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Full Paper

Ecological status of the lowland deciduous forest in Chang Kian Valley, Chiang Mai, northern Thailand

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Abstract: An ecological assessment of lowland deciduous dipterocarp-oak, seasonal, hardwood forest on the base of the east side of Doi Sutep-Pui, Chiang Mai province, was conducted. Seven selected sites representing the most intact condition to the worst one were surveyed. Plant species diversity and abundance declined as fire damage increased. Details on the number of species, their habits, size classes of trees, pioneer vs climax species, woody seedlings, coppices, and herbaceous ground flora are presented. Species lists for all these categories and their abundance are also included. Profile diagrams and photographs of some sites are shown. The conservation value of lowland forests has been largely neglected and now many places require reforestation. The degree of degradation is serious and will continue to deteriorate unless effective protective and remedial action is done.

Keywords: deciduous dipterocarp-oak, seasonal, hardwood forest (DOF) ; forest fire ; successional ecology ; Chang Kian, Chiang Mai

Introduction

During the hot-dry season with the highest temperatures (often over 40°C) between March-April, Chiang Mai basin was covered with dense, noxious smog which was up to 700 m thick in 2007 and well over 1300 m in 2010 [1] The cause was due to massive fires in the mountainous areas of the north including the adjacent Doi Sutep-Pui National Park, combined with traffic and construction pollution within the city. Nothing effective had been done to prevent other pollution episodes as occurred in 2007 and the toxic conditions were repeated to a greater extent in 2010. Extensive fires have become a risk factor for the environment, health and tourism [1].

Burning of agricultural fields and forested areas is a traditional annual event which has become increasingly more destructive and widespread in the northern provinces of Thailand. In upland areas (above 1000 m), primitive agricultural practices involving slash and burn methods are conducted by hill-tribe communities during the dry season to remove agricultural wastes and also to expand fields [2]. This has ruined much of the original forests and has prevented natural recovery of vegetation,

since fallow periods are reduced from many to mostly only a few years [3-5]. Biodiversity continuously decreases as the amounts of pesticides and chemical fertilisers increase and enter the environment. An overall increase in soil erosion and water pollution along with a decrease in water availability and quality, especially during the dry months of November to May, has resulted. Water shortages during this dry period and flooding during the rainy season are recent problems which Chiang Mai now experiences. All this, combined with deliberate burning of lowland vegetation and disturbance of adjacent soil, has resulted in the loss of forest cover and increases in environmental problems [6].

Research Site

Northern Thailand is situated in the monsoonal climatic region extending from Manipur State (NE India) throughout northern Burma, northern and eastern Thailand, central and southern Laos, Cambodia, to central and southern Vietnam. There is a distinct dry season from November to May and a hot period from March to May. The rainy season starts in May and ends in November. Lowland areas, i.e. below 850-m elevation, have deciduous forests while above this the forests become evergreen. There is a definite correlation between elevation and the amount of rainfall and temperature range. Lowland areas have less rainfall with Chiang Mai (350 m) receiving an annual average of about 1100 mm and at Puping Village on Doi Sutep (1375 m) it is 2095 mm [7]. Lowland temperatures frequently exceed 40°C in April-May while it is always considerably cooler at over 1000-m elevation.

Chiang Mai was established over 700 years ago with the forest of Doi Sutep (1601 m) and Doi Pui (1685 m) providing people with sustainable water supplies, timber, useful plants and wildlife. This situation was radically disrupted when lowland teak-dominated forests started to be cut in the late 1800's. By the mid-1900's all teak trees had been cut while other commercially valuable trees were being rapidly removed. About this time the first Hmong villages were established on the mountain. The upland forests were largely destroyed for agricultural expansion and the establishment of various "development" projects. Presently there are over 5500 hill-tribe people, mostly Hmong, living on the mountain [8].

Doi Sutep-Pui National Park was established on 14 April 1981 and since that time the amount of forest cover has steadily decreased along with increases in erosion and water turbidity. Wildlife has also been severely reduced to the extent that no large mammals or primates are present. The lowland vegetation on Doi Sutep-Pui, i.e. below *c.* 850 m, is deciduous dipterocarp-oak, seasonal hardwood forest (dof) which remains in various stages of degradation including that in the Chang Kian Valley, which is on the lower slopes on the east side of the national park [7]. Control of exploitation of natural resources on the mountain and attempts to properly reforest destroyed areas or control water pollution in settled places seem to have been unsuccessful, and although a fire control unit exists in the national park, fires still destroy several hundred hectares of vegetation each year.

Vegetation and Fire Threat

Lowland deciduous forests include deciduous, seasonal, hardwood + bamboo forest (bb/df) and deciduous dipterocarp-oak, seasonal, hardwood forest (dof)—the latter often incorrectly being referred to as "savanna" forest [9-10]. Areas of bb/df in Thailand began to be commercially exploited for valuable timber trees, especially teak (*Tectona grandis* L. f.,Verbenaceae) and other hardwood trees, from about 1870 [11]. Presently there remains only one area in Thailand in Mae Yom National Park, Phrae province, which has natural teak populations [12-13]. This area has also been illegally logged for decades and repeatedly threatened with a dam construction project. The reservoir of this dam would inundate a teak-dominated area up to an elevation of 260 m. This would destroy much of the remaining teak habitat in the country [13]. Natural teak in Doi Sutep-Pui National Park is rare and is only known from a few individuals below Pra Taht Temple at 850 m on the east side of the mountain.

Destroyed bb/df is succeeded by dof, not by bb/df [7, 12]. This is enhanced by fire which not only prevents bb/df vegetation to develop, but also destroys organics in the soil. With consequent degradation of soil quality and erosion, only species from dof are able to establish and grow. Dof is a

kind of fire-climax or edaphic-climax facies which has also been considered as fire-dependent secondary growth [14]. Research by Stott on fire in dof in Thailand [9-10] indicates that, depending on the amount of dry ground litter present, the average ground temperature during fire can reach 388°C. At 0.5-1 m high, the average is 169°C with an amazing 700-900°C in thicker vegetation. At 5-cm depth the temperature never exceeded 75°C. A typical fire moves at a rate of 1.6 cm/second. The cremating effect of fire on vegetation, soil organics and underground biodiversity along with erosion, human encroachment and lack of any conservation or protection have maintained dof forest in the region for centuries. Destruction of dof will result in perpetual deciduous secondary scrub or tertiary grassland vegetation [14]. The districts of Mae Awn and Sarapee, both in Chiang Mai province, and adjacent Lampoon area are good examples of this deplorable situation.

A detailed study by Putnam [15] during February-March 2009 in On Nuea subdistrict, *c.* 45 km SE of Chiang Mai University, revealed the causes and effects of burning in lowland areas. Fires that occurred in that area can be classed into 5 categories: 1) forest fire, 2) agricultural burining, 3) roadside burning, 4) open area fire and 5) domestic burning. Forest fires are deliberately set mainly for the supposedly increased forest product yields, especially the earth star mushroom (*Astreaus hygrometricus* (Pers.) Morgan, or "Hed Thob" or "Hed Phor" in Thai), which has seasonal availability and a high market price. In order to collect such products local farmers use fire either to clear the forest floor to make it easier to find the mushroom or because the fire is believed to stimulate the growth of this mushroom. "Cheap and fast" is a crucial explanation for the intentional use of fire to clear agricultural fields, overgrown roadsides and open areas. Cattle herders also burn areas to stimulate the growth of *Imperata* grass which is able to quickly produce new leaves during the hot-dry season. New leaves produced on burnt areas have a higher nutrient value, which is perfect for cattle grazing. Domestic burning involves the burning of both natural and refuse wastes from households. Various local administrative officers correctly admit that all fire incidents are man-made. Fires produce large amounts of smoke which often stagnates in the community area causing eye irritation and respiratory ailments. Large areas of degraded forest are destroyed by fire each year. The situation in On Nuea, as on Doi Sutep-Pui, has come to a point where fire contributes to the dry season haze, which has been a serious threat for both human health and environmental quality of Chiang Mai for years.

Objectives

The aim of this study is to assess the present condition of a forest as well as determine how the vegetation should be conserved and replanted. The lowland dof in Chang Kian Valley has been regularly burned and exploited for centuries. This has resulted in a very degraded facies. To get a proper understanding of the actual condition of the lowland deciduous dipterocarp-oak forest in Chang Kian Valley, this ecological survey is initiated. The actual condition of the dof there seems to vary. So in order to determine the range of difference, an intense ecological-taxonomic study of several different dof areas is required. The specific effects of fire on plant diversity, forest structure and seed recruitment also need to be determined to gauge the overall condition of the dof in the valley.

Methodology

Vegetation sampling

The survey was conducted during October-December 2008. This was just after the rainy season when the vegetation was most luxurious. Due to time and budget constraints, the survey team selected seven areas as initial sites (Table 1) which could be used to rapidly assess the entire valley. Each survey plot was 50x5 m where all woody species (including seedlings) were identified and measured for height and canopy width. DBH (diameter at breast height) of a tree was measured according to European/Canadian standard at 1.3 m [16], whereas all other woody plants (seedlings, saplings, treelets, shrubs, woody climbers and coppices) were measured at ground level. A distinction was made between seedlings and coppices since the ratio of these two growth forms is a good indicator of the destructive effects of fire. Seedlings are cremated by fire while many saplings and treelets are burned

and able to regrow at the base. Growth deformities and fire damage to larger woody individuals were also noted. For the ground flora, i.e. all plants up to 1 m tall, a 10-m diameter circular plot was made 2 m from the corner of each plot. Photographs of some sites are shown in Appendix 1.

Table 1. Survey plot locations and descriptions

Site	Elevation (metres)	Description
1. Pah Laht Temple	607	The most intact forest which has been protected from major disturbance for more than 50 years* (Photo 8)
2. Chang Kian Stream	474	Above the boy scout camp near Chang Kian Village and close to Chang Kian Stream, severely degraded and frequently burned by mushroom collectors (Photos 4 & 8)
3. Mae Yuak Noi 1	455	Near Nong Haw meditation centre, a regenerating forest which has uniform tree regrowth after being cleared 25 years ago (Photos 2, 3 & 5)
4. Mae Yuak Noi 2	490	Near site 3, but with more grass cover (Photos 6 & 7)
5. Huay Dtueng Tao 1	439	Above Huay Dteung Tao Lake, a very exposed, frequently burned, very eroded ridge (Photo 1)
6. Huay Dtueng Tao 2	453	Near site 5 and similar to it, but with more trees (Photo 1)
7. Huay Dtueng Tao 3	411	Gully below site 6 with less frequent fire than site 5, almost closed canopy

* Since a similar site could not be found in Chang Kian Valley, we selected Pah Laht Temple to represent the best dof conditions. This place is located in an adjacent valley, *c.* 2 km south of site 2.

To study the ground flora, i.e. all plants up to 1 m tall, a 10-m diameter circular plot was made 2 m from each corner of the plot. A diagram of the survey plot is shown in Figure 1.

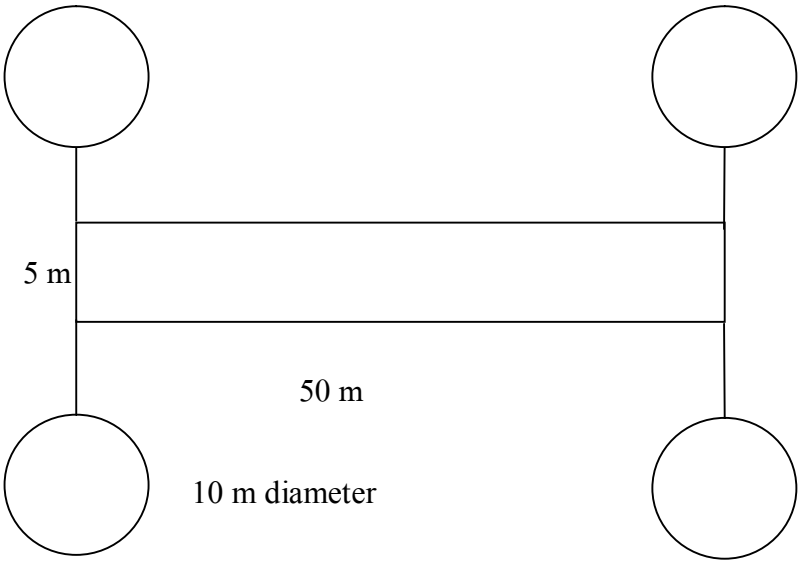

Figure 1. Diagram of the survey plot

Information from the circular plots include listing of all species, individual abundance and total ground cover vs. bare soil. Abundance was estimated using a modified Braun-Blanquet cover class scale [17] where: x = sparse, few individuals; 1 = common, small % coverage; 2 = covering 5 % of the area; 3 = covering 25-50 %; 4 = covering 50-75 %; and 5 = covering more than 75 %.

Ecological parameters

To properly assess the overall health of forested areas, several parameters were used. These factors include: species diversity and their abundances, canopy height and tree density, understory and ground flora densities, seedlings and coppices, soil erosion, and soil quality. These parameters will be explained in relation to the condition of the plots.

Results and Discussion

Forest structure diagrams

The vegetation data from the sampling plots including the botanical name, number of species and maximum height were used to construct the forest diagram for vegetation layer analysis of each plot. Figures 2-8 show the forest profile diagrams at the 7 sampling sites. The details for each species in the diagram is shown in Tables 2-8.

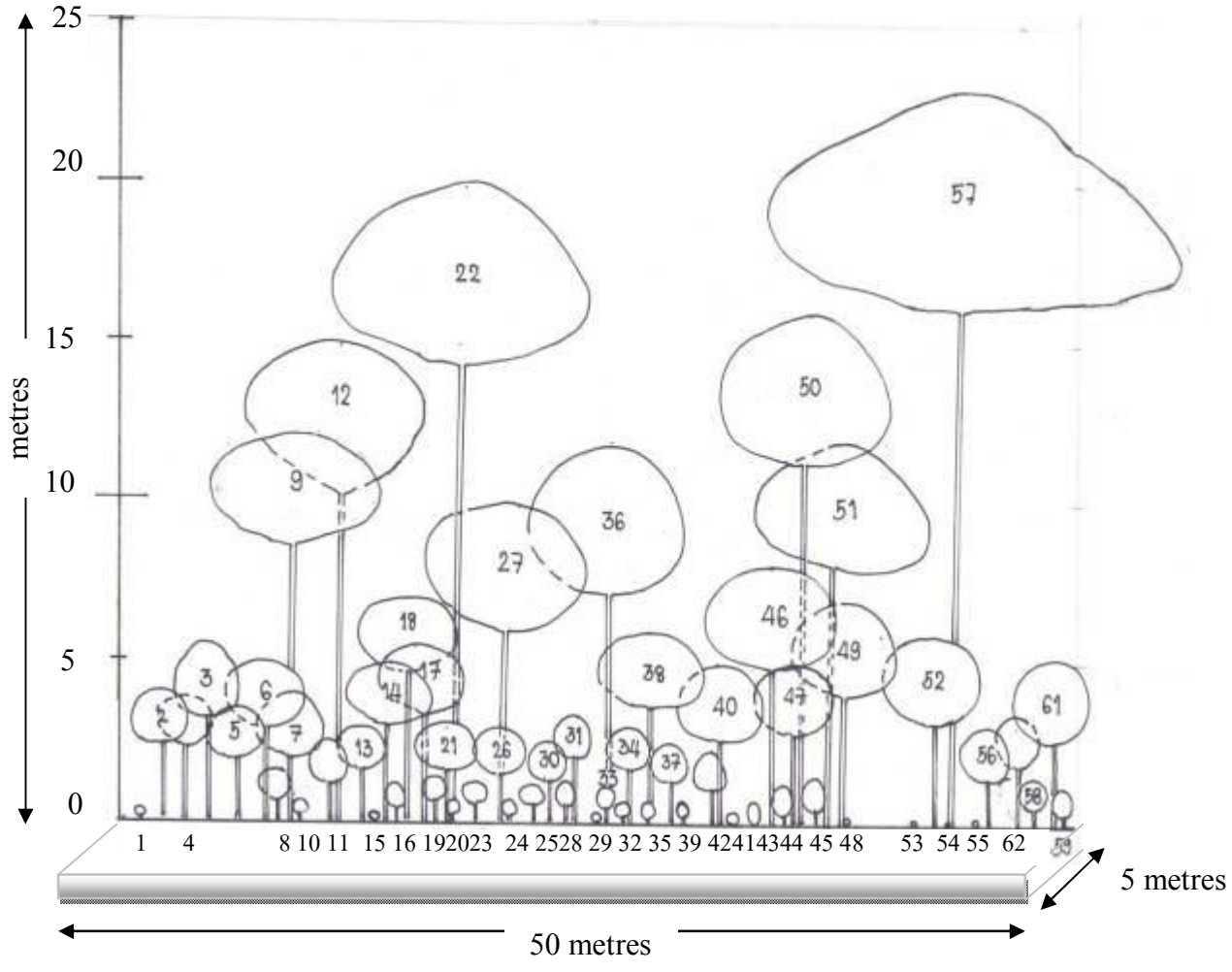

Figure 2. Forest profile diagram of site 1 (Pah Laht Temple)

Table 2. Species found in site 1 (Pah Laht Temple)
(Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Acacia megaladena* Desv. var. *megaladena*	Leguminosae, Mimosoideae	WC	0.24
2	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	Apocynaceae	WC	4.00
3	*Anneslea fragrans* Wall.	Theaceae	T	5.50
4	*Antidesma acidum* Retz.	Euphorbiaceae	T	3.50
5	*Aporosa octandra* (B.-H *ex* D. Don) Vick. var. *octandra*	Euphorbiaceae	T	3.00
6	*Aporosa villosa* (Lindl.) Baill.	Euphorbiaceae	T	5.00
7	*Breynia glauca* Craib	Euphorbiaceae	S	4.00
8	*Bridelia stipularis* (L.) Bl.	Euphorbiaceae	WC	1.80
9	*Buchanania lanzan* Spreng.	Anacardiaceae	T	12.00
10	*Calycopteris floribunda* (Roxb.) Lmk.	Combretaceae	WC	0.65
11	*Canarium subulatum* Guill.	Burseraceae	T	2.50
12	*Cansjera rheedii* J. F. Gmel.	Opilliaceae	WC	15.00
13	*Celastrus paniculatus* Willd.	Celastraceae	WC	3.00
14	*Cissus hastata* Miq.	Vitaceae	WC	5.00
15	*Cissus repanda* Vahl	Vitaceae	WC	0.41
16	*Clausena excavata* Burm.f. var. *excavata*	Rutaceae	L	1.20
17	*Craibiodendron stellatum* (Pierre) W.W.Sm.	Ericaceae	T	5.50
18	*Dalbergia cultrata* Grah. *ex* Bth.	Leguminosae, Papilionoideae	T	7.00
19	*Desmos dumosus* (Roxb.) Saff. var. *glabrior* Craib	Annonaceae	WC	1.23
20	*Dimocarpus longan* Lour. ssp. *longan* var. *longan*	Sapindaceae	T	0.70
21	*Diospyros ehretioides* Wall. *ex* G.Don	Ebenaceae	T	3.50
22	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	20.00
23	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Dipterocarpaceae	T	1.40
24	*Elaeocarpus floribundus* Bl. var. *floribundus*	Elaeocarpaceae	T	0.79
25	*Erythroxylum cuneatum* (Miq.) Kurz	Erythroxylaceae	S	1.40
26	*Eugenia albiflora* Duth. *ex* Kurz	Myrtaceae	T	3.00
27	*Eugenia grata* Wight var. *grata*	Myrtaceae	T	10.00
28	*Ficus hirta* Vahl	Moraceae	T	1.23
29	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	T	0.24
30	*Gardenia sootepensis* Hutch.	Rubiaceae	T	2.50
31	*Goniothalamus griffithii* Hk.f. & Thoms.	Annonaceae	L	3.50
32	*Irvingia malayana* Oliv. *ex* A. Benn.	Irvingiaceae	T	0.64
33	*Ixora cibdela* Craib	Rubiaceae	L	1.14
34	*Lannea coromandelica* (Houtt.) Merr.	Anarcardiceae	T	3.00
35	*Leea indica* (Burm.f.) Merr.	Leeaceae	L	0.69

Table 2. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
36	*Lithocarpus polystachyus* (Wall. *ex* A. DC.) Rehd.	Fagaceae	T	12.00
37	*Memecylon scutellatum* (Lour.) Hk. & Arn.	Melastomaceae	L	2.50
38	*Memecylon umbellatum* Burm.f.	Melastomaceae	L	6.00
39	*Millettia extensa* Bth. *ex* Baker	Leguminosae, Papilionoideae	WC	0.74
40	*Mitragyna rotundifolia* (Roxb.) O.K.	Rubiaceae	T	5.00
41	*Myxopyrum smilacifolium* (Wall.) Bl. var. *smilacifolium*	Oleaceae	WC	0.34
42	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	T	2.30
43	*Pavetta tomentosa* Roxb. *ex* Sm. var. *tomentosa*	Rubiaceae	L	0.75
44	*Phyllanthus emblica* L.	Euphorbiaceae	T	1.18
45	*Prismatomeris tetrandra* (Roxb.) K. Sch. ssp. *tetrandra*	Rubiaceae	L	1.50
46	*Quercus kerrii* Craib	Fagaceae	T	8.00
47	*Rothmannia sootepensis* (Craib) Brem.	Rubiaceae	T	5.00
48	*Schima wallichii* (DC.) Korth.	Theaceae	T	0.09
49	*Scleropyrum pentandrum* (Denn.) Mabb.	Santalaceae	T	7.00
50	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	16.00
51	*Shorea siamensis* Miq. var. *siamensis*	Dipterocarpaceae	T	12.00
52	*Spatholobus parviflorus* (Roxb.) O.K.	Leguminosae, Papilionoideae	WC	6.00
53	*Stereospermum colais* (B.-H. *ex* Dillw.) Mabb.	Bignoniaceae	T	0.40
54	*Symplocos racemosa* Roxb.	Symplocaceae	L	0.36
55	*Tarennoidea wallichii* (Hk.f.) Tirv. & Sastre	Rubiaceae	T	0.59
56	*Terminalia alata* Hey. *ex* Roth	Combretaceae	T	3.00
57	*Tetrastigma leucostaphyllum* (Denn.) Mabb.	Vitaceae	WC	23.00
58	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	Myrtaceae	L, T	1.40
59	*Vernonia parishii* Hk.f.	Compositae	L	1.10
60	*Vitex limoniifolia* Wall. *ex* Kurz	Verbenaceae	T	3.50
61	*Vitex peduncularis* Wall. *ex* Schauer	Verbenaceae	T	5.00

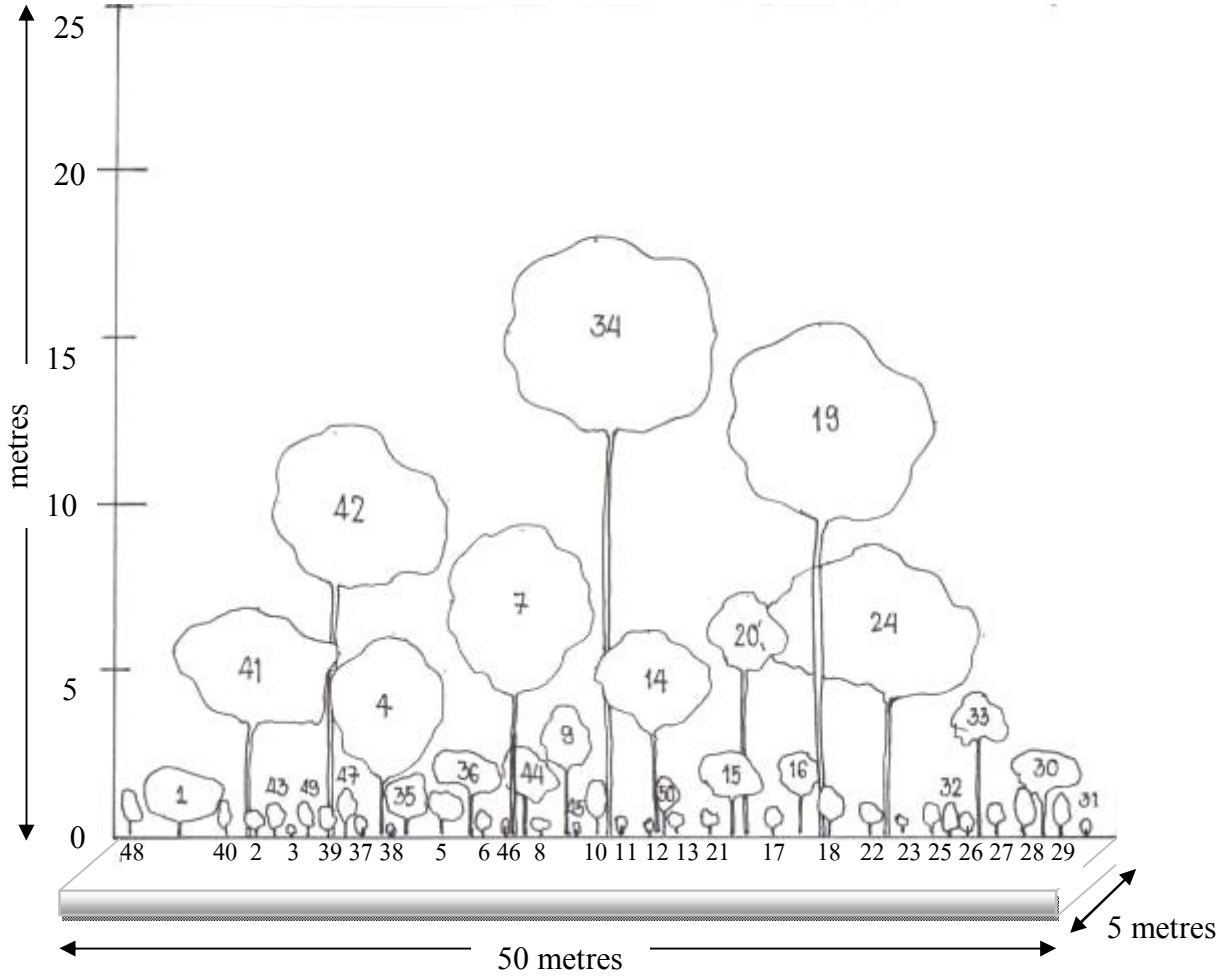

Figure 3. Forest profile diagram of site 2 (Chang Kian Stream)

Table 3. Species foun in site 2 (Chang Kian Stream)
(Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	Apocynaceae	WC	2.00
2	*Anneslea fragrans* Wall.	Theaceae	T	1.60
3	*Antidesma acidum* Retz.	Euphorbiaceae	T	0.17
4	*Aporosa villosa* (Lindl.) Baill.	Euphorbiaceae	T	0.83
5	*Breynia glauca* Craib	Euphorbiaceae	S	1.15
6	*Bridelia stipularis* (L.) Bl.	Euphorbiaceae	WC	0.84
7	*Buchanania lanzan* Spreng.	Anacardiaceae	T	9.00
8	*Calycopteris floribunda* (Roxb.) Lmk.	Combretaceae	WC	0.37
9	*Canarium subulatum* Guill.	Burseraceae	T	1.70
10	*Catunaregum spathulifolia* Tirv.	Rubiaceae	L	1.48
11	*Catunaregum tomentosa* (Bl. *ex* DC.) Tirv.	Rubiaceae	L	0.69
12	*Celastrus paniculatus* Willd.	Celastraceae	WC	0.45
13	*Clerodendrum serratum* (L.) Moon var. *wallichii* Cl.	Verbenaceae	L	0.62

Table 3. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
14	*Craibiodendron stellatum* (Pierre) W.W.Sm.	Ericaceae	T	5.50
15	*Dalbergia cultrata* Grah. *ex* Bth.	Leguminosae, Papilionoideae	T	2.50
16	*Desmodium oblongum* Bth.	Leguminosae, Papilionoideae	L	2.50
17	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	Dilleniaceae	T	1.10
18	*Diospyros ehretioides* Wall. *ex* G.Don	Ebenaceae	T	1.25
19	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	15.00
20	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Dipterocarpaceae	T	7.00
21	*Ellipeiopsis cherrevensis* (Pierre *ex* Finet & Gagnep.) R.E.Fr.	Annonaceae	S	0.89
22	*Embelia tsjeriamcottam* (Roem. & Schult.) A. DC. var. *tsjeriamcottam*	Myrsinaceae	WC	1.20
23	*Erythroxylum cuneatum* (Miq.) Kurz	Erythroxylaceae	S	0.57
24	*Eugenia cumini* (L.) Druce	Myrtaceae	L	8.00
25	*Gardenia obtusifolia* Roxb. *ex* Kurz	Rubiaceae	L	0.90
26	*Glochidion eriocarpum* Champ.	Euphorbiaceae	T	0.68
27	*Grewia abutilifolia* Vent. *ex* Juss.	Tiliaceae	L	1.00
28	*Grewia lacei* Drum. & Craib	Tiliaceae	L	1.60
29	*Hibiscus glanduliferus* Craib	Malvaceae	S	1.14
30	*Indigofera cassioides* Rottl. *ex* DC.	Leguminosae, Papilionoideae	S	2.00
31	*Ixora cibdela* Craib	Rubiaceae	L	0.32
32	*Leea indica* (Burm.f.) Merr.	Leeaceae	L	1.00
33	*Linostoma persimile* Craib	Thymelaeaceae	S	4.00
34	*Lithocarpus polystachyus* (Wall. *ex* A.DC.) Rehd.	Fagaceae	T	18.00
35	*Lophopetalum wallichii* Kurz	Celastraceae	T	1.70
36	*Mitragyna hirsuta* Hav.	Rubiaceae	T	3.00
38	*Pavetta fruticosa* Craib	Rubiaceae	S	0.38
39	*Phoenix loureiri* Kunth var. *loureiri*	Palmae	L	1.05
40	*Premna nana* Coll. & Hemsl.	Verbenaceae	S	1.00
41	*Quercus kerrii* Craib	Fagaceae	T	7.00
42	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	12.00
43	*Shorea siamensis* Miq. var. *siamensis*	Dipterocarpaceae	T	1.12
44	*Spatholobus parviflorus (*Roxb.) O.K.	Leguminosae, Papilionoideae	WC	4.00
45	*Stereospermum colais* (B.-H. *ex* Dillw.) Mabb.	Bignoniaceae	T	0.20
46	*Stereospermum neuranthum* Kurz	Bignoniaceae	T	0.40
47	*Terminalia alata* Heyne *ex* Roth	Combretaceae	T	1.70
48	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	Myrtaceae	T	2.00
49	*Vitex peduncularis* Wall. *ex* Schauer	Verbenaceae	T	0.90
50	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow.	Rubiaceae	T	2.50

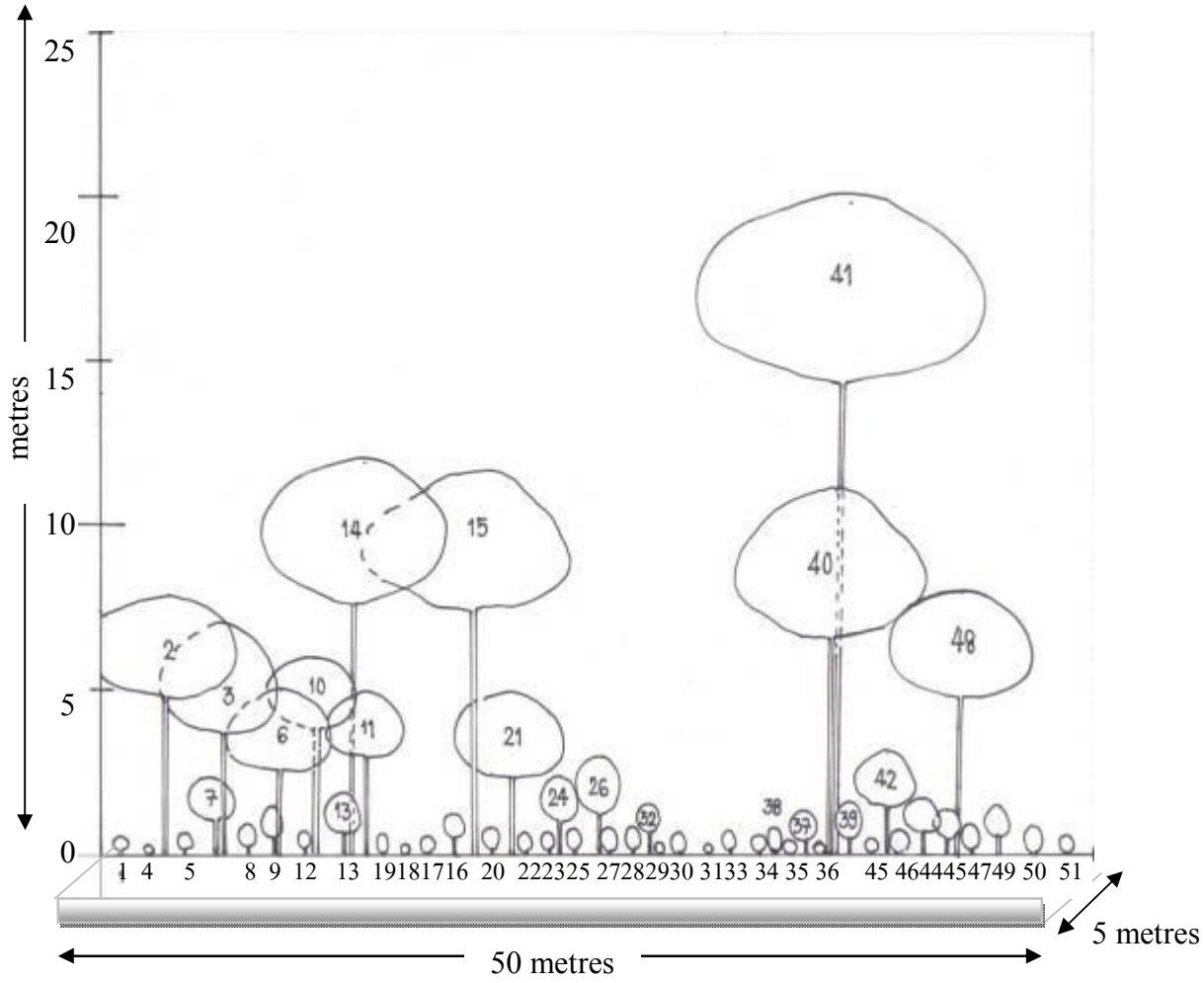

Figure 4. Forest profile diagram of site 3 (Mae Yuak Noi 1)

Table 4. Species found in site 3 (Mae Yuak Noi 1)
(Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	Apocynaceae	WC	0.56
2	*Anneslea fragrans* Wall.	Theaceae	T	8.00
3	*Aporosa villosa* (Lindl.) Baill.	Euphorbiaceae	T	7.00
4	*Bridelia stipularis* (L.) Bl.	Euphorbiaceae	WC	0.19
5	*Buchanania glabra* Wall. *ex* Hk.f.	Anacardiaceae	T	0.70
6	*Buchanania lanzan* Spreng.	Anacardiaceae	T	5.00
7	*Canarium subulatum* Guill.	Burseraceae	T	2.20
8	*Cansjera rheedii* J. F. Gmel.	Opilliaceae	WC	1.00
9	*Catunaregum spathulifolia* Tirv.	Rubiaceae	L	1.50
10	*Craibiodendron stellatum* (Pierre) W.W.Sm.	Ericaceae	T	6.00
11	*Dalbergia cultrata* Grah. *ex* Bth.	Leguminosae, Papilionoideae	T	5.00
12	*Dalbergia oliveri* Gamb. *ex* Prain	Leguminosae, Papilionoideae	T	0.60

Table 4. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
13	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	Dilleniaceae	T	2.00
14	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	12.00
15	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Dipterocarpaceae	T	12.00
16	*Ellipeiopsis cherrevensis* (Pierre *ex* Finet & Gagnep.) R.E.Fr.	Annonaceae	S	1.18
17	*Erythroxylum cuneatum* (Miq.) Kurz	Erythroxylaceae	S	0.67
18	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	T	0.25
19	*Gardenia obtusifolia* Roxb. *ex* Kurz	Rubiaceae	L	0.48
20	*Gluta usitata* (Wall.) Hou	Anacardiaceae	T	0.73
21	*Grewia abutilifolia* Vent. *ex* Juss.	Tiliaceae	L	5.00
22	*Grewia lacei* Drum. & Craib	Tiliaceae	L	0.60
23	*Hibiscus glanduliferus* Craib	Malvaceae	S	0.60
24	*Irvingia malayana* Oliv. *ex* A. Benn.	Irvingiaceae	T	2.20
25	*Ixora cibdela* Craib	Rubiaceae	L	0.83
26	*Lagerstroemia cochinchinensis* Pierre var. *ovalifolia* Furt. & Mont.	Lythraceae	T	2.50
27	*Leea indica* (Burm.f.) Merr.	Leeaceae	T	0.90
28	*Lithocarpus polystachyus* (A. DC.) Rehd.	Fagaceae	T	0.90
29	*Lophopetalum wallichii* Kurz	Celastraceae	T	0.11
30	*Mammea siamensis* (Miq.) T. And.	Guttifereae	T	0.80
31	*Memecylon scutellatum* (Lour.) Hk. & Arn.	Melastomaceae	L	0.13
32	*Mitragyna hirsuta* Hav.	Rubiaceae	T	1.60
33	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	T	0.79
34	*Pavetta fruticosa* Craib	Rubiaceae	S	0.60
35	*Phoenix loureiri* Kunth var. *loureiri*	Palmaceae	L	0.45
36	*Phyllanthus emblica* L.	Euphorbiaceae	T	0.55
37	*Premna nana* Coll. & Hemsl.	Verbenaceae	S	1.10
38	*Quercus kerrii* Craib	Fagaceae	T	0.80
39	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	1.60
40	*Shorea siamensis* Miq. var. *siamensis*	Dipterocarpaceae	T	11.00
41	*Spatholobus parviflorus* (Roxb.) O.K.	Leguminosae, Papilionoideae	WC	20.00
42	*Stereospermum colais* (B.-H. *ex* Dillw.) Mabb.	Bignoniaceae	T	3.00
43	*Strychnos nux-vomica* L.	Loganiaceae	T	0.27
44	*Symplocos racemosa* Roxb.	Symplocaceae	L	1.90
45	*Terminalia alata* Heyne *ex* Roth	Combretaceae	T	1.40
46	*Terminalia chebula* Retz. var. *chebula*	Combretaceae	T	0.75
47	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	Myrtaceae	T	0.95
48	*Vitex limoniifolia* Wall. *ex* Kurz	Verbenaceae	T	8.00
49	*Vitex peduncularis* Wall. *ex* Schauer	Verbenaceae	T	1.30
50	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow.	Rubiaceae	T	0.80

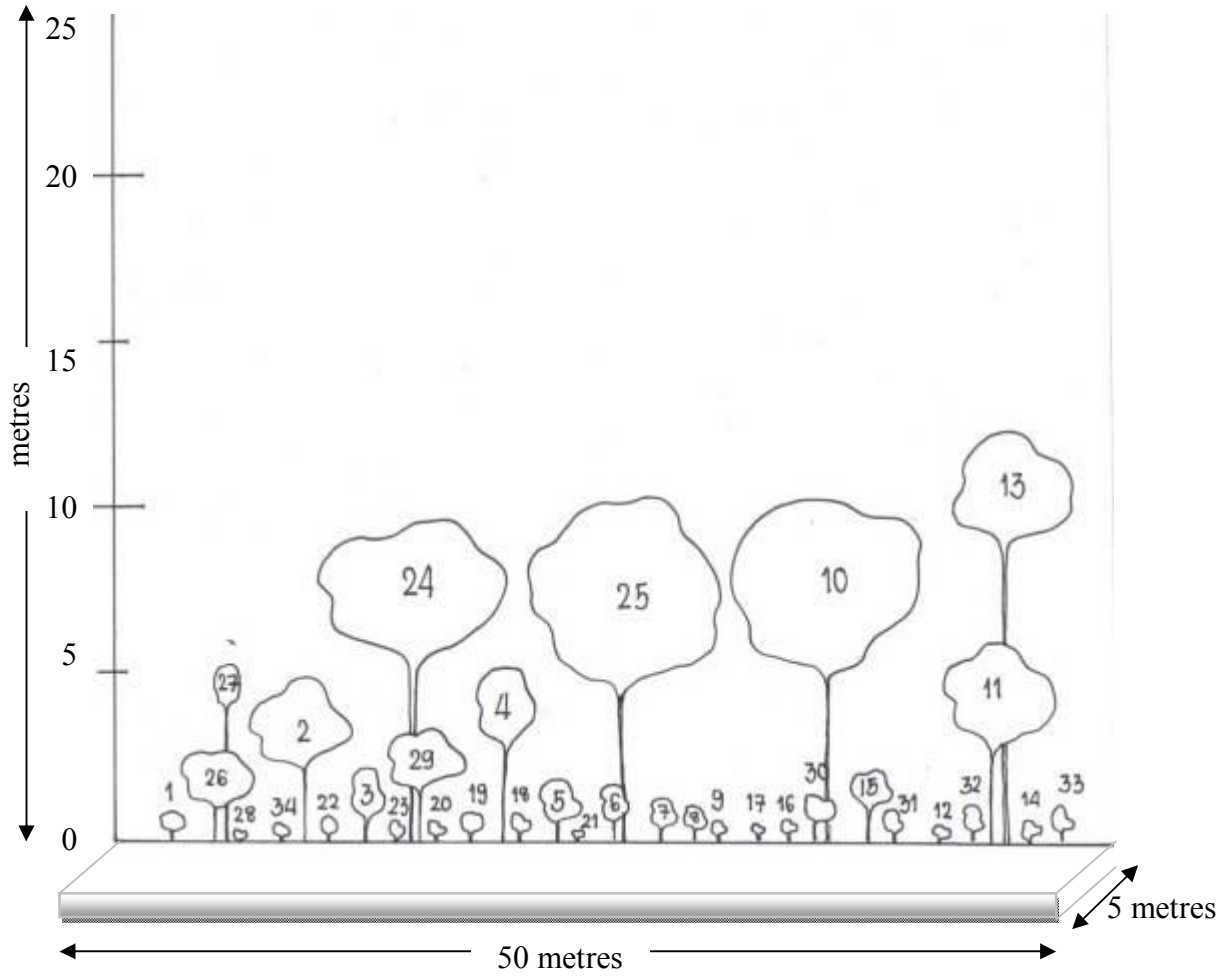

Figure 5. Forest profile diagram of site 4 (Mae Yuak Noi 2**)**

Table 5. Species found in site 4 (Mae Yuak Noi 2)
(Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Albizia odoratissima* (L.f.) Bth.	Leguminosae, Mimosoideae	T	0.34
2	*Aporosa villosa* (Lindl.) Baill.	Euphorbiaceae	T	4.50
3	*Buchanania glabra* Wall. *ex* Hk.f.	Anacardiaceae	T	2.00
4	*Buchanania lanzan* Spreng.	Anacardiaceae	T	5.00
5	*Canarium subulatum* Guill.	Burseraceae	T	1.40
6	*Catunaregum spathulifolia* Tirv.	Rubiaceae	L	1.05
7	*Craibiodendron stellatum* (Pierre) W.W.Sm.	Ericaceae	T	1.30
8	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	Dilleniaceae	T	0.75
9	*Diospyros ehretioides* Wall. *ex* G.Don	Ebenaceae	T	0.40
10	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	10.00
11	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Dipterocarpaceae	T	6.00
12	*Ellipeiopsis cherrevensis* (Pierre *ex* Finet & Gagnep.) R.E.Fr.	Annonaceae	S	0.14

Table 5. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
13	*Eugenia cumini* (L.) Druce	Myrtaceae	T	12.00
14	*Garcinia cowa* Roxb. *ex* DC.	Guttifereae	T	0.12
15	*Gardenia obtusifolia* Roxb. *ex* Kurz	Rubiaceae	L	2.00
16	*Gluta usitata* (Wall.) Hou	Anacardiaceae	T	0.75
17	*Leea indica* (Burm.f.) Merr.	Leeaceae	L	0.40
18	*Lophopetalum wallichii* Kurz	Celastraceae	T	0.90
19	*Memecylon scutellatum* (Lour.) Hk. & Arn.	Melastomaceae	L	0.80
20	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	T	0.70
21	*Parinari anamense* Hance	Rosaceae	T	0.20
22	*Phyllanthus emblica* L.	Euphorbiaceae	T	0.85
23	*Premna nana* Coll. & Hemsl.	Verbenaceae	S	0.07
24	*Quercus kerrii* Craib	Fagaceae	T	9.00
25	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	10.00
26	*Shorea siamensis* Miq. var. *siamensis*	Dipterocarpaceae	T	2.50
27	*Spatholobus parviflorus* (Roxb.) O.K.	Leguminosae, Papilionoideae	WC	5.00
28	*Stereospermum neuranthum* Kurz	Bignoniaceae	T	0.30
29	*Strychnos nux-vomica* L.	Loganiaceae	L	3.00
30	*Symplocos racemosa* Roxb.	Symplocaceae	T	1.60
31	*Terminalia alata* Heyne *ex* Roth	Combretaceae	T	0.95
32	*Terminalia chebula* Retz. var. *chebula*	Combretaceae	T	0.95
33	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	Myrtaceae	T	3.50
34	*Vitex limoniifolia* Wall. *ex* Kurz	Verbenaceae	T	0.60

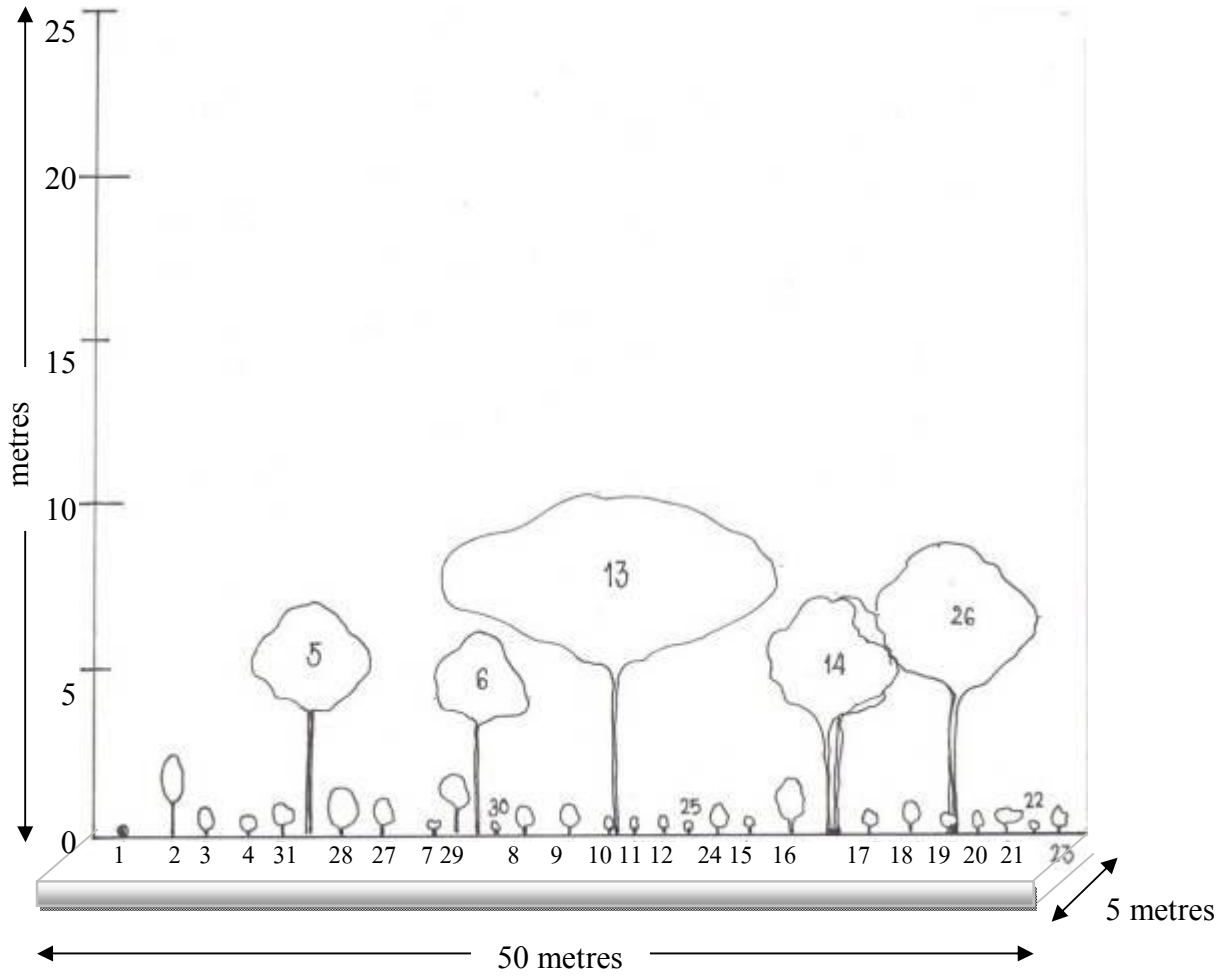

Figure 6. Forest profile diagram of site 5 (Huay Dtueng Tao 1)

Table 6. Species found in site 5 (Huay Dtueng Tao 1)
(Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	Apocynaceae	WC	0.08
2	*Aporosa villosa* (Lindl.) Baill	Euphorbiaceae	T	2.50
3	*Blinkworthia lycioides* Choisy	Convulvulaceae	S	0.71
4	*Bridelia stipularis* (L.) Bl.	Euphorbiaceae	WC	0.54
5	*Buchanania glabra* Wall. *ex* Hk.f.	Anacardiaceae	T	7.00
6	*Buchanania lanzan* Spreng.	Anacardiaceae	T	6.00
7	*Canarium subulatum* Guill.	Burseraceae	T	0.64
8	*Catunaregum spathulifolia* Tirv.	Rubiaceae	L	0.05
9	*Celastrus paniculatus* Willd.	Celastraceae	WC	0.73
10	*Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	Guttifereae	T	0.20
11	*Dalbergia cultrata* Grah. *ex* Bth.	Leguminosae, Papilionoideae	T	0.18
12	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	Dilleniaceae	T	0.22

Table 6. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
13	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	0.08
14	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Dipterocarpaceae	T	12.00
15	*Eugenia cumini* (L.) Druce	Myrtaceae	T	7.00
16	*Gardenia obtusifolia* Roxb. *ex* Kurz	Rubiaceae	L	1.60
17	*Glochidion eriocarpum* Champ.	Euphorbiaceae	L	0.36
18	*Grewia abutilifolia* Vent. *ex* Juss.	Tiliaceae	S	0.90
19	*Hibiscus glanduliferus* Craib	Malvaceae	L	0.40
20	*Meyna velutina* Roby.	Rubiaceae	L	0.72
21	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	T	0.53
22	*Pavetta fruticosa* Craib	Rubiaceae	S	0.09
23	*Phoenix loureiri* Kunth var. *loureiri*	Palmae	L	0.69
24	*Phyllanthus emblica* L.	Euphorbiaceae	T	0.75
25	*Quercus kerrii* Craib	Fagaceae	T	0.07
26	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	8.00
27	*Symplocos racemosa* Roxb.	Symplocaceae	L	1.05
28	*Terminalia alata* Heyne *ex* Roth	Combretaceae	T	1.30
29	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	Myrtaceae	T	1.50
30	*Vitex peduncularis* Wall. *ex* Schauer	Verbenaceae	T	0.23
31	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow.	Rubiaceae	T	0.90

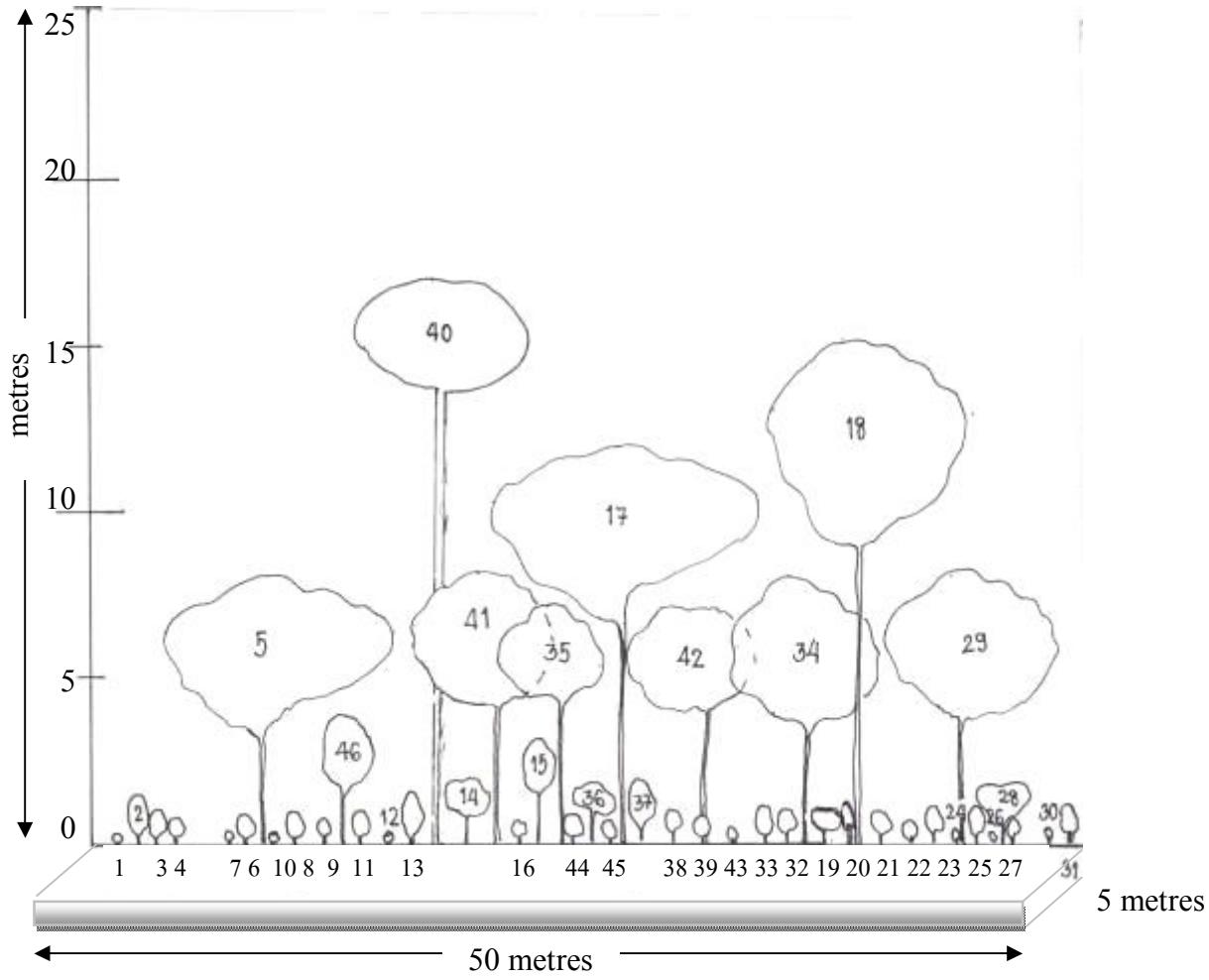

Figure 7. Forest profile diagram of site 6 (Huay Dtueng Tao 2)

Table 7. Species found in site 6 (Huay Dtueng Tao 2**)**
(Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Acacia megaladena* Desv. var. *megaladena*	Leguminosae, Mimosoideae	WC	0.10
2	*Albizia odoratissima* (L.f.) Bth.	Leguminosae, Mimosoideae	T	0.80
3	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	Apocynaceae	WC	1.60
4	*Anneslea fragrans* Wall.	Theaceae	T	0.65
5	*Aporosa villosa* (Lindl.) Baill.	Euphorbiaceae	T	8.00
6	*Blinkworthia lycioides* Choisy	Convulvulaceae	S	0.87
7	*Buchanania glabra* Wall. *ex* Hk.f.	Anacardiaceae	T	0.22
8	*Buchanania lanzan* Spreng.	Anacardiaceae	T	1.00
9	*Calycopteris floribunda* (Roxb.) Lmk.	Combretaceae	WC	0.60
10	*Canarium subulatum* Guill.	Burseraceae	T	0.22

Table 7. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
11	*Catunaregum spathulifolia* Tirv.	Rubiaceae	L	1.10
12	*Celastrus paniculatus* Willd.	Celastraceae	WC	0.05
13	*Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	Guttifereae	T	1.80
14	*Desmodium oblongum* Bth.	Leguminosae, Papilionoideae	L	2.00
15	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	Dilleniaceae	T	3.00
16	*Diospyros ehretioides* Wall. *ex* G. Don	Ebenaceae	T	0.60
17	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	12.00
18	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Dipterocarpaceae	T	15.00
19	*Erythroxylon cuneatum* (Miq.) Kurz	Erythroxylaceae	S	0.90
20	*Eugenia cumini* (L.) Druce	Myrtaceae	T	1.20
21	*Gardenia obtusifolia* Roxb. *ex* Kurz	Rubiaceae	L	0.80
22	*Glochidion eriocarpum* Champ.	Euphorbiaceae	L	0.52
23	*Hibiscus glanduliferus* Craib	Malvaceae	L	0.90
24	*Ixora cibdela* Craib	Rubiaceae	L	0.17
25	*Lagerstroemia macrocarpa* Kurz var. *macrocarpa*	Lythraceae	T	0.91
26	*Leea indica* (Burm.f.) Merr.	Leeaceae	T	0.62
27	*Memecylon scutellatum* (Lour.) Hk. & Arn.	Melastomaceae	L	0.80
28	*Millettia extensa* Bth. *ex* Baker	Leguminosae, Papilionoideae	WC	1.60
29	*Mitragyna hirsuta* Hav.	Rubiaceae	T	8.00
30	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	T	0.30
31	*Phoenix loureiri* Kunth var. *loureiri*	Arecaceae	L	2.00
32	*Phyllanthus emblica* L.	Euphorbiaceae	T	0.27
33	*Pterocarpus macrocarpus* Kurz	Leguminosae, Papilionoideae	T	1.00
34	*Quercus kerrii* Craib	Fagaceae	T	8.00
35	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	7.00
36	*Shorea siamensis* Miq. var. *siamensis*	Dipterocarpaceae	T	1.00
37	*Spatholobus parviflorus* (Roxb.) O.K.	Leguminosae, Papilionoideae	WC	1.92
38	*Strychnos nux-vomica* L.	Loganiaceae	T	0.50
39	*Symplocos racemosa* Roxb.	Symplocaceae	L	0.63
40	*Terminalia alata* Heyne *ex* Roth	Combretaceae	T	17.00
41	*Terminalia chebula* Retz. var. *chebula*	Combretaceae	T	8.00
42	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	Myrtaceae	T	7.50
43	*Ventilago denticulata* Willd.	Rhamnaceae	WC	0.05
44	*Vitex peduncularis* Wall. *ex* Schauer	Verbenaceae	T	1.10
45	*Walsura trichostemon* Miq.	Meliaceae	T	0.90
46	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow.	Rubiaceae	T	4.00

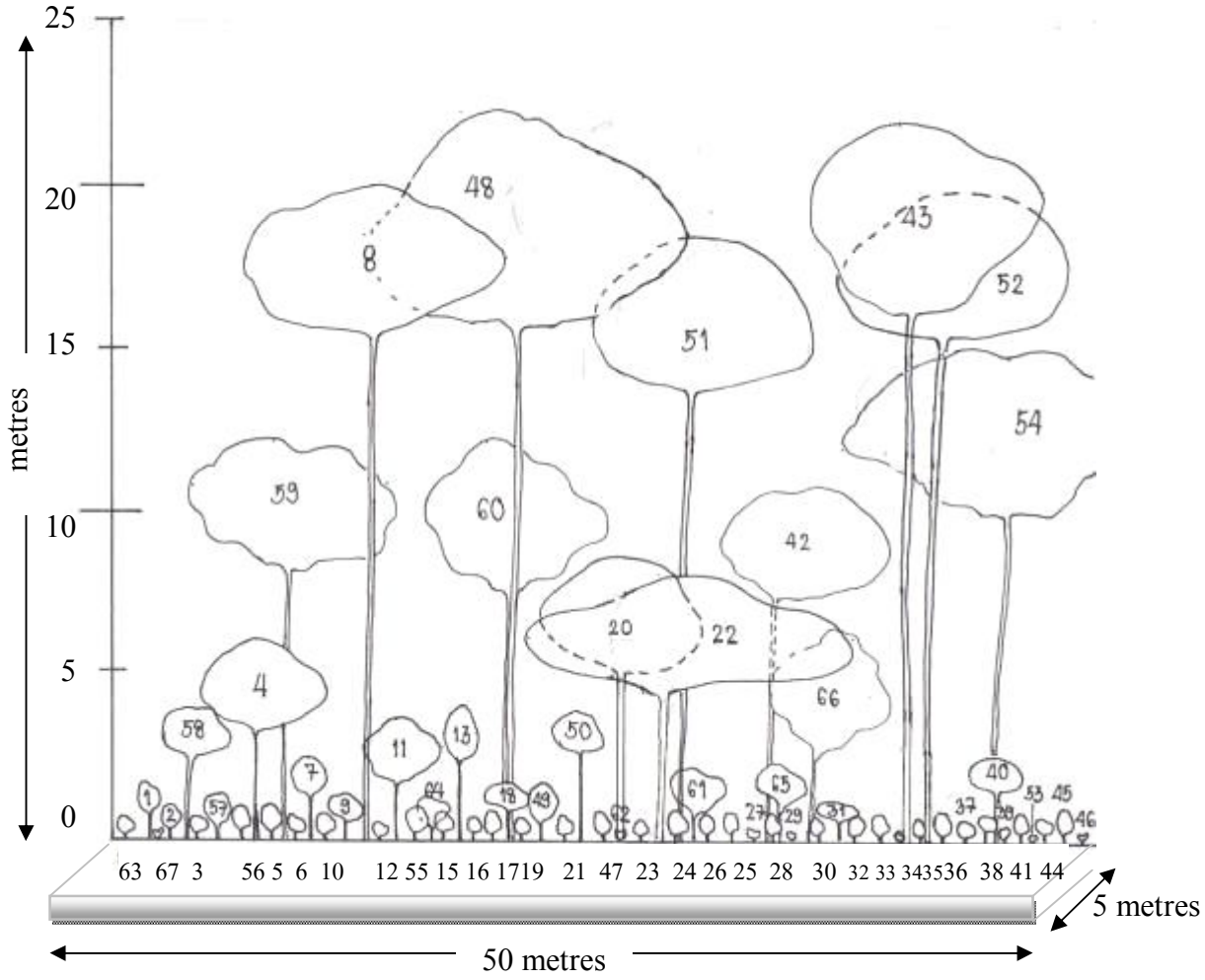

Figure 8. Forest profile diagram of site 7 (Huay Dtueng Tao 3)

Table 8. Species found in site 7 (Huay Dtueng Tao 3)
(Abbreviations for habit: B = bamboo, L = treelet, S = shrub, T = tree, WC = woody climber)

No.	Botanical name	Family	Habit	Max. height (m)
1	*Albizia odoratissima* (L.f.) Bth.	Leguminosae, Mimosoideae	T	0.80
2	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	Apocynaceae	WC	0.62
3	*Anneslea fragrans* Wall.	Theaceae	T	0.50
4	*Antidesma acidum* Retz.	Euphorbiaceae	T	6.00
5	*Aporosa octandra* (B.-H *ex* D.Don) Vick. var. *octandra*	Euphorbiaceae	T	0.90
6	*Aporosa villosa* (Lindl.) Baill.	Euphorbiaceae	T	0.53
7	*Bridelia stipularis* (L.) Bl.	Euphorbiaceae	WC	0.72
8	*Buchanania glabra* Wall. *ex* Hk.f.	Anacardiaceae	T	20.00
9	*Canarium subulatum* Guill.	Burseraceae	T	1.20

Table 8. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
10	*Cansjera rheedii* J. F. Gmel.	Opilliaceae	WC	0.90
11	*Catunaregum spathulifolia* Tirv.	Rubiaceae	L	0.82
12	*Celastrus paniculatus* Willd.	Celastraceae	WC	0.50
13	*Cissus repens* Lmk.	Vitaceae	WC	4.00
14	*Clausena excavata* Burm.f. var. *excavata*	Rutaceae	L	0.50
15	*Clerodendrum serratum* (L.) Moon var. *wallichii* Cl.	Verbenaceae	L	0.48
16	*Colona flagrocarpa* (Cl.) Craib	Tiliaceae	T	1.10
17	*Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	Guttifereae	T	1.60
18	*Dalbergia cana* Grah. *ex* Kurz var. *cana*	Leguminosae, Papilionoideae	T	0.65
19	*Dalbergia cultrata* Grah. *ex* Bth.	Leguminosae, Papilionoideae	T	22.00
20	*Dendrocalamus nudus* Pilg.	Gramineae, Bambusoideae	B	8.00
21	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	Dilleniaceae	T	0.38
22	*Dimocarpus longan* Lour. ssp. *longan* var. *longan*	Sapindaceae	T	0.75
23	*Diospyros ehretioides* Wall. *ex* G.Don	Ebenaceae	T	0.61
24	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Dipterocarpaceae	T	0.90
25	*Embelia tsjeriamcottam* (Roem. & Schult.) A. DC. var. t*sjeriamcottam*	Myrsinaceae	WC	0.80
26	*Erythroxylum cuneatum* (Miq.) Kurz	Erythroxylaceae	S	0.95
27	*Eugenia albiflora* Duth. *ex* Kurz	Myrtaceae	T	0.20
28	*Gardenia sootepensis* Hutch.	Rubiaceae	T	0.76
29	*Garuga pinnata* Roxb.	Burseraceae	T	0.20
30	*Gluta usitata* (Wall.) Hou	Anacardiaceae	T	0.45
31	*Grewia abutilifolia* Vent. *ex* Juss.	Tiliaceae	S	1.20
32	*Grewia eriocarpa* Juss.	Tiliaceae	T	0.86
33	*Grewia lacei* Drum. & Craib	Tiliaceae	L	1.00
34	*Helicteres elongata* Wall. *ex* Bojer	Sterculiaceae	S	0.17
35	*Hibiscus glanduliferus* Craib	Malvaceae	L	0.45
36	*Holarrhena pubescens* Wall. *ex* G.Don	Apocynaceae	T	0.95
37	*Irvingia malayana* Oliv. *ex* A. Benn.	Irvingiaceae	T	0.50
38	*Ixora cibdela* Craib	Rubiaceae	L	0.62
39	*Jasminum scandens* (Retz.) Vahl	Oleaceae	WC	0.22
40	*Lagerstroemia cochinchinensis* Pierre var. *ovalifolia* Furt. & Mont.	Lythraceae	T	5.00
41	*Leea indica* (Burm.f.) Merr.	Leeaceae	L	0.90
42	*Millettia extensa* Bth. *ex* Baker	Leguminosae, Papilionoideae	WC	12.00
43	*Morinda tomentosa* Heyne *ex* Roth	Rubiaceae	T	22.00
44	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	T	0.53
45	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	T	1.00
46	*Pavetta fruticosa* Craib	Rubiaceae	S	0.20

Table 8. (Continued)

No.	Botanical name	Family	Habit	Max. height (m)
47	*Polyalthia cerasoides* (Roxb.) Bth. *ex* Bedd.	Annonaceae	T	1.20
48	*Pterocarpus macrocarpus* Kurz	Leguminosae, Papilionoideae	T	22.00
49	*Quercus kerrii* Craib	Fagaceae	T	1.50
50	*Rothmannia sootepensis* (Craib) Brem.	Rubiaceae	T	3.50
51	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	T	18.00
52	*Shorea obtusa* Wall. *ex* Bl.	Dipterocarpaceae	T	20.00
53	*Shorea siamensis* Miq. var. *siamensis*	Dipterocarpaceae	T	0.30
54	*Spatholobus parviflorus* (Roxb.) O.K	Leguminosae, Papilionoideae	WC	15.00
55	*Sterculia balanghas* L.	Sterculiaceae	T	0.80
56	*Stereospermum neuranthum* Kurz	Bignoniaceae	T	0.96
57	*Strychnos nux-vomica* L.	Loganiaceae	T	1.13
58	*Symplocos racemosa* Roxb.	Symplocaceae	L	4.00
59	*Terminalia alata* Heyne *ex* Roth	Combretaceae	T	15.00
60	*Terminalia chebula* Retz. var. *chebula*	Combretaceae	T	12.00
61	*Terminalia mucronata* Craib & Hutch.	Combretaceae	T	2.00
62	*Vernonia parishii* Hk.f.	Compositae	L	0.22
63	*Vitex canescens* Kurz	Verbenaceae	T	0.50
64	*Vitex peduncularis* Wall. *ex* Schauer	Verbenaceae	T	1.20
65	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow.	Rubiaceae	T	2.50
66	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) Niels.	Leguminosae, Mimosoideae	T	6.00
67	*Ziziphus oenopolia* (L.) Mill. var. *oenopolia*	Rhamnaceae	WC	0.24

Forest profile diagrams make a clear illustration of the forest structure as they show the amount of species, their maximum sizes and vegetation layers which are different at each site. The number of species indicates the species richness and diversity. The canopy profile and layers can indicate the history of the area related to human disturbances such as logging and fire. Multi-vegetation layers indicate the stages of vegetation recovery with different size classes.

Site 1 at Pah Laht Temple had less disturbance than the other sites. The profile diagram shows that the size class 1-5 m was the main vegetation layer that densely covered the site. Above 5 m, tree size was randomly distributed, but enough to create cooler, shady conditions and an almost closed canopy. Some tall tree species were the deciduous *Dipterocarpus obtusifolius* var. *obtusifolius*, *Shorea obtusa*, *S. siamensis* var. *siamensis* and the evergreen *Lithocarpus polystachyus*. The highest number of individuals were found at this site. Other large species were *Buchanania lanzan* and *Eugenia grata* var. *grata*. The woody climbers at this site had the highest number of species, most individuals and largest sizes when compared with the other sites. This site also had a small seasonal stream with vegetation characteristic of mixed evergreen + deciduous (mxf) forest.

Site 2, in deciduous dipterocarp-oak forest (dof), had *Dipterocarpus obtusifolius* var. *obtusifolius*, *Lithocarpus polystachyus* and *Shorea obtusa* as the dominant tall and most abundant trees. This was the first time that the effects of fire were clearly seen. Most of the trees had burned stems and some damaged parts caused by fire which had resulted in coppiced regeneration. Two vegetation layers in this site were mainly coppiced species (*Glochidion eriocarpum* and *Buchanania lanzan*) and regenerating stumps (*Aporosa villosa*, *Tristaniopsis burmanica* var. *rufescens* and *Wendlandia tinctoria* spp. *floribunda*). This site is clearly a very degraded version of site 1.

Sites 5, 6 and 7 are located above Huay Dteung Tao Lake and represent an extremely degraded dof forest. Only one tree was more than 10 m high and less than 10 individuals were higher than 5 m. Small and randomly distributed seedlings of *Buchanania lanzan*, *Cratoxylon formosum* spp. *pruniflorum* and *Gardenia obtusifolia* were sometimes found beneath the dominant grasses and sedges. Site 5 was the most degraded site that had suffered from repeated fires and had the fewest trees over 5 m tall.

Site 6 was in a slightly better condition than site 5. The largest tree at this site was *Terminalia alata*. From the profile diagram (Figure 7) the vegetation layer at 5-10 m mostly had *Aporosa villosa*, *Mitragyna hirsuta*, *Quercus kerrii*, *Shorea obtusa*, *Terminalia chebula* var. *chebula* and *Tristaniopsis burmanica* var. *rufescens*. Woody species less than 5 m tall were dominated by *Cratoxylon formosum* spp. *pruniflorum* and *Tristaniopsis burmanica* var. *rufescens*, which are indicators of frequently burnt areas. The herbaceous ground flora, especially two grasses, *Arundinella setosa* var. *setosa* and *Apluda mutica*, uniformly covered the site.

Site 7 was situated on the same hill as sites 5 and 6, but in a gully and was less disturbed by fire. The plot was also partially covered by dense bamboo growth, *Dendrocalamus nudus*, and had a small stream. The site had a partial mxf facies and had the highest species richness and abundance of vegetation. The canopy was almost closed with 4 layers (Figure 8). *Buchanania glabra*, *Dalbergia cultrata*, *Morinda tomentosa*, *Pterocarpus macrocarpus* and *Shorea obtusa* all exceeded 20 m. The sub-canopy trees more than 10 m tall consisted of 3 species of *Terminalia* and the >1-5 m size class comprised *Lagerstroemia cochinchinensis* var. *ovalifolia*, *Quercus kerrii*, the 3 species of *Terminalia*, and *Xylia xylocarpa* var. *kerrii* (Table 8). More than 40 species of seedlings covered the plot.

Sites 3 and 4 were similar to sites 5 and 6 and had two indistinct tree layers. The tallest trees and most abundant coppices were Dipterocarpaceae, viz. *Dipterocarpus obtusifolius* var. *obtusifolius*, *D. tuberculatus* var. *tuberculatus*, *Shorea obtusa* and *S. siamensis* var. *siamensis* (Figures 4-5). Although the mean tree height at site 3 was more than at site 4, site 3 had a much denser tree layer up to 1 m tall. More than half of site 4 was covered by perennial grasses, which indicated that this site had had more fire damage than site 3.

Species composition and abundance

Sites 1 and 7 had the most woody species (61 and 67 respectively) while sites 4 and 5 had the least (34 and 31 respectively) (Figure 9). The other sites ranged between 46-50 species. The number of woody individuals at each site is depicted (Figure 10). Site 7 had the most with 1169 individuals, followed, surprisingly, by site 2 (952) and site 1 (876). Site 5 was lowest with 319 individuals.

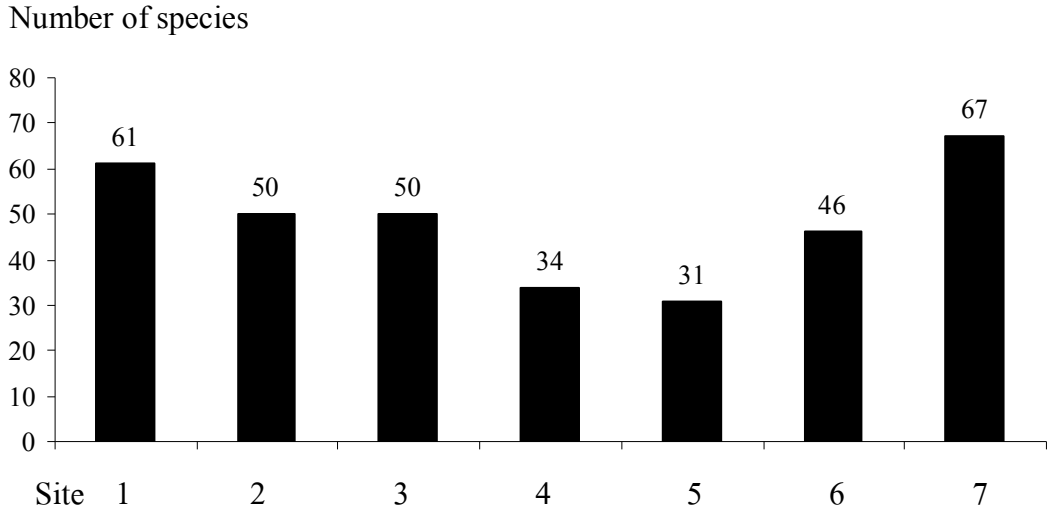

Figure 9. Number of woody species at each survey site

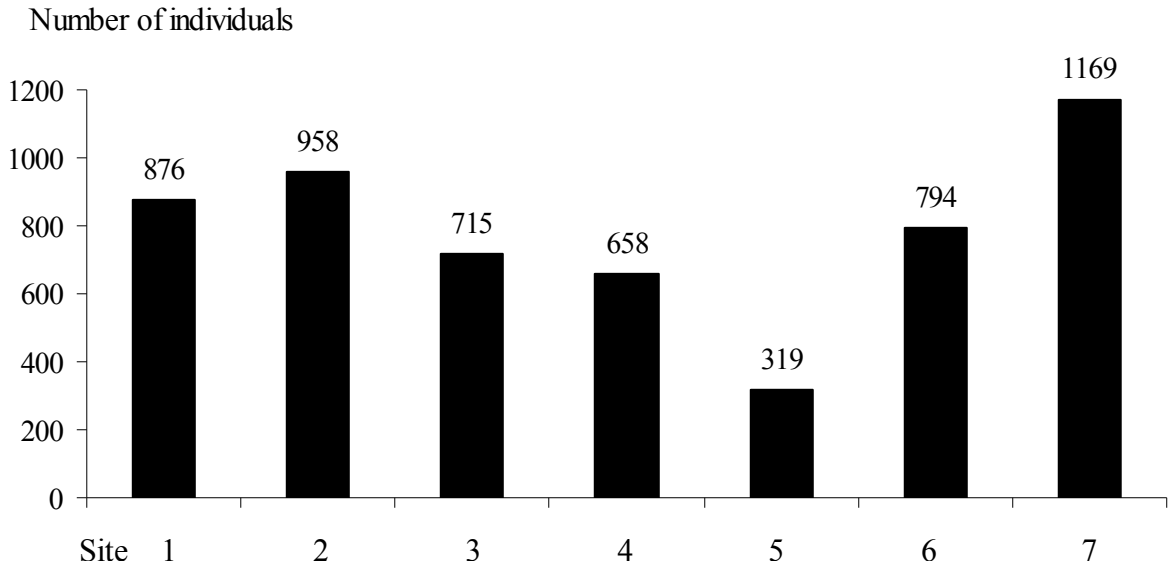

Figure 10. Number of individuals of woody species at each survey site

Species richness and diversity

Species richness is the total number of woody plant species in each site. Species diversity is calculated using both Shannon's and Simpson's diversity indices and MVSP 3.1, a multivariate statistical package program [18]. Shannon's index takes the number of species (species richness) and the relative abundance of the species (evenness) into account, while Simpson's reciprocal index measures the probability that two individuals randomly selected from a sample will belong to the same species. The details of these species diversity indices are shown in Appendix 2. Species richness and diversity at each site are shown in Table 9.

Table 9. Species richness and species diversity indices of each site

Site	Species richness	Shannon's index	Simpson's reciprocal index
1	61	3.38	20.06
2	50	2.83	10.97
3	50	3.06	13.62
4	34	2.44	6.83
5	31	2.58	9.14
6	46	2.45	5.30
7	67	3.37	20.00

The highest species diversity values are at site 1 for both diversity indices. Shannon's index value at site 1 is slightly higher than at site 7. Although the number of species (species richness) in site 1 was less than that in site 7, the abundance of each species (evenness) in site 1 was to some extent higher than that in site 7. For Shannon's index, the more equal the values of species abundance are, the higher the evenness of the community is (sites 1, 7 and 3). In contrast, if one or few species are dominating, the evenness of the community is low (sites 2, 5, 4, and 6). The higher evenness means the higher value of Shannon's index. High evenness indicates a lack of dominant species, which reflects the good health of the sample plots, since the dominance of one or few species in an ecosystem often results from negative human impacts [19].

Simpson's reciprocal index is the measurement of dominant species in the community, which could arise from disturbance. The higher the value, the greater is the diversity or the degree to which dominance is shared by many species. A lower value represents the possibility that two individuals randomly selected from a sample will belong to the same species. For example, site 2 and site 3 showed equal richness in species but site 2 was covered with coppiced regeneration species more than at site 3, which had less damage from fire. Simpson's reciprocal index shows that the influence by the dominant species is more than the actual diversity of degraded areas such as site 5, despite having the lowest species richness. Simpson's reciprocal index of site 5 is higher than those of sites 4 and 6, which were dominated by fire-tolerant, deciduous tree species.

Species categories and size class

All woody plants were classified into 6 size classes, viz. 1) 0-1 m, 2) >1-5 m, 3) >5-10 m, 4) >10-15 m, 5) >15-20 m and 6) >20 m, to show the composition of forest vegetation cover that consists of trees, shrubs and woody climbers, which are stratified from seedlings, saplings and mature plants growing to the top of the canopy. Woody plants in each size class at each survey site are shown in Table 10. Trees, shrubs and woody climbers are classified in different size classes as mentioned above for site comparison (Figures 11-13).

Table 10. Number of woody plants in each size class at each survey site

Site	Number of woody plants (number of species) for each size class					
	≤ 1 m	>1-5 m	>5-10 m	>10-15 m	>15-20 m	>20 m
1	625 (51)	211 (42)	25 (14)	12 (5)	2 (2)	-
2	773 (43)	168 (31)	10 (9)	6 (2)	1 (1)	-
3	568 (47)	108 (21)	27 (7)	12 (5)	-	-
4	591 (32)	55 (17)	11 (4)	1 (1)	-	-
5	278 (29)	31 (9)	9 (5)	1 (1)	-	-
6	735 (41)	44 (17)	12 (8)	2 (2)	1 (1)	-
7	1043 (63)	103 (23)	9 (2)	5 (3)	6 (5)	3 (3)

Table 10 shows that woody plants ≤ 1 m dominated all survey sites. The number of species and the number of individuals decreased on going up the size class. It is important to note that the number of woody plants more than 1 m tall was highest at site 1 and lowest at site 5. The number of individuals over 1 m tall in site 1 (251 individuals) was approximately double that in the next highest place—site 7, which had 126 plants. No woody plants higher than 15 m were found in sites 3, 4, and 5. Those which exceeded 20 m were only found in site 7 (Figure 11). Shrubs were most abundant in site 3 and taller shrubs (>1-5 m) were absent from sites 4 and 5 (Figure 12). Woody climbers were abundant in sites 1 and 7 (Figure 13). Site 1 showed many size classes of woody climbers although small-sized ones dominated the site, some large ones being found on trees that exceeded 15 m tall.

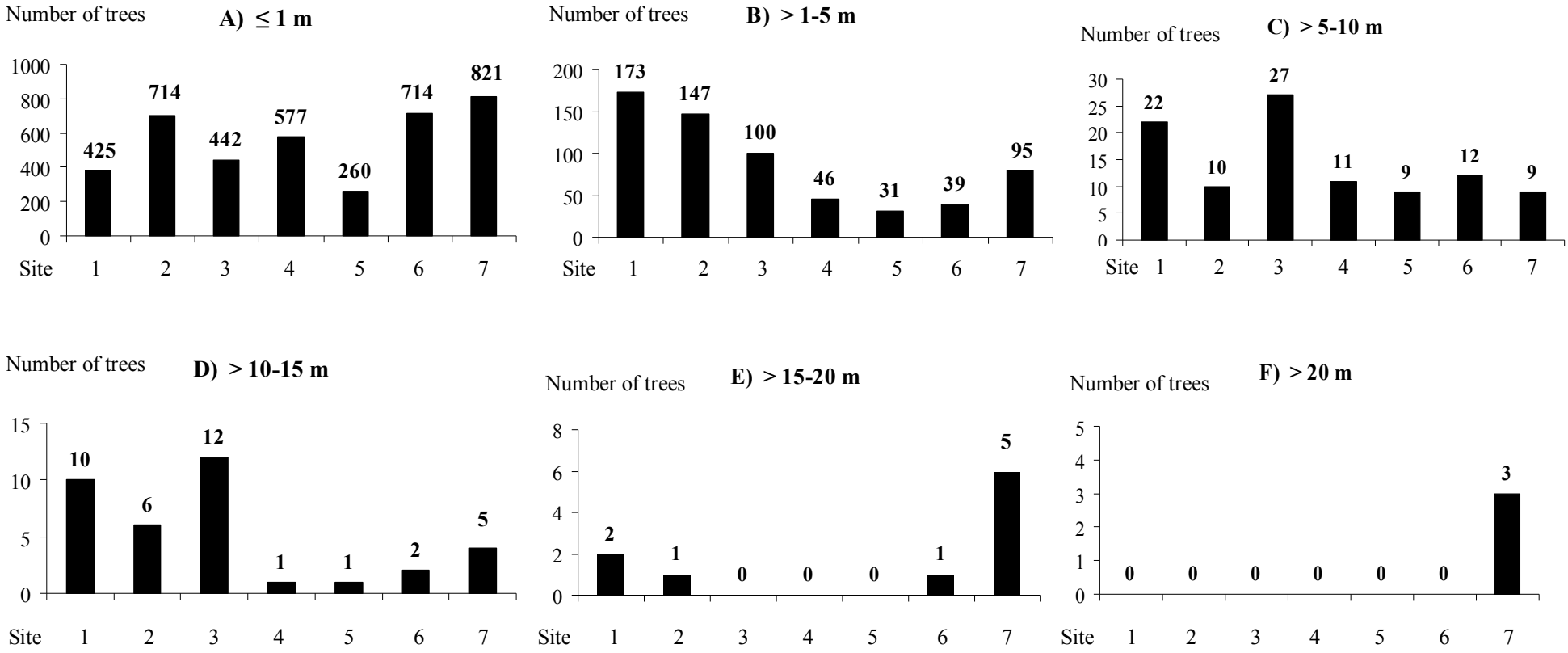

Figure 11. Number of trees at each site shown in different size class charts: A) ≤ 1 m, B) >1-5 m, C) >5-10 m, D) >10-15 m, E) >15-20 m and F) > 20 m

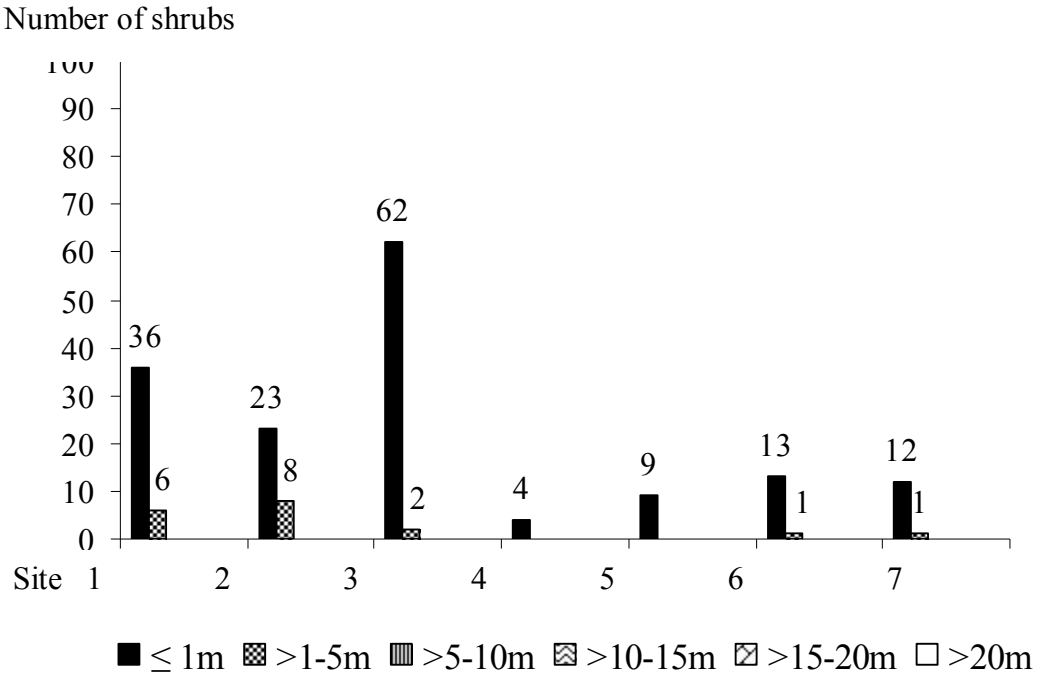

Figure 12. Number of shrubs at each site according to size class

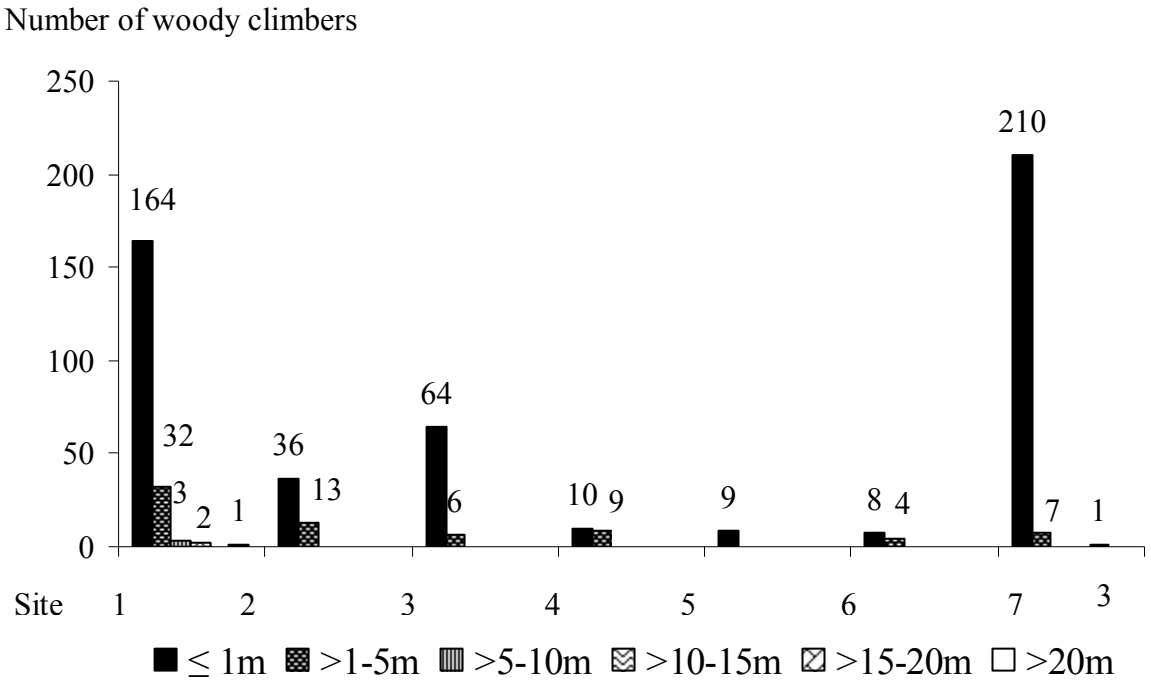

Figure 13. Number of woody climbers at each site according to size class

Seedlings

Young woody plants below the canopy are very important for forest stability and represent the new generation of forest species. Woody seedling species from the circular plots are shown in Table 13, which compares the species composition among sites.

Table 13. List of woody seedling species at each site

No.	Botanical name	Habit	Site						
			1	2	3	4	5	6	7
1	*Acacia megaladena* Desv. var. *megaladena*	WC							✓
2	*Albizia odoratissima* (L.f.) Bth.	T				✓			✓
3	*Amphineurion* (*Aganosma*) *marginata* (Roxb.) D.J. Midd.	WC	✓		✓				✓
4	*Anneslea fragran*s Wall.	T				✓			✓
5	*Antidesma acidum* Retz.	T	✓						✓
6	*Aporosa octandra* (B.-H. *ex* D. Don) Vick. var. *octandra*	T	✓						✓
7	*Aporosa villosa* (Lindl.) Baill.	T			✓	✓			✓
8	*Blinkworthia lycioides* Choisy	S				✓	✓		✓
9	*Breynia glauca* Craib	L,S	✓		✓	✓			
10	*Bridelia glauca* Bl.	L,S			✓				
11	*Bridelia stipularis* (L.) Bl.	WC	✓		✓				
12	*Buchanania glabra* Wall. *ex* Hk.f.	T			✓	✓	✓		
13	*Buchanania lanzan* Spreng.	T	✓	✓		✓	✓	✓	
14	*Canarium subulatum* Guill.	T	✓			✓			✓
15	*Cansjera rheedii* J. F. Gmel.	WC	✓		✓				
16	*Catunaregum spathulifolia* Tirv.	L	✓		✓	✓			✓
17	*Celastrus paniculatus* Willd.	WC							✓
18	*Cissus hastata* Miq.	WC	✓						
19	*Cissus repanda* Vahl	WC							✓
20	*Clausena excavata* Burm.f. var. *excavata*	L							✓
21	*Clerodendrum paniculatum* L.	L	✓						
22	*Clerodedrum serratum* (L.) Moon var. *wallichii* Cl.	L		✓					✓
23	*Colona flagrocarpa* (Cl.) Craib	T							✓
24	*Craibiodendron stellatum* (Pierre) W.W.Sm.	T			✓	✓			
25	*Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	T				✓	✓	✓	✓

Table 13. (Continued)

No.	Botanical name	Habit	Site						
			1	2	3	4	5	6	7
26	*Dalbergia cultrata* Grah. *ex* Bth.	T	✓		✓	✓			✓
27	*Dalbergia oliveri* Gamb. *ex* Prain	T			✓				
28	*Dalbergia velutina* Bth.	WC			✓				
29	*Desmodium oblongum* Bth.	L	✓						
30	*Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl.	T				✓			✓
31	*Diospyros ehretioides* Wall. *ex* G.Don	T	✓						✓
32	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	T	✓	✓	✓	✓		✓	✓
33	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	T	✓		✓				✓
34	*Ellipeiopsis cherrevensis* (Pierre *ex* Finet & Gagnep.) R.E.Fr.	S			✓	✓			
35	*Erythroxylum cuneatum* (Miq.) Kurz	S	✓	✓	✓	✓			✓
36	*Eugenia albiflora* Duth. *ex* Kurz	T							✓
37	*Eugenia cumini* (L.) Druce	T				✓			
38	*Eugenia grata* Wight var. *grata*	T	✓						
39	*Flemingia sootepensis* Craib	L	✓						
40	*Garcinia cowa* Roxb. *ex* DC.	T	✓		✓				✓
41	*Gardenia obtusifolia* Roxb. *ex* Kurz	L			✓	✓			
42	*Gardenia sootepensis* Hutch.	T	✓						
43	*Glochidion eriocarpum* Champ.	L,T					✓		✓
44	*Glochidion rubrum* Bl.	L,T	✓	✓					
45	*Gluta usitata* (Wall.) Hou	T			✓	✓			✓
46	*Grewia abutilifolia* Vent. *ex* Juss.	S							✓
47	*Grewia eriocarpa* Juss.	T						✓	✓
48	*Grewia lacei* Drum. & Craib	L			✓				
49	*Hibiscus glanduliferus* Craib	L	✓	✓	✓			✓	✓
50	*Hymenodictyon orixense* (Roxb.) Mabb.	T							✓
51	*Irvingia malayana* Oliv. *ex* A. Benn.	T			✓				✓
52	*Ixora cibdela* Craib	L	✓	✓	✓				✓
53	*Lagerstroemia cochinchinensis* Pierre var. *ovalifolia* Furt. & Mont.	T							✓
54	*Leea indica* (Burm.f.) Merr.	L	✓	✓	✓	✓		✓	✓
55	*Lophopetalum wallichii* Kurz	T			✓	✓			

Table 13. (Continued)

No.	Botanical name	Habit	Site						
			1	2	3	4	5	6	7
56	*Mammea siamensis* (Miq.) T. And.	T	✓						
57	*Memecylon scutellatum* (Lour.) Hk. & Arn.	T				✓			
58	*Millettia extensa* Bth. *ex* Baker	WC	✓						✓
59	*Mitragyna hirsuta* Hav.	T			✓				
60	*Ochna integerrima* (Lour.) Merr.	L			✓	✓			✓
61	*Oroxylum indicum* (L.) Kurz	L,T							✓
62	*Pavetta fruticosa* Craib	S			✓				
63	*Pavetta tomentosa* Roxb. *ex* Sm. var. *tomentosa*	L	✓						
64	*Phoenix loureiri* Kunth var. *loureiri*	L	✓	✓	✓	✓			✓
65	*Phyllanthus emblica* L.	T			✓				
66	*Pterocarpus macrocarpus* Kurz	T				✓			✓
67	*Pueraria stricta* Kurz	S						✓	
68	*Quercus kerrii* Craib	T	✓		✓	✓			✓
69	*Rothmannia sootepensis* (Craib) Brem.	T	✓						
70	*Schima wallichii* (DC.) Korth.	T	✓						
71	*Shorea obtusa* Wall. *ex* Bl.	T	✓	✓	✓	✓			✓
72	*Shorea siamensis* Miq. var. *siamensis*	T			✓	✓			✓
73	*Spatholobus parviflorus* (Roxb.) O.K.	WC	✓	✓	✓	✓			✓
74	*Stereospermum colais* (B.-H.*ex* Dillw.) Mabb.	T	✓						
75	*Stereospermum neuranthum* Kurz	T		✓					✓
76	*Strychnos nux-vomica* L.	T			✓	✓			✓
77	*Symplocos racemosa* Roxb.	L					✓		
78	*Tarennoidea wallichii* (Hk.f.) Tirv. & Sastre	T	✓						
79	*Terminalia alata* Heyne *ex* Roth	T				✓			✓
80	*Terminalia chebula* Retz. var. *chebula*	T							✓
81	*Tetrastigma leucostaphylum* (Denn.) Mabb.	WC	✓						
82	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	L,T			✓	✓	✓		✓
83	*Vernonia parishii* Hk. f.	L	✓						
84	*Vitex limoniifolia* Wall. *ex* Kurz	T	✓		✓	✓			

Table 13. (Continued)

No.	Botanical name	Habit	Site						
			1	2	3	4	5	6	7
85	*Vitex peduncularis* Wall. *ex* Schauer	T							✓
86	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow.	T				✓			✓
87	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) Niels.	T							✓
	Total Number of Species		**39**	**12**	**37**	**34**	**7**	**7**	**51**

Note: Abbreviations for habit: L = treelet, S = shrub, T = tree, WC = woody climber

The circular sampling plots had the most woody plant seedlings in site 7 (51 species), which was similar to the species composition in the 50x5-m survey plots. The fewest seedlings were found in sites 5 and 6 (7 species). Tree seedlings of Dipterocapaceae, *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius* and *Shorea obtusa* Wall. *ex* Bl., were found in 6 sites and 5 sites respectively. Other tree seedlings found in more than 4 sites were *Buchanania lanzan* Spreng., *Hibiscus glanduliferus* Craib, *Leea indica* (Burm.f.) Merr. and *Phoenix loureiri* Kunth var. *loureiri*. Common shrub and woody climber seedlings found in the circular plots were *Erythroxylum cuneatum* (Miq.) Kurz and *Spatholobus parviflorus* (Roxb.) O.K., except for sites 5 and 6.

Herbaceous ground flora

The proportion of herbaceous ground vegetation cover and open area, and dominant ground vegetation (any species which were not tree seedlings, covering more than 1% of the plot area) from the 4 circular plots in each site are listed in Table 14. It is notable that all ground flora circles had few individuals of most species and only a few species, mostly perennial, deciduous Gramineae (grasses) and Cyperaceae (sedges). These two families provide much of the fuel for fires (Photo 6). Dominant species were different between sites with more fire and sites with less fire. For example, *Arundinella setosa* Trin. var. *setosa* dominated sites 2, 3, 4 and 5. These sites suffered from more of fire while *Cyrtococcum accrescens* (Trin.) Stapf (Site 1) and *Eupatorium odoratum* L. (Site 7) were herbaceous cover dominating areas with less fire.

Table 14. Proportion of the cover of herbaceous ground flora and open area, and dominant ground vegetation species from the 4 circular plots at each site

Site	Circular plot	Cover	Open	Dominant species
Site 1				*Cyrtococcum accrescens* (Trin.) Stapf (Gramineae),
	1	65%	35%	*Globba schomburgkii* Hk.f. var. *schomburgkii* (Zingiberaceae)
	2	40%	60%	
	3	50%	50%	
	4	40%	60%	
Average		**48.75%**	**51.25%**	
Site 2				*Inula indica* L. (Compositae),
	1	95%	5%	*Scleria levis* Retz. (Cyperaceae),
	2	70%	30%	*Arundinella setosa* Trin. var. *setosa*, *Apluda mutica* L.,
	3	85%	15%	*Mnesithea striata* (Steud.) Kon. & Sos. (all Gramineae),
	4	80%	20%	*Globba reflexa* Craib (Zingiberaceae)
Average		**82.50%**	**17.50%**	
Site 3				*Arundinella setosa* Trin. var. *setosa*, *Eulalia siamensis* Bor,
	1	60%	40%	*Hyparrhenia rufa* (Nees) Stapf var. *siamensis* Clay.,
	2	60%	40%	*Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E.Hubb.
	3	40%	60%	*ex* Hubb. & Vaugh., *Polytoca digitata* (L.f.) Druce (all Gramineae)
	4	40%	60%	
Average		**50%**	**50%**	

Table 14. (Continued)

Site	Circular plot	Cover	Open	Dominant species
Site 4				*Scleria teresstris* (L.) Fass. (Cyperaceae),
	1	80%	20%	*Arundinella setosa* Trin. var. *setosa* and *Polytoca digitata* (L.f.) Druce
	2	60%	40%	(both Gramineae)
	3	50%	50%	
	4	50%	50%	
Average		**60%**	**40%**	
Site 5				*Fimbristylis straminea* Turr., *Rhynchospora rubra* (Lour.) Mak.,
	1	15%	85%	*Scleria levis* Retz. (all Cyperaceae),
	2	65%	35%	*Arundinella setosa* Trin. var. *setosa* , *Apluda mutica* L.,
	3	60%	40%	*Themeda triandra* Forssk. (all Gramineae),
	4	90%	10%	*Dunbaria bella* Prain (Leguminosae, Papilionoideae)
Average		**57.50%**	**43.50%**	
Site 6				*Fimbristylis dichotoma* (L.) Vahl ssp. *dichotoma*,
	1	15%	85%	*Fimbristylis straminea* Turr., *Scleria kerrii* Turr. (all Cyperaceae),
	2	99%	1%	*Arundinella setosa* Trin. var. *setosa*, *Apluda mutica* L.,
	3	99%	<1%	*Pennisetum polystachyon* (L.) Schult. (all Gramineae),
	4	80%	20%	*Pueraria stricta* Kurz (Leguminosae, Papilionoideae)
Average		**73.25%**	**27.75%**	
Site 7				*Eupatorium odoratum* L. (Compositae),
	1	60%	40%	*Scleria kerrii* Turr.(Cyperaceae),
	2	40%	60%	*Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E.Hubb. *ex* Hubb.
	3	65%	35%	& Vaugh. (Gramineae)
	4	70%	30%	
Average		**58.75%**	**42.25%**	

Fire

Fire has a disastrous effect on forest growth since it can kill young plants. Figures 14-16 show how damaging fire can be on vegetation. Site 1, which had been protected from fire more effectively than all the other sites, had the most woody species without fire damage (21 species), while sites 4 and 3 had the least (4 and 5 species respectively) (Figure 14). The ravages of fire are convincingly shown in Figures 15-16 where site 1 had the least number of individuals damaged by fire (176 or 20% of the total number of individuals) while site 5 had the fewest number of individuals (319) and highest percentage of damage (88.7%). The fire-damaged woody species and their fire-damaged percentage at each site are shown in Table 15. The species for each site are arranged in order of the number of fire-damaged individuals.

The percentage of damage of the woody plants caused by fire was lowest in site 1 where the most damage was to *Lithocarpus polystachyus* (Wall. *ex* A.DC.) Rehd. (63.16%). The damage of other species in site 1 ranged between 10.77-30%. In the more degraded sites, the highest percentages of damage of woody plants ranged between 84-100%, e.g. *Aporosa villosa* (Lindl.) Baill., *Dipterocarpus tuberculatus* Roxb var. *tuberculatus*, *Gluta usitata* (Wall.) Hou, *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn.& Lug. and *Shorea obtusa* Wall. *ex* Bl. High percentages of fire damage for many species (e.g. in site 7) revealed that extensive and frequent fire in the past had resulted in the coppicing of these species after fire.

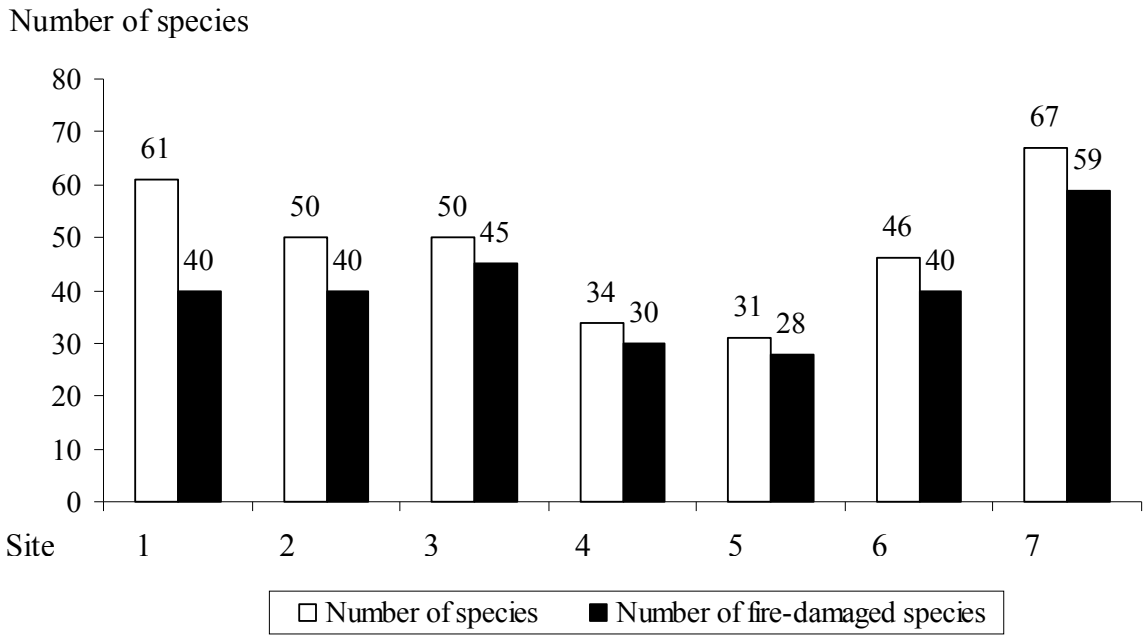

Figure 14. Number of woody species and number of species damaged by fire at each survey site

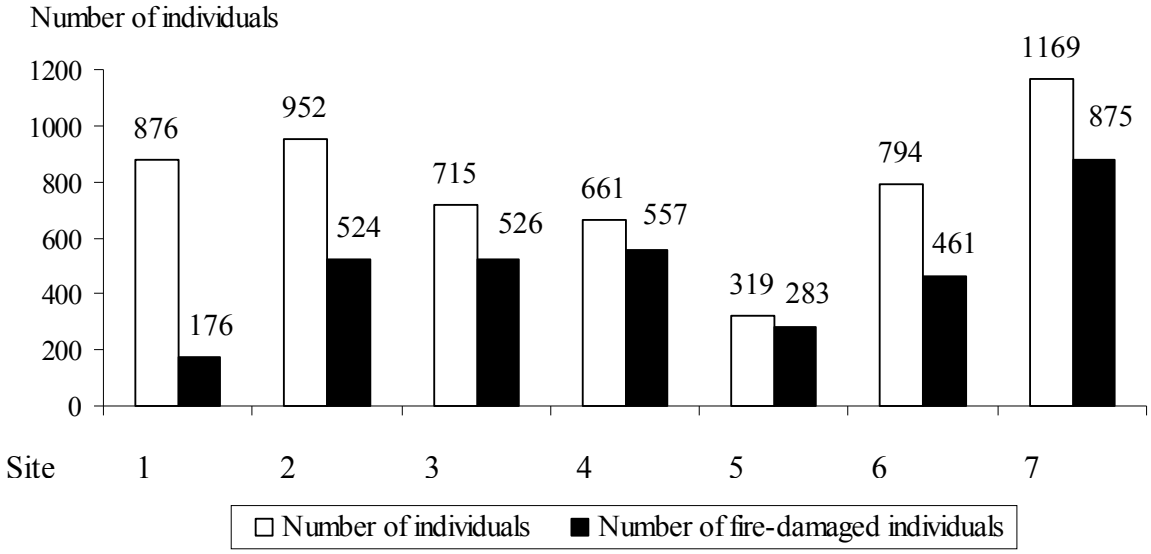

Figure 15. Number of individuals of woody species and the number of individuals damaged by fire at each survey site

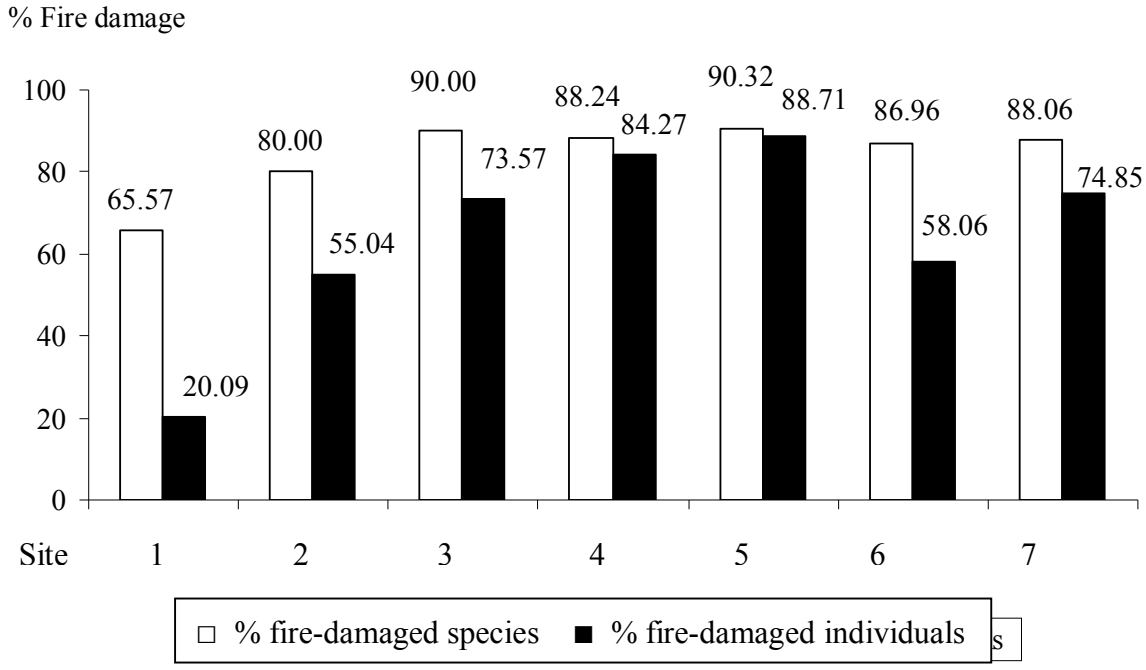

Figure 16. Percentage of fire-damaged species and fire-damaged individuals at each survey site

Table 15. List of fire-damaged species at each site and number and percentage of fire-damaged individuals

Site	Species	Total number	Fire-damaged number	% Fire damage
1				
	1. *Lithocarpus polystachyus* (Wall. *ex* A.DC.) Rehd.	114	72	63.16
	2. *Quercus kerrii* Craib	36	10	27.78
	3. *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	66	8	12.12
	4. *Rothmannia sootepensis* (Craib) Brem.	65	7	10.77
	5. *Gardenia sootepensis* Hutch.	24	6	25.00
	6. *Vernonia parishii* Hk. f.	24	5	20.83
	7. *Craibiodendron stellatum* (Pierre) W.W.Sm.	28	5	17.86
	8. *Buchanania lanzan* Spreng.	29	5	17.24
	9. *Breynia glauca* Craib	31	4	12.90
	10. *Shorea obtusa* Wall. *ex* Bl.	10	3	30.00
2				
	1. *Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	150	124	82.67
	2. *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	151	64	42.38
	3. *Shorea obtusa* Wall. *ex* Bl.	85	64	75.29
	4. *Glochidion eriocarpum* Champ.	127	48	37.80
	5. *Aporosa villosa* (Lindl.) Baill.	38	32	84.21
	6. *Quercus kerrii* Craib	30	24	80.00
	7. *Lithocarpus polystachyus* (Wall. *ex* A. DC.) Rehd.	28	21	75.00
	8. *Buchanania lanzan* Spreng.	92	20	21.74
	9. *Spatholobus parviflorus* (Roxb.) O.K.	37	17	45.95
	10. *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug.	16	13	81.25

Table 15. (Continued)

Site	Species	Total number	Fire-damaged number	% Fire damage
3				
	1. *Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	134	115	85.82
	2. *Shorea obtusa* Wall. *ex* Bl.	60	51	85.00
	3. *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	59	39	66.10
	4. *Spatholobus parviflorus* (Roxb.) O.K.	60	35	58.33
	5. *Dalbergia cultrata* Grah. *ex* Bth.	35	31	88.57
	6. *Ochna integerrima* (Lour.) Merr.	31	28	90.32
	7. *Ellipeiopsis cherrevensis* (Pierre *ex* Finet & Gagnep.) R.E.Fr.	35	20	57.14
	8. *Gluta usitata* (Wall.) Hou	20	18	90.00
	9. *Shorea siamensis* Miq. var. *siamensis*	26	15	57.69
	10. *Quercus kerrii* Craib	20	15	75.00
4				
	1. *Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	191	177	92.67
	2. *Shorea obtusa* Wall. *ex* Bl.	122	113	92.62
	3. *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	84	54	64.29
	4. *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn.& Lug.	40	39	97.50
	5. *Eugenia cumini* (L.) Druce	33	32	96.97
	6. *Ochna integerrima* (Lour.) Merr.	23	22	95.65
	7. *Craibiodendron stellatum* (Pierre) W.W. Sm.	19	19	100.00
	8. *Catunaregum spathulifolia* Tirv.	21	17	80.95
	9. *Gluta usitata* (Wall.) Hou	12	12	100.00
	10. *Spatholobus parviflorus* (Roxb.) O.K.	19	7	36.84
5				
	1. *Gardenia obtusifolia* Roxb. *ex* Kurz	59	59	100.00
	2. *Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	52	51	98.08
	3. *Buchanania lanzan* Spreng.	53	48	90.57
	4. *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn.& Lug.	35	35	100.00
	5. *Shorea obtusa* Wall. *ex* Bl.	15	15	100.00

Table 15. (Continued)

Site	Species	Total number	Fire-damaged number	% Fire damage
6				
	1. *Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	315	149	56.83
	2. *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn.& Lug.	108	40	37.04
	3. *Hibiscus glanduliferus* Craib	53	34	64.15
	4. *Buchanania lanzan* Spreng.	36	33	91.67
	5. *Aporosa villosa* (Lindl.) Baill.	22	22	100.00
	6. *Glochidion eriocarpum* Champ.	31	21	67.74
	7. *Shorea obtusa* Wall. *ex* Bl.	23	20	86.96
	8. *Catunaregum spathulifolia* Tirv.	18	18	100.00
	9. *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	35	16	45.71
	10. *Terminalia chebula* Retz. var. *chebula*	14	12	85.71
7				
	1. *Lagerstroemia cochinchinensis* Pierre var. *ovalifolia* Furt. & Mont.	119	108	90.76
	2. *Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	118	86	72.88
	3. *Millettia extensa* Bth. *ex* Baker	71	68	95.77
	4. *Shorea obtusa* Wall. *ex* Bl.	65	61	93.85
	5. *Colona flagrocarpa* (Cl.) Craib	74	50	67.57
	6. *Vitex peduncularis* Wall. *ex* Schauer	43	42	97.67
	7. *Dalbergia cultrata* Grah. *ex* Bth.	60	36	60.00
	8. *Catunaregum spathulifolia* Tirv.	31	29	93.55
	9. *Albizia odoratissima* (L.f.) Bth.	41	24	58.54
	10. *Celastrus paniculatus* Willd.	96	13	13.54

Sucessional ecology and forest condition assessment

After fire disturbance, a degraded forest regenerates and various ecological changes occur. For an accurate forest condition assessment, we focused on ecological species groups, i.e. climax and pioneer species, which are two basic kinds of vegetation that appear, develop and often persist in a natural order of sucession in disturbed or cleared areas. The percentage of fire damage, species diversity, and the tree size of the two species groups are discussed here.

Initial species which colonise an area are called pioneer species and include herbaceous flora (often weeds) and various kinds of woody plants. The latter group is called secondary growth and includes plants which are light demanding (shade intolerant), rapid-growing, and arrive by wind or are dispersed by small animals (especially birds). As these species develop, often annually or in several years, soil nutrients, moisture and shade increase. Eventually, conditions are suitable for the development of more permanent, i.e. climax or primary, vegetation. As long as fire, erosion and cutting do not occur, this vegetation can develop into a stable system which maintains itself naturally. In Appendix 3 the tree species found in the plots have been categorised as being either pioneer or climax. The dispersal mechanism of their fruits/seeds and number at each site are also noted.

From the survey results, the number of climax tree species was more than pioneer (secondary growth) species at all sites. This indicated that dof had reached a climax stage in the past but had been continuously degraded by humans. Periodic fire had maintained a stable fire-climax ecosystem. In this study, 3 species of Dipterocarpaceae: *Dipterocarpus obtusifolius* var. *obtusifolius*, *D. tuberculatus* var. *tuberculatus* and *Shorea obtusa* were the dominant components of the upperstorey while abundant non-Dipeterocarpaceae were *Buchanania lanzan*, *Quercus kerrii* and *Tristaniopsis burmanica* var. *rufescens*. Large trees of these climax species that were less damaged by fire than smaller trees remained conspicuous in the sites. In the understorey, a high number of woody climbers in sites 1 and 7 also indicated better forest conditions. Sites with high diversity, compared to those with lower diversity on the open slopes, were the consequence of more climax trees that were protected or survived fire. It is likely that vegetation on lower-angled slopes or in gullies is less susceptible to fire than that on steep slopes and ridges. Soil water content on flatter areas is also higher compared with that on on steeper slopes [20].

Early sucessional plant communities after fire may be dominated with some pioneer species. For example, sites 6 and 7 had the highest numbers of *Cratoxylum formosum* spp. *Pruniflorum*—a fire-tolerant, deciduous, wind-dispersed, pioneer tree. Site 7 also had the highest number and species richness of pioneer species in the open understorey. The abundance of pioneer species indicates that fire affects the vegetation composition with pioneer species increasing after repeated disturbance or decreasing if disturbance has been prevented [21]. More pioneer tree species having small seeds dispersed by wind or small birds are found on the steep slopes and ridges while most climax trees are found in flatter slopes or near a gully. The high number of pioneer trees and the high percentages of fire damage in sites 6 and 7 resulted from the topographic position of the plots. The same trend was reported in burned lowland dipterocarp rainforest in East Kalimantan, Indonesia [22]. Pioneer species also impede the regeneration of climax species by shading them during the first stage of succession [23]. Herbaceous ground cover, especially the fire-resistant grasses, *Arundinella setosa* var. *setosa*, *Imperata cylindrica* var. *major* and *Pennisetum polystachyon*, outgrow the surviving climax species in the early stage of recovery after fire. If subsequent fire ceases and succession continues, fast-growing pioneer species will provide suitable conditions for climax trees that slowly develop under shaded conditions.

Tree size can be used to assess the forest condition. Most of the large-sized trees are climax species which have a higher chance of survival after fire than small individuals. Large pioneer trees (>5 m high) are rare. Seedlings and saplings of pioneer trees on steep slopes tend to be suppressed by herbaceous flora that dominates the understorey after fire. Although degraded

sites are dominated by a few fire-tolerant species, protection of the remaining larger-sized trees from another fire will help reduce soil erosion and flash-flooding, and provide seed sources for forest recovery.

Key points for lowland decidouous forest recovery

Continuous human abuse of forests, especially with fire and logging, has had a degrading effect on plant diversity and resulted in loss of soil nutrients with accompanying erosion and siltation of streams. Fire kills all seedlings and most seeds while damaging saplings and understory vegetation. Forest recovery may be difficult after subsequent fires which lead to extirpation of some understorey tree species. Perennial herbs are not killed by fire since their underground rhizomes and tubers resist the heat. The seed bank of annual herbs as well as mushroom spores and mycelia are a direct indicator of fire damage and forest health. The early recovery of these species in burned forest crucially depends on surviving trees and coppicing regeneration [24]. When considering reforesting of demolished lowland deciduous or evergreen forests, soil improvement in degraded sites can be enhanced by planting mycorrhiza-associated species for nitrogen fixation and increased nutrient accumulation in the soil. Climax tree species which are animal-dispersed should have priority since their seed bank is usually absent in highy disturbed sites [25]. If subsequent fires continue, wind-dispersed species will invade more successfully. This will result in forest ecosystem dominated by relatively few pioneer species since the ability of animal-dispersed species to develop is negated due to the absence of large seed dispersers. Forest biodiversity can be more rapidly augmented by planting animal-dispersed climax species.

Conclusions

From this preliminary, rapid assessment of the lowland dof condition in Chang Kian Valley, Chiang Mai, several conclusions can be made:

1. All of the forest plots are in various stages of degradation, all caused by man.
2. Most areas are in poor condition as indicated by mostly sparse woody, often deformed or stunted growth and many bare areas where nothing grows and severe erosion has occurred.
3. Fires, all of which are intentionally started, are the main cause of this problem.
4. Fire not only destroys forest biodiversity and vegetation and retards forest growth, but also results in erosion, air pollution and flash-flooding.
5. Fire prevention has not been effective in the valley.
6. Unless serious and effective remedial action is taken to halt further forest degradation, the present situation will continue to decline, that is the environmental quality will get worse in Chiang Mai.
7. Proper replanting of severely degraded places is urgently required since natural regeneration has stopped in many places.

Recommendations

1. Professional assistance is required from many legitimate specialists to help alleviate the rapidly declining level of environmental quality in Chiang Mai.
2. The government must assist since legislation and enforcement of laws concerning forest encroachment are its responsibility.
3. All fires, logging, hunting and other abuses of forest resources (agricultural expansion, trash dumping and settlement) must cease.

4. Research proving that fire is actually detrimental to forest growth should be continued.
5. Public awareness must be promoted to gain the support of local people in understanding the problems and eventually help in protecting the forest.
6. Financial support must be provided by the government and perhaps also by the public.
7. Continued research on forest biodiversity must be done in zoology (insects, birds and mammals), fungi, vegetation, bryology, ecology, soil, erosion and hydrology.
8. A vegetation map of the area indicating the various conditions of growth, based on our work, should be produced for Chang Kian Valley.
9. An effective reforestation project should be started.
10. A plan must be implemented to indicate which forested areas require immediate restorative action, places where protection is needed, and sites that can be used for research, recreation and education.
11. Soil in the study sites should be professionally surveyed to show that the condition of the vegetation directly correlates with soil quality.
12. Competent research on the effects of fire on mushroom growth should be conducted.
13. These recommendations should be implemented as soon as possible.

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Appendix 1: Photos

Photo 1. Evidence of forest fires on the lower slopes of Doi Sutep-Pui in Chang Kian Valley including sites 5 and 6 (2 October 2008)

Photo 2. After a fire has stopped, the burned area on the right shows that dry organic matter has almost totally disappeared. (Site 3, 23 December 2008)

Photo 3. The burning of dry vegetation kills many plants and soil organisms, retards future growth, encourages soil erosion and flooding, and produces smoke which pollutes the air in Chiang Mai. Ground temperature during a fire averages 338°C and at 0.5-1 m high the average is 169°C. (Site 3, 23 December 2008)

Photo 4. Saplings up to 5 m tall (left) in an area near site 2 have their leaves killed by fire and seedlings cremated. Those individuals (right) able to survive burning are variously damaged and have their growth retarded. Loss of soil nutrients and soil erosion also result in impoverished plant development. (Site 2, 28 September 2008)

Photo 5. Uniform tree regrowth at site 3 is an indicator of original clearing of forest cover 25 years ago where frequent fires have caused biodiversity and forest regeneration to steadily decline. (Site 3, 23 December 2008)

Photo 6. The ground flora at site 4 is dominated by perennial, deciduous Cyperaceae and Gramineae. The aerial parts of these plants become dry and very combustible during the hot-dry season when fires are started. Bare areas, deformed tree growth and low biodiversity are indicative of fire damage. (Site 4, 23 December 2008)

Photo 7. Fire readily kills seedlings and damages saplings. The picture on the left shows how coppicing regrowth of several years has been destroyed by successive fires. *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius* (right) with a destroyed stem and *D. tuberculatus* Roxb. var. *tuberculatus* (Dipterocarpaceae) above and to the right are dominant surviviors in burned dof areas. (Site 4, 23 December 2008)

Photo 8. Site 1 (left) at Pah Laht Temple, the most intact and best developed place surveyed, has been protected from major disturbance for more than 50 years. In contrast, site 2 (right), prior to burning in 2009, clearly shows the ravages of previous fires. Continuous human disturbances have severely degraded all of the dof in Chang Kian Valley. (Pah Laht Temple, 21 September 2008; Site 2, 28 September 2008)

Appendix 2

Species diversity indices

Shannon's index = H' = $\Sigma\, p_i ln p_i$

where p_i = proportion of individuals of the i^{th} species

Simpson's reciprocal index = 1 / D

where $D = \Sigma p_i^2 = \dfrac{\Sigma\, n_i\,(n_i - 1)}{N\,(N-1)}$

p_i = proportion of individuals of the i^{th} species

$= n_i/N$

n_i = number of individual of the i^{th} species

N = total number of individual

Appendix 3

Tree species categorised as pioneer and climax species, their dispersal mechanisms and numbers at each site

No.	Botanical name	Deciduous/ Evergreen	Pioneer/Climax	Dispersal mechanism	Site						
					1	2	3	4	5	6	7
1	*Albizia odoratissima* (L.f.) Bth.	Deciduous	Pioneer	Wind	-	-	-	5	-	6	41
2	*Anneslea fragrans* Wall.	Deciduous	Climax	Animal	15	5	4	-	-	1	1
3	*Antidesma acidum* Retz.	Deciduous	Pioneer	Animal	14	2	-	-	-	-	23
4	*Aporosa octandra* (B.-H *ex* D.Don) Vick. var. *octandra*	Deciduous	Climax	Animal	3	-	-	-	-	-	29
5	*Aporosa villosa* (Lindl.) Baill.	Deciduous	Climax	Animal	8	38	13	9	1	22	5
6	*Buchanania glabra* Wall.	Deciduous	Climax	Animal	-	-	5	5	9	2	2
7	*Buchanania lanzan* Spreng.	Deciduous	Climax	Animal	29	92	5	8	53	36	-
8	*Canarium subulatum* Guill.	Deciduous	Climax	Animal	17	7	7	4	1	3	4
9	*Catunaregum spathulifolia* Tirv.	Deciduous	Climax	Animal	-	5	13	21	7	18	31
10	*Catunaregum tomentosa* (Bl. *ex* DC.) Tirv.	Deciduous	Climax	Animal	-	1	-	-	-	-	-
11	*Clausena excavata* Burm. f. var. *excavata*	Deciduous	Pioneer	Animal	7	-	-	-	-	-	22
12	*Clerodendrum serratum* (L.) Moon var. *wallichii* Cl.	Deciduous	Pioneer	Animal	-	4	5	-	-	-	10
13	*Colona flagrocarpa* (Cl.) Craib	Deciduous	Pioneer	Wind	-	-	-	-	-	-	24
14	*Craibiodendron stellatum* (Pierre) W.W.Sm.	Evergreen	Climax	Wind	28	18	-	19	-	-	-
15	*Cratoxylon formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog.	Deciduous	Pioneer	Wind	-	-	-	-	21	315	118
16	*Dalbergia cana* Grah. *ex* Kurz	Deciduous	Pioneer	Wind	-	-	-	-	-	-	2
17	*Dalbergia cultrata* Grah. *ex* Bth.	Deciduous	Pioneer	Wind	45	1	35	-	1	-	60
18	*Dalbergia oliveri* Gamb. *ex* Prain	Deciduous	Pioneer, Climax	Wind	-	-	1	-	-	-	-
19	*Desmodium oblongum* Bth.	Deciduous	Climax	Wind	-	31	-	-	-	6	-
20	*Dillenia obovata* (Bl.) Hoogl.	Deciduous	Climax	Animal	-	-	-	-	-	-	3

Appendix 3. (Continued)

No.	Botanical name	Deciduous/ Evergreen	Pioneer/Climax	Dispersal mechanism	Site						
					1	2	3	4	5	6	7
21	*Dillenia parviflora* Griff.	Deciduous	Climax	Animal	-	8	30	6	1	13	-
22	*Dimocarpus longan* Lour. *ssp. longan* var. *longan*	Evergreen	Climax	Animal	1	-	-	-	-	-	2
23	*Diospyros ehretioides* Wall. *ex* G.Don	Evergreen	Climax	Animal	2	4	-	1	-	1	2
24	*Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius*	Deciduous	Climax	Wind	66	151	59	84	1	35	4
25	*Dipterocarpus tuberculatus* Roxb. var. *tuberculatus*	Deciduous	Climax	Wind	2	150	134	191	52	15	-
26	*Elaeocarpus floribundus* Bl. var. *floribundus*	Evergreen	Climax	Animal	1	-	-	-	-	-	-
27	*Eugenia albiflora* Duth. *ex* Kurz	Evergreen	Climax	Animal	4	-	-	-	-	-	2
28	*Eugenia cumini* Merr.	Deciduous	Climax	Animal	-	7	-	33	3	1	-
29	*Eugenia grata* Wight var. *grata*	Evergreen	Climax	Animal	3	-	-	-	-	-	-
30	*Ficus hirta* Vahl	Deciduous	Pioneer	Animal	3	-	-	-	-	-	-
31	*Flacourtia indica* (Burm.f.) Merr.	Deciduous	Pioneer	Animal	2	-	1	-	-	-	-
32	*Garcinia cowa* Roxb. *ex* DC.	Evergreen	Climax	Animal	-	-	-	2	-	-	-
33	*Gardenia obtusifolia* Roxb. *ex* Kurz	Deciduous	Climax	Animal	-	2	3	10	59	6	-
34	*Gardenia sootepensis* Hutch.	Deciduous	Climax	Animal	24	-	-	-	-	-	3
35	*Garuga pinnata* Roxb.	Deciduous	Climax	Animal	-	-	-	-	-	-	1
36	*Glochidion eriocarpum* Champ.	Deciduous	Pioneer	Animal	-	127	-	-	5	31	-
37	*Gluta usitata* (Wall.) Hou	Deciduous	Climax	Animal	-	-	32	12	-	-	5
38	*Goniothalamus griffithii* Hk.f. & Thoms.	Evergreen	Climax	Animal	2	-	-	-	-	-	-
39	*Grewia abutifolia* Pers.	Deciduous	Climax	Animal	-	3	12	-	-	-	-
40	*Grewia eriocarpa* Juss.	Deciduous	Pioneer	Animal	-	1	-	-	-	-	10
41	*Grewia lacei* Drum. & Craib	Deciduous	Pioneer	Animal	-	-	2	-	-	-	1
42	*Hibiscus glanduliferus* Craib	Deciduous	Pioneer	Wind	-	-	-	-	4	53	4
43	*Holarrhena pubescens* Wall. *ex* G.Don	Deciduous	Climax	Wind	-	-	-	-	-	-	4

Appendix 3. (Continued)

No.	Botanical name	Deciduous/ Evergreen	Pioneer/Climax	Dispersal mechanism	Site						
					1	2	3	4	5	6	7
44	*Irvingia malayana* Oliv. *ex* A. Benn.	Evergreen	Climax	Animal	3	-	5	-	-	-	24
45	*Ixora cibdela* Craib	Evergreen	Climax	Animal	23	1	11	-	-	1	31
46	*Lagerstroemia cochinchinensis* Pierre var. *ovalifolia* Furt. & Mont.	Deciduous	Climax	Wind	-	-	1	-	-	-	119
47	*Lagerstroemia macrocarpa* Kurz var. *macrocarpa*	Deciduous	Climax	Wind	-	-	-	-	-	1	-
48	*Lannea coromandelica* (Houtt.) Merr.	Evergreen	Climax	Animal	1	-	-	-	-	-	-
49	*Leea indica* (Burm.f.) Merr.	Deciduous	Climax	Animal	11	13	9	2	-	6	16
50	*Lithocarpus polystachyus* (Wall. *ex* A. DC.) Rehd.	Evergreen	Climax	Animal	114	28	1	-	-	-	-
51	*Lophopetalum wallichii* Kurz	Deciduous	Climax	Animal	-	6	5	2	-	-	-
52	*Mammea siamensis* (Miq.) T. And.	Evergreen	Climax	Animal	-	-	1	-	-	-	-
53	*Memecylon scutellatum* (Lour.) Hk. & Arn.	Evergreen	Climax	Animal	4	-	10	1	-	1	-
54	*Memecylon umbellatum* Burm.f.	Evergreen	Climax	Animal	4	-	-	-	-	-	-
55	*Meyna velutina* Roby.	Deciduous	Climax	Animal	-	-	-	-	1	-	-
56	*Mitragyna hirsuta* Hav.	Deciduous	Climax	Wind	-	1	3	-	-	4	-
57	*Mitragyna rotundifolia* (Roxb.) O.K.	Deciduous	Climax	Wind	1	-	-	-	-	-	-
58	*Morinda tomentosa* Heyne *ex* Roth	Deciduous	Climax	Animal	-	-	-	-	-	-	2
59	*Ochna integerrima* (Lour.) Merr.	Deciduous	Climax	Animal	8	6	31	23	2	2	21
60	*Oroxylum indicum* (L.) Kurz	Deciduous	Pioneer	Wind	-	-	-	-	-	-	1
61	*Parinari anamense* Hance	Evergreen	Climax	Animal	-	-	-	1	-	-	-
62	*Pavetta tomentosa* Roxb. *ex* Sm. var. *tomentosa*	Deciduous	Climax	Animal	4	-	-	-	-	-	-
63	*Phoenix loureiri* Kunth var. *loureiri*	Evergreen	Climax	Animal	-	3	1	-	1	1	-

Appendix 3. (Continued)

No.	Botanical name	Deciduous/ Evergreen	Pioneer/Climax	Dispersal mechanism	Site						
					1	2	3	4	5	6	7
64	*Phyllanthus emblica* L	Deciduous	Pioneer	Animal	1	-	1	7	4	2	-
65	*Polyalthia cerasoides* (Roxb.) Benth. *ex* Bedd.	Deciduous	Pioneer	Animal	-	-	-	-	-	-	5
66	*Premna nana* Coll. & Hemsl.	Deciduous	Pioneer	Animal	-	4	16	2	-	-	-
67	*Prismatomeris tetrandra* (Roxb.) K.Sch. ssp. *tetrandra*	Evergreen	Climax	Animal	16	-	-	-	-	-	-
68	*Pterocarpus macrocarpus* Kurz	Deciduous	Climax	Wind	-	-	-	-	-	1	16
69	*Quercus kerrii* Craib	Deciduous	Climax	Animal	36	30	20	3	1	3	10
70	*Rothmannia sootepensis* (Craib) Brem.	Evergreen	Climax	Animal	65	-	-	-	-	-	1
71	*Schima wallichii* (DC.) Korth.	Evergreen	Pioneer,Climax	Wind	1	-	-	-	-	-	-
72	*Schleichera oleosa* (Lour.) Oken	Deciduous	Climax	Animal	-	-	-	-	-	-	2
73	*Scleropyrum pentandrum* (Denn.) Mabb.	Evergreen	Climax	Animal	1	-	-	-	-	-	-
74	*Shorea obtusa* Wall. *ex* Bl.	Deciduous	Climax	Wind	10	85	60	122	15	23	65
75	*Shorea siamensis* Miq. var. *siamensis*	Deciduous	Climax	Wind	4	2	26	7	-	5	1
76	*Sterculia balanghas* L.	Deciduous	Climax	Wind	-	-	-	-	-	-	2
77	*Stereospermum* colais (B.-H.*ex* Dillw.) Mabb.	Deciduous	Climax	Wind	4	1	2	-	-	-	-
78	*Stereospermum neuranthum* Kurz	Deciduous	Climax	Wind	-	4	-	1	-	-	3
79	*Strychnos nux-vomica* L.	Deciduous	Climax	Animal	-	-	1	1	-	3	22
80	*Symplocos racemosa* Roxb.	Deciduous	Climax	Animal	1	-	1	1	2	7	3
81	*Tarennoidea wallichii* (Hk.f.) Tirv. & Sastre	Evergreen	Climax	Animal	7	-	-	-	-	-	-
82	*Terminalia alata* Heyne *ex* Roth	Deciduous	Climax	Wind	1	7	1	1	15	9	14
83	*Terminalia chebula* Retz. var. *chebula*	Deciduous	Climax	Animal	-	-	1	2	-	14	8
84	*Terminalia mucronata* Craib & Hutch.	Deciduous	Climax	Wind	-	-	-	-	-	-	7

Appendix 3. (Continued)

No.	Botanical name	Deciduous/ Evergreen	Pioneer/Climax	Dispersal mechanism	Site						
					1	2	3	4	5	6	7
85	*Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn.& Lug.	Evergreen	Climax	Wind	2	16	12	40	35	108	-
86	*Vernonia parishii* Hk. f.	Evergreen	Climax	Wind	24	-	-	-	-	-	1
87	*Vitex canescens* Kurz	Deciduous	Pioneer	Animal	-	-	13	-	-	-	1
88	*Vitex limoniifolia* Wall. *ex* Kurz	Deciduous	Pioneer, Climax	Animal	3	-	-	11	-	-	-
89	*Vitex peduncularis* Wall. *ex* Schauer	Deciduous	Climax	Animal	7	3	3	-	1	8	43
90	*Walsura trichostemon* Miq.	Evergreen	Climax	Animal	-	-	-	-	-	1	-
91	*Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* Cow.	Evergreen	Pioneer	Wind	-	15	1	-	6	4	1
92	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) Niels.	Deciduous	Climax	Wind	-	-	-	-	-	-	31