

REGENERATION STATUS AND SPECIES DIVERSITY ALONG THE FIRE GRADIENTS IN TROPICAL DECIDUOUS FOREST OF CHHATTISGARH

M. K. Jhariya* and P. R. Oraon

Department of Forestry, College of Agriculture, I.G.K.V., Raipur (Chhattisgarh)

*Author for correspondence: manu9589@gmail.com

Abstract: The present work aimed to study the impact or behavior of forest fire on regeneration status and diversity indices. Four sites were selected; in each of these sites pre-fire and post-fire observation were taken for measuring varying degree of disturbances. A total of 19 seedlings species were recorded during pre-fire season and 14 seedlings species were recorded during post-fire season, respectively. Along the fire gradients the tree species exhibited highest density of seedlings in low fire zone. It showed that non-fire zone contained more species as compared to burnt areas. The diversity pattern showed that the medium fire zone had maximum diversity followed by non-fire zone, whereas low fire zone had minimum Shannon index. Seedling density drastically reduced after post-fire (27.63%). In the high fire zone the seedling layer was much affected which will result discontinuation of conversion into sapling with the progress of time and ultimately the gap in the regeneration status.

Keywords: Diversity, Forest fire, Pre-fire, Post-fire, Regeneration

INTRODUCTION

Fire has been a part of the co-evolution of seasonally dry-forests and grasslands across the globe (Keeley and Bond, 1999). Forest fires cause enormous loss to the forest ecosystem, diversity of flora and fauna, and economic wealth. In India, out of 67.5 million ha of forests, about 55% of the forest cover is being annually subjected to fires (Gubbi, 2003). In accordance with positive attributes that fire enhances the productivity of ecosystems by releasing chemicals and nutrients locked up in the old herbage, but the uncontrolled fire destructs the micro-flora and micro-fauna in the top soil and litter layers in forests could have impacts on the organic decomposition and soil fertility (Kodandapani, 2001). Indian forests are burnt every summer, as it is believed to encourage the growth of succulent fresh grasses after the first rains. The forests are also burnt for collecting non-timber forest products, hunting and various other reasons. Very few studies that are available from Indian forests report that fires mostly affect ground vegetation. The findings of the present study will help to researcher, ecologist and foresters to work in other localities of the same area. Therefore, the present study was undertaken to investigate the impact of forest fire on regeneration status and diversity of different forest fire sites.

MATERIAL AND METHOD

The present study was conducted at Boramdeo Wildlife Sanctuary of Kawardha Forest Division in Chhattisgarh, Central India, after the repeated reconnaissance survey of Boramdeo Wildlife Sanctuary. The study area is located between 21° 23' - 22° 00' North latitude and 80° 58' - 82° 34' East longitude. The entire area of Boramdeo Wildlife Sanctuary is located in the Maikla Range of the Satpura hills. Total four sites (High, medium, low and non-fire zone) were selected; in each of these sites

pre-fire and post-fire observation were taken for measuring varying degree of disturbances. The disturbance gradients (forest fire zones) were categorized by historical data taken from forest department.

The vegetation data were collected was analysed in different fire zones (i.e., high, medium, low and non-fire zone). A quadrat, of 5 x 5 m size was randomly laid for measuring seedling. The seedlings (<10 cm GBH) were measured at the collar height. Vegetational data were quantitatively analysed for frequency, density, abundance (Curtis and McIntosh, 1950). The relative frequency, relative density and relative basal area values were calculated following Phillips (1959). Regeneration status of species was totally based on population size of the seedlings and saplings (Khan *et al.*, 1987). Good regeneration if seedlings > saplings > adults; fair regeneration, if seedlings > or ≤ saplings ≤ adults; poor regeneration, if the species survives only in sapling stage, but no seedlings (saplings may be <, > or = adults). If a species is present only in adult form it is considered as not regenerating. Diversity indices were calculated following Sagar and Singh (1999).

RESULT AND DISCUSSION

During pre-fire in low and non-fire zone recorded similar number of seedling species (13 species) but the density was slightly higher (13680 individuals ha⁻¹) in low fire zone (Table 1) as compared to non-fire zone (12720 individuals ha⁻¹). The basal area also showed the similar trend. High fire zone recorded the lowest number of species (7) having the density of 10400 individuals ha⁻¹, whereas the medium fire zone showed a slight increase in species number (9) and density (10960 individuals ha⁻¹) as compared to high fire zone. The variability was noticed in the Shannon index from site to site in the study area of Boramdeo Wildlife Sanctuary. The seedling layer showed the highest Shannon index values recorded for medium

fire zone (2.80) followed by low fire zone (2.70), non-fire zone (2.47) and high fire zone (2.10). The Cd value was highest for high fire zone (0.29) followed by non-fire (0.25), low fire (0.22) and medium fire zone (0.17) whereas highest species richness values were recorded by low and non-fire zones (1.26 for both). The equitability (e) value was ranged from 0.96 to 1.27 across the fire zones. The lowest value of beta diversity was found under high fire zone. As far as the regeneration status concerned during pre-fire the species achieved 60% good regeneration under the low fire zone followed by non-fire, moderately fire and high fire zone. Few species was not regenerating at all (Table 3-7).

The total density of seedlings during post-fire season across the fire zones were ranged from 6800 to 10480 ha⁻¹. The high fire zone was recorded minimum density and number of species during both the season. Basal area value was drastically reduced after the fire as compare to pre-fire season. The value of Shannon index (Table 2) were ranged from 2.56 to 2.77, equitability 1.05 to 1.23, species richness 0.79 to 1.19, concentration of dominance 0.19 to 0.22 and beta diversity 1.16 to 1.75.

The high fire zone showed lower number of tree species as compared to non-fire zone. Kafle (2004) also reported that protected area (non-fire zone) also supports greater tree population as compared to fire affected areas. This might be happen due to repeated frequency and intensity of high fire disturbances during past whereas in medium and low fire zones, the number further declined as compared to non-fire zone therefore, the non-fire zone supported higher tree density. Kodandapani *et al.* (2008) have also reported the similar trend in his study while comparing the spatial, temporal and ecological characteristics of forest fires in the dry tropical ecosystem in the Western Ghats. Joshi (1990) observed higher values of seedling density on burned sites as compared to unburnt stand. The low fire zone supported highest number of seedlings ha⁻¹ as compared to other fire zones. This result can be correlated to the effects of fire on juvenile die back. Several juvenile escaped from fire did not undergo stem die back, they exhibit height and growth patterns similar to unburnt seedlings (Saha, 2002). According to Kodandapani (2001) fire enhances the productivity of ecosystems by releasing chemicals and nutrients locked up in old herbage this results to regeneration of seedlings benefited from forest fire. The density values of seedlings and saplings are considered as regeneration potential of the species. The presence of good regeneration potential shows suitability of a species to the environment. Climatic factors and

biotic interference influence the regeneration of different species in the vegetation across the different fire zones with varying degree of fire intensity and frequency. Higher seedling density values get reduced to sapling due to the biotic or anthropogenic disturbance and due to the competition for the resource utilizations. There are three major components which cause the success of regeneration of the tree species. These are the ability to initiate new seedlings, ability of seedlings and saplings to survive and the ability of seedlings and saplings to grow in the given site in a specific period of time (Good and Good, 1972).

Shannon index for seedling layer were ranged from 2.10 to 2.80, equitability 0.96 to 1.27, species richness 0.64 to 1.26, concentration of dominance 0.17 to 0.29 and beta diversity 1.46 to 2.71. This result also supports the findings made by Naidu and Sribasuki (1994) that young plants are more badly affected by fires than mature one. The lesser diversity in the frequent fire occurring dry deciduous forest leading to nonspecific forests, frequent fires could also lead to stands where most trees are even aged (Kodandapani 2001). Kafle (2004) reported that the protected area supported greater number of ground flora species. However, the burnt area contained higher species diversity and evenness indices than the protected area intotal.

CONCLUSION

The results on regeneration of tropical deciduous forests of the study area clearly demonstrated that density of seedlings as well as number of species decreased in high fire zone during pre-fire and post-fire season due to repeated frequency and high intensity of the fire in such area. In the high, medium and non-fire zone of post-fire season the regeneration of species also decreased, where as in low fire zone its density was increased due to reduction of competition and providing the clean bed to the growing ones. Due to severe fire, reduction of density may recorded in different gradient, if this type of anthropogenic pressure continues there is more threat to these forests in terms of species richness and there may be also possibility of invasion of exotic species to the fragile ecosystem. There is urgent need for management strategies to these forests is dependent on costs and ease at which they can be implemented and the benchmark we want to achieve. So as a first step, setting up an ecological reference level at which the landscape will be managed needs to be established based on scientific studies.

Table 1. Regeneration of species in different fire zones during the pre-fire and post-fire season in Boramdeo Wildlife Sanctuary.

Species	Pre-fire season				Post-fire season			
	High Fire Zone	Medium Fire Zone	Low Fire Zone	Non-Fire Zone	High Fire Zone	Medium Fire Zone	Low Fire Zone	Non-Fire Zone
<i>Anogeissus latifolia</i> Wall ex Bedd.	--	+	+	+	+	+	+	+
<i>Buchanania lanzan</i> Spreng.	+	--	+	+	+	+	+	+
<i>Butea monosperma</i> (Lamk) Taub.	--	--	--	--	+	--	--	--
<i>Casearia graveolens</i> Dalz.	+	+	+	+	--	--	--	--
<i>Cassia fistula</i> Linn.	--	+	--	+	+	+	+	+
<i>Chloroxylon swietenia</i> D.C.	--	+	--	--	--	--	--	--
<i>Dalbergia paniculata</i> Roxb.	--	+	--	--	--	--	--	--
<i>Diospyros melanoxylon</i> Roxb.	+	+	+	+	+	+	+	+
<i>Grewia tiliaefolia</i> Vahl.	--	--	--	--	--	+	+	+
<i>Kydia calycina</i> Roxb.	--	+	+	--	--	--	--	--
<i>Lagerstroemia parviflora</i> Roxb.	+	+	+	+	--	+	+	+
<i>Mitragyna parviflora</i> (Roxb.) Korth.	--	--	--	+	--	--	--	--
<i>Ougeinia ojeinensis</i> (Roxb.) Hochr.	--	+	+	+	--	+	+	+
<i>Emblica officinalis</i> Gaertn	--	--	+	--	--	+	+	+
<i>Saccopetalum tomentosum</i> (H F.) Thoms	--	--	--	+	--	--	--	--
<i>Schleichera oleosa</i> (Lour.) Oken	--	--	+	+	--	--	--	--
<i>Shorea robusta</i> Gaertn.f.	+	--	+	+	+	--	+	+
<i>Sterculia urens</i> Roxb.	--	--	+	--	--	+	--	--
<i>Syzygium cumini</i> (Linn.) Skeels.	+	--	+	--	+	--	+	+
<i>Terminalia alata</i> Heyne ex Roth.	+	--	--	+	+	+	+	+
<i>Terminalia chebula</i> Retz.	--	--	+	+	--	--	--	+

+ indicating presence of the species whereas -- indicating absent of the species in different fire zone

Table 2. Comparisons of community characters of different forest fire zones of Boramdeo Wildlife Sanctuary during pre-fire and post-fire season

		Pre-fire season			
Vegetation Layer	Characters	High Fire Zone	Medium Fire Zone	Low Fire Zone	Non-Fire Zone
Seedling Layer	Species	7	9	13	13
	Density (individuals ha ⁻¹)	10400	10960	13680	12720
	Basal Area (m ² h ⁻¹)	0.48	1.81	2.25	1.86
	Shannon Index (H')	2.10	2.80	2.70	2.47
	Simpson's Index (Cd)	0.29	0.17	0.22	0.25
	Species richness (d)	0.64	0.86	1.26	1.26
	Equitability (e)	1.08	1.27	1.05	0.96
	Beta diversity (βd)	2.71	2.11	1.46	1.46
		Post-fire season			
Vegetation Layer	Characters	High Fire Zone	Medium Fire Zone	Low Fire Zone	Non-Fire Zone
Seedling Layer	Species	8	10	11	12
	Density (individuals ha ⁻¹)	6800	7680	10480	9600
	Basal Area (m ² h ⁻¹)	0.477	0.560	0.562	0.70
	Shannon Index (H')	2.56	2.77	2.65	2.62

Simpson's Index (Cd)	0.20	0.19	0.21	0.22
Species richness (d)	0.79	1	1.08	1.19
Equitability (e)	1.23	1.20	1.10	1.05
Beta diversity (β d)	1.75	1.4	1.27	1.16

Table 3. Regeneration status of tree species in High Fire Zone of Bhoramdeo Wildlife Sanctuary

Species	Seedlings ha ⁻¹	Saplings ha ⁻¹	Trees ha ⁻¹	Status
<i>Adina cordifolia</i> Hook.f.	--	--	15	Not regenerating
<i>Anogeissus latifolia</i> Wall ex Bedd.	--	20	10	Poor regeneration
<i>Bridelia retusa</i> (Linn.) Spreng.	--	--	5	Not regenerating
<i>Buchanania lanzan</i> Spreng.	320	15	5	Good regeneration
<i>Butea monosperma</i> (Lamk) Taub.	--	5	--	Poor regeneration
<i>Casearia graveolens</i> Dalz.	720	--	--	Fair regeneration
<i>Diospyros melanoxylon</i> Roxb.	3360	55	--	Good regeneration
<i>Grewia tiliaefolia</i> Vahl.	--	5	--	Poor regeneration
<i>Lagerstroemia parviflora</i> Roxb.	560	15	--	Good regeneration
<i>Lannea coromandelica</i> (Houtt.) Merr.	--	--	15	Not regenerating
<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	--	10	40	Poor regeneration
<i>Emblia officinalis</i> Gaertn	--	30	--	Poor regeneration
<i>Schleichera oleosa</i> (Lour.) Oken	--	10	15	Poor regeneration
<i>Shorea robusta</i> Gaertn.f.	4400	90	110	Good regeneration
<i>Sterculia urens</i> Roxb.	--	20	5	Poor regeneration
<i>Syzygium cumini</i> (Linn.) Skeels.	800	5	--	Good regeneration
<i>Terminalia alata</i> Heyne ex Roth.	240	15	35	Good regeneration
<i>Terminalia chebula</i> Retz.	--	10	--	Poor regeneration

Table 4. Regeneration status of tree species in Medium Fire Zone of Bhoramdeo Wildlife Sanctuary

Species	Seedlings ha ⁻¹	Saplings ha ⁻¹	Trees ha ⁻¹	Status
<i>Adina cordifolia</i> Hook.f.	--	--	5	Not regenerating
<i>Anogeissus latifolia</i> Wall ex Bedd.	720	60	60	Good regeneration
<i>Boswellia serrata</i> Roxb. ex Colebr.	--	5	25	Poor regeneration
<i>Buchanania lanzan</i> Spreng.	--	--	15	Not regenerating
<i>Careya arborea</i> Roxb.	--	--	10	Not regenerating
<i>Casearia graveolens</i> Dalz.	1440	155	25	Good regeneration
<i>Cassia fistula</i> Linn.	880	5	--	Good regeneration
<i>Chloroxylon swietenia</i> D.C.	320	--	--	Fair regeneration
<i>Dalbergia paniculata</i> Roxb.	240	25	15	Good regeneration
<i>Diospyros melanoxylon</i> Roxb.	2800	80	10	Good regeneration
<i>Kydia calycina</i> Roxb.	800	35	10	Good regeneration
<i>Lagerstroemia parviflora</i> Roxb.	2720	105	30	Good regeneration
<i>Lannea coromandelica</i> (Houtt.) Merr.	--	20	55	Poor regeneration
<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	1040	55	65	Good regeneration
<i>Emblia officinalis</i> Gaertn	--	5	5	Poor regeneration
<i>Semecarpus anacardium</i> L.	--	15	15	Poor regeneration
<i>Sterculia urens</i> Roxb.	--	25	15	Poor regeneration

Table 5. Regeneration status of tree species in Low Fire Zone of Bhoramdeo Wildlife Sanctuary

Species	Seedlings ha ⁻¹	Saplings ha ⁻¹	Trees ha ⁻¹	Status
<i>Adina cordifolia</i> Hook.f.	--	10	15	Poor regeneration
<i>Aegle marmelos</i> Linn.	--	--	5	Not regenerating
<i>Anogeissus latifolia</i> Wall ex Bedd.	400	20	--	Good regeneration

<i>Buchanania lanzan</i> Spreng.	640	110	10	Good regeneration
<i>Butea monosperma</i> (Lamk) Taub.	--	10	--	Poor regeneration
<i>Casearia graveolens</i> Dalz.	2640	10	--	Good regeneration
<i>Cassia fistula</i> Linn.	--	10	10	Poor regeneration
<i>Diospyros melanoxylon</i> Roxb.	1440	60	--	Good regeneration
<i>Kydia calycina</i> Roxb.	560	25	--	Good regeneration
<i>Lagerstroemia parviflora</i> Roxb.	1040	100	30	Good regeneration
<i>Lannea coromandelica</i> (Houtt.) Merr.	--	10	5	Poor regeneration
<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	80	15	40	Good regeneration
<i>Emblica officinalis</i> Gaertn	400	20	5	Good regeneration
<i>Schleichera oleosa</i> (Lour.) Oken	80	5	5	Good regeneration
<i>Semecarpus anacardium</i> L.	--	--	15	Not regenerating
<i>Shorea robusta</i> Gaertn.f.	5600	185	185	Good regeneration
<i>Sterculia urens</i> Roxb.	80	--	--	Fair regeneration
<i>Syzygium cumini</i> (Linn.) Skeels.	480	35	--	Good regeneration
<i>Terminalia alata</i> Heyne ex Roth.	--	15	15	Poor regeneration
<i>Terminalia chebula</i> Retz.	240	10	--	Good regeneration

Table 6. Regeneration status of tree species in Non-Fire Zone of Boramdeo Wildlife Sanctuary

Species	Seedlings ha ⁻¹	Saplings ha ⁻¹	Trees ha ⁻¹	Status
<i>Adina cordifolia</i> Hook.f.	--	--	5	Not regenerating
<i>Anogeissus latifolia</i> Wall ex Bedd.	640	70	30	Good regeneration
<i>Bombax ceiba</i> Linn.	--	5	--	Poor regeneration
<i>Bridelia retusa</i> (Linn.) Spreng.	--	--	20	Not regenerating
<i>Buchanania lanzan</i> Spreng.	800	100	15	Good regeneration
<i>Casearia graveolens</i> Dalz.	1840	50	15	Good regeneration
<i>Cassia fistula</i> Linn.	80	--	10	Fair regeneration
<i>Diospyros melanoxylon</i> Roxb.	2640	75	--	Good regeneration
<i>Garuga pinnata</i> Roxb.	--	--	5	Not regenerating
<i>Grewia tiliacifolia</i> Vahl.	--	10	5	Poor regeneration
<i>Kydia calycina</i> Roxb.	--	20	5	Poor regeneration
<i>Lagerstroemia parviflora</i> Roxb.	80	60	5	Good regeneration
<i>Lannea coromandelica</i> (Houtt.) Merr.	--	10	25	Poor regeneration
<i>Madhuca longifolia</i> Roxb.	--	--	5	Not regenerating
<i>Mitragyna parviflora</i> (Roxb.) Korth.	480	25	15	Good regeneration
<i>Ougeinia oojeinensis</i> (Roxb.) Hochr.	80	25	70	Good regeneration
<i>Emblica officinalis</i> Gaertn	--	15	--	Poor regeneration
<i>Saccopetalum tomentosum</i> (H F.) Thoms	80	10	15	Good regeneration
<i>Schleichera oleosa</i> (Lour.) Oken	400	10	5	Good regeneration
<i>Shorea robusta</i> Gaertn.f.	5440	465	345	Good regeneration
<i>Sterculia urens</i> Roxb.	--	5	5	Poor regeneration
<i>Terminalia alata</i> Heyne ex Roth.	80	20	20	Good regeneration
<i>Terminalia chebula</i> Retz.	80	15	10	Good regeneration

Table 7. Regeneration status of species in different fire zones of Boramdeo Wildlife Sanctuary

Fire Zones	Regeneration status (in percentage)			
	Good regeneration	Fair regeneration	Poor regeneration	Not regenerating
High Fire Zone	33.33	5.55	44.44	16.66
Medium Fire Zone	47.06	5.88	29.41	17.65
Low Fire Zone	60	5	25	10
Non-Fire Zone	52.17	4.35	26.09	17.40

ACKNOWLEDGEMENT

Thanks to forest department of Chhattisgarh, India for providing necessary support during the field work.

REFERENCE

- Curtis, J.T. and McIntosh, R.P.** (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, **31**: 434-455.
- Good, N.F. and Good, R.E.** (1972). Population dynamics of tree seedlings and saplings in mature Eastern hardwood forest. *Bull Torrey Bot. Club*, **99**.
- Gubbi, S.** (2003). Fire, fire burning. Deccan Herald, dated on 5-01-2003, Bangalore. India.
- Joshi, N.K.** (1990). Effect of fire on vegetation composition, forest floor, litter fall, litter decomposition and nutrient return in pure and mixed Sal forest of Garhwal Himalaya. *Ph.D. Thesis*, H.N.B. Garhwal University Srinagar. pp. 344.
- Kafle, S.K.** (2004). Effects of Forest Fire Protection on Plant Diversity in a Tropical Deciduous Dipterocarp-Oak Forest, Thailand. Proceedings of the second international symposium on fire economics, planning and policy: A Global View. pp. 465-472.
- Keeley, J.E. and Bond, A.W.** (1999). Mast flowering and semelparity in bamboos: the bamboo fire cycle hypothesis. *The American Naturalist*, **154**: 383-391.
- Khan, M.L.; Rai, J.P.N. and Tripathi, R.S.** (1987). Population structure of some tree species in disturbed and protected sub-tropical forests of north-east India. *Acta Oecologia*, **8**: 247-255.
- Kodandapani, N.** (2001). Forest fires: Origins and Ecological Paradoxes. *Resonance*, **6**: 34-41.
- Kodandapani, N.; Cochrane, M. and Sukumar, R.** (2008). A comparative analysis of spatial, temporal and ecological characteristics of forest fires in seasonally dry tropical ecosystems in the Western Ghats, India. *Forest Ecology and Management*, **256**: 607-617.
- Naidu, C.V. and Sribasuki, K.P.** (1994). Effect of Forest fire on Tree Species on different areas of Aeshachalam Hills. *Journal of Tropical Forestry*, **10** (III).
- Phillips, E.A.** (1959). Methods of Vegetation Study. Holt R and Winston New York USA. pp. 105.
- Sagar, R. and Singh, J.S.** (1999). Species diversity and its measurement. *The Botanica*, **49**: 9-16.
- Saha, S.** (2002). Anthropogenic fire regime in a deciduous forest of central India. *Current Science*, **82**(9): 1144-1147.