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Article *in* Ecology Environment and Conservation · March 2014

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Eco. Env. & Cons. 20 (3) : 2014; pp. (159-164)
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ISSN 0971–765X

Is the forest fire can affect the regeneration and species diversity

Bhimappa Kittur[1], Manoj Kumar Jhariya[2*] and Chaman Lal[3]

[1]Department of Silviculture and Agroforestry, Kerala Agriculture University, College of Forestry, Thrissur (Kerala)
[2]Department of Forestry, College of Agriculture, I.G.K.V., Raipur (CG)
[3]Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (HP)

ABSTRACT

The present work aimed to study the impact of forest fire on regeneration and diversity in Achanakmar-Amarkantak Biosphere Reserve. For the study four sites were selected each of these sites pre-fire and post-fire observation were taken for measuring varying degree of fire disturbances. The total density of seedlings during pre-fire season across fire zones ranged from 7200 to 11280 seedlings ha^{-1}, while during post-fire season from 5840 to 10000 seedlings ha^{-1}. The total change in density of seedlings ranged from 1280 to 1360 seedlings ha^{-1}. The results pursued on regeneration that total number of spices found in high fire zone of pre-fire season was 14 and its density was 7520 seedlings ha^{-1}. After post-fire season in high fire zone the seedlings number was 9 and its density was changed 6000 seedlings ha^{-1}, whereas in medium fire zone seedling number was increased. The diversity pattern ranged from 2.86 to 3.30 in pre-fire season. It was highest under non-fire zone followed by medium fire zone and high fire zones. The decline of species richness in time after forest fire might be caused primarily by the elimination of some early species which were over topped and shaded out by rapidly growing fire hardy species. In high fire zones more than 44% seedling population decreased after fire season, it will adversely affect the forests stratification in future. Fires have negative impacts on native plant diversity, with varying effects on species and ecosystems, including the potential for localized extinction.

Key words : *Forest fire, Disturbance, Diversity, Regeneration, Vegetation*

Introduction

Forest fire is the one of the most frequent hazard in natural forests. Fire threats not only to the forest wealth but also to the entire regime of fauna and flora seriously disturbing the bio-diversity of the region. In India, out of 67.5 million ha of forests, about 55% of the forest cover is being annually subjected to fires (Gubbi, 2003). Forest fire has important effects on composition, structure and diversity in tropical deciduous forests (Jhariya *et al*., 2012). The forest burning is believed to encourage the growth of succulent grasses. A reason also that burning helps for easy collection of non-timber forest products, hunting and various other reasons (Kodandapani, 2001). In many places, periodic blazing is consistent and attuned with the adaptations of species and natural processes that help to sustain and rejuvenate ecosystems (Hanson and Stuart, 2005). The shifts in species concerto in natural forest occur slowly under customary conditions (Swaine *et al*., 1987), but ruinous disturbances can reduce structural and biological complexity of virgin forests (Schindele *et al*., 1989). Fires have negative impacts on native plant diversity, with varying effects on species composition and ecosystems, including the

***Corresponding author's email:** manu9589@gmail.com

potential for localized extinction.

Achanakmar- Amarkantak Biosphere Reserve, one among the important natural heritage sites of Central India situated in Bilaspur district of Chhattisgarh. The study area is located between 22^0 15' to 22^0 58' North latitude and 81^0 25' to 82^0 5' East longitude, having an area of 3836 sq. km. The Baigas are the dominant tribe whose livelihood and economy mainly depends on these forests. However several years these forests were subjected to severe biotic and abiotic disturbances. Therefore its necessary to evaluate the severity of damage caused by the anthropogenic factors. Presently there is a dearth of both qualitative and quantitative information of impact of forest fire on vegetation status in this region. Therefore, the present study was undertaken to investigate the impact of forest fire on regeneration and diversity of different fire zones.

Materials and Methods

The study was conducted based on some hypothesis *i.e.*, (1) the seedling regeneration is inversely proportional severity of forest fire and continuous fires caused to invesion of fire hardy species. (2) medium and low intensity forest fires are better for vegetational structure and diversity as in accordance with intermidiate disturbance hypothesis. 3) long term fire protection is not congenial for seedling growth and development.

Delineation and identification of fire prone areas were done on the basis of historical ground fire data in conjunction with satellite remote sensing data provided by NRSA as pre-fire and immediately next year of fire occurrence as post-fire to evaluate the seedling regeneration, on the basis of frequency of forest fire damage. Total four zones *viz*. high, medium, low and non-fire were selected; in each of these zones pre-fire and post-fire observation were taken. 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 and abundance (Curtis and McIntosh, 1950). The relative frequency, relative density and relative basal area values were calculated following Phillips (1959). As regards regeneration status of species was totally based on population size of the seedlings (Khan *et al.*, 1987). Diversity indices were calculated following Sagar and Singh (1999).

Results and discussion

We analysed forest fires effects on patterns of species regeneration and diversity in tropical forests along an extended gradient of fire severity. Data persuaded that the total number of species ranged from 14 to 17 species ha^{-1} during pre-fire season (Table 1). Highest density were recorded under medium fire zone whereas lowest under non fire zone. The basal area recorded highest in low fire zone, while it had lowest under high fire zone (Table 2). The medium forest fire accordingly supported to our assumption when applied in a forest where disturbance histories are localized and patchy, the spatial interpretation in which the variety of local disturbance histories contributes to and maintains species richness (Pickett and White, 1985). As in case higher density was observed in *Casearia graveolens* followed by *Diospyros melanoxylon* under low fire zone this may due to the both species are better survived under low fire impact as compared to others. Therefore the total density of seedlings during pre-fire season across fire zones ranged from 7,200 to 10,400 ha^{-1}, while during post-fire season from 5,840 to 10,000 ha^{-1}. According to Kodandapani (2001) mild fire enhances the productivity of ecosystem by releasing chemicals and nutrients locked up in old herbages this results greater regeneration of seedlings. Naidu and Sribasuki (1994) reported that young plants are more badly affected by fires than mature one. The lesser diversity in the frequent fire occurring in deciduous forest leading to nonspecific forests and frequent fires could also lead to stands where most trees are even aged (Kodandapani, 2001) our findings are also in accordance with others. Shannon index for seedling layer were ranged from 2.86 to 3.30, equitability 1.06 to 1.25, species richness 1.46 to 1.71, concentration of dominance 0.13 to 0.20 and beta diversity 1.35 to 1.64. Similar findings were also made by Jhariya *et al*. (2012) for tropical deciduous forest of Chhattisgarh. Increase in species richness in medium and low fire zones and inversely decrease in non-fire zones holds good with Connell's (1978) original formulation proposes that in a community or forest left undisturbed, competitive exclusion will ultimately eliminate all but the late successional species from the system - a process that can be prevented by disturbance.

The structural analysis of seedling layer in high fire zone presented in table 2, that total density and basal area were found to be 7520 seedlings ha^{-1} and

0.578 m^2 ha^{-1}, respectively. Density of pioneer species (*Casearia graveolens* and *Diospyros melanoxylon*) showed a unimodal response to disturbance across all zones, but the increase was always monotonic. Hence, *Diospyros melanoxylon* had highest density and frequency value followed by *Tectona grandis, Shorea robusta* and *Bauhinia vahlii*. Lower density and frequency values were recorded by *Dalbergia sissoo, Wrightia tinctoria, Embelia robusta* and *Schleichera oleosa*. The basal area varied between 0.001 to 0.275 m^2 ha^{-1} for individual species. The highest basal area was recorded by *Tectona grandis* followed by *Diospyros melanoxylon* and *Lagerstroemia parviflora.* In contrary the lower basal area was observed in *Dalbergia sissoo* followed by *Embelia robusta* and *Schleichera oleosa.* The IVI values ranged from 4.30 to 81.39. The highest IVI was recorded by *Tectona grandis* followed by *Diospyros melanoxylon*, *Lagerstroemia parviflora* and *Bauhinia vahlii*. Whereas it was lower under *Dalbergia sissoo, Embelia robusta* and *Schleichera oleosa.* We had anticipated a monotonic decline in fire susceptible spices, as fire resistant species perform best at medium and low fire disturbance. A/F ratio values ranged between 0.03 and 0.25. It indicated that the most of the species showed contiguous distribution and some species showed random distribution.

The structural analysis of seedling layer under medium fire zone mentioned in Table 2. Total density and basal area were found to be 11360 seedlings ha^{-1} and 0.78 m^2 ha^{-1}, respectively. The density of seedlings ranged from 80 to 3360 ha^{-1}. In accordance with Sheil & Burslem (2003); Roxburgh *et al*. (2004); Shea *et al*. (2004) with maximum diversity under intermediate disturbance levels can arise from different underlying mechanisms. Species density was higher at intermediate levels of disturbance; the increase in number of pioneer species with disturbance more than outweighed the loss of fire resistance species. Evidently, at intermediate levels of disturbance (6–13%), sufficient opportunities exist for pioneer species to establish and persist (Kittur and Jhariya, 2012). At higher disturbance levels, species density and richness decline due to loss of fire resistance species. It can be obvious that IVI values ranged from 3.42 to 56.46. *Diospyros melanoxylon* recorded higher IVI, whereas it was lowest under *Ventilago maderaspatana*. A/F ratio values ranged between 0.03 to 0.10. It indicated that the most of the species showed contiguous distribution and random distribution. Variation across forest types in the number of species in the regeneration may result in different responses to disturbance in terms of species density. In our case, the density of seedlings ranged from 80 to 3360 ha^{-1}. Total density and basal area of seedlings in the low fire affected zone was 10,400 ha^{-1} and 1.29 m^2 ha^{-1}, respectively. The lower density was recorded by *Bauhinia vahlii* followed by *Dalbergia sissoo, Diospyros montana, Schleichera oleosa* and *Stereospermum chelenoides.* The basal area values of seedlings ranged between 0.001 and 0.423 m^2 ha^{-1}. The IVI values in low fire affected zone ranged between 3.45 and 77.97. A/F ratio values ranged between 0.01 and 0.11. It indicated that the most of the species showed contiguous distribution and few species showed random distribution.

Structure and composition of seedling layer under non-fire zone mentioned in Table 2 that total density and basal area of seedlings in non-fire zone were found to be 7200 ha^{-1} and 0.61 m^2 ha^{-1}, respectively. The density of seedlings ranged from 80 to 1120 ha^{-1}. *Diospyros melanoxylon, Casearia graveolens* and *Lagerstroemia parviflora* showed higher values of density and maximum frequency. The IVI values of seedling ranged from 4.92 to 66.18. Shannon Index was highest under non fire zone. But Simpson's Index is highest in medium fire zone. Whereas beta diversity was equal in high and non fire zones of pre-fire season. A/F ratio ranged between 0.02 and 0.25. It indicated that the most of the species showed contiguous and random distribution and few species showed regular distribution.

Fire was historically a major influence on landscape patterns and species diversity in the forests (Delcourt and Delcourt, 1997). High intensity fires cause negative impacts on native plant diversity, with varying effects on species and ecosystems, including the potential for localized extinction. After forest fire the area gets secondary succession if the fire is of high intensity. In post-fire season the density of seedlings of individual species ranged from 320 to 3440 ha^{-1}. The density and frequency were found to be highest in *Diospyros melanoxylon*, whereas it was lowest under *Bombax ceiba* followed by *Grewia tiliaefolia*, *Adina cordifolia* and *Zizyphus oenoplia*. *Diospyros melanoxylon* showed highest basal area followed by *Ougeinia dalbergoides*, whereas it was lowest in *Cassia fistula*. The IVI values of seedlings ranged from 9.44 to 150.78. *Diospyros melanoxylon* recorded highest IVI value whereas lowest was recorded by *Grewia tiliaefolia.* A/F ratio values ranged between 0.03 and 0.19. It indicated

that the most of the species showed contiguous distribution and few species showed random distribution.

For disturbance to be a mechanism maintaining diversity, competitive exclusion of some of the species has to be precluded by some degree of disturbance (Sheil and Burslem, 2003). This overall contribution can be gauged from our data by comparing seedling density and IVI values in medium fire zones of post-fire season after sustained low distur-

Table 1. Regeneration of species during the pre-fire and post-fire season in Achanakmar-Amarkantak Biosphere Reserve

Species	Pre-fire season				Post-fire season			
	High Fire Zone	Medium Fire Low	Zone Fire Zone	Non Fire Zone	High Fire Zone	Medium Fire Zone	Low Fire Zone	Non Fire Zone
Adina cordifolia Hook.f.	–	+	+	–	+	+	–	–
Aegle marmelos (L.)	–	–	–	–	–	+	+	+
Anogeissus latifolia Wall ex Bedd.	–	–	–	–	–	+	–	+
Bauhinia malabarica	–	–	–	–	–	+	+	-
Bauhunia vahlii	+	+	+	+	+	+	+	–
Bombax ceiba Linn.	–	–	–	–	+	+	–	–
Bridelia retusa (L.) Spreng.	–	–	–	–	–	+	+	+
Buchanania lanzan Spreng.	+	–	–	+	–	+	–	+
Carisa spinarum	–	—	—	—	—	—	+	–
Casearia graveolens Dalz.	+	+	+	+	—	—	—	–
Cassia fistula Linn.	–	+	+	+	+	+	+	+
Cryptolepsis Buchanani	–	–	–	–	–	–	+	–
Dalbargia sissoo	+	—	+	–	–	–	–	–
Dillenia pentagyna	—	—	—	–	–	–	+	+
Diospyros embryopteris	—	—	—	–	–	–	–	+
Diospyros melanoxylon Roxb.	+	+	+	+	+	+	+	+
Diospyros montana	—	—	+	—	—	–	–	–
Embelia robusta Roxb.	+	+	+	+	—	–	–	–
Emblica officinalis Gaertn	—	—	—	—	—	+	+	–
Gardenia turgida	—	—	—	—	—	—	—	–
Grewia tiliaefolia Vahl.	—	—	—	—	+	—	+	–
Holarrhena antidysenterica Wall.	—	+	—	+	—	+	+	–
Kydia calycina Roxb.	—	—	—	—	—	+	—	—
Lagerstroemia parviflora Roxb.	+	+	+	+	—	—	+	+
Madhuca indica	–	+	–	–	—	—	–	–
Ougeinia dalbergoides	–	–	–	–	+	–	–	–
Ougeinia oojeinensis (Roxb.) Hochr.	—	+	–	–	—	+	+	–
Pterocarpus marsupium	–	–	–	–	–	–	+	–
Saccopetalum tomentosum (H F.) Thoms	—	+	+	+	–	–	–	+
Schleichera oleosa (Lour.) Oken	+	+	+	+	–	+	+	–
Semecarpus anacardium L.	+	+	–	–	–	–	–	–
Shorea robusta Gaertn.f.	+	+	+	+	–	+	+	+
Stereospermum chelenoides	–	–	+	–	–	+	+	–
Syzygium cumini (Linn.) Skeels.	+	+	+	+	–	–	–	–
Tectona grandis	+	–	–	–	–	+	+	–
Terminalia arjuna	–	–	–	–	+	+	+	–
Terminalia chebula Retz.	–	–	–	–	–	+	–	–
Teminalia tomentosa	–	–	–	–	–	+	+	–
Ventilago maderaspatana Tul	–	+	–	+	–	+	+	–
Wrightia tinctoria	+	–	–	–	–	–	–	–
Zizypus oenoplia	–	–	–	–	+	–	–	+
Zizyphus xylopyra (Retz.)Willd.	+	+	+	+	–	+	+	–

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

bance with estimated peak IVI.

Total density and basal area values in medium fire affected zone were 5,840 seedlings ha^{-1} and 0.309 m^2 ha^{-1}, respectively (Table 2). The density and basal area of seedling ranged from 80 to 640 ha^{-1} and 0.001 to 0.052 m^2 ha^{-1}, respectively. Basal area of seedlings in medium fire affected zone was found to be higher in *Tectona grandis* and *Kydia calycina* followed by *Terminalia chebula*, *Schleichera oleosa* and *Ventilago maderaspatana*, whereas it was lower under *Aegle marmelos*, *Bauhinia malabarica*, *Ougeinia oojeinensis* and *Terminalia arjuna*. The highest IVI was recorded by *Diospyros melanoxylon* and lowest by *Aegle marmelos* followed by *Bauhinia malabarica* and *Ougeinia oojeinensis*. A/F ratio values ranged between 0.03 and 0.10. The density of seedlings ranged from 80 to 1600 ha^{-1}. Higher values of density and frequency were observed in *Bridelia retusa*, *Shorea robusta* and *Diospyros melanoxylon* followed by *Kydia calycina*, *Stereospermum chelenoides*, *Holarrhena antidysentrica* and *Tectona grandis*. In contrary lowest density was recorded by *Grewia tiliaefolia* followed by *Lagerstroemia parviflora*, *Bauhinia malabarica*, *Cassia fistula*, *Dillenia pentagyna*, *Ougeinia oojeinensis*, *Pterocarpus marsupium* and *Zizyphus xylopyra*. The basal area values ranged between 0.001 and 0.079 m^2 ha^{-1}. The basal area was highest in *Diospyros melanoxylon* followed by *Tectona grandis*, *Bridelia retusa* and *Kydia calycina*. A/F ratio values ranged between 0.02 and 0.40.

In non-fire zone during post-fire season the total density and basal area values were found to be 6400 seedlings ha^{-1} and 0.28 m^2 ha^{-1}, respectively. *Cassia fistula, Diospyros melanoxylon and Dillenia pentagyna* showed higher values of density and frequency, whereas *Aegle marmelos, Anogeissus latifolia, Buchanania lanzan* and *Lagerstroemia parviflora* showed lower values. The higher basal area was found in *Diospyros melanoxylon* followed by *Cassia fistula* and *Bridelia retusa* whereas lower basal area was recorded by *Aegle marmelos, Anogeissus latifolia, Buchanania lanzan, Diospyros embryopteris, Lagerstroemia parviflora, Shorea robusta* and *Zizyphus oenoplia*. The IVI values ranged from 5.82 to 98.52. *Diospyros melanoxylon* showed highest IVI followed by *Cassia fistula* and *Dillenia pentagyna*. Based on basal area and IVI values *Diospyros melanoxylon* was found to be predominant plant species in the seedling layer. A/F values ranged between 0.02 and 0.19. It indicated that the most of the species showed con-

Table 2. Comparisons of community characters of Achanakmar- Amarkantak Biosphere Reserve 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	14	17	15	14
	Density (individuals ha^{-1})	7520	11280	10400	7200
	Basal Area (m^2h^{-1})	0.577	0.780	1.29	0.61
	Shannon Index (H')	3.18	3.26	2.86	3.30
	Simpson's Index (Cd)	0.14	0.14	0.20	0.13
	Species richness (d)	1.46	1.71	1.51	1.46
	Equitability (e)	1.21	1.15	1.06	1.25
	Beta diversity (âd)	1.64	1.35	1.53	1.64
Post-fire season					
Vegetation Layer	Characters	High Fire Zone	Medium Fire Zone	Low Fire Zone	Non-Fire Zone
Seedling Layer	Species	9	24	24	12
	Density (individuals ha^{-1})	6000	5840	10000	6400
	Basal Area (m^2h^{-1})	0.65	0.309	0.518	0.285
	Shannon Index (H')	2.15	4.29	4.17	2.33
	Simpson's Index (Cd)	0.36	0.06	0.07	0.29
	Species richness (d)	0.92	2.65	2.50	1.26
	Equitability (e)	0.98	1.35	1.31	0.94
	Beta diversity (âd)	3.89	1.46	1.46	2.92

tiguous and random distribution and few species were distributed regularly. Shannon Index was highest in medium fire zone. It was lowest in high fire zone. In case of Simpson's Index which is inversely proportional to Shannon Index. The species richness was higher in medium fire zone followed by low fire, non fire and high fire zones. Beta diversity was highest in high fire zone and lowest in medium and low fire zones.

Conclusion

It reflects that moist deciduous forests of Chhattisgarh are ecologically rich as compared to other tropical forests in terms of structure, composition and diversity. The forest fires are behaved differently in different fire zone and the species composition and diversity indices are independent with intensity of forest fire. So the setted hypothesis is not in conjunction with the observed results. Therefore, in case of moist deciduous forests the forests fire may change the overall species composition and diversity, irrespective of intensity of forest fire. Hence for management is concern forester should consider the type and time of forest fire occurrence based on these the controlled measures can be adapted.

Acknowledgement

Thanks to forest department of Chhattisgarh, India for providing necessary support during the field work and was carried out under the aegis of National Remote Sensing Center forest fire project.

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