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Effect of Forest Fire on Stand Structure in Raja Musa Peat Swamp Forest Reserve, Selangor, Malaysia

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Abstract: The objective of this study was to investigate the effect of forest fire on forest structure in the peat swamp forest. The study was conducted in Raja Musa Forest Reserve which has been experiencing fire occurrences since 1996. Ten plots each measuring 50×20 m were systematically set up both in the burnt and unburnt area and plant inventory were conducted between September 2001 to June 2002. Results showed that there were 10 families and 22 families in burnt and unburnt area, respectively. In terms of family, Euphorbiaceae (61.9%) rank first in the burnt area. *Imperata cylindrica* from family of Poaceae had the most coverage on burnt plot. For tree diameter distribution, trees with diameter class of 10.1-15.0 cm and 15.1-20.0 cm had the highest number in the unburnt area while trees with diameter class of 5.1-10.0 cm was the highest in burnt area. Shannon's diversity index in burnt area was 1.62, lower compared to unburnt area which was 2.40. Evenness index for burnt area was 0.68, lower than unburnt area which was 0.71. This study shows that fire affects the species composition and stand structure of the forest and herbaceous vegetation, such as Poaceae was found to be abundant in burnt area compared to unburnt area.

Key words: Forest disturbance, fire effects, tree diversity

INTRODUCTION

Fire plays an important role in determining the structure of forests in some ecosystem (Laurance, 2003; Wood, 1989). Vegetation responds to burning varies with the severity of the burning (Phillips and Waldrop, 2008; Whittle *et al*., 1997) and adaptability of individual plant species to fire (Ellis, 2000).

The increased in fire occurrences in the tropical forest has led to concerns on the impact of forest fire on the forest structure and stand dynamics of tropical forest ecosystem (Cochrane and Schulze, 1998). Tropical peat swamp forest is also under threat of forest fire due to drought and conversion of peat swamp forest into agricultural land (Shlisky *et al*., 2007). The construction of transport canal in the tropical peat swamp forest causes the water to be drained out, increases the risk of fire occurrences in the forest (Nuruddin *et al*., 2006). Tropical peat swamp forest stored vast amount of carbon and it is estimated to be 70 Gt or up to 20% of total soil carbon (Maltby, 1997). Forest fires in tropical peat swamp forest can release carbon into the atmosphere (Page *et al*., 2002).

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Study by Wood (1989) in tropical forest in Sabah showed that burnt forests suffered severe canopy lost and ground cover was dominated by grasses or woody creepers. In severe burnt areas of tropical forest, fast growing grasses may dominate the areas making them more prone to fire. This is term as positive feedback in which successive cycles of fire occurrences increases the areas under grasses which further increase the risk of forest fire occurrences (Laurance and Williamson, 2001).

Many studies on effects of fires on tropical forest have been conducted (Kinnaird and Brien, 1998; Wood, 1989; Barlow *et al*., 2002). A study by Kinnaird and Brien (1998) in Bukit Barisan Selatan National Park, Southwest Sumatra showed that fires killed 2.4% of trees outright and injured a further 16.3% of trees. In the 6 months after the fires tree mortality increased to 24.6% in burnt plots, versus 9.8% in unburnt plots. Forest fires also decreases the canopy cover by damaging the tree crown due to scorching. Yeager *et al*. (2003) reported a study in lowland dipterocarp forest in Kalimantan, Indonesia which showed canopy cover was lower in the burned compared to unburned transects and tree species richness was lower in burned transects in lowland dipterocarp and peat swamp compared to the unburned forests of similar type. However, very few studies on effects of forest fires have been conducted in Malaysia.

The objective of this study was to investigate the impact of forest fire on the tropical peat swamp forest structure.

MATERIALS AND METHODS

This study was conducted between September 2001 to June 2002 at Raja Musa Forest Reserve at compartment 101, which is adjacent to mining area (Berjuntai Tin Berhad) located in latitude of 03°26'08'' North and longitude of 101°25'09'' East. Annual rainfall at Tanjong Karang meteorological station ranged from 1336 to 2673 mm, while monthly mean rainfall ranged from 86 to 245 mm. The highest rainfall occurred in November (245 mm) while the lowest occurred in June (86 mm). The annual rain days ranged from 113 to 187 days and monthly mean rain days ranged from 9 to 18 days (Lailan *et al*., 2004). Together with Sungai Karang Forest Reserve the forests popularly called as North Selangor Peat Swamp Forests (NSPSF) because this is the only Peat Swamp Forest Reserve can be found in Northern part of Selangor. The size of compartment 101 is 416 ha. During unusually long drought seasons, often precipitated by El Nino events, this forest becomes vulnerable to fires.

Ten plots were set up, respectively on burnt and unburnt area using systematic sampling design. The size of each plot is 50×20 m which recorded trees diameter (dbh), shrubs and herbs whereby classification of vegetation was according to individuals' height.

Data for herbaceous were collected according to their percentage coverage in the plot. Percentage coverage of herbaceous was conducted by identifying the species and observation of the coverage of each species in the sample plot.

All measurements on burnt and unburnt area were recorded in an inventory form. Shannon's diversity index was calculated for both burnt and unburnt plots. Measures such as the well-known Shannon's diversity index takes into account the relative abundance of species. This index is often used as a diversity measure as they take both evenness and species richness into account. The higher the value of the index, the higher is the species diversity.

RESULTS AND DISCUSSION

Total numbers of trees enumerated from both burnt and unburnt plots in Raja Musa Forest Reserve, Selangor are shown in Table 1. Numbers of trees enumerated in burnt and unburnt were 21 and 80, respectively. Result shows that there were 7 families in burnt area and 14 families in unburnt area for the trees in 3-10 m height class.

From the study it was found that trees in diameter classes of 10.1-15.0 cm and 15.1-20.0 cm in unburnt plots had higher individuals with 17 trees compared to same diameter class in the burnt area plots. On the other hand, in burnt plots, highest number of individuals was 6 trees found to be in diameter classes of 5.1-10.0 cm. The result showed in burnt areas, big trees in higher diameter classes have been killed by the fire but there is some regeneration by the higher number of small diameter class trees.

In term of number of individuals in burnt plot (Table 2). Euphorbiaceae was the most abundant with 13 trees (61.9%) and followed by Lauraceae and Fabaceae both with 2 individuals each (9.5%) followed by Moraceae, Hypercaceae, Myrtaceae and Dilleniaceae with a single individual (4.8%). In unburnt plost, Euphorbiaceae was the most abundant

Table 1: Total No. of individuals in study plots (3.0-10.0 m height) in Raja Musa forest reserve

Vernacular name	Botanical name	Family	Burnt	Unburnt
Antoi	*Cythocalyx* sp.	Annonaceae	0	1
Ara	*Ficus* sp.	Moraceae	1	1
Geronggang	*Cratoxylum arborescens*	Hypercaceae	1	0
Jangkang	*Xylopia* sp.	Annonaceae	0	2
Kedondong	*Canarium* sp.	Burseraceae	0	6
Kelat	*Eugenia* sp.	Myrtaceae	1	15
Mahang	*Macaranga hypoleuca*	Euphorbiaceae	13	38
Medang	*Behschmiedia* sp.	Lauraceae	2	1
Mendong	*Elaeocarpus masterii*	Elaeocarpaceae	0	1
Meranti Pa'ang	*Shorea bracteolata*	Dipterocarpaceae	0	6
Meranti Paya	*Shorea platycarpa*	Dipterocarpaceae	0	3
Nyatoh	*Palaqium* sp.	Sapotaceae	0	1
Penarahan	*Knema* sp.	Myristicaceae	0	1
Putat	*Barringtonia* sp.	Lecythidaceae	0	1
Ramin	*Gonystylus* sp.	Thymelaeceae	0	1
Saga	*Adenenthera paronina*	Fabaceae	2	1
Simpoh	*Dillenia* sp.	Dilleniaceae	1	1
Total			21	80

Table 2: Total No. of individual and percentatage by family (3.0-10.0 m height) in the study plots

Burnt			Unburnt		
Family	No. of individual	%	Family	No. of individual	%
Moraceae	1	4.8	Annonaceae	3	3.8
Hypercaceae	1	4.8	Moraceae	1	1.3
Myrtaceae	1	4.8	Burseraceae	6	7.5
Euphorbiaceae	13	61.9	Myrtaceae	15	18.8
Lauraceae	2	9.5	Euphorbiaceae	38	47.5
Fabaceae	2	9.5	Lauraceae	1	1.3
Dilleniaceae	1	4.8	Elaeocarpaceae	1	1.3
Total	21	100.0	Dipterocarpaceae	9	11.3
			Sapotaceae	1	1.3
			Myristicaceae	1	1.3
			Lecythidaceae	1	1.3
			Thymelaeceae	1	1.3
			Fabaceae	1	1.3
			Dilleniaceae	1	1.3
			Total	80	100.0

family with 38 trees (47.5%), followed by Myrtaceae (18.8%) and Dipterocarpaceae (11.3%) with number of trees 15 and 9, respectively. Number of trees from Burseraceae were 6 trees (7.5%) and Annonaceae with 3 trees (3.8%) whereas Moraceae, Lauraceae, Elaeocarpaceae, Sapotaceae, Myristicaceae, Lecythidaceae, Thymelaeceae, Fabaceae and Dilleniaceae each with a single tree (1.3%).

From this study, it was found that Pandanaceae rank first in taxonomic diversity for tree 1.5-10.0 m height in burnt area (Table 3) which is represented by *Pandanus* sp. (29%). In the unburnt plots Palmae had the most trees making up 17% of the total trees. Time since disturbance may be an important factor affecting species composition, particularly in terms of post-disturbance species with short life spans.

For herbaceous vegetation in burnt plot, Poaceae was the most abundant family (48.0%) followed by Urticaceae (19.5%) and Melastomataceae (13.0%) (Table 4). In unburnt plot, the most abundant herbaceous vegetation belongs to the family Melastomataceae (17.40%), the second most abundant is Palmae (10.66%), followed by Blechnaceae (10.64%) and Pandanaceae (7.34%).

The Shannon's diversity index, H' for burnt plot was calculated at 1.62 while for unburnt plot was 2.55 (Table 5) which showed that the unburnt plots' species composition was higher than the burnt plot due to trees in burnt plots were killed by fire. Evenness index, E5 of burnt plot, gave a value of 0.68 and 0.71 for unburnt plot (Fig. 1).

Herbaceous vegetation that was found mostly in burnt plot is from the Poaceae family (48%), *Imperata cylindrica* had the most coverage. This showed that after fire most of the area would be populated by herbaceous vegetation. Light demanding species like *Imperata cylindrica* dominate shade-loving species because they grow faster and can withstand water stress in open areas. Furthermore grasses are able to populate the burnt area due to the effectiveness of spread of seeds and their fast growing nature (Rochadi *et al.*, 2000). The presence of grasses can increase the risk of forest fire and causes recurrent forest fire

Table 3: Number of trees by family in 1.5-10.0 m height strata

Family	Burnt area	Unburnt
Anacardiaceae	0	2
Annonaceae	0	2
Burseraceae	1	11
Combretaceae	0	1
Dilleniaceae	3	7
Dipterocarpaceae	0	1
Ebenaceae	0	2
Euphorbiaceae	52	10
Fabaceae	16	16
Guttiferae	0	2
Lauraceae	4	2
Melastomataceae	12	0
Meliaceae	0	1
Moraceae	4	3
Myristicaceae	1	0
Myrtaceae	11	6
Palmae	0	18
Pandanaceae	54	14
Rhizophoraceae	0	2
Sapotaceae	0	1
Sterculiaceae	0	3
Thymelaeaceae	0	4
Urticaceae	26	0
Total	184	108

Table 4: Abundance of herbaceous vegetation by family

	Coverage (%)	
Family	Burnt area	Unburnt
Urticaceae	19.5	4.6
Melastomataceae	13.0	17.4
Blechnoceae	7.0	10.6
Asteraceae	3.5	3.2
Gleicheniaceae	4.5	4.8
Hypolepidaceae	3.0	0.0
Polypodiaceae	1.5	0.0
Poaceae	48.0	0.0
Thymelaeaceae	0.0	5.7
Anacardiaceae	0.0	0.6
Myristicaceae	0.0	1.0
Myrtaceae	0.0	7.0
Guttiferae	0.0	2.6
Lauraceae	0.0	0.5
Fabaceae	0.0	2.3
Annonaceae	0.0	1.3
Euphorbiaceae	0.0	0.7
Dipterocarpaceae	0.0	2.4
Moraceae	0.0	0.6
Burseraceae	0.0	6.6
Olacoceae	0.0	7.9
Pteridaceae	0.0	0.6
Dilleniaceae	0.0	1.5
Palmae	0.0	10.7
Pandanaceae	0.0	7.3
Total	100.0	100.0

Table 5: Comparison of diversity indices at 4 sites

Study location	Shannon's diversity index	Eveness index	References
North Kuala Langat Peat swamp forest reserve	5.61	0.84	Lepun (1999)
Ayer Hitam forest reserve	4.10	NA	Sulaiman (1998)
Raja Musa forest reserve	2.55	0.71	Present study (unburnt)
Raja Musa forest reserve	1.62	0.68	Present study (burnt)

NA: Not available

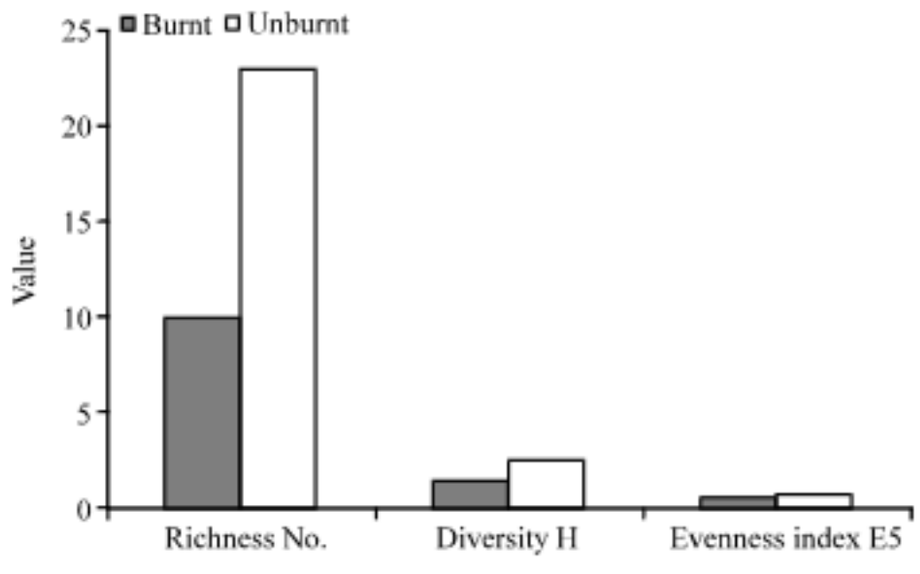

Fig. 1: Species diversity index for burnt and unburnt plot

(Goldammer, 1999). This causes a situation known as positive feedback in fire susceptibility (Cochrane *et al*., 1999) and transforms the burnt area into grass and shrub dominated landscape (Kinnaird and Brien, 1998).

The results shows that species diversity in Raja Musa Peat swamp forest was the lowest compared to the previous study by Lepun (1999) at Kuala Langat North peat swamp

forest, Selangor where H' was 5.61 and also by a study of tropical lowland forest, Ayer Hitam forest reserve, Puchong, Selangor where H' was 4.10 (Sulaiman, 1998). This concur with a study by Yeager *et al*. (2003) in Tanjung Puting National Park, Kalimantan, peat swamp forest which showed that species diversity (H') was lower in burned transects than in unburned areas. Fires not only reduced the species diversity of the burned stand but also killed the seeds in the seed bank since most of peat fires occurs below the surface and ground fire.

CONCLUSIONS

The study showed that unburnt plots species composition was higher than the burnt plots in Raja Musa peat swamp forest with Shannon's diversity H' index of 2.55 and 1.62 for unburnt and burnt plots, respectively. Evenness index were 0.68 and 0.71 for burnt and unburnt plots, respectively. The difference of 0.03 in Evenness index between burnt and unburnt plot showed that the evenness of species in both area is almost the same. The family of Pandanaceae rank first in taxonomic diversity in burnt plot for the trees with height 1.5-10.0 m, while for vegetation with 3.0-10.0 m height, Euphorbiaceae make up 61.9% of the total trees in burnt plots. This study also shows that fire changes the diversity and forest structure of the study area. Fire has management implications on the diversity of the tropical peat swamp forest.

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