorded.

The main set of the collection is deposited at Aarhus (AAU) while a set which may be regarded as nearly complete is deposited at Forest Herbarium, Bangkok (BKF) (Larsen & Warncke, 1966).

Thai - Danish botanical expedition was continued in 1968 mainly concentrated on the northern part of the country, which comprising Doi Suthep, Bo Luang, Chiang Dao and Fang in Chiang Mai and Mae Sariang district in Mae Hong Son. A total of 1,230 numbers were recorded and represented in at least 7 duplicates which distributed to the following herbaria: Aarhus (AAU), Forest Herbarium, Bangkok (BKF), Copenhagen (C), Edinburgh (E), Kew (K), Leiden (L) and Paris (P) (Larsen & Warncke, 1969). In 1990, they collected vascular plants around Thung Salaeng Luang and Phu Hin Rongkla in Phitsanulok, and Doi Phu Kha, Sila Peth waterfall and Tham Pa Tok in Nan. The main set is deposited at Aarhus (AAU), first duplicate set was in Forest Herbarium, Bangkok (BKF) and second duplicate set at the herbarium of the Biology Department, Prince of Songkla University (PSU) (Larsen, 1991).

Since the Thai - Danish botanical expedition started, the collection is about 60,000 numbers from all over Thailand. Unfortunately, report on the Thai - Danish botanical expedition is not continuously done, the exact collected numbers from northern Thailand could not be traced.

Thai – Japanese botanical activity commenced in 1957 after the ninth Pacific Science Congress. T. Tuyama collected about 700 numbers in northern Thailand. H. Ogawa, K. Yoda and A. Kira of the Osaka City University made an ecological study of the vegetation of Thailand (Ogawa et al., 1961). The team collected some 3,000 numbers of mostly sterile materials from northern, central and peninsular Thailand. These collections are deposited at Tokyo (TI) and Osaka (OSA), respectively.

From 1965 onwards, botanical activity was aimed to contribute to the Flora of Thailand Project. The first expedition was led by M. Tagawa and K. Iwatsuki, of the University of Kyoto, in collaboration with Thai botanists from Forest Herbarium (BKF). The activity is carried on with fruitful results and also the participation of other botanists, namely G. Murata, H. Koyama, T. Shimizu and N. Fukuoka. The collections amounted to about 120,000 numbers, mainly deposited at Forest Herbarium, Bangkok (BKF) and Kyoto (KYO) (Smitinand, 1989). However, the exact collected numbers from northern Thailand could not be traced.

It should be mentioned that Thai - Japanese botanical expedition was undertaken in several parts of the country in 1979, also for the purpose to contribute to the Flora of Thailand Project. Through three-month expedition, five trips were made from north to south, covering all of the floristic districts of Thailand. As a result, 138 localities were botanized and about 30,000 sheets of vascular plants were collected including the first trip, which was made in the north between 6-29 October. The collection was mainly deposited in the herbarium of Kyoto University (KYO), Forest Herbarium (BKF) and Shinshu University (SHIN) (Shimizu et al., 1980).

In 1988, Thai - Japanese botanical expedition was concentrated on Doi Inthanon National Park, Chiang Mai, the highest mountain of Thailand (2,565 m), which covered an area about 482.4 km^2. The purpose was to provide the material for supporting the Flora of Thailand project. A total of 1,274 vascular plant species were recorded including 31 new records and endemic for Doi Inthanon and 37 new species (Koyama & Phengklai, 1989). The activity on Doi Inthanon is still currently being carried on, with continuous up to date checklists and reports including new recorded plants to Doi Inthanon (Koyama, 1986; Konta et al., 1999; Konta & Phengklai, 2000). In Febuary and December 1998 expeditions, specimens are deposited at National Science Museum, Tsukuba (TNS) and Forest Herbarium (BKF) (Konta et al., 1999; Konta & Phengklai, 2000).

M.E.D. Poore, R.G. Robbins, T. Smitinand and C. Atthyasaivisut made an excursion to Doi Inthanon, Chiang Mai, the highest mountain of Thailand (2,565 m), between 27 October and 4 November 1962. The collection is 520 numbers and deposited at Forest Herbarium, Bangkok (BKF) (Robbins & Smitinand, 1966).

Thai - Dutch botanical expeditions started from 1965 and ended in 1975, collected all over Thailand. A number of botanists from Rijksherbarium, Leiden (L), i.e. A. Touw and H. Hennipman in 1965, H.P. Nooteboom in 1968, F. van Beusekom between 1968-1969 and R. Geesink between 1971-1975 in collaboration with Thai

botanists from Forest Herbarium (BKF) collected about 14,000 numbers. The collection is deposited both at Forest Herbarium, Bangkok (BKF) and Leiden (L). However, the exact collected numbers from northern Thailand could not be traced.

Jr. J.O. Sawyer and C. Chermsirivathana collected vascular plants of Doi Suthep and Doi Pui, Chiang Mai, between February through May 1966. A total of 679 species were recorded. Voucher specimens are deposited at Department of Agriculture, Bangkok (BK) (Sawyer & Chermsirivathana, 1969).

I. Alsterlund, a Swedish botanist, collected orchids for the University of Gö teborg in 1967. She collected about 400 living orchids in Doi Inthanon and Doi Chiang Dao, Chiang Mai. The collection is in Göteborg (GB) (Smitinand, 1989).

C. Phengklai and others investigated plant diversity at Bo Luang – Omkoi, road No.1099, Chiang Mai between kilometre 97 - 98 on the right hand side, which cuts through the pine and hill evergreen forest, at an altitude about 850 m a.s.l., between 1987-1988. A total of 99 species of vascular plants were recorded (Phengklai et al., 1988). Voucher specimens are deposited at Forest Herbarium, Bangkok (BKF).

J.F. Maxwell collected vascular plants from Doi Suthep-Pui National Park between 1987-2000. A total of 2,247 species belonging to 195 families are enumerated including 1 new species (since synonomized), 2 new combinations, and new records of 1 family, 2 genera and 14 species (Maxwell & Elliott, 2001). Voucher specimens are deposited at Chiang Mai University Herbarium, Chiang Mai (CMU). A number of duplicates are distributed to Forest Herbarium, Bangkok (BKF), Leiden (L), and others.

J.F. Maxwell and others surveyed the vascular flora of Doi Khun Tan National Park, Lamphun-Lampang between 1993-1995. At least 165 families and 1,285 species were found there. Four new records for the flora of Thailand were reported (Maxwell et al., 1995). Between 1995-1997, they surveyed the vascular flora of Jae Sawn National Park, Lampang. A total of 1,353 species were found including 7 new record species for Thailand (Maxwell et al., 1997).

P. Palee and J.F. Maxwell surveyed the vascular flora of Doi Muang Awn, limestone mountain, Chiang Mai, since 1989 with intermittent visits until late 1998. A total of 227 species belonging to 69 families were found. Voucher specimens are deposited at Chiang Mai University Herbarium, Chiang Mai (CMU) (Palee & Maxwell, 2000).

P. Chantaranothai and others made the expeditions in many parts of Thailand in 1990 including some areas in the north. The collection is 230 numbers from Doi Suthep, Doi Inthanon, and Northern Botanic Garden, Maesa in Chiang Mai and Thung Salaeng Luang and Phu Hin Rongkla in Phitsanulok (Simpson et al., 1995).

J. Tovaranonte made a comparative ethnobotanical study of Tai Lue, Hmong and Yao in Nan province at Baan Hia, Pua district, Baan Doi Tiu, Tha Wang Pha district and Baan Suncharern, Tha Wang Pha district, respectively, between April 1995 – April 1997. The result revealed that 273 species belonging to 98 families and

221 genera are used and classified into 4 groups as medicinal plants, edible plants, economic plants and plants of other usage. Majority usages of plants are medicinal plants (Tovaranonte, 1998).

W. Chuakul and P. Saralamp made an ethnomedical survey on the utilization of medicinal plants used by Tai Lue at Phu Kham village, Pua district, Nan, between December 1995 – October 1996. The result revealed that 123 species of medicinal plants belonging to 58 families are commonly used. Voucher specimens are deposited at Department of Pharmaceutical Botany, Faculty of Pharmacy, Mahidol University, Bangkok (Chuakul & Saralamp, 1999).

T. Boonkerd and P. Ratchata surveyed and collected pteridophytes at Khun Korn Waterfall Forest Park, Muang district, Chiang Rai, between October 1997 – October 1999. A total of 357 specimens of ferns and fern allies were collected. There are 154 species and 11 infraspecific taxa belonging to 24 families and 64 genera. Voucher specimens are deposited at Professor Kasin Suvatabhandhu Herbarium, Department of Botany, Chulalongkorn University, Bangkok (BCU) and Forest Herbarium, Bangkok (BKF) (Boonkerd & Ratchata, 2002).

C. Trisonthi and P. Trisonthi made an ethnobotanical study of minorities (Yunnan Chinese, Akha, Lisu, Lahu and Mien) at Doi Maesalong, Chiang Rai. The result revealed that these minorities utilized over 500 species. They are mainly used for subsistence as food, medicine and in religious ceremonies. Voucher specimens are deposited at Ethnobotanical Research Section, Faculty of Science, Chiang Mai University, Chiang Mai (Trisonthi & Trisonthi, 1999).

A. Jampeetong surveyed wild flowering plants at Doi Ang Khang, Fang district, Chiang Mai, between June 1999 – May 2000. The area is at an elevation between 1,400-1,900 m and includes limestone mountain. One hundred and thirty-seven species belonging to 62 families and 119 genera were collected. Voucher specimens are deposited at Ethnobotanical Research Section, Faculty of Science, Chiang Mai University, Chiang Mai (Jampeetong, 2001). Subsequently, A. Boonsongthae continued to survey flowering plants at Doi Ang Khang, between May 2000 – May 2002. The result revealed that 239 species belonging to 82 families and 189 genera were collected including 71 species which found by Jampeetong (2001). Voucher specimens are also deposited at Ethnobotanical Research Section, Faculty of Science, Chiang Mai University, Chiang Mai (Boonsongthae, 2003).

W. Sankamethawee studied vascular ground flora at Mai Muang Nao arboretum, Hod district, Chiang Mai, between March 2001 – February 2002. The area includes 0.8 km^2 of deciduous dipterocarp-oak with some pine forest on granite bedrock at 950-1,125 m in elevation. *Dipterocarpus obtusifolius* Teijsm. ex Miq. and many species of Fagaceae are dominant species in the study sites. There are 262 species of vascular plants belonging to 59 families and 180 genera. Ome hundred and thirty species are described in this study based on the author collections. Voucher specimens are deposited at Chiang Mai University Herbarium, Chiang Mai (CMU) (Sankamethawee, 2003).

A. Inta surveyed plant species diversity in Chiang Mai University Academic Area, Sribuaban subdistrict, Muang district, Lamphun, between March 2002 - April 2003. The area is 4,700 rai. The elevation ranges between 355-430 m. There are two main forest types in the study area: dipterocarp forest that dominated by *Shorea obtusa* Wall., *Dipterocarpus tuberuculatus* Roxb., *Shorea siamensis* Miq. and *Millettia extensa* Benth., and mixed deciduous forest that dominated by *Dipterocarpus obtusifolius* Teijsm. ex Miq., *Tectona grandis* L.f. and *Buchanania latifolia* Spreng. There are 171 species belonging to 66 families and 137 genera. Voucher specimens are deposited at Ethnobotanical Research Section, Faculty of Science, Chiang Mai University, Chiang Mai (Inta, 2003).

It is worthwhile to mention that a number of botanists attached to the large two herbaria in Thailand:

Department of Agriculture, Bangkok (BK), ca. 80,000 specimens, namely Jarey Sadakorn, Chirayuphin Chandraprasong, Prayat Sangkhachand, Sakon Sutheesorn, Umphai Youngboonkird, J.F. Maxwell, Pramote Triboun, and others; and the Forest Herbarium (BKF), ca. 180,000 specimens, namely Chamlong Phengkhlai, Thawatchai Santisuk, Chawalit Niyomdham, Kongkanda Chayamarit, Thawatchai Wongprasert, Rachun Pooma, Somran Suddee, Leena Phuphathanaphong, and others made the collections all over Thailand. However, the exact collected numbers from northern Thailand could not be traced.

Besides these herbaria, Chiang Mai University Herbarium (CMU) stored about 20,000 specimens mostly from Chiang Mai and northern Thailand.

Since 1994, botanists attached to Queen Sirikit Botanic Garden, Chiang Mai, namely Weerachai Nanakorn, Paisan Thongsorn, Santi Watthana, Monton Norsangsri, Rachada Pongsattayapipat, Watchana Bunchai, Piyakaset Suksathan, Charun Maknoi, Surangrath Inthamusika, Chaiyuth Glamwaewwong, Sawittree Sasrirat, Voranuch Laongsri and Prachaya Srisanga collected about 25,000 numbers from northern Thailand and other regions and deposited at Queen Sirikit Botanic Garden Herbarium (QBG).

BOTANICAL EXPLORATION ON DOI PHU KHA

The botanical expedition reports, biographies, theses, personal communication and information extracted from the relevant publications were used to enumerate the botanical explorations on Doi Phu Kha. It should be noted that a number of foreign botanists in collarboration with Thai botanists from Forest Herbarium (BKF) had collected some specimens from Doi Phu Kha mainly in specific groups. There are published information related to the discoveries concerning vascular plants on Doi Phu Kha such as new record plants and new species from which additional data had been obtained.

A.F.G. Kerr, an Irish medical doctor and botanist who worked in Thailand between 1902-1932, made a large botanical collection and regulation surveyed for the whole country. His collection is over 20,000 numbers, of which more than half was collected from northern Thailand. He was the first botanist who visited Doi Phu Kha. The information extracted from his report for the Botanical Section between 1 September 1920 – 31 December 1922: tours in Maharat and Payap, northern Siam – The record no. 8 (April 1923), shown that he visited Doi Phu Kha and vicinity between 25 February and 6 March 1921. His itinerary and collected specimens are cited below.

25-27 February, Doi Phu Kha (19° 08′ N 101° 07′ E, 1,700 m), *Kerr* 4901-4963.

1-2 March, Via the mountainous district of Muang Pua (19° 12′ N 100° 55′ E), *Kerr* 4964-4971.

2-3 March, Going E to Ban Sakat and to a village peopled by Tins, hence named Ban Tin, *Kerr* 4972-4987.

3 March, Collecting on Mt Pu Huat (19° 18′ N 101° 15′ E, 1,700 m), *Kerr* 4988-5002.

4 March, Back at Ban Tin, *Kerr* 5003-5012.

5-6 March, At Muang Pua, *Kerr* 5013-5019.

Thus, a total of 119 numbers (*Kerr* 4901-5019) were collected on Doi Phu Kha and its vicinity. The complete set is deposited at Kew (K) and British Museum (BM). Duplicates were distributed to Aberdeen (ABD), Edinburgh (E), Dublin (TCD), Paris (P) and Department of Agriculture, Bangkok (BK) (Jacobs, 1962). Since that time, the collecting activities in Doi Phu Kha had been overlooked.

Prof. Dr. Thawatchai Santisuk, Forest Herbarium (BKF), Royal Forest Department, Thailand, had a first visit to Doi Phu Kha in 1989 and discovered *Bretschneidera sinensis* Hemsl. (Bretschneideraceae). This is a monotypic family, newly recorded for Thailand with limited distribution record and at that time it was only known from southern China and northern Vietnam (Santisuk, 1989). Since then, the botanical exploration on Doi Phu Kha has much been continued and expanded. After his first visit, he had been revisiting periodically (Santisuk, 1998a). The main set of his specimens is deposited at Forest Herbarium, Bangkok (BKF).

Dr. Rachun Pooma, Forest Herbarium (BKF), Royal Forest Department, also had a first visit to Doi Phu Kha in 1989 and had been revisiting periodically in particular with foreign botanists. His collection is about 500 numbers from here and vicinity. The main set of his specimens is deposited at Forest Herbarium, Bangkok (BKF) (pers. comm.).

Thai - Danish botanical expedition, now led by Prof. Dr. Kai Larsen, Aarhus University, Denmark, has made continuous expeditions throughout Thailand since 1965 to collect supplementary material which to be treated in the account of the Flora of Thailand (Larsen & Warncke, 1966; Larsen, 1979). In 1990, they collected vascular plants around Doi Phu Kha (13 Dec.), Sila Peth waterfall (14 Dec.) and Tham Pa Tok (15 Dec.) in Nan province. Specimens main set is deposited at Aarhus University (AAU), Denmark. First duplicates set is at Forest Herbarium (BKF), Thailand and second duplicates set is at the herbarium of the Biology Department, Prince of Songkla University (PSU), Thailand. (Larsen, 1991). After 1990 expedition, Doi Phu Kha had been revisited intermittently in 1993 and 1995 (Larsen & Larsen, 1995; Tange, 1998).

Students from Biology Department, Chiang Mai University, under the direction of Dr. Chusie Trisonthi, made botanical survey and ethnobotanical research of hill tribe minorities (Khamu, Lua or Lawa, H'tin or Tin) at Doi Phu Kha National Park and surrounding areas, since 1995 (Tangtragoon, 1998; Spanuchat, 1999; Thakun & Trisonthi, 1999; Yaso & Trisonthi, 1999; Yaso, 2000; Thongsorn, 2001). Voucher specimens especially medicinal and wild food plants are deposited at Ethnobotanical Research Section, Faculty of Science, Chiang Mai University, Chiang Mai. The results of their theses are reviewed as follows:

T. Tangtragoon made a comparative ethnobotanical study of Khamu, Lawa (Lua) and H'tin (Tin) in Nan province at Baan Nam Lu, Songkwae district, Baan Tei Glang, Pua district and Baan Ja Lang, Pua district, respectively, between May 1995 – June 1996. The result revealed that 232 species belonging to 85 families and 199 genera are used and classified into 5 groups as medicinal plants, edible plants, plants used for housing, economic plants and plants of miscellaneous uses. There are 165, 126 and 97 species used by of Khamu, Lawa and H'tin, respectively. Majority usages of these plants in all three villages are edible plants (Tangtragoon, 1998).

R. Spanuchat surveyed flowering plants around Doi Phu Kha National Park Headquarters, between March 1998 – January 1999. Forty-four species belonging to 31 families and 40 genera were recorded (Spanuchat, 1999).

K. Thakun made a comparative ethnobotanical study of H'tin (1 village) and Lua (2 villages) in Bo Kluea Neua subdistrict, Bo Kluea district, Nan province, between June 1998 – May 1999. The result revealed that 230 species belonging to 93 families and 187 genera are used and classified into 5 groups as medicinal plants, edible plants, plants used for housing and utensils, economic plants and plants of miscellaneous uses. Majority usages of these plants in all three villages are edible plants (Thakun & Trisonthi, 1999).

T. Yaso made a comparative ethnobotanical study of H'tin (2 villages) and Lua (1 village) in Phu Phaa subdistrict, Bo Kluea district, Nan province, between March 1998 – February 1999. The result revealed that 255 species belonging to 94 families and 212 genera are used and classified into 6 groups as medicinal plants, edible plants, plants used for housing and utensils, economic plants, plants used in ceremonies and plants of miscellaneous uses. Majority usages of these plants in all three villages are edible plants (Yaso & Trisonthi, 1999; Yaso, 2000).

P. Thongsorn made an ethnobotanical study of Tin (H'tin) in Baan Pa Kum, Dongpaya subdistrict, Bo Kluea district, Nan province, between March 1997 – October 2000. The result revealed that 41 species belonging to 31 families and 40 genera are used from 97 collected species (Thongsorn, 2001).

Staff from Queen Sirikit Botanic Garden, Chiang Mai, led by Dr. W. Nanakorn, has made the botanical surveys throughout Thailand especially the northern region since 1994. Doi Phu Kha and surrounding areas were also visited. About 130 numbers of vascular plant specimens were collected and deposited at Queen Sirikit Botanic Garden Herbarium (QBG).

It should be noted that only in the recent years, Doi Phu Kha area became easily accessible by botanists because of the unsteadiness of political situation in the past and just the new strategic route occurred, thus, there has not been any previous details of floristic work recorded.

TAXONOMIC LITERATURE ON DOI PHU KHA

There are number of botanical records from Doi Phu Kha since the area was first visited by Dr. A.F.G. Kerr in 1921. The accounts are as follows:

New species:

Dalbergia verrucosa Craib (Fabaceae) described by Craib (1927) from type specimen *A.F.G. Kerr* 4930 (BK, K), collected from Doi Phu Kha, altitude 1,700 m, 26 February 1921. Niyomdham in Niyomdham & Hô (1996) changed its status under a variety rank of *D. velutina* Benth. as *D. velutina* Benth. var. *verrucosa* (Craib) Niyomdham.

Allomorphia sylvarum Geddes (Melastomataceae) described by Geddes (1930) from type specimen *A.F.G. Kerr* 4921, collected from Doi Phu Kha, altitude 1,200-1,600 m, 26 February 1921. Maxwell (1983) reduced it to a synonym under the name of *Oxyspora balansae* (Cogn.) J.F. Maxwell.

Embelia disticha Fletcher (Myrsinaceae) described by Fletcher (1936) from type specimen *A.F.G. Kerr* 4922, collected from Doi Phu Kha, altitude 1,700 m, 26 February 1921. Larsen & Hu (1996) reduced it to a synonym under the name of *E. pulchella* Mez.

Lobelia leucanthera Kerr (Campanulaceae) described by Kerr (1936) from type specimen *A.F.G. Kerr* 4923, collected from Doi Phu Kha, altitude 1,700 m, 26 February 1921. Now, it is considered as a synonym of *L. nicotianaefolia* Roth ex Roem. & Schult.

Thunbergia colpifera B. Hansen (Acanthaceae) described by Dr. B. Hansen, Botanical Museum, Copenhagen, Denmark, from type specimen *K. Larsen et al.* 41944 (Holo-AAU, Iso-C), from hill evergreen forest at altitude between 1,500-1,600 m (Hansen, 1995).

Fosbergia thailandica Tirveng. & Sastre (Rubiaceae) described by Dr. D.D. Tirvengadum and Dr. C. Sastre, Laboratoire de Phanérogamie, Muséum National d' Histoire Naturelle, Paris, France, from type specimen *R. Pooma* 438, during a taxonomic revision on the recently established genus, *Fosbergia* Tirveng. & Sastre, as an endemic species only known from the type localities (Tirvengadum & Sastre, 1997).

Jasminum persissanthum P.S. Green (Oleaceae) described by Dr. P.S. Green, Royal Botanic Gardens, Kew, United Kingdom, from type specimen *A.F.G. Kerr* 4924 (Holo-K, Iso-L), which collected from Doi Phu Kha, 26 February 1921, during a taxonomic account of the Oleaceae for the Flora of Thailand (Green, 2000). This is an endemic species only known from the type material (Green, 1995).

Ophiopogon siamensis M.N. Tamura (Convallariaceae) described by Dr. M.N. Tamura, Osaka City University, Osaka, Japan. Type specimen, *M.N. Tamura* 7004 (Holo-KYO, Iso-BKF, OSA), collected from Doi Inthanon, Chiang Mai. This is an endemic species only known from northern Thailand: Doi Inthanon, Chiang Mai; Doi Tung, Chiang Rai and Doi Phu Kha, Nan. Of which, only *M.N. Tamura & R. Pooma* 7036 (KYO), at 1,550-1600 m, is a representative collected specimen from Doi Phu Kha (Tamura, 1998a).

Caryota gigas Hahn ex Hodel (Arecaceae), endemic species only known from Doi Phu Kha at altitude between 1,400–1,600 m of hill evergreen forest. Type specimen is *D. Hodel & P. Vatcharakorn* 1773 (Holo-BK, Iso-BH). Paratypes are *A.F.G. Kerr* 4957 (BM, K), *Hahn & Pooma* 5920 (BH, BKF, K, WIS) and 6734 (WIS) (Hodel, 1998).

Aristolochia longeracemosa B. Hansen & L. Phuphat. (Aristolochiaceae) described by Dr. B. Hansen, Botanical Museum, Copenhagen, Denmark and Leena Phuphathanaphong, Forest Herbarium, Royal Forest Department, Bangkok, Thailand. This is an endemic species only known from the type material, *Banziger* 667 (Holo-C, Iso-herb. Banziger), at altitude 1,100 m from Doi Phu Kha (Hansen & Phuphathanaphong, 1999).

Lasianthus rhinocerotis Bl. subsp. *xishuangbannaensis* H. Zhu & H. Wang described by Zhu Hua and Wang Hong, Kunming Section of Xishuangbanna Tropical Botanic Garden, Kunming, China. Type specimen, *H. Zhu & H. Wang* 98-11-01 (Holo-HITBC), collected from Mengsoon, Xishuangbanna, Yunnan, China. There are also known from Doi Phu Kha, when this subspecies was described, from *Tirvengadum et al.* 2013 (AAU) (Zhu et al., 2000).

New records for the account of the Flora of Thailand:

Families:

Bretschneideraceae (*Bretschneidera sinensis* Hemsl.), monotypic family or monotypic genus (Bayer & Appel, 2003), and rare species, which distribution record at that time was only known from southern China and northern Vietnam. In Thailand, it is only known from lower montane forest, alt. 1,400-1,500 m, at Doi Phu Kha National Park (Santisuk, 1989).

Helwingiaceae (*Helwingia himalaica* Hook.f. & Thoms. ex C.B. Clarke), monogeneric family, but sometimes regarding has conspecific with the family Cornaceae (Mabberley, 1997). The genus, *Helwingia* Willd., consists of ca. 4 species distributed in E Himalayas eastwards to Japan and southwards to northern Thailand. In Thailand, it is only known from one locality in lower montane forest, alt. 1,100 m, on a steep slope by streams in Doi Phu Kha National Park. (Pooma, 1997).

Carlemanniaceae (*Silvianthus tonkinensis* (Gagnep.) Ridsd.), poorly known genus and family (Tange, 1998). This family consists of 2 genera: *Carlemannia* Benth. and *Silvianthus* Hook.f., which consists of 3 and 2 species, respectively. Sometimes, it is regarded as having conspecific with the family Caprifoliaceae (Mabberley, 1997).

Genera:

Carlemannia tetragona Hook.f. (Carlemanniaceae or Caprifoliaceae), new genus recorded for Thailand (Nanakorn, 2004).

Species:

Indigofera caudata Dunn (Fabaceae), rare species, only known distribution record in southern China and Laos (Larsen & Larsen, 1995).

Acer wilsonii Rehd. (Aceraceae), newly recorded during a systematic study of the genus *Acer* (Aceraceae) in Thailand (Santisuk, 1998a).

Equisetum diffusum D. Don (Equisetaceae), newly recorded for Thailand after the publication of the Flora of Thailand in 1979 (Nanakorn, 1998).

Agapetes inopinnata Airy Shaw (Ericaceae), rare species, of which distribution record was only known from Myanmar and southern China (Watthana & Trisonthi, 1999).

Bauhinia wallichii J.F. Macbr. (Fabaceae), newly recorded for Thailand after the publication of the Flora of Thailand in 1984 (Larsen, 1999).

Ardisia dawnaea C.E. Parkinson (Myrsinaceae), newly recorded for Thailand after the publication of the Flora of Thailand in 1996 (Larsen & Hu, 2001).