สังคมพืชในป่าเบญจพรรณที่มีความถี่ไฟต่างๆ ณ เขตรักษาพันธุ์สัตว์ป่าห้วยขาแข้ง ประเทศไทย

Plant Community in Mixed Deciduous Forest with Fire Frequencies at Huai Kha Khaeng Wildlife Sanctuary, Thailand

Oranut Ninkhet, Benjawan Kumros, Kobsak Wanthongchai,
Chongrak Wacharinrat[1], and Sapit Diloksumpun
Department of Siliviculture, Faculty of Forestry, Kasetsart University, Bangkok

ABSTRACT: This paper is presented as some results from thesis research on effects fire frequencies on soil respiration and carbon balance in mixed deciduous forest (MDF) at Huai Kha Khaeng Wildlife Sanctuary (HKK), Uthai Thani province. Plant composition and structure were surveyed at the permanent sampling plot of a ha (100 x 100 m) for five plots with different burning frequencies: annual burning (M2), 1-year fire free interval (M5), 2-year fire free interval (M9), 4-year free interval (M1), and unburned or control (M10) during February to March 2012. The objective of this study aims to know plant composition and community with those fire frequencies as to be the primary data for estimation of biomass and carbon storage. Trees identification and measurement of their diameter at breast height (DBH) and height were conducted. Species diversity index, and importance value index (IVI) were calculated in order to explain species composition and community among plots. The results showed that there are 74 of tree species found from all five plots. Though number of trees species in each fire frequencies plot are slightly different varying between 4-12 species but their values in species diversity of Shannon-Wiener index are lesser varying (0.02-0.2). *Schleichera oleosa* is the most dominant tree species with IVI in all plots except the 2-year fire free interval plot where it is the second and *Shorea obtusa*; deciduous dipterocarp species is the highest value. However, most of tree species found on top five IVI are commonly vegetation presence in MDF: *Xylia xylocarpa* var *kerrii*, *Lannea coromandelica*, and *Croton roxburghii*. Further study of this forest community would be essential for the estimation of carbon stock and balance of MDF with different fire frequencies.

Keywords: fire frequencies, plant community, carbon storage, mixed deciduous forest, Huai Kha Khaeng Wildlife Sanctuary

INTRODUCTION

As climate change resulting in drier and warmer climates has potential to increase fire occurrence and intensity fire behavior, therefore, effectiveness of forest management is needed to cope with future forest fire; particularly in fire-dependent forest types (Liu *et al*., 2010). Even though fire is climax factor for existing of fire-dependent forest ecosystems, for examples, coniferous boreal, temperate, and tropical forest, more fire frequency would impact on fuel supply (litter) and quantity of carbon emission from burning process and soil respiration (Rs) via soil microbial decomposition of litter and soil organic matter. The fire management under current and future climate change is so challenged. Scientific research how fire frequencies affect Rs and carbon balance in fire-dependent forest types is interested and initially studied to explore options for mitigation and adaptation. However, studying on this research in Thailand is rare even though researches on Rs and/ or carbon balance in many forest types have been implemented in two fire-dependent forest types; dry dipterocarp forest (DDF) (Sahunalu, 1994; Hanpattanakit *et al*., 2009a; 2009b; Hanpattanakit *et al*., 2010; Sanwangsri *et al*., 2010) and mixed deciduous forest (MDF) (Panuthai *et al*., 2004; 2005; Diloksumpun and Staporn, 2009; Diloksumpun *et al*., 2009). Such reasons are brought to do research program in MDF permanent plots established with different burning frequency since 2007, at Huai Kha Khaeng Wildlife Sanctuary (HKK) - a Natural World Heritage since 1991, a part of Thailand's Western Forest Complex (WFC), covering area about 2,780 km^2 or 278,013.92 ha, containing a great biodiversity both forest flora and fauna which over half (54.47%) of forest cover is deciduous forest combined mainly MDF (42.12%) and DDF (12.35%) (Forest Research Center, 1997). The research program is named as "Effects of fire frequencies on soil respiration and carbon balance in mixed deciduous forests, Huai Kha Khaeng Wildlife Sanctuary, Thailand". The main objectives and scope of this research program are showed as Figure 1.

MATERIALS AND METHODS

4. STUDY SITE

The plant survey were undertaken in 5 permanent sampling plots of 1 ha (100 x 100 meter) in MDF where were established in 2007 and located at between Pha Nongmoo and Pong Changphuak, HKK, Uthai Thani province (Figure 2). A plot represents as a treatment of fire frequency. Thus, five plots with different fire frequencies consist of unburned (M10), annual burning (M2), 1-year fire free interval (M5), 2-year fire free interval (M9), and 4-year fire free interval (M1). Burning and fire control activities in each plot have conducted since 2007 which are summarized and showed as Table 1.

5. DATA COLLECTIONS

Trees (DBH > 4.5 cm and height > 1.30 m) were identified and tagged number in the subplots of 10 x 10 meter (Figure 2). Measurement of their DBH and height were conducted by using measuring tape and Haga at all plots during February-March 2012. Collected data were calculated for species

composition, diversity, and the importance value index (IVI).

6. DATA ANALYSIS

3.1 Species composition and diversity

All observed trees at each plot were made of a species list. The species diversity of trees was evaluated by using the Shannon-Wiener index (*H'*) which could be computed as follows (Shannon and Weaver, 1949).

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i) = -\sum_{i=1}^{S} \frac{n_i}{N} \ln \frac{n_i}{N}$$

Where:

H' = The species diversity index of Shannon and Wiener

S = The total number of species (also called species richness)

pi = The proportion of individuals of a given species to the total number of individuals in the community (*ni/N*)

ni = The number of individuals in species *i*

N = The total number of all individuals

ln = The natural logarithm

Table 1 Prescribed burning and fire control activities plan after year 2007

Fire frequencies	Symbols	2007* / 2550*	2008 / 2551	2009 / 2552	2010 / 2553	2011 / 2554	2012 / 2555	2013 / 2556	2014 / 2557
unburned (control)	M10								
annual burning	M2								
1-yr fire free interval	M5								
2-yr fire free interval	M9				**				
4-yr fire free interval	M1								

Remark: = Burnt as prescribed = Burnt as prescribed but not succeeds = plan to burn

* = All plots were burnt to get the same starting point ** = Fire came/could not protect fire

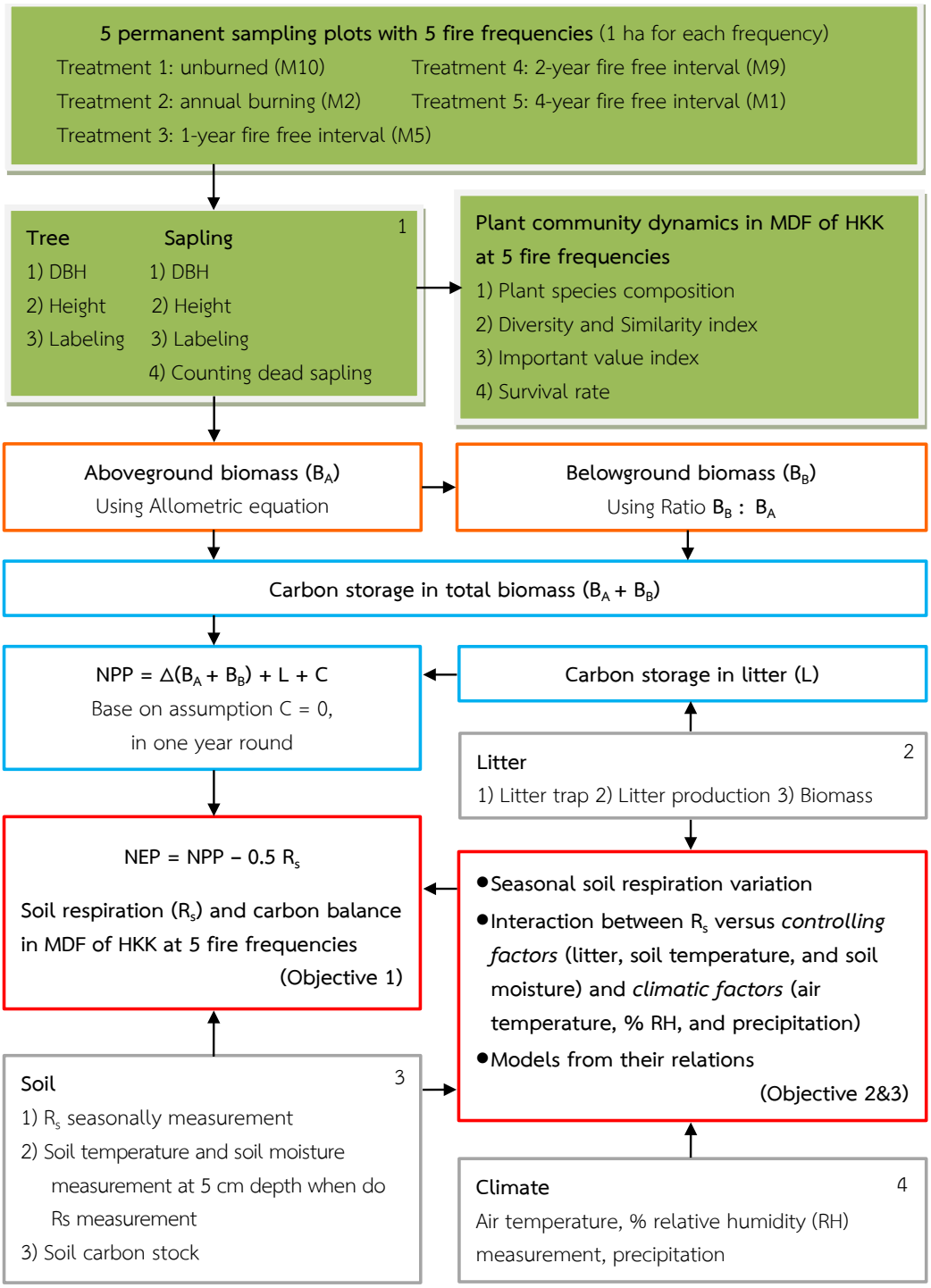

Figure 1 The scope of research program "Effects of fire frequencies on soil respiration and carbon balance in mixed deciduous forests, Huai Kha Khaeng Wildlife Sanctuary, Thailand". The dark boxes represent a research work of this paper.

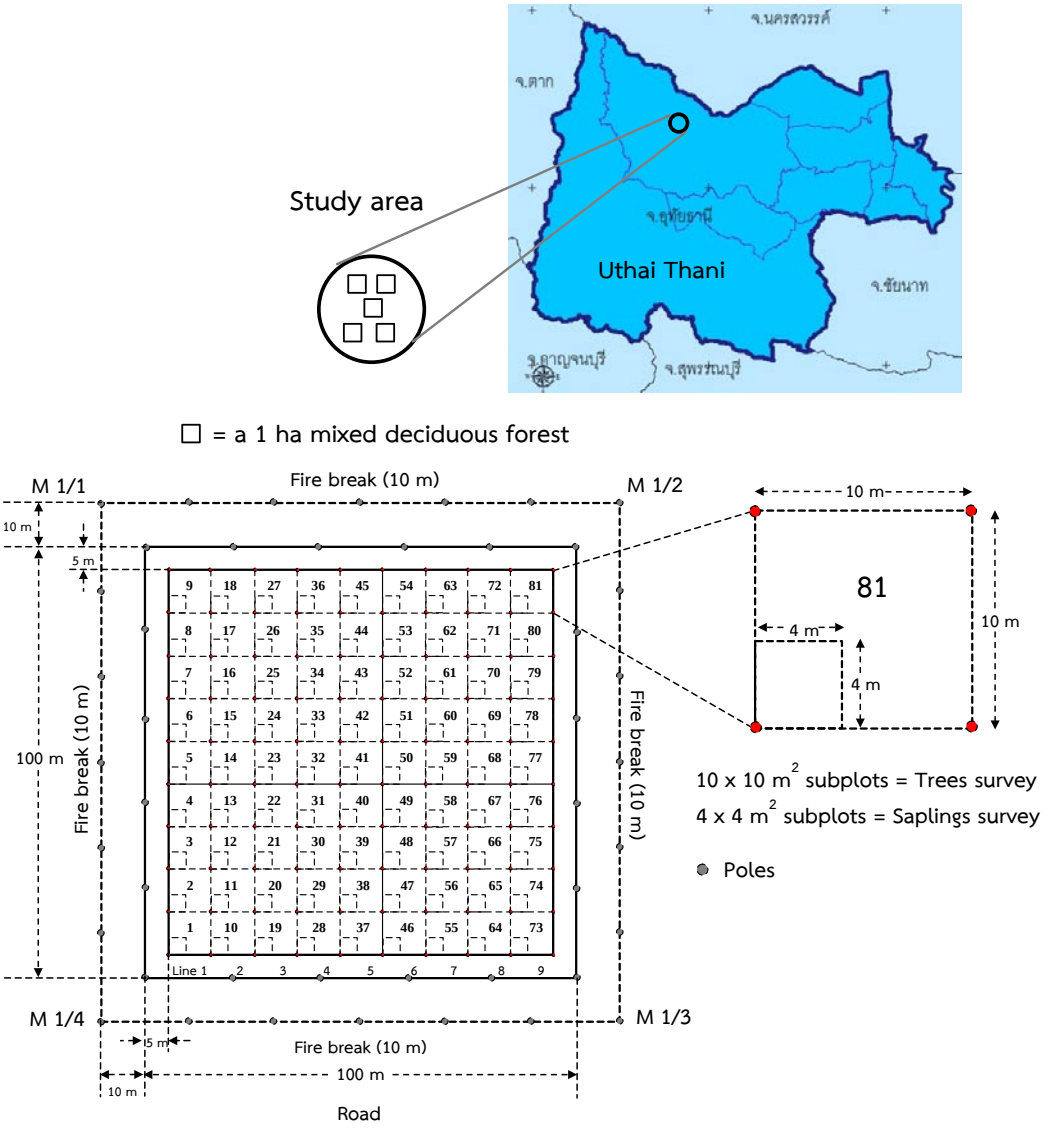

Figure 2 Study area and a permanent sampling plot for data collection

3.2 Importance value index (IVI)

The importance value index (IVI) of trees at each plot was calculated by summing up the relative percentages of basal area, density, and frequency as following equations (Whittaker, 1970).

IVI = RD + RF + RDo

Where:

Relative density (RD)

$$= \frac{\text{Density of a species (D)} \times 100}{\text{Total density of all species}}$$

$$\text{Density (D)} = \frac{\text{Total number of a species}}{\text{Total areas of plots sampled}}$$

Relative frequency (RF)

$$= \frac{\text{Frequency value for a species (F)}}{\text{Total of all frequency values of all species}} \times 100$$

Frequency (F)

$$= \frac{\text{Number of plots in which a species occurs}}{\text{Total number of plots sampled}}$$

Relative dominance (RDo)

$$= \frac{\text{Dominance for a species (Do)}}{\text{Total dominance of all species}} \times 100$$

$$\text{Dominance (D)} = \frac{\text{Total basal area of a species}}{\text{Area sampled}}$$

RESULTS AND DISCUSSION

8. SPECIES DIVERSITY AND DENSITY

Plant communities of MDF in Thailand have been divided into several sub-types by using existing of teak (*Tectona grandis*) and bamboo. Teak is not found in MDF at HKK. The vegetation of HKK has been classified into five types: 1) hill evergreen forest 2) dry evergreen forest, 3) dry dipterocarp forest, 4) MDF, and 5) MDF with bamboo forest (Forest Research Center, 1997). The permanent sampling plots are located in MDF without bamboo though there are small clumps of bamboo scattering in two plots for this study: one and eight clumps in the 2-year fire free frequency plot and the annual burning plot, respectively.

From all five plots with five fire frequencies, 74 of tree species were found (Table 2). Regardless of Bamboo species found in two plots (the annual burning plot and 2-year fire free interval plot), number of species found in all plots are slightly different (4-12 species) (Table 3). Anyway, their values in species diversity of Shannon-Wiener index are lesser varying (0.02-0.2) (Table 3). It might imply that there are evenness both in number of species and distribution of each individual within study plots. Thus, it is noticed that the plot where has higher number of species diversity index would much have higher in density (individuals/ha), for example, in the plots of 2-year and 1-year fire free interval and also the unburned plot (Table 3). For the 4-year fire free interval plot and the annual burning plot, however, the latter has higher the number of species (51) but contain lower species diversity index (2.94) and density. It can be explained that the individual number and distribution of each tree species in the annual burning plot is lesser than the 4-year fire free interval plot. This might be influenced either by fire frequency with increasing on trees and saplings mortality or by previously trees establishment. Furthermore, it is remarkable that higher tree density may not provide higher value in biomass and carbon storage. Lower density with higher average of DBH and height may provide the larger amount of biomass and carbon storage (Table 3). Tree growth following fire, therefore, would be an importance variable for variability of carbon storage in forest ecosystem and fire frequency seems directly impact on tree growth.

Table 2 List of tree species found at all five fire frequencies plots

No.	Official Thai Name	Scientific Name	Family (ICBN)	Habit
1	Kang khi mot	*Albizia odoratissima* (L. f.) Benth.	Fabaceae	T
2	Saraphi pa	*Anneslea fragrans* Wall.	Theaceae	ST
3	Ta khian nu	*Anogeissus acuminata* (DC.) Guill. & Perr.	Combretaceae	T
4	Nom wua	*Anomianthus dulcis* (Dunn) J.Sinclair	Annonaceae	C
5	Mao khai pla	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae	S/ST
6	Lot	*Aporosa villosa* (Lindl.) Baill.	Phyllanthaceae	ST
7		*Bamboo* sp.	Gramineae	B
8	Siao dok khao	*Bauhinia* sp.	Fabaceae	ST
9	Liang	*Berrya mollis* Wall. ex Kurz	Tiliaceae	T
10	Ngio pa	*Bombax anceps* Pierre var. *anceps*	Bombaceae	T
11	Maka	*Bridelia ovata* Decne.	Euphorbiaceae	ST
12	Teng nam	*Bridelia retusa* (L.) A.Juss.	Euphorbiaceae	ST
13	Mamuang hua maeng wan	*Buchanania lanzan* Spreng.	Anacardiaceae	T
14	Cha paen	*Callicarpa arborea* Roxb.	Lamiaceae	S/ST
15	Makok kluean	*Canarium subulatum* Guill.	Burseraceae	T
16	Kradon	*Careya sphaerica* Roxb.	Lecythidaceae	T
17	Kruai pa	*Casearia grewiifolia* Vent. var. *grewiifolia*	Flacourtiaceae	ST
18	Ratcha phruek	*Cassia fistula* L.	Fabaceae	T
19	Ma khet	*Catunaregam tomentosa* (Blume ex DC.) Tirveng	Rubiaceae	S/ST
20	Khi non khai	*Celtis tetranda* Roxb.	Cannabaceae	T
21	Tio kliang	*Cratoxylum cochinchinense* (Lour.) Blume	Hypericaceae	T
22	Tio khon	*Cratoxylum formosum* (Jack) Dyer subsp. *pruniflorum* (Kurz)	Hypericaceae	T
23	Plao yai	*Croton roxburghii* N.P. Balakr.	Euphorbiaceae	S/ST
24	Chingchan	*Dalbergia oliveri* Gamble ex Prain	Fabaceae	T
25	San yai	*Dillenia obovata* (Bl.) Hoogl.	Dilleniaceae	T
26	Ma khang daeng	*Dioecrescis erythroclada* (Kurz) Tirveng.	Rubiaceae	S/ST
27	Phaya rak dam	*Diospyros variegata* Kurz	Ebenaceae	T
28	Kham rok	*Ellipanthus tomentosus* Kurz	Connaraceae	ST
29	Sat	*Erythrophleum succirubrum* Gagnep.	Fabaceae	T
30	Khae hang khang	*Fernandoa adenophylla* (Wall. ex G. Don) Steen.	Bignoniaceae	T
31	Khammok luang	*Gardenia* sp.	Rubiaceae	T
32	Chang nao	*Gomphia serrata* (Gaertn.) Kanis	Ochnaceae	S
33	Po kaen thao	*Grewia eriocapa* Juss.	Tiliaceae	ST
34	Khae rokfa	*Heterophragma sulfureum* Kurz.	Bignoniaceae	ST
35	Mok yai	*Holarrhena pubescens* Wall. ex G.Don	Apocynaceae	S/ST
36	Kwao	*Holdina cordifolia* (Roxb.) Ridsdale	Rubiaceae	T
37	Som kop	*Hymennodictyon orixense* (Roxb.) Mabb.	Rubiaceae	T
38	Krabok	*Irvingia malayana* Oliv. ex A. W. Benn.	Irvingiaceae	T
39	Ta baek daeng	*Lagerstroemia calyculata* Kurz.	Lythraceae	T

Table 2 (Cont'd)

No.	Official Thai Name	Scientific Name	Family (ICBN)	Habit
40	Ta baek na	*Lagerstroemia floribunda* Jack.	Lythraceae	T
41	Ta baek dong	*Lagerstroemia ovalifolia* Teijsm. & Binn.	Lythraceae	T
42	Salao plueak bang	*Lagerstroemia venusta* Wall.	Lythraceae	T
43	Kuk	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	T
44	Ma fueang change	*Lepisanthes tetraphylla* (Vahl) Radlk.	Sapindaceae	T
45	Mi men	*Litsea glutinosa* (Lour.) C.B. Robinson	Lauraceae	T
46	Khae hua mu	*Markhamia stipulata* Seem.	Bignoniaceae	T
47	Phlong mueat	*Memecylon edule* Roxb.	Melastomataceae	S/ST
48	Phlapphla	*Microcos tomentosua* Sm.	Malvaceae	T
49	Kra phi chan	*Milletia brandisiana* Kurz	Fabaceae	T
50	Salak pa	*Morinda anustifolia* Roxb. var *scrabidula* Craib	Rubiaceae	S/ST
51	Yo pa	*Morinda coreia* Ham.	Rubiaceae	ST
52	Si siat plueak	*Pentace burmanica* Kurz	Tiliaceae	T
53	Ma kham pom	*Phyllanthus emblica* L.	Phyllanthaceae	T
54	Yang on	*Polyalthia viridis* Craib	Annonaceae	T
55	Pradu	*Pterocarpus macrocarpus* Kurz	Fabaceae	T
56	Ta khro	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	T
57	Samae san	*Senna garrettiana* (Craib) Irwin & Barneby	Fabaceae	T
58	Teng	*Shorea obtusa* Wall. ex Blume	Dipterocarpaceae	T
59	Phayom	*Shorea roxburghii* G. Don	Dipterocarpaceae	T
60	Rang	*Shorea siamensis* Miq.	Dipterocarpaceae	T
61	Ma kha tae	*Sindora siamensis* Teijsm. & Miq.	Fabaceae	T
62	Makok	*Spondias pinnata* Kurz	Anacardiaceae	T
63	Po daeng	*Sterculia guttata* Roxb.	Malvaceae	T
64	Rok fa	*Terminalia alata* Heyne ex Roth	Combretaceae	T
65	Samo thai	*Terminalia chebula* Retz.	Combretaceae	T
66	Haen na	*Terminalia glaucifolia* Craib	Combretaceae	T
67	Pha sian	*Vitex canescens* Kurz.	Lamiaceae	T
68	Khai nao	*Vitex glabrata* R.Br.	Lamiaceae	T
69	Sawong	*Vitex limonifolia* Wall.	Lamiaceae	T
70	Ka sam pik	*Vitex peduncularis* Wall. ex Schauer	Lamiaceae	T
71		*Vitex* sp.	Lamiaceae	T
72	Kat lin	*Walsura trichostemon* Miq.	Meliaceae	T
73	Daeng	*Xylia xylocarpa* (Roxb.) Taub. var *kerrii* (Craib & Hutch.)	Fabaceae	T
74	Wa	*Zyzygium cumini* (L.) Sheels	Myrtraceae	T

Remark: ICBN = International Code of Botanical Nomenclature, C = Climber, S/ST = Shrub/Shrubby tree
ST = Shrubby tree, T = Tree

Table 3 Number of tree species found in each plot and their diversity, average DBH and height, density, overall biomass and carbon stock

Fire frequency/Plot	Number of Species	Species diversity (Shannon-Wiener index)	Average DBH (cm)	Average Height (m)	Density (stems/ha)	Density (individuals/ha)
annual burning (M2)	51	2.94	16.8	12.7	632	615
1-year fire free interval (M5)	56	3.02	13.1	9.9	995	981
2-year fire free interval (M9)	60	3.14	11.2	9.4	1,432	1,393
4-year fire free interval (M1)	48	3.12	17.3	15.2	698	680
unburned (M10)	51	3.00	13.9	11.2	906	874
Average		3.04	14.5	11.7	933	909

9. **Tree composition and the importance value index (IVI)**

Typically plant species in family of Fabaceae (Leguminosae), Combretaceae, and Verbenaceas are commonly found in MDF of Thailand with no associated tree species in groups of deciduous dipterocarp: *Diptercarpus intricatus*, *D. obtusifolius*, *D. tuberculatus*, *Shorea obtusa*, and *S. siamensis* (Santisuk, 2012). However, few trees of the last two species were found in this study together with species generally presence in both MDF and dry dipterocarp forest (DDF). These tree species are *Canarium subulatum*, *Careya sphaerica*, *Holdina cordifolia*, *Pterocarpus macrocarpus*, *Shorea roxburghii*, and *Xylia xylocarpa* var *kerrii* (Table 4 -8).

From first five of the highest IVI in each fire frequency plot, most of tree species found are commonly vegetation presence in MDF: *Schleichera oleosa*, *Croton roxburghii*, *Lannea coromandelica*, and *Xylia xylocarpa* var *kerrii*. The species which has the highest IVI for all plots is *Schleichera oleosa* except the 2-year fire free interval plot where it is the second and *Shorea obtusa*, one of dominant deciduous dipterocarp species, is the highest value. Moreover, *Shorea obtusa* is on top five IVI species in the 1-year fire free interval plot (Table 5). Presence of *Shorea obtusa* and other tree species from DDF in this study may imply that the study area might not be uniform. However, it is noticed that *Schleichera oleosa* (fire tolerant species) and *Croton roxburghii* [a pioneer shrubby tree species of fire low intensity disturbed forest (Kutintara, 1999)] could be found at all plots. This means forest area was frequently disturbed by fire for long time ago resulting in

crossing species between DDF and MDF. Anyway, MDF normally cover in small patch and occur with DDF since variability of environmental factors in the area (Marod and Kutintara, 2009). Evaluation on DBH class distribution of tree associated with checking fire history before 2007 would be required to inform fire disturbance.

At Maeklong Watershed Research Station, Kanchanaburi province where carbon cycling has been studied in MDF with bamboo, found that

Table 4 Importance value index (IVI) of trees in the annual burning plot (M2)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
1	*Schleichera oleosa* (Lour.) Oken	15.82	13.57	12.99	42.38
2	*Croton roxburghii* N.P. Balakr.	23.24	13.85	2.53	39.63
3	*Lagerstroemia ovalifolia* Teijsm. & Binn.	6.84	8.31	15.21	30.36
4	*Grewia eriocapa* Juss.	7.42	6.65	2.15	16.22
5	*Pentace burmanica* Kurz	3.13	3.88	8.96	15.96
6	*Fernandoa adenophylla* (Wall. ex G. Don) Steen.	5.27	6.65	2.80	14.73
7	*Vitex limonifolia* Wall.	1.76	2.22	7.67	11.65
8	*Vitex* sp.	2.15	2.49	5.00	9.64
9	*Bombax anceps* Pierre var. *anceps*	1.56	2.22	5.13	8.91
10	*Pterocarpus macrocarpus* Kurz	0.98	1.39	5.68	8.04
11	*Spondias pinnata* Kurz	1.37	1.94	4.36	7.66
12	*Markhamia stipulata* Seem.	3.13	3.32	1.15	7.60
13	*Terminalia glaucifolia* Craib	1.76	2.49	2.62	6.87
14	*Diospyros variegata* Kurz	2.93	3.60	0.24	6.77
15	*Callicarpa arborea* Roxb.	1.76	2.22	1.98	5.96
16	*Erythrophleum succirubrum* Gagnep.	1.17	1.39	2.67	5.23
17	*Walsura trichostemon* Miq.	1.37	1.66	1.65	4.68
18	*Berrya mollis* Wall. ex Kurz	1.37	1.94	1.09	4.39
19	*Holdina cordifolia* (Roxb.) Ridsdale	1.17	1.39	1.61	4.16
20	*Ellipanthus tomentosus* Kurz	1.95	1.66	0.51	4.12
21	*Vitex glabrata* R.Br.	0.78	0.83	2.31	3.92
22	*Aporosa villosa* (Lindl.) Baill.	1.37	1.39	0.87	3.62
23	*Hymennodictyon orixense* (Roxb.) Mabb.	0.78	1.11	1.39	3.28
24	*Sterculia guttata* Roxb.	1.37	1.66	0.14	3.17
25	*Sindora siamensis* Teijsm. & Miq.	0.59	0.55	1.59	2.73
26	*Casearia grewiifolia* Vent. var. *grewiifolia*	0.98	1.11	0.48	2.56
27	*Lagerstroemia venusta* Wall.	0.78	1.11	0.26	2.15
28	*Anogeissus acuminata* (DC.) Guill. & Perr.	0.39	0.55	1.17	2.12
29	*Lannea coromandelica* (Houtt.) Merr.	0.59	0.83	0.56	1.98
30	*Cassia fistula* L.	0.78	0.83	0.29	1.90
31	*Polyalthia viridis* Craib	0.39	0.55	0.89	1.83
32	*Microcos tomentosua* Sm.	0.78	0.83	0.09	1.70
33	*Dalbergia oliveri* Gamble ex Prain	0.59	0.55	0.47	1.61
34	*Lagerstroemia floribunda* Jack.	0.20	0.28	0.71	1.18
35	*Grardenia* sp.	0.39	0.55	0.04	0.99
36	*Vitex peduncularis* Wall. ex Schauer	0.20	0.28	0.51	0.98
37	*Zyzygium cumini* (L.) Sheels	0.20	0.28	0.39	0.86
38	*Lepisanthes tetraphylla* (Vahl) Radlk.	0.20	0.28	0.34	0.81
39	*Lagerstroemia calyculata* Kurz.	0.20	0.28	0.30	0.77
40	*Cratoxylum cochinchinense* (Lour.) Blume	0.20	0.28	0.29	0.76
41	*Careya sphaerica* Roxb.	0.20	0.28	0.22	0.70
42	*Shorea roxburghii* G. Don	0.20	0.28	0.16	0.63
43	*Xylia xylocarpa* (Roxb.) Taub. var *kerrii* (Craib &	0.20	0.28	0.15	0.62
44	*Dillenia obovata* (Bl.) Hoogl.	0.20	0.28	0.13	0.60
45	*Catunaregam tomentosa* (Blume ex DC.) Tirveng	0.20	0.28	0.07	0.54
46	*Irvingia malayana* Oliv. ex A. W. Benn.	0.20	0.28	0.06	0.53
47	*Morinda coreia* Ham.	0.20	0.28	0.05	0.53
48	*Anomianthus dulcis* (Dunn) J.Sinclair	0.20	0.28	0.05	0.52
49	*Antidesma ghaesembilla* Gaertn.	0.20	0.28	0.01	0.48
50	*Bauhinia* sp.	0.20	0.28	0.01	0.48
51	*Memecylon edule* Roxb.	0.20	0.28	0.01	0.48
	Bamboo sp.				
		100.00	100.00	100.00	300.00

Table 5 Importance value index (IVI) of trees in the 1-year fire free interval plot (M5)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
1	*Schleichera oleosa* (Lour.) Oken	15.72	10.69	14.23	40.43
2	*Lannea coromandelica* (Houtt.) Merr.	10.44	8.32	13.99	32.61
3	*Croton roxburghii* N.P. Balakr.	13.96	10.89	1.91	26.95
4	*Grewia eriocapa* Juss.	9.43	8.12	6.78	24.20
5	*Shorea obtusa* Wall. ex Blume	6.16	3.96	12.56	22.60
6	*Markhamia stipulata* Seem.	7.17	7.52	2.95	17.68
7	*Lagerstroemia ovalifolia* Teijsm. & Binn.	3.40	3.96	6.51	13.82
8	*Walsura trichostemon* Miq.	2.77	3.96	6.37	13.06
9	*Berrya mollis* Wall. ex Kurz	3.14	4.16	2.46	9.97
10	*Vitex canescens* Kurz.	2.14	1.98	3.00	7.21
11	*Ellipanthus tomentosus* Kurz	2.14	2.77	1.86	6.74
12	*Vitex peduncularis* Wall. ex Schauer	1.76	1.98	2.55	6.51
13	*Albizia odoratissima* (L. f.) Benth.	1.26	1.98	2.40	5.63
14	*Pterocarpus macrocarpus* Kurz	1.01	1.39	2.82	5.20
15	*Spondias pinnata* Kurz	0.50	0.79	3.44	4.73
16	*Diospyros variegata* Kurz	1.76	2.38	0.59	4.71
17	*Xylia xylocarpa* (Roxb.) Taub. var *kerrii* (Craib & Hutch.) I.C.Nielsen	1.64	2.57	0.51	4.70
18	*Terminalia glaucifolia* Craib	1.13	1.78	1.57	4.59
19	*Callicarpa arborea* Roxb.	1.13	1.58	1.68	4.38
20	*Lagerstroemia calyculata* Kurz.	1.26	1.58	1.42	4.24
21	*Terminalia alata* Heyne ex Roth	1.26	1.39	0.86	3.49
22	*Irvingia malayana* Oliv. ex A. W. Benn.	0.50	0.79	2.05	3.34
23	*Vitex limonifolia* Wall.	0.88	1.19	0.95	3.01
24	*Sindora siamensis* Teijsm. & Miq.	0.38	0.59	1.80	2.76
25	*Grardenia* sp.	0.75	1.19	0.41	2.35
26	*Antidesma ghaesembilla* Gaertn.	0.75	0.79	0.27	1.81
27	*Hymennodictyon orixense* (Roxb.) Mabb.	0.50	0.79	0.48	1.77
28	*Bridelia ovata* Decne.	0.63	0.99	0.07	1.68
29	*Sterculia guttata* Roxb.	0.50	0.79	0.21	1.49
30	*Morinda coreia* Ham.	0.38	0.59	0.33	1.30
31	*Cratoxylum formosum* (Jack) Dyer subsp. *pruniflorum* (Kurz) Gogel.	0.38	0.59	0.24	1.21
32	*Holdina cordifolia* (Roxb.) Ridsdale	0.38	0.59	0.13	1.10
33	*Litsea glutinosa* (Lour.) C.B. Robinson	0.38	0.59	0.09	1.05
34	*Memecylon edule* Roxb.	0.38	0.59	0.07	1.04
35	*Aporosa villosa* (Lindl.) Baill.	0.38	0.59	0.05	1.01
36	*Microcos tomentosua* Sm.	0.25	0.40	0.13	0.90
37	*Pentace burmanica* Kurz	0.25	0.40	0.22	0.86
38	*Phyllanthus emblica* L.	0.38	0.40	0.07	0.84
39	*Holarrhena pubescens* Wall. ex G.Don	0.25	0.40	0.16	0.80
40	*Dalbergia oliveri* Gamble ex Prain	0.13	0.20	0.48	0.80
41	*Fernandoa adenophylla* (Wall. ex G. Don) Steen.	0.25	0.40	0.11	0.76
42	*Terminalia chebula* Retz.	0.13	0.20	0.43	0.75
43	*Cratoxylum cochinchinense* (Lour.) Blume	0.25	0.40	0.06	0.70
44	*Cassia fistula* L.	0.25	0.40	0.05	0.70
45	*Lagerstroemia venusta* Wall.	0.13	0.20	0.12	0.44
46	*Casearia grewiifolia* Vent. var. *grewiifolia*	0.13	0.20	0.11	0.43
47	*Anneslea fragrans* Wall.	0.13	0.20	0.10	0.43

Table 5 (Continued)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
48	*Celtis tetranda* Roxb.	0.13	0.20	0.09	0.42
49	*Careya sphaerica* Roxb.	0.13	0.20	0.05	0.37
50	*Gomphia serrata* (Gaertn.) Kanis	0.13	0.20	0.04	0.36
51	*Bauhinia* sp.	0.13	0.20	0.04	0.36
52	*Erythrophleum succirubrum* Gagnep.	0.13	0.20	0.03	0.35
53	*Shorea roxburghii* G. Don	0.13	0.20	0.02	0.34
54	*Senna garrettiana* (Craib) Irwin & Barneby	0.13	0.20	0.02	0.34
55	*Catunaregam tomentosa* (Blume ex DC.) Tirveng	0.13	0.20	0.02	0.34
56	*Dillenia obovata* (Bl.) Hoogl.	0.13	0.20	0.01	0.34
		100.00	**100.00**	**100.00**	**300.00**

Table 6 Importance value index (IVI) of trees in the 2-year fire free interval plot (M9)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
1	*Shorea obtusa* Wall. ex Blume	16.98	8.54	18.40	43.93
2	*Schleichera oleosa* (Lour.) Oken	10.17	6.77	10.57	27.52
3	*Lannea coromandelica* (Houtt.) Merr.	7.84	6.63	11.19	25.66
4	*Croton roxburghii* N.P. Balakr.	9.05	7.66	1.94	18.65
5	*Lagerstroemia ovalifolia* Teijsm. & Binn.	6.47	6.04	3.39	15.90
6	*Grewia eriocapa* Juss.	4.91	5.30	4.05	14.26
7	*Xylia xylocarpa* (Roxb.) Taub. var *kerrii* (Craib & Hutch.) I.C.Nielsen	3.88	4.86	4.88	13.62
8	*Aporosa villosa* (Lindl.) Baill.	4.91	5.15	1.81	11.88
9	*Hymennodictyon orixense* (Roxb.) Mabb.	2.67	3.68	3.94	10.30
10	*Walsura trichostemon* Miq.	1.72	2.65	5.75	10.12
11	*Lagerstroemia calyculata* Kurz.	3.79	3.98	1.67	9.44
12	*Berrya mollis* Wall. ex Kurz	3.28	3.09	2.39	8.76
13	*Pterocarpus macrocarpus* Kurz	0.95	1.47	4.18	6.60
14	*Vitex peduncularis* Wall. ex Schauer	1.55	2.21	2.41	6.17
15	*Markhamia stipulata* Seem.	2.50	2.95	0.70	6.15
16	*Spondias pinnata* Kurz	0.86	1.33	2.80	4.99
17	*Antidesma ghaesembilla* Gaertn.	1.03	1.62	2.04	4.69
18	*Heterophragma sulfureum* Kurz.	1.21	1.77	1.51	4.48
19	*Ellipanthus tomentosus* Kurz	1.38	1.91	0.68	3.98
20	*Holdina cordifolia* (Roxb.) Ridsdale	0.78	0.88	1.59	3.25
21	*Vitex limonifolia* Wall.	0.78	1.18	1.24	3.19
22	*Albizia odoratissima* (L. f.) Benth.	0.60	0.88	1.60	3.09
23	*Terminalia glaucifolia* Craib	0.78	1.33	0.70	2.80
24	*Pentace burmanica* Kurz	0.95	1.62	0.20	2.77
25	*Sterculia guttata* Roxb.	0.86	1.33	0.53	2.72
26	*Cratoxylum formosum* (Jack) Dyer subsp. *pruniflorum* (Kurz) Gogel.	0.78	1.18	0.72	2.68
27	*Bombax anceps* Pierre var. *anceps*	0.52	0.74	1.22	2.47
28	*Shorea roxburghii* G. Don	0.60	1.03	0.67	2.30
29	*Morinda coreia* Ham.	0.43	0.74	1.03	2.20
30	*Erythrophleum succirubrum* Gagnep.	0.78	1.18	0.15	2.10
31	*Litsea glutinosa* (Lour.) C.B. Robinson	0.52	0.88	0.27	1.68
32	*Irvingia malayana* Oliv. ex A. W. Benn.	0.26	0.44	0.87	1.57

Table 6 (Continued)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
33	*Fernandoa adenophylla* (Wall. ex G. Don) Steen.	0.69	0.59	0.26	1.54
34	*Bauhinia* sp.	0.52	0.88	0.14	1.54
35	*Callicarpa arborea* Roxb.	0.43	0.44	0.62	1.49
36	*Casearia grewiifolia* Vent. var. *grewiifolia*	0.34	0.59	0.47	1.40
37	*Diospyros variegata* Kurz	0.34	0.59	0.09	1.03
38	*Grardenia* sp.	0.26	0.44	0.30	1.00
39	*Canarium subulatum* Guill.	0.26	0.44	0.30	1.00
40	*Celtis tetranda* Roxb.	0.26	0.44	0.26	0.96
41	*Lagerstroemia venusta* Wall.	0.26	0.44	0.15	0.85
42	*Memecylon edule* Roxb.	0.34	0.44	0.06	0.85
43	*Cassia fistula* L.	0.34	0.44	0.05	0.84
44	*Bridelia ovata* Decne.	0.26	0.44	0.12	0.82
45	*Sindora siamensis* Teijsm. & Miq.	0.09	0.15	0.48	0.71
46	*Bridelia retusa* (L.) A.Juss.	0.26	0.29	0.09	0.65
47	*Buchanania lanzan* Spreng.	0.17	0.29	0.16	0.63
48	*Shorea siamensis* Miq.	0.09	0.15	0.33	0.56
49	*Zyzygium cumini* (L.) Sheels	0.17	0.15	0.18	0.50
50	*Careya sphaerica* Roxb.	0.17	0.29	0.03	0.50
51	*Terminalia alata* Heyne ex Roth	0.09	0.15	0.22	0.46
52	*Vitex canescens* Kurz.	0.09	0.15	0.21	0.44
53	*Vitex glabrata* R.Br.	0.09	0.15	0.15	0.38
54	*Catunaregam tomentosa* (Blume ex DC.) Tirveng	0.17	0.15	0.01	0.33
55	*Anneslea fragrans* Wall.	0.09	0.15	0.08	0.32
56	*Dioecrescis erythroclada* (Kurz) Tirveng.	0.09	0.15	0.08	0.32
57	*Dalbergia oliveri* Gamble ex Prain	0.09	0.15	0.02	0.25
58	*Microcos tomentosua* Sm.	0.09	0.15	0.01	0.24
59	*Holarrhena pubescens* Wall. ex G.Don	0.09	0.15	0.01	0.24
60	*Dillenia obovata* (Bl.) Hoogl.	0.09	0.15	0.01	0.24
	Bamboo sp.				
		100.00	100.00	100.00	300.00

Table 7 Importance value index (IVI) of trees in the 4-year fire free interval plot (M1)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
1	*Schleichera oleosa* (Lour.) Oken	24.14	14.82	17.32	55.86
2	*Lagerstroemia ovalifolia* Teijsm. & Binn.	6.35	7.29	13.30	26.78
3	*Xylia xylocarpa* (Roxb.) Taub. var *kerrii* (Craib & Hutch.) I.C.Nielsen	4.36	5.53	5.22	15.18
4	*Croton roxburghii* N.P. Balakr.	8.35	6.03	0.58	15.10
5	*Erythrophleum succirubrum* Gagnep.	3.09	3.02	8.24	14.62
6	*Pentace burmanica* Kurz	2.72	3.27	7.28	13.20
7	*Lagerstroemia calyculata* Kurz.	3.45	4.02	5.11	12.49
8	*Lannea coromandelica* (Houtt.) Merr.	4.36	4.02	3.20	11.47
9	*Bombax anceps* Pierre var. *anceps*	2.72	3.02	5.67	11.34
10	*Vitex* sp.	3.27	3.52	4.28	11.33
11	*Markhamia stipulata* Seem.	4.72	4.77	1.03	10.40
12	*Callicarpa arborea* Roxb.	2.54	2.76	2.96	8.20

Table 7 (Continued)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
13	*Pterocarpus macrocarpus* Kurz	1.27	1.76	3.86	6.85
14	*Sterculia guttata* Roxb.	2.36	2.26	2.03	6.59
15	*Walsura trichostemon* Miq.	2.00	2.76	1.65	6.36
16	*Berrya mollis* Wall. ex Kurz	2.18	3.02	1.08	6.22
17	*Grewia eriocapa* Juss.	2.00	2.51	0.92	5.38
18	*Hymennodictyon orixense* (Roxb.) Mabb.	1.81	2.51	0.51	4.79
19	*Terminalia glaucifolia* Craib	1.45	1.76	1.56	4.74
20	*Ellipanthus tomentosus* Kurz	1.63	2.01	0.51	4.46
21	*Vitex limonifolia* Wall.	1.09	1.51	1.63	4.20
22	*Irvingia malayana* Oliv. ex A. W. Benn.	0.54	0.75	2.40	3.68
23	*Holdina cordifolia* (Roxb.) Ridsdale	1.09	1.26	1.01	3.50
24	*Shorea obtusa* Wall. ex Blume	0.73	0.75	1.75	3.21
25	*Fernandoa adenophylla* (Wall. ex G. Don) Steen.	1.45	1.51	0.20	3.12
26	*Cratoxylum cochinchinense* (Lour.) Blume	1.09	1.26	0.41	2.73
27	*Milletia brandisiana* Kurz	0.91	1.26	0.22	2.36
28	*Vitex glabrata* R.Br.	0.54	0.75	0.90	2.18
29	*Careya sphaerica* Roxb.	0.36	0.50	1.18	2.04
30	*Spondias pinnata* Kurz	0.73	1.01	0.17	1.89
31	*Microcos tomentosua* Sm.	0.54	0.75	0.40	1.86
32	*Bridelia ovata* Decne.	0.73	1.01	0.03	1.74
33	*Casearia grewiifolia* Vent. var. *grewiifolia*	0.54	0.75	0.44	1.72
34	*Dalbergia oliveri* Gamble ex Prain	0.54	0.50	0.67	1.71
35	*Senna garrettiana* (Craib) Irwin & Barneby	0.36	0.50	0.43	1.29
36	*Lagerstroemia venusta* Wall.	0.36	0.50	0.30	1.15
37	*Dalbergia cultrata* Graham ex Benth	0.54	0.50	0.11	1.14
38	*Aporosa villosa* (Lindl.) Baill.	0.36	0.50	0.10	1.13
39	*Cassia fistula* L.	0.36	0.50	0.27	1.12
40	*Grardenia* sp.	0.36	0.50	0.20	1.06
41	*Litsea glutinosa* (Lour.) C.B. Robinson	0.36	0.50	0.16	1.01
42	*Diospyros variegata* Kurz	0.36	0.50	0.04	0.90
43	*Bauhinia* sp.	0.36	0.50	0.01	0.87
44	*Albizia odoratissima* (L. f.) Benth.	0.18	0.25	0.43	0.86
45	*Memecylon edule* Roxb.	0.18	0.25	0.02	0.62
46	*Sindora siamensis* Teijsm. & Miq.	0.18	0.25	0.13	0.56
47	*Canarium subulatum* Guill.	0.18	0.25	0.07	0.49
48	*Shorea roxburghii* G. Don	0.18	0.25	0.02	0.45
		100.00	100.00	100.00	300.00

Table 8 Importance value index (IVI) of trees in the unburned plot (M10)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
1	*Schleichera oleosa* (Lour.) Oken	18.93	12.74	14.36	45.36
2	*Croton roxburghii* N.P. Balakr.	22.03	11.89	2.06	36.57
3	*Pentace burmanica* Kurz	3.81	4.88	11.15	19.71
4	*Lannea coromandelica* (Houtt.) Merr.	4.38	5.52	7.64	17.66
5	*Lagerstroemia ovalifolia* Teijsm. & Binn.	4.80	4.46	4.84	14.20
6	*Markhamia stipulata* Seem.	4.10	4.46	1.94	10.35
7	*Walsura trichostemon* Miq.	2.54	3.40	3.90	9.75

Table 8 (Continued)

No.	Scientific Name	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Importance Value Index (IVI)
8	*Vitex* sp.	2.40	2.55	4.11	9.11
9	*Xylia xylocarpa* (Roxb.) Taub. var *kerrii* (Craib & Hutch.) I.C.Nielsen	3.25	4.25	1.72	9.10
10	*Vitex limonifolia* Wall.	0.99	1.49	5.90	8.34
11	*Terminalia glaucifolia* Craib	1.98	2.55	2.62	7.08
12	*Vitex peduncularis* Wall. ex Schauer	1.27	1.70	4.06	6.99
13	*Berrya mollis* Wall. ex Kurz	2.12	2.76	1.92	6.73
14	*Lagerstroemia calyculata* Kurz.	1.27	1.91	3.57	6.71
15	*Bridelia ovata* Decne.	2.54	3.18	0.19	6.24
16	*Bombax anceps* Pierre var. *anceps*	1.27	1.70	3.24	6.16
17	*Hymennodictyon orixense* (Roxb.) Mabb.	1.55	2.34	2.31	6.15
18	*Shorea obtusa* Wall. ex Blume	0.85	1.27	3.59	5.68
19	*Spondias pinnata* Kurz	1.55	2.34	1.29	5.12
20	*Pterocarpus macrocarpus* Kurz	0.56	0.85	3.37	4.76
21	*Vitex glabrata* R.Br.	0.56	0.85	3.09	4.76
22	*Diospyros variegata* Kurz	2.12	2.34	0.38	4.76
23	*Cratoxylum formosum* (Jack) Dyer subsp. *pruniflorum* (Kurz) Gogel.	1.27	1.27	2.00	4.50
24	*Sterculia guttata* Roxb.	1.69	2.34	0.47	4.44
25	*Grardenia* sp.	1.41	2.12	0.67	4.16
26	*Erythrophleum succirubrum* Gagnep.	0.71	1.06	1.89	3.64
27	*Vitex canescens* Kurz.	0.99	1.27	1.06	3.42
28	*Senna garrettiana* (Craib) Irwin & Barneby	1.27	1.27	0.40	2.90
29	*Aporosa villosa* (Lindl.) Baill.	0.99	1.06	0.21	2.37
30	*Holdina cordifolia* (Roxb.) Ridsdale	0.42	0.64	1.27	2.32
31	*Callicarpa arborea* Roxb.	0.42	0.64	0.94	1.98
32	*Fernandoa adenophylla* (Wall. ex G. Don) Steen.	0.71	1.06	0.20	1.94
33	*Catunaregam tomentosa* (Blume ex DC.) Tirveng	0.71	1.06	0.08	1.83
34	*Canarium subulatum* Guill.	0.42	0.64	0.46	1.50
35	*Grewia eriocapa* Juss.	0.56	0.85	0.06	1.45
36	*Litsea glutinosa* (Lour.) C.B. Robinson	0.42	0.64	0.34	1.38
37	*Diospyros ehretioides* Wall. Ex G. Don	0.14	0.21	0.85	1.20
38	*Microcos tomentosua* Sm.	0.28	0.42	0.03	1.14
39	*Careya sphaerica* Roxb.	0.42	0.64	0.08	1.13
40	*Dalbergia oliveri* Gamble ex Prain	0.28	0.42	0.42	1.12
41	*Lagerstroemia venusta* Wall.	0.28	0.42	0.12	0.96
42	*Celtis tetranda* Roxb.	0.28	0.42	0.17	0.87
43	*Casearia grewiifolia* Vent. var. *grewiifolia*	0.28	0.42	0.08	0.77
44	*Morinda anustifolia* Roxb. var *scrabidula* Craib	0.14	0.21	0.35	0.70
45	*Anneslea fragrans* Wall.	0.14	0.21	0.19	0.54
46	*Sindora siamensis* Teijsm. & Miq.	0.14	0.21	0.17	0.52
47	*Lepisanthes tetraphylla* (Vahl) Radlk.	0.14	0.21	0.09	0.43
48	*Polyalthia viridis* Craib	0.14	0.21	0.07	0.42
49	*Buchanania lanzan* Spreng.	0.14	0.21	0.05	0.40
50	*Antidesma ghaesembilla* Gaertn.	0.14	0.21	0.01	0.36
51	*Bauhinia* sp.	0.14	0.21	0.01	0.36
		100.00	100.00	100.00	300.00

Xylia xylocarpa var *kerrii* (26.82) and *Schleichera oleosa* (25.18) was also on top five IVI species from a ha study plot (Ladpala *et al*., 2004) and differences in forest strucuture vary on topography and forest fire disturbance. The most dominant species with the highest IVI was *Pterocarpus macrocarpus* (34.4) and two species left were *Halarrhena pubescen* (24.30) and *Berrya cordifolia* (19.62). In addition, there were two dominant bamboo species which were *Bambusa tulda* and *Gigantochloa albaciliata*.

The study site in this research is defined as MDF without bamboo, however, there are small clumps of bamboo scattering in two plots: the annual burning plot (eight clumps) and the 2-year fire free frequency plot (one clump). It is interesting that there are many clumps of bamboo in the annual burning plot. As both the bamboo under-growth and frequent forest fires could be dominant factors that prevent continuous regeneration (Marod *et al.*, 1999) and also found that the smallest tree size in DBH (5-10 cm) had the highest mortality. Thus, more fire frequently occurs in this plot, bamboo could be more dominated and successful regeneration of trees would not occur. Moreover, saplings and seedling would be affected by surface fire which occurs frequently in MDF (Akaakara, 2000). The results from study on impact of fire on plant in MDF at Phu Kradung National Park showed that fire did affect on saplings but tree would be hardly influenced. Seedlings were completely dead after fire (Sutthichat, 1996). These influence the structure and dynamics of MDF which in turn carbon stock and balance of forest ecosystem. Long term study might be required and monitored in order to notify how fire frequencies influence on tree growth and biomass. However, how much which plots with different fire frequencies in this study could storage carbon, it would depend on existing trees (species composition, density, and growth). Homogeneous site selection, thus, is vital for study area and should be carefully evaluated. Changes in species and number of saplings and their survivals are useful information to explain trend dynamic of plant community, biomass, and overall carbon storage since fire, but it is not mentioned herein.

CONCLUSION AND RECOMMENDATION

The species composition of all different fire frequencies plots slightly different but their species diversity indexes of Shannon-Wiener index (*H'*) vary in narrow and are quite high value (average 3.04). The lowest and highest of tree density are in the annual plot (632 stems/ha or 615 individuals/ha) and the 2-year fire free interval plot (1,432 stems/ha or 1,393 individuals/ha). Different in tree density might be influenced by fire both before and after fire in 2007. Anyway, the average of tree density

from 5 plots is quite high (933 stems/ha or 909 individuals/ha) but it is not good guarantee to obtain higher biomass. All together with DBH and height of tree must be considered.

The MDF with different burning frequencies are dominant with *Schleichera oleosa*, *Croton roxburghii*, *Lannea coromandelica*, *Xylia xylocarpa* var *kerrii*, *Largerstromia ovarifolia, Grewia eriocarpa*, *Penteace burmania*, and *Erythrophleum succirubrum*. Such tree species are on top five of the highest IVI. Only *Shorea obtusa*, one of dominant deciduous dipterocarp species, is the highest value of IVI in the 2-year fire free interval plot. As the study areas adjacent to DDF and MDF with bamboo, therefore, establishment of a ha permanent plot for five plots would be in ecotone and find some tree species entrance from other forest ecosystem.

The stand structure including number of species, density, and IVI would be useful background information in the next process of research program, particularly estimation on aboveground and below-ground biomass, carbon storage in biomass and litter production. Further evaluation such as DBH class distribution might be required. However, all these data will be brought to calculate changes in carbon stock and balance of MDF with different burning frequencies.

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