

Fire behavior at Kuan-Kreng peat forest, Nakorn Sri Thammarat province

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Abstract:

Kuan-Kreng swamp forest located in southern Thailand and covers an area of 24,000 ha. About 2,100 ha burned in 2012. These fires lead to the changes in ecosystem structures and functions. Thus, fire management is very important. Unfortunately, peat fire information for Thailand has never been systematically investigated. This research aims to learn about forest fire and fuel characteristics in Kuan-Kreng swamp forest. Twelve plots of 30x30 m which consisted of 4 plots in lowland *Malaleuca*'s stand, 4 plots in upland stand and 4 plots in open grassland. The average Pre-burn fuel load for lowland, upland and grassland sites were 11.96, 21.20 and 13.73 ton/ha, respectively. Undergrowth litter contain the highest heat value (4289.19 ca/ g), while heat content of peat soil was lowest (3280.73 cal/g). All of fire behavior descriptors were highest in grassland and lowest in lowland, ROS in grassland was highest, though there were non-significant differences. FH and FL were significant highest in grassland. However, FH and FL were not significantly difference between *Malaleuca* sites. FI in this study was highest in grassland (720.6 kW m⁻¹), and it was lowest in lowland site (87.5 kW m⁻¹). However, FI varied from plot to plot, resulting in non-significant differences between sites.

Keywords: fire behavior; Peat fire; Kuan-Kreng peat forest

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1. Introduction

Kuan-Kreng tropical peat forest (KK-TPF) is a fire sensitive ecosystem, which is normally unburned due to the existing of water on the soil surface. However, people try to encroach the KK-TPF, by draining water off the peat land follows by burning. Therefore, fire statistics were very high during the drought period (2100 ha burned in 2012). These fires lead to the changes in ecosystem structures and functions. Thus, fire management, which fuel and fire behaviors are the necessary for the success of planning, is very important. Unfortunately, peat fire information for Thailand has never been systematically investigated.

2. Methodology

Prior to burning, twelve plots of 30x30 m which consisted of 4 plots in lowland *Malaleuca cajuputi* stand, 4 plots in upland stand and 4 plots in open grassland. Prior to burning, biomass of *M. cajuputi* were estimated using allometric equations. Tree dbh, high and bark thickness were also measured. Aboveground fuel loads (litter and under growth) were estimated within eight 1x1 subplots, using harvesting techniques. Burning experiments took place during April-July 2014 using head-fire burning techniques. To estimate rate of spread (ROS) and flame height (FH), 2 sets of 2 m – tall iron stakes was placed every 3 m perpendicular to the front of the fire. Immediately after burning, post-fire residues (ash plus charcoal and unburned material) were estimated in eight 50x50 cm subplots. Heat value of the fuel was analyzed and calculated. Fire intensity (FI) and flame length (FL) were calculated using Byram (1959) equations.

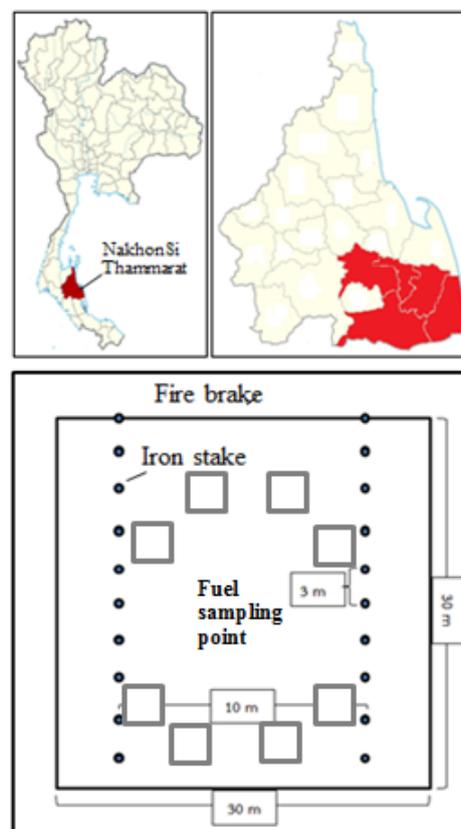


Fig. 1 Study site and plot's map.

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$$I_B = 0.007H * Wa * r \quad (1)$$

$$L = 0.0775 * I_B^{0.46} \quad (2)$$

Where H is the net of low heat of combustion (cal g^{-1}) (Table 1), Wa is the fuel consumed in active flaming front (ton ha^{-1}), r is the linear rate of fire spread (m min^{-1}), L is flame length (m) and I_B is fireline intensity (kW m^{-1}).

3. Results and discussion

3.1 Pre-burn fuel loads and fuel consumption

The Pre-burn fuel load includes litter, undergrowth, *Malaleuca*'s bark and leaf (Table 2). The average Pre-burn fuel load for lowland, upland and grassland sites were 11.96, 21.20 and 13.73 ton ha^{-1} , respectively. The ratio of litter, undergrowth (ug), *Malaleuca*'s bark and leaf for all sites were 18, 19, 27 and 36 %, respectively (Fig. 2). The average ratio of fuel consumption for each fuel type of all three sites were 88, 7, and 5% for burned litter and under growth (surface fuel), *Malaleuca*'s barks, and *Malaleuca*'s leaves, of each initial values, respectively (Fig. 2).

It was clear that fuel type in the open grassland was dominated by pure stand of either *Leprionia articulata*, *Eleocharis ochrostachys*, or *Scleria poaeformis*. An average tree size at the upland areas was absolutely bigger than that of lowland areas, though tree density of upland sites was lower than that of lowland sites. Therefore leaf and bark biomass were highest for the upland. Clearly, litter loads was highest in most sites, owing its heavy-weight compared to the undergrowth.

Table 1 Heat content in different fuel types (cal g^{-1}) in Melaleuca peat forest

Litter	Undergrowth	leaf	Bark	Peat	grassland weed
4227.72	4075.14	5181.51	5502.96	3280.73	3675.54

Table 2 Pre-burn fuel load and fuel consumption from burning experiment

Plot	Surface fuel (ton/ha)					Fuel consumed (ton/ha)			
	Leaf	Bark	Litter	UG	Total	Surface Fuel*	Leaf	Bark	Total
Lowland	2.96	2.61	4.00	2.38	11.96	2.31 ^a	0.20	0.60	3.12 ^a
	(1.62)	(1.62)	(3.53)	(1.76)	(3.21)	(1.84)	(0.25)	(0.37)	(1.63)
Upland	3.31	4.59	10.21	3.09	21.20	8.90 ^b	0.52	0.42	9.84 ^b
	(1.05)	(2.51)	(4.79)	(1.64)	(8.16)	(3.49)	(0.26)	(0.21)	(3.84)
Grassland	-	-	5.76	7.97	13.73	10.45 ^b	-	-	10.45 ^b
	-	-	(2.31)	(6.05)	(4.50)	(5.44)	-	-	(5.44)

Remark: Standard deviations are given in parentheses. ^a, ^b indicate significant difference (ANOVA F-test or t-test) between sites at the 95% confidence level. * Litter plus undergrowth

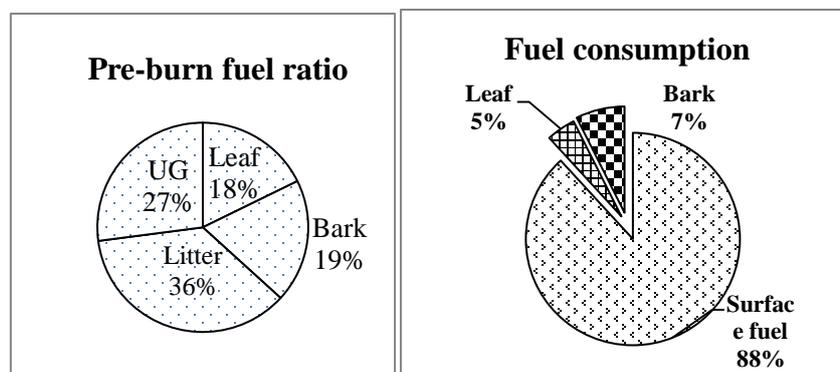


Fig. 2 Pre-burn fuel load and fuel consumption portions.

3.2 Fuel heat content

Undergrowth litter contain the highest heat value (4289.19 cal g⁻¹), while heat content of peat soil was lowest (3280.73 cal g⁻¹) (Table 1). Heat content value for peat may be underestimated due to the soil particle contamination. Bark's heat content was relatively high compared to other fuel type. Therefore, tree trunk may be damaged or small tree may be died when surface fire spread up to the tree trunk and hence burns the bark. In addition, the burning bark can be blown away as a "spot fire" ahead the burning site. This makes difficulty for forest fire control.

3.3 Fire behaviors

All fire behavior descriptors were highest in grassland and lowest in lowland, though there were not statistically different for many parameters owing to the high variation within each site (Table 3). Fire temperatures at each level above surface (either 20, 50 or 100 cm aboveground) were not significantly different between sites. ROS in grassland was highest, though there were non-significant difference. FH and FL were significant highest in grassland. However, FH and FL were not significantly difference between melaleuca sites. FI in this study was highest in grassland (720.6 kW m⁻¹), and it was lowest in melaleuca lowland site (87.5 kW m⁻¹). However, FI varied from plot to plot, resulting in non-significant differences between sites.

Table 3 Quantitative fire behavior characteristics for experimental fires with difference area

Plot	Fire temp. (°C) above soil surface			ROS (m min ⁻¹)	FH (m)	FI (kW m ⁻¹)	FL (m)
	20 cm	50 cm	100 cm				
Lowland site	511.10 (18.54)	375.52 (45.10)	238.85 (46.91)	0.96 (0.49)	2.15 ^{ab} (1.52)	87.47 (64.33)	0.57 ^a (0.22)
Upland site	478.76 (43.93)	300.24 (98.17)	248.38 (125.92)	0.66 (0.55)	1.33 ^a (0.83)	177.65 (154.66)	0.77 ^{ab} (0.35)
Grassland site	526.30 (55.32)	428.02 (90.94)	270.89 (38.41)	2.09 (1.30)	4.97 ^b (2.41)	720.61 (800.63)	1.42 ^b (0.73)

Remark: Standard deviations are given in parentheses; ^{a, b} indicate significant differences (ANOVA F-test) between sites of each fire behavior parameter at the 95% confidence level



Fig. 3 Forest fire characteristic and post-burned fuel characteristic at Kuan Kreng peat forest.

Fire behavior in KK-TPF was classified as low to moderate fire intensity, according to Andrew (1980). Undergrowth fuel loads may play important role for fire behavior in grassland plot. FL was

affected by wind and fuel height. FL grassland site was highest because of the area openness (and hence wind velocity) and optimum fuel compactness. In addition, the better fuel arrangement and fuel continuity in grassland leads to the faster fire spread, compared to those of melaleuca sites of which patches burning sometimes occurred. The fact that main fuel type for lowland site was litter, of which its compactness and wetness. Moreover, tree density for this site was high, that limits the influence of wind to fire behaviors. Although the fuel properties for the upland site was drier, but the main fuel type and tree density were similar to that of lowland sites, resulted in the same pattern of fire behaviors.

Although fire behavior descriptors for these experimental burnings were not relatively higher than other burnings (see Wanthongchai et al. (2011) Wanthongchai et al. (2013), Wiriya (2009), Kaitpraneet and Thaiutsa (1987)), carbon losses and emissions should be considered. Based on 47% C content (IPCC, 2006), carbon losses after fires for lowland, upland, and open grassland sites was 1.47, 4.62, and 4.91 tonC ha⁻¹, respectively (3.67 tonC ha⁻¹ in average). During the 2012 exceptional drought period in Nakorn Sri Thammarat province, (from March to September), which fires had destroyed ca. 2100 ha. of the Kuan Kreng secondary peat forest. The estimation of aboveground carbon loss due to the 2012 wildfire at KK-TPF, therefore, was about 7707 tonC.

4. Conclusion and recommendation

This study showed that although fuel loads at the melaleuca forest for upland site was relatively high, fire behaviors may not necessary high. In fact fire behaviors for open grassland area was highest among all sites at Kuan Kreng, of which forest fire managers must pay more attentions to prevent and control the fire for this landuse type. Moreover, aboveground carbon losses caused by fire was also relatively high, while the belowground carbon losses has not been estimated in this study. When the aboveground and belowground carbon losses was pooled, the number of carbon losses owing to wildfire must be higher than this estimation. Therefore, fire management policy must pay more attention on fire prevention and rapid initial fire attack to control the fire and hence reduce carbon losses from KK-TPF wildfire.

5. Acknowledgements

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- Pak Pha Nang Forest Fire Control Station

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