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IMPACT OF DRY SEASON FIRE ON TREE DIVERSITY OF A TROPICAL DRY FOREST IN BANDIPUR NATIONAL PARK, SOUTH INDIA

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Abstract

A study was conducted at the tropical dry forest of Bandipur, south India, to understand the impact of dry season fire on survival and mortality of different species. A total of 4235 trees belonging to 66 species were enumerated in both burnt and un-burnt areas of Bandipur National Park. Standard vegetation indices were calculated to characterize the natural vegetation of the park. Of the total 2679 trees were recorded from burnt area. Fire resulted in mortality of 679 trees belonging to 33 species. *Tectona grandis* (Teak) suffered maximum mortality because of fire followed by *Anogeissus latifolia*. Large proportion of *Anogeissus latifolia* and *Terminalia crenulata* trees survived the fire. Mortality of different species was significantly related to the population sizes of each species and also the survival of each species. There was a disproportionate mortality across different size classes.

Key words: Tropical dry forest, Bandipur, tree diversity, fire, mortality, survival

Özet

Bu çalışmada Hindistan'ın güneyinde bulunan Bandipur bölgesindeki kurak tropikal ormanlarda, kurak mevsim yangınlarının farklı türlerin hayatta kalma performansları üzerindeki etkileri araştırılmıştır. Bandipur millî parkında yangın geçirmiş ve yanmamış alanlarda bulunan 66 türe ait 4235 ağaç numaralandırılmıştır. Millî parktaki doğal bitki örtüsünü tanımlamak için standart indislere başvurularak hesaplamalar yapılmıştır. Yangın geçirmiş alanda 2679 adet ağaç tespit edilmiştir. Yangın 33 türe ait 679 ağaç bireyini kurutmuştur. *Anogeissus latifolia*'dan sonra yanan *Tectona grandis* (Tik) türü yangından en fazla zarar gören tür olmuştur. *Anogeissus latifolia ve Terminalia crenulate* türlerine ait bireylerin çoğu yangından kurtulmuştur. Farklı türlere ait bireylerin hayatta kalma veya kalamamasının, her bir türe ait toplum büyüklüğü ve hayatta kalma gücüne anlamlı derecede bağlı olduğu tespit edilmiştir. Farklı büyüklüklerdeki bireyler arasında yaşamını yangın neticesinde yitirmeleri bakımından orantısızlık bulunduğu gözlemlenmiştir.

Anahtar kelimeler: Tropikal kurak orman, Bandipur, ağaç çeşitliliği, yangın, ölüm, hayatta kalma.

INTRODUCTION

Ever since early hunter and gatherer groups learnt to use the fire about 50, 000 years ago, fire has been an integral part of the human life (Gadgil and Meher-Homji 1985; Saha, 2003). Fires have been used extensively to clear forested landscapes for agriculture intentionally for example "Jhum" one of the slash and burn practice, is prevalent in northeast India, "podu" cultivation of ragi (*Eleusine corocana*) in south India to raise teak plantations after clearing forests. There could be accidental fires due to usage of forests. The incidences, intensity and scale of destruction by natural fires probably because of lightening are still largely unknown. However, in peninsular India the fires are attributed to humans. It is argued that fragmentation of landscapes and expansion of agriculture has made forested landscapes more prone to fire incidences (Gadgil & Guha, 1993, Kodandapani et al 2004).

Fire as a natural disturbance factor in dry forests is a matter of debate; however, it is argued that dry forests did not evolve under selection pressure of fire (Saha & Howe 2001; Saha 2002). Human induced fires are said to cause savannization of forested landscapes by hampering regeneration of species and altering the structure of forests (Saha 2001; Saha & Howe 2006). Wild fires are characterized by intensity, residence time and return interval. Each of these factors has significant influence on the vegetation. Nature and characteristics of the fire depends on the local weather conditions.

Fires in Indian context have been used in the past as a management regime to stimulate germination of important timber species such as teak (*Tectona grandis*) and sal (*Shorea robusta*). However, our understanding on the impacts of dry season fire is limited. Studies on wildfire have focused on extent and damage in an area (Somashekar et al 2009), fire regimes (Saha 2002), impact on diversity by causing seedling mortality and enhancing clonal propagation (Saha & Howe 2003), increasing fire frequencies across peninsular India (Kodanpani et al 2004) and ecological characteristics of dry season fires (Kodandapani et al 2008). The impact of dry season fire on forest dynamics is being carried out in dry forests of Mudumalai by research team from Indian Institute of Science (Sukumar et al 1998, 2005)

The objective of this current study is to understand the impact of canopy fire that swept through some parts of Bandipur National Park. Specifically we ask following questions 1.What is the observed mortality pattern? 2. How many species survived the fire? 3. Is there a size class specific mortality because of fire?

MATERIALS AND METHODS

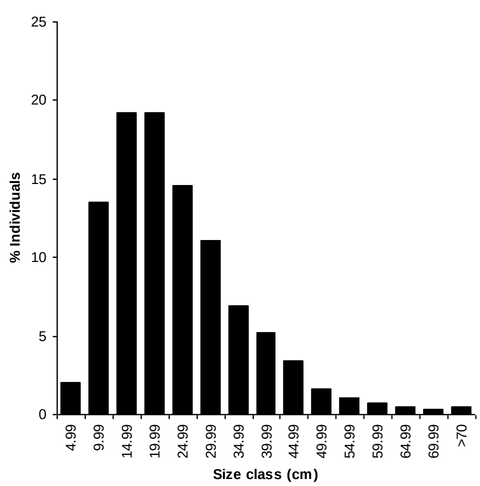
Site description

Present study was carried out in Bandipur National Park (BNP) (11°35'N -11°58 N latitude, 76°12' E -76°53' E longitude). BNP was declared tiger reserve in 1972 and it is a national park. BNP was included in Nilgiri Biosphere Reserve (NBR), the country's first biosphere reserve in 1986. BNP has to the north the dry Deccan plateau, to the west it has Nagerhole National Park, to the east is a conglomeration of settlements and forest while to the south it has Mudumalai Tiger Reserve (Tamilnadu). Topography is generally undulating with elevations ranging from 700 meters ASl to 1450 meters ASL (Gopalaswamy betta) with a deep gorge towards south-east of the park that is a political boundary between Karnataka and Tamilnadu. Perennial rivers that drain the park are the Moyar and the Kabini. Geologically BNP is classified under granite-gneiss complex of the Archean group with chief rocks being gneiss, granites and charnockites Climate is tropical savanna, hot and seasonally dry tropical in nature with distinct wet and dry seasons (IMD, 1984). . It has temperature ranging from 10° C during the cold season to 35° C during the hot season. Rainfall is mostly from southwest monsoon during the months of June-September. Retreating monsoon is active during October-November that brings rain to the eastern part. Rainfall in the park varies from 800 to 1600 mm per annum. Because of topography there is a distinct rainfall gradient along east (dry) and west (wet) direction. Hence the vegetation also varies along this direction with tropical moist deciduous forests (west) to tropical dry thorn forests (east) through tropical dry deciduous forests largely in the central part of the park. Largely vegetation of BNP has been classified as woodland – savanna type under broad category of tropical dry deciduous forest (teak dominated). Vegetation is characterized by *Anogeissus-Tectona-Terminalia* association (Pascal 1982). Floristics of the park is dominated by species such as *Anogeissus latifolia, Terminalia crenulata*, *Tectona grandis*. Other important canopy trees include *Pterocarpus marsupium*, *Dalbergia latifolia, Shorea roxburghii* (only dipterocarp in dry forest), *Stereospermum personatum* and *Adina cordifolia*. The understorey include species such as *Cassia fistula, Phyllanthus emblica*, and *Kydia calycina*. Ground flora is dominated by tall perennial grass species such as *Themeda cymbaria, Themeda triandra, Cymbopogon flexosus* and *Imperata cylindrica*. Herbaceous species include several species belonging to families such as Fabaceae, Lamiaceae and Apiaceae. (Prasad & Sharatchandra, 1994; Prasad 2009). Quantitative description of the vegetation is given in (Mehta et al. 2008a). Detailed description of the study area is given in (Somashekar et al. 2009; Mehta et al. 2008 b; Puyravaud et al. 1992; Prasad & Hedge 1986; Sharatchandra & Gadgil 1977).

We followed plot less method for enumeration. We enumerated trees >1 cm dbh (diameter at breast height) in both burnt and un-burnt areas. We decided the perimeter of the burnt area with help of trees having distinct signs of burning and also with local knowledge of forest guards and watchers. We enumerated trees for the species, measured their sizes and estimated their heights qualitatively. Cause of the death was ascertained after inspection of trees for fire marks, elephant debarking or other symptoms. The causes were classified as fire related mortality; elephant related mortality and all others were put in other causes. Data was also kept on trees that survived the fire.

RESULTS

A total of 4235 trees belonging to 66 species were enumerated from both burnt and un-burnt areas in the national park. Community wide measure of heterogeneity (Shannon-Weiner's (H') index) was 2.46 and probability of picking two species (Simpson's index) was 0.81. Fisher's alpha was 11.1. Evenness and dominance of a particular species were low indicating multi-species dominance in the forest. Most abundant species was *Anogeissus latifolia* (37.45%), followed by *Tectona grandis* (13.93%) and *Terminalia crenulata* (11.33%). These three species accounted for a total of 62.7% of total abundance. Top ten species accounted for 83% of the total abundance (Table 1). There were twelve species with one individual each. Overall size class distribution of individuals showed a typical inverted "J" distribution (Fig. 1). There 80% of individuals below 30 cm DBH and there was large concentration of individuals between 5-25 cm dbh (67%) suggesting that BNP is relatively a young or recovering(secondary) forest. There was only 1.2% of individuals which were above >60 cm dbh. There were large numbers of individuals in 6-8 meter height class (21%).



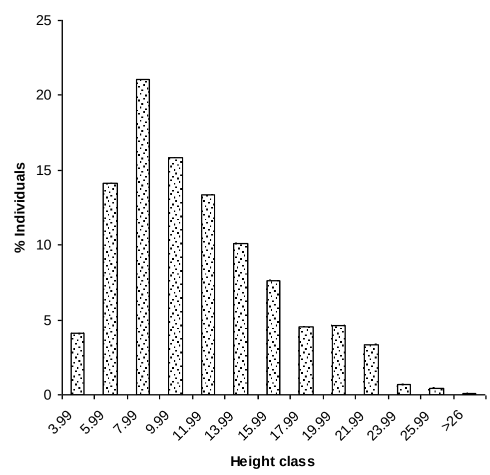


Figure 1. Community wide distribution of individuals in various size classes at Bandipur National Park.

Figure 2. Height class distribution of Individuals in BNP

Table 1. Abundabces of top ten species in BNP

Sl. No	Species (Family)	Number of Individuals	Relative abundance (%)	Cumulative Abundance (%)
1	*Anogeissus latifolia* (Combretaceae)	1586	37.44	37.44
2	*Tectona grandis* (Verbenaceae)	590	13.93	51.38
3	*Terminalia crenulata* (Combretaceae)	480	11.33	62.71
4	*Phyllanthus emblica* (Euphorbiaceae)	314	7.41	70.12
5	*Shorea robusta* (Dipterocarpaceae)	133	3.14	73.27
6	*Shrebera switenioides* (Oleaceae)	103	2.43	75.70
7	*Terminalia chebula* (Combretaceae)	103	2.43	78.13
8	*Grewia tiliifolia* (Tiliaceae)	85	2.00	80.14
9	*Lagerstroemia parvifolia* (Lythraceae)	68	1.60	81.74
10	*Dalbergia lanceolaria* (Fabaceae)	55	1.28	83.04

About 75% of the stand was between 4 and 14 meter height. There were about 4% of trees above 20meters in height (Fig. 2).As the enumeration did not assume any dimension; we are expressing the basal area as per tree basis. The total basal area was 213.2 m² from 4406 individuals that were enumerated resulting in 0.048 m² per tree. But this number varies between size classes. For example trees in 25-30 cm dbh class which accounts for 11.09% of total stand accounts for 13.5% of total basal area resulting in 0.0589 m² per tree. But trees above 70cm dbh which accounts for 0.4% of total stand had 5.4% of the total basal area resulting in 0.52m² per tree.

A total of 2679 trees belonging to 65 species were enumerated in the burnt area. A total of 679 (25.3%) trees belonging to 33 species found dead because of fire. *Anogeissus latifolia* (26.7%) and *Tectona grandis* (55.5%) suffered maximum mortality (Table 2). There were 68 (2.53%) trees dead because of "other causes" and elephants. There were 841 (31.3%) trees survived after they were impacted by fire. None of the species recorded 100% mortality. The survival rates varied across species for example species such as *Cordia obliqua, Hyminodictyon orixense, Schleichera oleosa, Scherebera switeniodes*, *Stereospermum personatum* and *Radermachera xylocarpa* had more than 50% survival rate while species such as *Anogeissus latifolia* had 29.6% and *Tectona grandis* 33.5% as the survival rate (Table 2). A total of 40.7% (1091 trees) trees were not affected by fire. Species such as *Boswelia serrata, Fluggea leucopyros and Phyllanthus indofischeri* were not impacted by fire at all (Table 2). Among the dominant species such as *Anogeissus latifolia, Tectona grandis* and *Terminalia crenulata* 41.1%, 7.6% and 48.2% of the population was not impacted by fire.

Table 2. Survival and mortality of species impacted by dry season fire in BNP.

Sl. No	Species (Family)	Number of Individuals	Mortality (%)	Survival after fire (%)
1	Anogeissus latifolia (Combretaceae)	991	26.74	29.96
2	Tectona grandis (Verbenaceae)	394	55.58	33.5
3	Terminalia crenulata (Combretaceae)	255	20.78	29.80
4	Phyllanthus emblica (Euphorbiaceae)	174	18.96	16.66
5	Shorea roxburghii (Dipterocarpaceae)	1	100	0
6	Shrebera switenioides (Oleaceae)	9	11.11	88.88
7	Terminalia chebula (Combretaceae)	52	7.96	23.07
8	Grewia tiliifolia (Tiliaceae)	59	3.38	11.86
9	Lagerstroemia parvifolia (Lythraceae)	73	24.6	26.02
10	Dalbergia lanceolaria (Fabaceae)	55	0	4.54
11	Randia dumetorum (Rubiaceae)	50	22.0	24.0
12	Cassia fistula (Fabcaeae)	36	16.6	44.4
13	Pterocarpus marsupium (Fabcaeae)	35	20.0	20.0
14	Ziziphus xylopyrus (Rhmnaceae)	28	10.71	25.0
15	Bridelia retusa (Euphorbiaceae)	35	20.0	20.0
16	Stereospermum personatum (Bignoniaceae)	38	15.78	71.05
17	Premna tomentosa (Verbenaceae)	37	0.0	45.94
18	Terminalia paniculata (Combretaceae)	11	9.09	18.18
19	Hyminodiction orixense (Rubiaceae)	30	23.33	73.33
20	Schleichera oleosa (Sapindaceae)	27	7.40	92.59
21	Bauhinia racemosa (Fabaceae)	25	0	36.0
22	Cassine glauca (celastraceae)	26	15.38	23.07
23	Cordia obliqua (Boraginaceae)	26	19.23	11.53
24	Cordia wallichii (Boraginaceae)	12	16.66	83.33
25	Grewia sp. (Tiliaceae)	20	0	10.0
26	Careya arborea (Lecythidaceae)	12	16.66	25.0
27	Diospyros montana (Ebenaceae)	18	22.22	33.33
28	Randia tamilnadensis (Rubiaceae)	1	0	0
29	Vitex altissima (Verbenaceae)	15	20.0	13.33
30	Dalbergia latifolia (Fabcaeae)	10	30.0	40.0
31	Radermachera xylocarpa (Bignoniaceae)	12	8.33	66.66
32	Erythroxylon monogynum (Linaceae)	12	0	0
33	Butea monosperma (Fabaceae)	8	0	0
34	Cassia spectabilis (Fabaceae)	8	12.5	87.5

35	Acacia chundra (Fabaceae)	7	14.28	0
36	Semecarpus anacardium (Anacardiaceae)	3	0	33.33
37	Bombax cieba (Bombacaceae)	6	0	83.33
38	Mitragyna parviflora (Rubiaceae)	6	0	100
39	Stereospermum atrovirens (Bignoniaceae)	6	16.66	0
40	Cordia obliqua (Boraginaceae)	26	19.23	11.53
41	Ficus benghalensis (Moraceae)	4	0	50
42	Plurostylis (Celastraceae)	1	100	0
43	Cipadessa baccifera (Meliaceae)	4	75.0	25.0
44	Erioleana quinquilocularis (Sterculiaceae)	4	50.0	50.0
45	Casearia esculenta (Flacourtiaceae)	2	0	100
46	Givotia rottleriformis (Euphorbiaceae)	3	0	33.33
47	Maytenus emarginata (Celastraceae)	3	0	0
48	Acacia leucophloea (Fabaceae)	2	0	50
49	Boswelia serrata (Burseraceae)	2	0	0
50	Garuga pinnata (Burseraceae)	2	0	100
51	Gmelina arborea (Verbenaceae)	1	0	0
52	Madhuca neeriifolia (Sapotaceae)	2	0	50
53	Moringa (Moringaceae)	2	0	0
54	Phyllanthus indofischeri (Euphorbiaceae)	2	0	0
55	Albizia odoratissima (Fabaceae)	2	0	100
56	Antidesma menasu (Euphorbiaceae)	-	-	-
57	Bauhinia malabarica (Fabaceae)	2	0	50
58	Buchanannia lanzan (Ancardiaceae)	1	0	100
59	Flacourtiaceae indica (Flacourtiaceae)	1	0	100
60	Fluggea leucopyros (Euphorbiaceae)	1	0	0
61	Gyrocarpus jacqinus (Hernandiaceae)	1	0	0
62	Lannea coromandelica (Anacardiaceae)	1	2	100
63	Morinda tinctoria (Apocyanaceae)	2	0	0
64	Syzygium cumini (Myrtaceae)	-	-	-
65	Terminalia bellerica (Combretaceae)	1	0	100

Mortality of trees because of fire across various species was significantly related to population sizes of species in the stand ($r = 0.94$, $p>0.0001$) also the survival of trees after fire ($r = 0.99$, $p>0.0001$) and trees not affected by fire ($r = 0.94$, $p>0.0001$) was significantly related to population sizes of various species. Percent mortality of species because of fire and their survival percent were not related ($r = -0.21$, $p>0.08$), however, there was a negative trend. Trees between 10 and 25 cm dbh class suffered high mortality which accounted for 46% of the total mortality (Fig. 3). The mortality across size classes was significantly different from stand. There is a disproportionate mortality across size classes (KS test, D = 0.7272, p<0.01). Survival of trees across various size classes was also significantly different from the stand (KS test, D = 0.6363, p<0.02). Large proportions of trees were not affected by fire in less than 5 cm dbh class. But among trees in 20 – 50 cm size class there was high mortality between 30% and 40% observed.

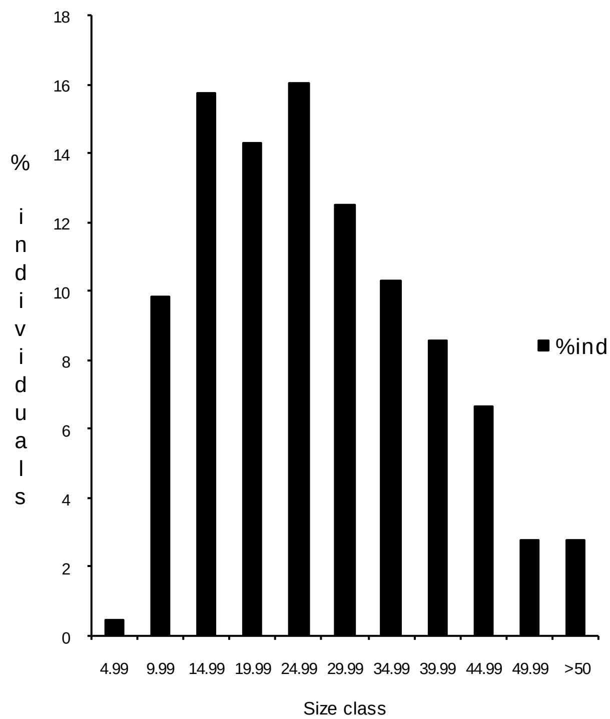


Figure 3. Mortality of individuals in different size classes

Among trees over 50 cm dbh class, though many of them were impacted by fire and large number of them (>70%) survived after a mega fire. Large numbers of trees were not affected by fire in the 5 to 25 cm dbh class.

DISCUSSION

Anthropogenic fires in dry forests of India are a regular event. These forests have experienced the fire for thousands of years (Gadgil & Chandran 1988). These fires are set for different reasons including facilitation of NTFP collection. The ecology of dry season ground fires in dry forests of India are yet to be studied in depth, However, there are studies in central and south India in this direction. Saha (2002) has characterized the intensity of fire in dry forests of central India through temperature as a proxy. She found that the temperature of dry season fire ranged from 316° C to 510 ° C during April and <45°C to 510 °C in March fires. Temperatures of fire varied from 79°C to 760° C in dry forests of south India but, mostly around 500° C in many cases (Mondal pers.comm). Intensity of fires depends on the spatial variation in fuel load and local weather conditions of that day. Saha (2002), has characterized the fire return interval of one year for central Indian dry forests. Kodandapani et al. (2004), has estimated fire return interval for dry forests in south India to be 3.3 years and has found that this interval is increasing over the last century. These factors that characterize the dry season fires, ultimately suggested to affect the diversity and structure of forests (Saha & Howe 2001; 2009)

Forest fires in BNP have not been characterized except for the spatial extent of spread and identification of fire prone areas with satellite images (Somashekar et al. 2009). Puyravaud et al. (1995), did report that less fire prone area had high tree density and high fire prone area had low tree density. Low tree density plots also suffered high sapling mortality though the regeneration was high. Our study however focused on impacts of canopy fire that spread through after a long years of protection from fire.

An overall mortality of 25% of standing stems from the past three fires is on the higher side compared to mortality figures reported from dry forests of Mudumalai (Sukumar et al. 1998; 2005). Mortality figures for dry forests of Mudumalai for stems >1cm dbh is 7.62±4.84 (4.04 – 16.27, N= 6) during the fire years.(Sukumar et al. unpublished results from 50 ha plot (1988-2008) , fire years were 1989, 91,92,95,96, 2002) while for the stems between 10 cm to 30 cm dbh it was 0.59±0.41(0.197- 1.397) and for stems>30 cm it was 0.16±0.137(0.00 – 0.356). Species such as *Anogeissus latifolia* and *Tectona grandis* suffered high mortality. Mortality was also proportional to density of each species.

It is suggested that dry season fires reduces the diversity of forests by killing saplings and additionally suppresses the growth of saplings so as to alter the structure of the forest(Saha & Howe 2003; 2009). This prompts us to ask the question whether there is a change in the diversity of BNP landscape after the fire and is there a compositional shift in terms of abundance pattern of at least dominant species? There was a small change in absolute number of species after the fire. Species number reduced from 65 to 63 species by loosing *Shorea roxburghii* (Dipterocarpaceae) and *Pleurostylis wightii* (Ceastraceae). There is a slight increase in the heterogeneity of the system from 2.54 to 2.67 which may not be significant. There was no compositional change and minor change in the abundance pattern of species. In both cases *Anogeissus latifolia*, dominated the floristics. However there is shuffle in the ranks of some species. For example, *Tectona grandis* which ranked second before fire with a loss of 58.8% of its population, was the third abundant species after fire. *Terminalia crenulata* with a loss of 21.9% of the population became the second abundant species after fire (Table 3). Most species have shown declining trend in the population. Among the abundant species large change was seen in *Tectona grandis* (-58.8%), followed by *Anogeissus latifolia* (-28%), *Lagerstroemia parviflora* (-26%). The species that have shown either low or no changes were *Premna tomentosa* (0%), *Grewia tiliifolia* (3%) and *Dalbergia lanceolaria* (1.18%). At this stage it is not possible to speculate the reasons for their decline. There could be plethora of explanations including both biological and environmental factors. The speculated compositional and diversity changes may require long-term observations and even with 24 years of study on dynamics of dry forests, there was no shift observed in the floristic composition of dry forests in Mudumalai (Sukumar et al. unpublished results).

Table 3: Changes in the abundance and ranks in several species impacted by dry season fire in BNP.

Species	Abundance prior to fire	Abundance after fire	% Change	Rank before fire	Rank after fire
Anogeissus latifolia (Combretaceae)	991	705	-28.85	1	1
Terminalia crenulata (Combretaceae)	255	199	-21.96	3	2
Tectona grandis (Verbenaceae)	394	162	-58.88	2	3
Phyllanthus emblica (Euphorbiaceae)	174	136	-21.83	4	4

Grewia tiliifolia (Tiliaceae)	59	57	-3.38	6	5
Lagerstroemia parvifolia (Lythraceae)	73	54	-26.02	5	6
Dalbergia lanceolaria (Fabaceae)	55	54	-1.81	7	7
Terminalia chebula (Combretaceae)	52	48	-7.69	8	8
Premna tomentosa (Verbenaceae)	37	37	0	11	9
Randia dumetorum (Rubiaceae)	50	33	-34.0	9	10
Stereospermum personatum (Bignoniaceae)	38	31	-18.4	10	11
Cassia fistula (Fabcaeae)	36	29	-19.44	12	12
Bridelia retusa (Euphorbiaceae)	35	29	-17.14	13	13
Schleichera oleosa (Sapindaceae)	27	25	-7.40	17	14
Ziziphus xylopyrus (Rhmnaceae)	28	24	-14.28	16	15
Pterocarpus marsupium (Fabcaeae)	35	23	-34.28	14	16
Hyminodiction orixense (Rubiaceae)	30	23	-23.33	15	17
Bauhinia racemosa (Fabaceae)	25	23	-8.0	20	18
Cassine glauca (celastraceae)	26	22	-15.38	19	19
Grewia sp. (Tiliaceae)	20	20	0.0	21	20
Cordia obliqua (Boraginaceae)	26	17	-34.61	18	21
Diospyros montana (Ebenaceae)	18	13	-27.77	22	22
Vitex altissima (Verbenaceae)	15	12	-20.0	23	23
Erythroxylon monogynum (Linaceae)	12	12	0.0	26	24
Radermachera xylocarpa (Bignoniaceae)	12	11	-8.33	27	25
Careya arborea (Lecythidaceae)	12	10	-16.66	24	26
Cordia wallichii (Boraginaceae)	12	10	-16.66	25	27
Terminalia paniculata (Combretaceae)	11	10	-9.09	28	28
Shrebera switenioides (Oleaceae)	9	8	-11.11	30	29
Butea monosperma (Fabaceae)	8	8	0.0	31	30
Cassia spectabilis (Fabaceae)	8	7	-12.5	32	31
Dalbergia latifolia (Fabcaeae)	10	6	-40.0	29	32
Acacia chundra (Fabaceae)	7	6	-14.28	33	33
Bombax cieba	6	6	0	34	34

(Bombacaceae)					
Mitragyna parviflora (Rubiaceae)	6	6	0	35	35
Stereospermum atrovirens (Bignoniaceae)	6	5	-16.66	36	36
Ficus benghalensis (Moraceae)	4	4	0	40	38
Givotia rottleriformis (Euphorbiaceae)	3	3	0	42	39
Maytenus emarginata (Celastraceae)	3	3	0	43	40
Semecarpus anacardium (Anacardiaceae)	3	3	0	44	41
Erioleana quinquilocularis (Sterculiaceae)	4	2	-50.0	39	42
Plurostylis (Celastraceae)	4	2	-50.0	41	43
Acacia leucophloea (Fabaceae)	2	2	0.0	45	44
Albizia odoratissima (Fabaceae)	2	2	0.0	46	45
Bauhinia malabarica (Fabaceae)	2	2	0.0	47	46
Boswelia serrata (Burseraceae)	2	2	0.0	48	47
Casearia esculenta (Flacourtiaceae)	2	2	0.0	49	48
Garuga pinnata (Burseraceae)	2	2	0.0	50	49
Moringa (Moringaceae)	2	2	0.0	53	51
Phyllanthus indofischeri (Euphorbiaceae)	2	2	0.0	54	52
Cipadessa baccifera (Meliaceae)	4	1	-75.0	38	53
Madhuca neeriifolia (Sapotaceae)	2	1	-50.0	52	54
Buchanannia lanzan (Ancardiaceae)	1	1	0	55	55
Flacourtiaceae indica (Flacourtiaceae)	1	1	0	56	56
Fluggea leucopyros (Euphorbiaceae)	1	1	0	57	57
Gyrocarpus jacqinus (Hernandiaceae)	1	1	0.0	58	58
Lannea coromandelica (Anacardiaceae)	1	1	0.0	59	59
Gmelina arborea (Verbenaceae)	1	1	0.0	60	60
Randia tamilnadensis (Rubiaceae)	1	1	0.0	63	62
Terminalia bellerica (Combretaceae)	1	1	0.0	65	63
Shorea roxburghii	1	0	-100	64	64

(Dipterocarpaceae)					

The compositional changes may be brought out by repeated top killing of seedlings (Saha & Howe 2006; Geeta Ramaswami pers. comm.). Repeated fires could also result in structural modification by stunting the trees.
Canopy fires in BNP though resulted in large scale population change, there was no drastic change in either diversity or composition was observed. Large number of individuals survived after a major fire indicating the resilience of the dry forests. We need long-term studies on fire-forest interaction to understand the long-term impacts of repeated burning on the diversity and compositional changes in dry forests. There should be pragmatic and area specific policy on dry season fires in the country.
But we can expect structural changes in the forests of BNP. The conspicuous absence of individuals in the lower size classes may possibly be attributed to frequent ground fires and occasional canopy fires that sweeps through the forests. These speculations could be strengthened by long-term observations on incidences of fire and response of the vegetation.

CONCLUSIONS

The central zone of the BNP is *Anogeissus latifolia* dominated forest with propensity to dry season fire. The diversity and structure of the forest is comparable to other dry forests in India. The big fire has resulted in 25% of the trees dead and 41% of the trees not affected at all. There was considerable proportion of trees survived after the fire. *Anogeissus latifolia* and *Tectona grandis* suffered maximum mortality because of fire. Each species had differential rates of survival after the fire.

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