International Research Journal of Biological Sciences _____ ISSN 2278-3202
Vol. **4(2),** 7-15, February **(2015)** *Int. Res. J. Biological Sci.*

Species Composition of Understory Vegetation and Large Herbivore Abundance in Burnt and an Unburnt Deciduous Dipterocarp Forest at Huai Kha Khaeng Wildlife Sanctuary, Thailand

Sookchaloem Duangchai[1*], Methula ThulaniSihle[2], Bhumpakphan Naris[1] and Maneerat Sompoch[3]
[1]Department of Forest Biology, Faculty of Forestry, Kasetsart University, Bangkok, THAILAND
[2]Graduate School, Kasetsart University, Bangkok, THAILAND
[3]Department of National Parks, Wildlife and Plant Conservation, Bangkok, THAILAND

Available online at: www.isca.in, www.isca.me
Received 24th September 2014, revised 11th November 2014, accepted 20th January 2015

Abstract

The species composition in burnt and unburnt deciduous dipterocarp forest (DDF) at Huai KhaKhaeng Wildlife Sanctuary (HKKWS) was carried out by identifying and comparing ground flora, seedling and sapling species. The Importance Value Index (IVI), indices for species diversity, similarity, richness and evenness were analyzed. Wildlife abundance was determined by identifying and counting dung and pellet groups of large herbivores. There were more species of ground flora, seedlings and saplings in burnt area than in unburnt area. Dominant ground flora species based on the IVI value were Heteropogontriticeus (R.Br.) Stapf ex Craib in burnt area and Polyalthiadebilis(Pierre) Finetand Gagnep.inunburnt area. Dominant seedling species were Shoreaobtusa Wall. Ex Blume in burnt area and Polyalthia debilis(Pierre) Finetand Gagnep.inunburnt area. Dominant sapling species were Xyliaxylocarpa (Roxb.) Taub.in burnt area and Terminaliamucronata Craiband Hutch.inunburnt area. The Menhinick's index showed that the species richness of ground flora, seedlings and saplings were higher in burnt area than in unburnt area.The species similarity of ground flora, seedlings and saplings between burnt and unburnt areas was low. For analysing herbivore abundance the dung and pellet densities showed that elephant, banteng, Sambar deer and common barking deer were more abundant in burnt area than in unburnt area and gaur did not inhabit the study area.

Keywords: Species composition, species diversity, understory vegetation, deciduousdipterocarp forest.

Introduction

The Deciduous Dipterocarp Forest (DDF) is part of the seasonally dry forests. It loses its leaves during the winter season; it is characterized by low annual rainfall and a predictable dry season(Murphy and Lugo, 1986). In Thailand, the DDF is the most extensive forest type covering as much as 45% of the total forest area, it isfound in elevation ranges of 150m to 1300m above mean sea level[1]. Thailand's DDFs are fire dependent ecosystems. Frequent, often annual, low intensity fires of human origin are common in the DDF throughout Thailand[2]. Wildfires occur on a yearly basis in the DDF at HuaiKhaKhaeng Wildlife Sanctuary (HKKWS) which is a protected area. There have been attempts to suppress all fires especially in the protected areas. Many fire prevention programmes have been launched throughout Thailand due to environmental concerns[3].

The understory vegetation plays an important role in the regeneration of the forest overstory, it is likely that at least part of the pioneer species that grow after a disturbance such as fire will eventually grow into the forest overstory thus affecting the tree composition of the forest[4]. Fire can also be used to improve wildlife habitat[5]. Wildlife populations can be affected directly or indirectly by wildfire[6].Forage plants consumed by large herbivores consist of grasses and woody plants, which are mostly found in the understory of the DDF. These vegetation types have received little attention. The present study focused on understory vegetation species composition, herbivore abundance and soil properties, by comparing between burnt and unburnt areas at HKKWS. Therefore determining species composition of plants and the large herbivore abundance is important for proper decision making, application of management practices and understanding of how fire disturbance can affect the deciduous dipterocarp forest ecosystem structure.

The objectives of the study were to determine and compare the understory vegetation species composition, species richness, species diversity, species similarity and wildlife abundance between a burnt area and an unburnt area in the deciduous dipterocarp forest.

Material and Methods

Research Site: The study was conducted in the UthaiThani Province at HuaiKhaKhaeng Wildlife Sanctuary. The HKKWS was declared a National World Heritage Site by UNESCO in

December 1991. It is located in the western part of Thailand (15^0 00' to 15^0 50' N, 99^0 00'to 99^0 28'E) and 2,750 km² in size. The main area lies in LanSak, HuaiKhrot and Ban Rai districts in UthaiThani Province, a small part of the area at the north is located in Umphand district, Tak Province. The northern boundary is with NakronSawan and Tak Province and the southern borders are with Khanchanaburi and Suphanburi Provinces[7]. The study was carried out in the Deciduous Dipterocarp Forest.

Two sites were selected, one which has been subjected to fire on an annual basis (burnt area) and one which has not been subjected to fire for the past 5 years (unburnt area). A 1100m line transect was set at each site, then 10m X 10m plots were set at 100m intervals, thus each site had ten 10m X 10m plots in which understory vegetation and large herbivore sampling was conducted. The study was conducted between February 2014 and June 2014.

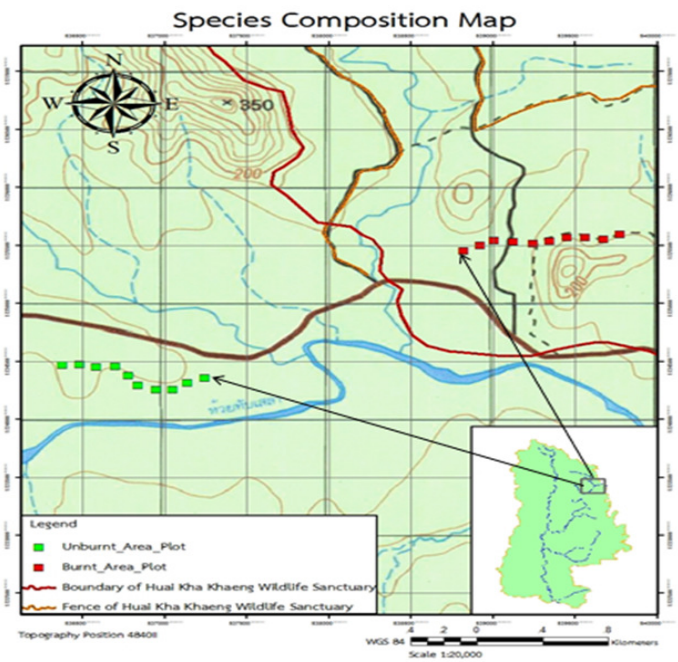

Figure-1
The study site and study plots (burnt and unburnt areas) at HuaiKhaKhaeng Wildlife

Methodology: Understory Vegetation Sampling: The understory vegetation sampling was carried out between February and June 2014; this was to facilitate the easy identification of flowering plants. The data was collected from two sites of the deciduous dipterocarp forest, unburnt and burnt site. In each site the area was divided according to the vegetation homogeneity, and then demarcated according to their landscapes. A line transect of 1,100 m was set, at every 100 m plots of 10 m x 10 m. At the four corners, sub-plots of 0.5 m x 0.5 m were set for ground flora sampling. Plots of 1 m x 1 m and 4 m x 4 m were set on one corner for seedling and sapling sampling respectively. The Thai plant nomenclature was used[8].

Ground Flora Sampling: In this study the ground flora is defined as all vegetation life forms less than 130 cm height; shrubs, climbers and herbaceous plants. Shrubs are woody perennial plants of lower stature and sometimes several basal stems. Herbs are flowering plants with no woody tissue above the ground, they include grasses and forbs. Forbs are non-grass-like plants with tap root, generally broad leafed with solid non-jointed stems. The data for the ground flora was collected from the 0.5 m x 0.5 m plots. There were 40 plots in each site. Template specimens were collected and later compared and identified at the Forest herbarium, Department of National Parks, Wildlife and Plant Conservation, Bangkok.

Seedling sampling: In the study, seedlings were defined as small woody plants with a height less than 130 cm. For determining species composition of the seedlings in both burnt area and unburnt area, they were identified and recorded. The diameter of seedlings was measured at the base of the plant. Template specimens were collected and later compared and identified at the Forest herbarium, Department of National Parks Wildlife and Plant Conservation.

Sapling Sampling: Saplings were defined as trees and shrubby trees of more than 130 cm height and diameter at breast height (DBH) less than 4.5 cm. For determining species composition of the saplings in both burnt area and unburnt areas, they were identified and recorded. Template specimens were collected and later compared and identified at the Forest Herbarium, Department of National Parks Wildlife and Plant Conservation.

In order to determine the quantitative relationships between the ground flora, seedling and sapling species in a burnt area and an unburnt area, the importance value index was calculated[9].

Importance Value Index (IVI): Relative density, relative frequency and relative dominance for all the vegetation in both burnt area and unburnt area were determined and calculated. The importance value index was calculated using the following equation[10]:

IVI ground flora= Relative dominance + Relative frequency (1)

IVI seedlings= Relative dominance + Relative frequency + Relative density (2)

IVI saplings= Relative dominance + Relative frequency + Relative density (3)

Where;

Density (D) = $\frac{\text{Total number of a species}}{\text{Total area of sampled plots}}$, Relative density (RD) = $\frac{\text{Density of a species (D)}}{\text{Total density of all species}}$ x 100, Frequency (F) =

$\frac{\text{Number of plots in which a species occurs}}{\text{Total number of sample plots}}$, Relative frequency (RF) =

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

$\frac{\text{Total basal area of a species}}{\text{Area sampled}}$, Relative dominance (RDo)

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

Species diversity of understory vegetation: Species Diversity: In order to determine the species diversity of ground flora, seedlings and saplings burnt and unburnt areas, the Shannon-Wiener Index of diversity was used.

The Shannon Wiener Index (H): This index is based on communication theory and stems from a common question in communication[11]. The Shannon Wiener Diversity Index will be used to determine species diversity for the vegetation samples.

$$H= -\Sigma [pi \ln pi] \quad (4)$$

Where: H= Shannon-Wiener Diversity index, pi= Proportion of total sample made up of the ith species.

Species Evenness: Species Evenness: It is the relative abundance which each species is represented in an area[11].

$$E=\frac{H}{\ln (S)} \quad (5)$$

Where: E= Evenness,.H= Shannon Wiener diversity index, S= Number of species

Species Richness: Species Richness: To determine and compare the species richness between burnt and unburnt areas the Menhinick's index was used. The Menhinick's index is calculated using the following equation[12].

$$D=\frac{S}{\sqrt{N}} \quad (6)$$

Where: D= Species richness, S= Number of different species represented in sample, N= Total number of individual organisms in sample

Species Similarity: Species Similarity: To determine the level of similarity between ground flora, seedlings and saplings in burnt and unburnt areas, the Sorensen Index was used.

Sorensen Index: This is the simplest method for evaluating the similarity between two quadrant samples. The value will be close to 1 if the sites have most of their species in common and for very dissimilar sites, the value would be close to 0. The species similarity was calculated using the following equation[13].

$$QS=\frac{2G}{A+B} \quad (7)$$

Where : QS= is the quotient of similarity and ranges from 0-1, A= number of species in burnt area, B= number of species in unburnt area, Wildlife Abundance.

Wildlife indices in the form of dung and pellet density were used to determine the large herbivores abundance in the burnt and unburnt site. The Faecal Standing Crop (FSC) method was used. The herbivore abundance in burnt and unburnt areas was then determined, compared and tested by statistics.

The herbivores abundance was determined by monitoring and counting the dung and pellets of wild herbivores such as the elephant, gaur, banteng, Sambar deer and the common barking deer[14].

A line transect of 1100m was used (Same transacts and plots as the ones for vegetation sampling). Every 100 m, plots of 10mX10m were set and the dung count for large herbivores such as Asian elephants, gaur and banteng was conducted. Smaller plots of 1m X 1m were set at the corners of the larger plots, faecal pellet groups of common barking deer and Sambar deer were identified and counted. For Sambar deer and common barking deer, the plots were smaller in order to improve pellet detection. The dung density and pellet group density was then calculated. Only 5 species (Asian elephants, Banteng, Gaur, Sambar deer and common barking deer) of herbivores were considered in the study.
The dung and pellets were calculated by a formula for density [14].

$$\text{Dung or pellet density}=\frac{\text{Number of dung or pellets}}{\text{Total Area}} \times 100 \quad (8)$$

Soil Sampling: The soil samples were taken at 3 different points along each transect of 1100 m to capture variation and at two depths to ensure that plant nutrients available to both short rooted plants and deep rooted plants are determined. At each sampling point, soil samples were first taken from the topsoil (0-25 cm), and the topsoil was then removed with a hoe, taking care not to unnecessarily disturb the soil when taking the subsoil (25 cm- 50 cm) sample[15]. The soil samples were then put in polythin bags then sent to the Soil Science Laboratory, Faculty of Forestry, Kasetsart University for analysis. The following soil elements were analysed; pH, organic matter, total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium, ash and moisture content. Three soil samples were collected from each site (0 m, 550 m, and 1100 m) at two depth levels (0-25 cm and 25-50 cm).

Statistical Package for Data Analysis: All data was entered into Microsoft Excel and all data processing and analyzing was done. To get the comparative account of vegetation species diversity between a burnt area and an unburnt area the two-sample t-test of SPSS was used for determining the level of significant difference.

Results and Discussion

Species Composition and IVI, Ground Flora, From all the 80 ground flora plots there were 55 species found from 28 different families. The total number of species found in burnt area was 35 species from 19 different families. The total number of species found in unburnt area was 33 species from 19 different families. The species composition and IVI of ground flora are shown in table-1.

Seedlings: In the 20 seedlings plots there were 18 species from 11 different families found. In burnt area , 12 species from 10 different families were found. In unburnt area, 9 species from 7 different families were found. The IVI for seedlings was calculated by summing up the relative density, relative frequency and relative dominance The species composition and IVI are shown in on table-2.

Saplings: In the 20 sapling plots, 12 species from 8 different families were found. In burnt area p, 8 species from 5 different families were found. In unburntarea , 5 species from 5 different families were found. The species composition and IVI are shown on table-3.

Species Diversity: For ground flora, the species diversity of Shannon-Weiner Index for the burnt area was 3.14 and for the unburnt area it was 3.18. For the seedlings, the species diversity of Shannon-Wiener index for burnt area was 2.39 and for the unburnt area it was 2.10. The species diversity for saplings in a burnt area was 2.02 and in an unburnt area it was 1.56 as shown in table-4.

Species Richness: The species richness for ground flora, seedlings and saplings was higher in the burnt areas than in the unburnt areas. The values of species richness are shown in table 5 below.

Table-1
Species composition and IVI of ground flora

NO.	IVI	Burnt Area	Family	IVI	Unburnt Area	Family
1	30.1	*Heteropogontriticeus* (R.Br.) Stapf ex Craib	Gramineae	38.4	*Polyalthiadebilis* (Pierre) FinetandGagnep.	Annonaceae
2	21.9	*Vetiverianemoralis* A. Camus	Gramineae	21.9	*Heteropogontriticeus* (R.Br.) Stapf ex Craib	Gramineae
3	19.0	*Chromolaenaodorata* (L.) R.M. King and H. Rob.	Compositae	15.9	*Panicum maximum*Jacq.	Gramineae
4	10.4	*Cyperuscyperoides*(L.) Kuntze	Cyperaceae	14.6	*Spilanthesiabadicensis*A.H . Moore	Compositae
5	10.1	*Lagestroemiamacrocarpa*Wall.	Lythraceae	14.4	*Vetiverianemoralis* A. Camus	Gramineae
6	8.2	*Holarrhenacurtisii* King and Gamble	Apocynaceae	12.1	*Chromolaenaodorata* (L.) R.M. King and H. Rob.	Compositae
7	7.8	*Vignasp*	Leguminosae	9.8	*Casearia grewifolia* Vent.	Flacourtiaceae
8	7.7	*Sidacordifolia*L.	Malvaceae	6.6	*Cyrtococcum patens* (L.) A. Camus	Gramineae
9	7.6	*Themedatriandra*Forssk. G	Gramineae	6.5	*Praxelisclematidea*R.M. Kingand H. Rob.	Compositae
10	7.0	*Osbeckiachinensis*L.	Melastomataceae	5.7	*Cyperuscyperoides* (L.) Kuntze	Cyperaceae
11	5.7	*Jasminumgrandiflorum* (L.) Kobuski	Oleaceae	5.2	*Elephantopusscaber*L.	Compositae
12	5.4	*Pterocarpusmacrocarpus*Kurz.	Leguminosae	4.5	*Commelinadiffusa*Burm.f	Commelinaceae
13	5.2	*Sacciolepisturgida*Ridl.	Gramineae	4.2	*Barringtoniaacutangula*(L.) Gaertn.	Lecythidaceae
14	4.6	*Pogostemonquadrifolius*Kuntze.	Labiatae	4.0	*Eragrostisatrovirens* (Desf.) Steud.	Gramineae
15	3.9	*Imperatacylindrica*(L.) P.Beauv.	Gramineae	3.9	*Cyperushaspan*L.	Cyperaceae
16	3.7	*Syzygiumcumini* (L.) Skeels	Myrtaceae	3.5	*Xyliaxylocarpa* (Roxb.) Taub.	Leguminosae
17	3.6	Unknown sp1	Scrophulariaceae	3.3	Unknown sp 2	Leguminosae
18	3.6	*Uvariaargentea*Blume	Annonaceae	2.5	*Erythroxylumcambodianum*Pierre	Erythroxylaceae
19	3.4	*Shoreaobtusa*Wall.exBlume	Dipterocarpac	2.5	*Spermacocepusilla*Wall.	Rubiaceae

NO.	IVI	Burnt Area	Family	IVI	Unburnt Area	Family
			eae			
20	3.2	*Pennisetumpolystachion*(L.) Schult.Schult.	Gramineae	2.4	*Croton hutchinsonianus*Hosseus	Euphorbiaceae
21	2.9	*Costusspeciosus*(Koen) Sm.	Costaceae	1.7	*Careyasphaerica*Roxb.	Lecythidaceae
22	2.4	*Setariaparviflora*(Poir.) Kerguelen	Gramineae	1.7	*Litseaglutinosa* (Lour.) C.B.Rob.	Lauraceae
23	2.4	*Curcuma plicata* Wall.	Zingiberaceae	1.6	*Helicteresangustifolia* L.	Stereuliaceae
24	2.1	*Xyliaxylocarpa* (Roxb.) Taub.	Leguminosae	1.5	*Jasminumgrandiflorum* (L.) Kobuski	Oleaceae
25	1.9	*Terminaliamucronata*Craiband Hutch.	Combretaceae	1.5	*Clematis meyeniana*Walp.	Ranunculaceae
26	1.9	*Praxelisclematidea*R.M. Kingand H. Rob.	Compositae	1.5	*Murdanniaspirata*(L.) G. Bruckn.	Commelinaceae
27	1.9	*Croton hutchinsonianus*Hosseus	Euphorbiaceae	1.3	*Beilschmiediafagifolia*Nees	Lauraceae
28	1.7	*Metadinatrichotoma* (Zoll. Ex Merr.) Bakh.f.	Rubiaceae	1.2	*Oplismenuscompositus* (L.) P.Beauv.	Gramineae
29	1.6	*Diplacrumcaricinum*R.Br.	Cyperaceae	1.2	*Catunaregamtomentosa*(Blume ex DC) Tirveng.	Rubiaceae
30	1.5	*Dalbergiacultrata*Graham ex Benth.	Leguminosae	1.2	*Colona auriculata*(Desv.) Craib	Malvaceae
31	1.5	*Commelinadiffusa*Burm.f.	Commelinaceae	1.2	*Osbeckiachinensis*L.	Melastomataceae
32	1.5	*Paederialinearis* Hook. f.	Rubiaceae	1.2	*Diplacrumcaricinum*R.Br.	Cyperaceae
33	1.5	*Fernandoaadenophylla* (Wall. ex G.Don) Steenis	Bignoniaceae	1.2	*Markhamiastipulata*Seem.	Bignoniaceae
34	1.5	*Cyrtococcum patens* (L.) A. Camus	Gramineae			
35	1.4	*Spermacocepusilla*Wall.	Rubiaceae			

Table-2
The species Importance Value Index (IVI) of seedlings

NO.	IVI	Burnt Area	Family	IVI	Unburnt Area	Family
1	106.0	*Shoreaobtusa*Wall.exBlume	Dipterocarpaceae	120.0	*Polyalthiadebilis*(Pierre) FinetandGagnep.	Annonaceae
2	40.2	*Polyalthiadebilis* (Pierre) FinetandGagnep.	Annonaceae	53.2	*Terminaliamucronata*Craiband Hutch.	Combretaceae
3	26.5	*Xyliaxylocarpa* (Roxb.) Taub.	Leguminosae	26.7	*Croton hutchinsonianus*Hosseus	Euphorbiaceae
4	24.2	*Dilleniaobovata*(Blume) Hoogland	Dilleniaceae	25.2	*Dilleniaobovata*(Blume) Hoogland	Dilleniaceae
5	22.1	*Pterocarpusmacrocarpus*Kurz.	Leguminosae	19.1	*Aporosavillosa*(Wall. ex Lindl.) Baill.	Euphorbiaceae
6	20.1	*Lanneacoromandelica*(Houtt.) Merr.	Anacardiaceae	16.1	*Xyliaxylocarpa* (Roxb.) Taub.	Leguminosae
7	16.4	*Grewiaeriocarpa*Juss.	Tiliaceae	13.7	*Grewiahirsuta*Vahl	Tiliaceae
8	9.6	*Terminaliaalata*Heyne.ex Roth	Combretaceae	13.2	*Vitexlimonifolia*Wall.	Labiatae
9	9.6	*Cratoxylumformosum*(Jack) Dyer.	Guttiferae	12.0	*Bauhinia saccocalyx*Pierre	Leguminosae
10	9.0	*Fernandoaadenophylla* (Wall. ex G.Don) Steenis	Bignoniaceae			
11	8.4	*Vitexpenuncularis*Wall ex Schauer	Labiatae			
12	7.8	*Terminaliachebula*Retz	Combretaceae			

Table-3
The species Importance Value Index (IVI) of saplings

NO.	IVI	Burnt Area	Family	IVI	Unburnt Area	Family
1	63.8	*Xyliaxylocarpa* (Roxb.) Taub.	Leguminosae	82.3	*Terminaliamucronata*Craiband Hutch.	Combretaceae
2	60.9	*Shoreaobtusa*Wall.exBlume	Dipterocarpaceae	73.9	*Dilleniaobovata*(Blume) Hoogland	Dilleniaceae
3	42.9	*Sindorasiamensis*Teijsm.andMiq.	Leguminosae	52.5	*Casearia grewifolia* Vent.	Flacourtiaceae
4	39.6	*Terminaliaalata*Heyne.ex Roth	Combretaceae	48.6	*Gardenia obtusifolia*Roxb. ex Kurz	Rubiaceae
5	35.7	*Diospyrosehretioides*Wall. ex G.Don	Ebenaceae	42.2	*Beilschmiediafagifolia*Nees	Lauraceae
6	19.2	*Terminaliamucronata*Craiband Hutch.	Combretaceae			
7	19.1	*Shoreasiamensis*Miq.	Dipterocarpaceae			
8	18.6	*Metadinatrichotoma* (Zoll. Ex Merr.) Bakh.f.	Rubiaceae			

Table-4
Species diversity of Shannon-Wiener Index

	Ground flora		Seedlings		Saplings	
	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt
Number of species	35	33	12	9	8	5
Species Diversity Index (H)	3.14	3.18	2.39*	2.10	2.02*	1.56
Evenness	0.88	0.91	0.96	0.96	0.97	0.97

*Significant difference at $p<0.05$

Table-5
Species richness of Menhinick's index

	Ground flora		Seedlings		Saplings	
	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt
Number of species (S)	35	33	12	9	8	5
Number of individuals (N)	72	83	65	66	11	7
Species richness (D)	4.1	3.6	1.5	1.1	2.7	1.9

Species Similarity: The species similarity was calculated using the Sorensen Index. The similarity of ground flora was 0.38; for the seedlings, the similarity was 0.29; for the saplings, the similarity was 0.15; and for trees the similarity was 0.38 as shown in table 6. The ground flora had higher similarity value compared to the other vegetation life forms.

Table-6
Species similarity by Sorensen index

	Ground flora	Seedlings	Saplings
Number of species in burnt area	35	12	8
Number of species in unburnt area	33	9	5
Number of species shared	13	3	1
Similarity	0.38	0.29	0.15

Soil properties: Soil samples were taken from two levels in both burnt and unburnt areas; 0-25 cm depth and 25-50 cm depth. The following soil elements were analysed; organic matter, pH, total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium, ash and moisture percentage. In burnt area, the pH, exchangeable potassium, exchangeable calcium, ash and moisture percentage were higher in the subsoil than surface soil. In unburnt area, organic matter, total nitrogen, available phosphorus, exchangeable calcium and ash percentage were higher in the surface soil than subsoil. Table 7 shows the quantities of the various soil elements that were analysed. In the deciduous dipterocarp forest at HuaiKhaKhaeng Wildlife Sanctuary, soil textures are sandy loam at the surface and sandy clay-loam in the subsurface horizons[16].

Wildlife Abundance: The Herbivores abundance was determined by calculating the dung density and pellet group density. The dung and pellet densities indicated that there were more herbivores in burnt area than in unburntarea as shown in table 8 below.

Table-7
Soilchemical properties

Parameters analyzed	Burnt area (0-25cm)	Unburnt area (0-25cm)	Burnt area (25-50cm)	Unburnt area(25-50cm)
pH (1:1)	5.51	5.1	5.5	5.53
Organic matter %	0.93	0.46	0.56	0.2
Total N	0.03	0.06	0.02	0.04
Available P (mg/kg)	5.96	64.48	3.26	42.74
Exchangeable K (mg/kg)	39.82	17.5	41.78	18.12
Exchangeable Ca (mg/kg)	263	72.88	304.2	40.42
Ash%	2.56	1.49	5.16	0.99
Moisture %	1.03	0.97	4.02	1.1

Table-8
Dung density and pellet group density

Species	Burnt Area	Unburnt Area
	Dung/Pellet density	Dung/Pellet density
Asian elephant (*Elephasmaximus*Linnaeus)	60 dung/ha*	30 dung/ha
Banteng (*Bosjavanicus*D'Alton)	80 dung/ha*	60 dung/ha
Gaur (*Bosgaurus*Smith)	0 dung/ha	0 dung/ha
Sambar deer (*Cervus unicolor* Kerr)	3250 pellet groups/ha*	500 pellet groups/ha
Common barking deer (*Muntiacusmuntjak* Zimmermann)	750 pellet groups/ha*	250 pellet groups/ha

*Significant difference at $p<0.05$

This study showed that effects of fire resulted in higher species composition for ground flora, which was shown by a higher species richness of ground flora in the burnt area compared to the unburnt area. Species composition of plants after fire disturbance was higher than in areas with no disturbance and this could be due to the emergence of new species[17]. In the study it was also observed that species richness in burnt area was higher for all the vegetation classes studied compared to the unburnt areas. The species richness index (Menhinick) was found to be high in the burnt area than in an unburnt area. Species richness was higher in burnt areas than in unburnt areas[18]. The understory fires are generally non-lethal to the dominant vegetation[6]. This could be the reason that in this study it was observed that in the five most dominant species of ground flora according to the importance value index, 2 species (*Heteropogontriticeus* and *Vetiverianemoralis*) appeared in both burnt and unburnt areas and three plant families (Gramineae, Compositae and Cyperaceae) were represented amongst the five most dominant families in both burnt and unburnt areas. In the five most important species of seedlings, 2 species (*Polyalthiadebilis*and *Dilleniaobovata*) appeared in both burnt and unburnt areas, and two plant families (Leguminosae and Dilleniaceae) were represented amongst the five most dominant families in both burnt and unburnt areas. Amongst the top five dominant species of saplings in burnt and unburnt area, there were no species that appeared in both areas; only 2 plant families (Combretaceae and Rubiaceae) were represented among the top ranked families in both burnt and unburnt areas. This shows that understory fire is non-lethal to the dominant vegetation.

The low ground flora species diversity in the burnt area could be due to the elimination of disturbance sensitive species. The elimination of disturbance sensitive species leads to a decrease in plant diversity[19]. The species similarity was very low in all the vegetation classes when calculated using the Sorensen's similarity index. The values are closer to zero. When the values are closer to zero than they are to one, the similarity is said to be low[13].

In this study it was found that the Asian elephants, banteng, Sambar deer and common barking deer were more abundant in burnt area than inunburnt area. The dung and pellet group densities were significantly higher in the burnt area than in unburnt area. The burnt area where the elephants had a higher density is dominated by grasses and is not very far from human settlements. Asian elephants prefer feeding on grass; they switch to browse when grasses are unavailable [20]. Banteng dung density was higher in the burnt area than in unburnt area.Banteng prefer more open areas, especially the plains or the deciduous forest[21]. Banteng prefer grasses and forbs which are abundant in the open canopy forests of the DDF[22]. The burnt area of the study site meets all the criteria mentioned by the authors; abundant grasses and forbs, open canopy. This results in high preference of the burnt area by the banteng. *Shoreaobtusa, Heteropogontriticeus, Imperatacylindrica*are amongst the major seasonal forage species eaten by banteng during the dry season[22]. In this study these plant species were found in a burnt area during the dry season where the banteng density was higher compared to the unburnt area. In protected forest areas of Thailand, the Sambar deer populations are often concentrated around anthropogenic grass and scrub, rather than the forest itself[23]. HKKWS is a protected area; the burnt area of the DDF consists of more grass species than unburnt area, which makes it more preferable to the Sambar deer hence the

higher abundance of the Sambar deer in burnt area than in unburnt area. The burnt area had more species of grasses compared to unburnt area. The common barking deer feeds on various grasses, buds, flowers and fruits[24]. This could be one of the reasons there is a high pellet density in the burnt area. The suitable habitats for the common barking deer comprise of forest gaps in the deciduous dipterocarp forest[5].In both burnt and unburnt areas, there was no dung of gaur found during the time of the study. This could be attributed to the position of the study area which was 500 m either side away from the road towards the HKKWS headquarters. There was very low density of Gaur in the study area compared to Sambar deer and banteng due to the vicinity of the road towards the headquarters of HKKWS[25]. The findings were similar to the findings of this study whereby there was no Gaur dung found whereas.

Conclusion

Fire has a positive effect on the species composition of the understory vegetation (ground flora, seedlings and saplings) in the DDF at HKKWS. There were more species of ground flora, seedlings and saplings in the burnt area compared to the unburnt area. The Menhinick's index showed that the species richness for the ground flora, seedlings and saplings was higher in the burnt area compared to the unburnt area. The dominant ground flora based on IVI values in burnt area was *Heteropogontriticeus* (30.1) in unburnt area *Polyalthiadebilis* (38.4). The dominant seedlings in burnt area were *Shoreaobtusa* (106.2) and*Polyalthiadebilis* (120.3) in unburnt area. The dominant saplings in burnt area were *Xyliaxylocarpa* (63.8) and *Terminaliamucronata* (82.3) in unburnt area. For ground flora; in both burnt and unburnt areas, the Gramineae family was the most dominant. *Imperatacylindrica*(L.)P.Beauv., was only found in burnt area.*Chromolaenaodorata*(L.) King and H. Rob which is an invasive species in Thailand was amongst the five most important species found in a burnt area in the Deciduous Dipterocarp Forest.

There was higher large herbivore abundance in burnt area than in unburnt area. The dung and pellet density showed that Asian elephants, banteng, Sambar deer and barking deer were more abundant in burnt area than in unburnt area. There was no indication of the presence of gaur in both burnt and unburnt areas, this could be attributed to the DDF not being a suitable habitat for gaur; they prefer the moist forest types. Gaur did not inhabit the study site.

References

1. Bunyavejchewin S, Barker P.J. and Davies S.J., Seasonally Dry Tropical Forests in Continental Southeast Asia, Structure, Composition, and Dynamics, The Ecology and Conservation of Seasonally Dry Forests in Asia, Smithosonian Institution Scholarly Press, Washington DC, **(2011)**

2. Wanthonchai K., Banhus J. and Goldammer J.G., Nutrient Losses Through Prescribed Burning of Above Ground Litter and Understory in Dry Dipterocarp Forest of Different Fire History, *Catera,* **74,** 321-332 **(2008)**

3. Wanthongchai K. and Goldammer J.G., Fire Management in South and Southeast Asia's Seasonally Dry Forests, Colonial Approaches, Current Problems and Perspectives, The Ecology and Conservation of Seasonally Dry Forests in Asia, Smithosonian Institution Scholarly Press, Washington DC, **(2011)**

4. Slik J.W.F., Verburg R.W. and Kebler P.J.A., Effects of Fire and Selective Logging on the Tree Species Composition of Lowland Dipterocarp Forest in East Kalamantan, Indonesia, *Biodiversity and Conservation,* **11,** 5-98 **(2002)**

5. Himmapan W., Boonyawat S. and Kaitpraneet S., Behaviour of Burning Fire in Dry Deciduous Dipterocarp Forest at the HuaiKhaKhaeng Wildlife Sanctuary, UthaiThani Province, *Thai Journal of Forestry,* **25,** 112-124 **(2006)**

6. Monroe M.E. and Converse S.J., The Effects of Early Season and Late Season Prescribed Fires on Small Mammals in a Sierra Navada Mixed Conifer Forest, *Forest Ecology and Management,* **236,** 229-240 **(2006)**

7. Himmapan W. and Kaitprancet S., Effect Of Burning Fire on Fuel Bed Properties in The Dry Deciduous Dipterocarp Forest at HuaiKhaKhaeng Wildlife Sanctuary, Uthai Thani Province, *Thai Journal of Forestry,* **27,** 107-119 **(2008)**

8. Smitinand T., Thai Plant Names, The Forest Herbarium, Royal Forest Department, Thailand, **(2001)**

9. Saravanan V., Shanthi R., Kumar R., Balasubramanian P.A. and Damodara A., Influence of Forest Fire on Flora Diversity of the Degraded Shola Forest Ecosystem, *International Research Journal of Biological Sciences*, **3(1),** 49-56 **(2014)**

10. Whittaker R.H., Communities and Ecosystems, Macmillan Co., Collier-Macmillan Ltd., London, **(1970)**

11. Shannon C.E.A., Mathematical Theory of Communication, *The Bell System Technical Journal*, **27,** 623-656 **(1948)**

12. Whittaker R.H., Evolution of species diversity in land communities, *Evolutionary Biology*, **10,** 250-268 **(1977)**

13. Sorensen T.A., Method of Establishing Groups of Equal Amplitude in Plant Sociology Based on Similarity of Species and its Application to Analyses of the Vegetation on Danish Commons, *Biologiske Skirifer,* **5,** 1-34 **(1948)**

14. Bhumpakphan N., Survey and Monitoring of the Wildlife in Western Forest Complex, Department of Forest Biology, Faculty of Forestry, Kasetsart University, Thailand , **(2003)**

15. Agyare W.A., Soil Characterization and Modeling of Spatial Distribution of Saturated Hydraulic Conductivity at Two Sites in the Volta Basin of Ghana, Ecology and Development Series, No. 17. Centre of Development Research, University of Bonn, **(2004)**

16. Bunyavejchewin S., La Frankie J.V., Baker P.J., Davies S.J. and Ashton P.S., Forest Trees of Huai Kha Khaeng Wildlife Sanctuary, Thailand, Data from 50 hectare Forest Dynamics Plot. National Parks, Wildlife and Plant Conservation Department Report, Bangkok, **(2009)**

17. Fang Y., Study on the Response of the Species Diversity of *Pinus Massoniana* Plantation to Fire Disturbance, *Journal of Agricultural Science,* **36(31),** 13629-13631 **(2008)**

18. Sutumo D. and Fardila D., Floristic Composition of Groundcover Vegetation after the 2010 Pyroclastic Fire on Mount Merapi, *JMHT,* XIX, **1,** 54-62 **(2013)**

19. Peterson D.W. and Reich P.W., Fire Frequency and Tree Canopy Structure Influence Plants Species Diversity in a Forest-grassland Ecotone. Plant Ecol, **194,** 5-16 **(2008)**

20. Sukumar R, The Living Elephants : Evolutionary Ecology, Behaviour and Conservation, Oxford University Press, New York, **(2003)**

21. Lekagul B. and McNeely J., Mammals of Thailand, 2nd edition. Bangkok, Thailand : Saha KarnBhaet Co, **(1988)**

22. Bhumpakphan N and Mc Shea W.J., Ecology of Gaur and Banteng in the Seasonally Dry Forests of Thailand, Smithsonian Institution Scholarly Press, Washington, D.C., **(2011)**

23. Black P.A. and Gonzalez S., *Muntiacusmuntjak*., Deer Red List Authority, The IUCN Red List of Threatened Species **(2008)**

24. Sukmasuang R., Ecology of Barking Deer (*Muntiacus*spp.) in HuaiKhaKhaeng Wildlife Sanctuary, Ph.D. Thesis. Kasetsart University, **(2001)**

25. Tapule W., Wildlife Responses to Design and Utilization of Road in Huai Kha Khaeng Wildlife Sanctuary, Master Degree Thesis, Kasetsart University, **(2005)**