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Structure, Composition and Diversity of Degraded Dry Tropical Forest in Balamdi Watershed of Chhattisgarh Plain, India

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ABSTRACT Pattern of structure, composition and diversity of woody vegetation in over and under storey degraded Dry Tropical Forest of Chhattisgarh, India was evaluated in four different aspects. The density, frequency, basal area and IVI alongwith diversity indices viz. Shannon index, Simpson index, Species richness, Equitability and Beta diversity were computed to see the variation in plant community. The study illustrated the variation in tree species from 6 (eastern aspect) to 9 (southern aspect) in overstorey and 5 (eastern and western aspect) to 9 (southern aspect) in understoried forest. The *Cleistanthus collinus* with highest IVI value in northern (52.52) and western aspect (59.90), *Boswellia serrata* in southern (48.98) and *Terminalia alata* in eastern aspect (56.16) were the predominant tree species in overstorey vegetation. The highest IVI of *Diospyros melanoxylon* (64.80) in northern, *Boswellia serrata* and *Madhuca indica* (both with 39.15) in southern, *Madhuca indica* (71.40) in eastern and *Cleistanthus collinus* (75.15) in western aspect recorded predominant vegetation layer in the understorey of dgraded forest. The Shannon index, Simpson's index, Species richness, Equitability and Beta diversity values were almost higher in overstorey as compared to understorey as a result; the present study reveals the poor regeneration pattern in the degraded forest.

INTRODUCTION

The degradation of tropical forest is proceeding at unprecedented rate that is destroying the biodiversity and natural resource of the region. The removal of vegetation and loss of soil productivity through human disturbances has negative impact on local and regional ecology and economics (Grainger 1988). Moreover, the varying topography from place to place also plays an important role in composition of the forest (Singh 2006) that sometimes make it more degradable. In order to rehabilitate and reclaim the degraded forest to meet the biomass demand, the Social Forestry Programme was launched in India during 1980 followed by more participatory Joint Forest Management (JFM) Programme (Bhat et al. 2001).

Tropical forest ecosystems are one of the richest terrestrial ecosystems which support a variety of life forms and maintain huge global biodiversity (Shi and Singh 2002). The phytosociology is one of the important aspects for analyzing the structure, composition and phytodiversity for thoroughly understanding the vegetation dynamics. Both structure and diversity of vegetation have strong functional role in controlling ecosystem processes like biomass production, cycling of water and nutrients (Gower et al. 1992). The strong correlation also exist between structural diversity and species diversity (Sahu et al. 2008). The present study in degraded dry tropical forests of Chhattisgarh plains is an attempt to work out the status of degraded forest in a patch of tropical forest domain. In view of this, the present study was carried out to analyze the structure, composition and diversity of tree vegetation in degraded Dry Tropical Forest in Chhattisgarh Plain.

MATERIALS AND METHODS

The study was conducted in Balamdi Watershed of Barnawapara Sanctuary, Raipur district of Chhattisgarh, India during 2001-2002. A typical watershed situated between 21^0 20' to 21^0 26' North latitudes and 82^0 21' to 82^0 26' East longitudes representing a part of degraded dry tropical forest on Balamdi river in Raipur forest division was selected for phytosociological and diversity analysis in different aspects. The watershed comprises an area of 7200 ha, of which more than 70 % area was predominantly covered by different types of luxuriant forests (Mixed Forest, Teak Forest, Sal Mixed Forest and Degraded Forest). The attempt of the study was to evaluate the degraded forest area which is in the fringe of the habitation.

The climate of the study area was moist humid, tropical consisting three major seasons viz., rainy, winter and summer. The average

annual rainfall in the study area ranged from 1200–1350 mm with the highest rainfall in July. The mean monthly maximum temperature of the study area varies from 27.3^{0}C in January to 41.8^{0}C in May and mean monthly minimum temperature from 12.7 ^{0}C in January to 27.3 ^{0}C in May.

Structure and Composition Analysis

The structure and composition analysis for characterization of tree communities in degraded forest was performed and the Density, Basal area, Frequency and IVI were analyzed. Similarly, the diversity parameters were also analyzed for the degraded forest types. The phytosociological analysis has been carried by randomly laying sample plots of 20 x 20m. The number of sample plots varied according to size and variation existing in the strata. In each sample plot, the trees of overstorey and understorey were enumerated followed by measurement of Diameter at Breast Height (DBH). The vegetation data in each stratum was quantitatively analyzed for frequency, density and abundance (Curtis and Mc Intosh 1950), IVI (Philips 1959), diversity (Shannon and Wiener 1963), concentration of dominance (Simpson 1949), equitability (Pielou 1975), species richness (Margalef 1958), Beta diversity (Whittaker 1972, 1977).

RESULTS AND DISCUSSION

Structure and Composition of Degraded Forest

Structural analysis of over and understorey vegetation of degraded forests in the northern aspect (Table 1) had higher density and frequency values for *Cleistanthus collinus* and *Terminalia alata* in overstorey and *Diospyros melanoxylon* and *Terminalia alata* in understorey. However, basal area was higher in *Madhuca indica* and *Diospyros melanoxylon* in both layers. The IVI values ranged from 32.19 to 52.52 and from 33.59 to 64.80 for over and understorey, respectively. *Cleistanthus collinus* and *Diospyros melanoxylon* in overstorey, *Diospyros melanoxylon* and *Terminalia alata* in understorey were recognized as predominant plant communities. *Tectona grandis* and *Ougeinia oojeinensis* in overstorey, while *Buchanania lanzan* and *Cleistanthus collinus* in understorey were recognized as suppressed plant communities in degraded forest under northern aspect.

Data on structural attributes in over and understorey vegetation of degraded forests under southern aspect are presented in table 2. Density and basal area values were higher for *Boswellia serrata* and *Madhuca indica* and lower for *Tectona grandis and Dalbergia sissoo* in overstorey whereas in understorey the higher density was recorded by *Boswellia serrata* and *Madhuca indica* and maximum frequency in *Buchanania lanzan* and *Diospyros melanoxylon*. The higher basal area in understorey layer was noted in *Schleichera oleosa*. The IVI values ranged from 21.99 to 48.98 for overstorey and 22.22 to 42.43 for understorey vegetation. On the basis of higher IVI values, *Boswellia serrata* and *Madhuca indica* in overstorey and *Diospyros melanoxylon* and *Boswellia serrata* in understorey were recognized as predominant plant communities. The codominant association in the overstorey were *Buchanania lanzan* and *Diospyros melanoxylon*, while *Schleichera oleosa* and *Terminalia alata* were recognized as suppressed plant community in this layer. In understorey, *Buchanania lanzan* and *Terminalia*

Table 1: Structure and composition of degraded forest in the northern aspect

S. No.	*Name of the species*	*Density (Trees/ha)*	*Frequency (%)*	*Basal area (m^2/ha)*	*IVI*	*Density (Trees/ha)*	*Frequency (%)*	*Basal area (m^2/ha)*	*IVI*
		Overstorey				*Understorey*			
1	*Buchanania lanzan*	41.75	66.67	0.4425	39.58	16.75	33.33	0.02	33.59
2	*Cleistanthus collinus*	58.25	100.00	0.385	52.52	16.75	33.33	0.02	33.59
3	*Diospyros melanoxylon*	33.25	66.67	1.1325	50.18	33.25	66.67	0.03	64.80
4	*Madhuca indica*	33.25	33.33	1.3275	45.68	16.75	33.33	0.03	41.92
5	*Ougeinia oojeinensis*	41.75	33.33	0.71	36.46	8.25	33.33	0.03	36.04
6	*Terminalia alata*	50.00	66.67	0.5025	43.63	25.00	66.67	0.02	50.59
7	*Tectona grandis*	33.25	33.33	0.6375	32.19	25.00	33.33	0.02	39.47
	Total	291.75	400.00	5.135		141.75	300.00	0.17	

Table 2: Structure and composition of degraded forest in the southern aspect

S. No.	Name of the species	Density (Trees/ha)	Frequency (%)	Basal area (m^2/ha)	IVI	Density (Trees/ha)	Frequency (%)	Basal area (m^2/ha)	IVI
		Overstorey				Understorey			
1	*Boswellia serrata*	44.50	33.33	1.33	48.98	19.50	22.22	0.03	39.15
2	*Buchanania lanzan*	25.00	55.56	0.44	34.81	14.00	33.33	0.02	34.85
3	*Cleistanthus collinus*	27.75	44.44	0.39	31.86	14.00	22.22	0.02	29.30
4	*Dalbergia sissoo*	14.00	22.22	0.64	21.99	5.50	11.11	0.03	22.22
5	*Diospyros melanoxylon*	16.75	33.33	1.13	33.48	16.75	33.33	0.03	42.43
6	*Madhuca indica*	27.75	44.44	1.33	44.74	19.50	22.22	0.03	39.15
7	*Schleichera oleosa*	19.50	22.22	0.95	28.85	2.75	11.11	0.05	26.77
8	*Terminalia alata*	25.00	33.33	0.50	28.74	14.00	22.22	0.03	34.60
9	*Tectona grandis*	16.75	33.33	0.64	26.72	16.75	22.22	0.02	31.57
	Total	216.75	322.22	7.34		122.25	200.00	0.26	

alata as codominant, while *Dalbergia sissoo* and *Schleichera oleosa* were identified as suppressed community in degraded forests in the southern aspect.

The structural parameters of over and understorey vegetation of degraded forests in the eastern aspect (Table 3) reported with highest density and frequency values in *Terminalia alata*, while maximum basal area was attained by *Madhuca indica* and *Diospyros melanoxylon* in overstorey. *Madhuca indica* and *Tectona grandis* in understorey recorded higher density, whereas *Terminalia alata* attained higher frequency in this layer. IVI values ranged from 41.08 to 54.98 in overstorey and 39.54 to 71.40 in understorey. *Terminalia alata* and *Madhuca indica* in the overstorey and *Madhuca indica* and *Diospyros melanoxylon* in the understorey were recognized as predominant plant communities. *Tectona grandis* and *Buchanania lanzan* were recognized as suppressed plant communities in both over and understorey vegetation of degraded forest under eastern aspect.

In western aspect, the higher density and frequency were recorded by *Cleistanthus collinus* followed by *Ougeinia oojeinensis* and *Madhuca indica* in the overstorey, while *Terminalia alata* and *Cleistanthus collinus* in the understorey vegetation of degraded forest (Table 4). Basal area was found to be higher in *Madhuca indica* and *Diospyros melanoxylon* in the overstorey. The lower density and frequency values were recorded by *Buchanania lanzan* and *Diospyros melanoxylon* in overstorey, while *Madhuca indica* and *Terminalia alata* showed lower values in understorey. The IVI values ranged from 24.42 to 59.90 for overstorey and 44.19 to 75.15 for understorey vegetation. *Cleistanthus collinus* and *Madhuca indica* were recognized as predominant plant communities in both over and understorey vegetation. The codominant asscociations of *Ougeinia oojeinensis* and *Terminalia alata* in overstorey and *Diospyros melanoxylon* in understorey were formed in degraded forests in the western aspect.

Diversity Analysis

Degraded forests showed higher Shannon index values in the southern and northern aspects in

Table 3: Structure and composition of degraded forest in the eastern aspect

S. No.	Name of the species	Density (Trees/ha)	Frequency (%)	Basal area (m^2/ha)	IVI	Density (Trees/ha)	Frequency (%)	Basal area (m^2/ha)	IVI
		Overstorey				Understorey			
1	*Buchanania lanzan*	50.00	50.00	0.44	42.44	12.50	50.00	0.02	39.54
2	*Diospyros melanoxylon*	12.50	100.00	1.13	53.01	12.50	100.00	0.03	65.69
3	*Madhuca indica*	37.50	50.00	1.33	54.98	37.50	50.00	0.03	71.40
4	*Schleichera oleosa*	50.00	50.00	0.95	52.66	-	-	-	-
5	*Terminalia alata*	50.00	100.00	0.50	56.16	25.00	100.00	0.02	63.82
6	*Tectona grandis*	37.50	50.00	0.64	41.08	37.50	50.00	0.02	59.54
	Total	237.50	400.00	4.99		125.00	350.00	0.12	

Table 4: Structure and composition of degraded forest in the western aspect

S. No.	Name of the species	Density (Trees/ha)	Frequency (%)	Basal area (m^2/ha)	IVI	Density (Trees/ha)	Frequency (%)	Basal area (m^2/ha)	IVI
		Overstorey				Understorey			
1	*Buchanania lanzan*	18.75	25.00	0.44	24.42	-	-	-	-
2	*Cleistanthus collinus*	50.00	100.00	0.39	59.90	25.00	50.00	0.02	75.15
3	*Diospyros melanoxylon*	18.75	25.00	1.13	37.88	12.50	25.00	0.05	67.74
4	*Madhuca indica*	31.25	50.00	1.33	54.81	12.50	50.00	0.03	68.78
5	*Ougeinia oojeinensis*	43.75	50.00	0.71	48.14	-	-	-	-
6	*Terminalia alata*	43.75	50.00	0.50	44.12	12.50	25.00	0.02	44.19
7	*Tectona grandis*	25.00	25.00	0.64	30.92	12.50	25.00	0.02	44.19
	Total	231.25	325.00	5.14		75.00	175.00	0.13	

overstorey and in the western and northern aspects in understorey, whereas the Simpson index values were higher in southern aspect of overstorey and eastern aspect of understorey (Table 5). Shannon index values in overstorey ranged from 1.69 to 1.96 and in understorey from 1.63 to 1.92. Species richness was higher in the western aspect for overstorey and southern aspect for understorey. The equitability values were higher in the northern aspect in overstorey and southern aspect in understorey. Beta diversity values ranged from 3.25 to 4.33 in overstorey and 2.88 to 5.2 in understorey. The higher beta diversity was found in the southern aspect for over and understorey vegetation of degraded forest (Table 5).

Results of this study indicated that aspect had marked effect on structure, composition and diversity of degraded forests of Chhattisgarh. The average basal area in the degraded forest was lower as compared to the normal forest. This was due to poor density of trees and also maximum number of trees distributed in lower diameter classes. The poor stocking density in degraded forest was also ascribed due to increased removal of tree cover in this type as most of these forests are easily accessible, which are distributed within 5-6 km radius around habitation.

In the present study, the number of tree species, density and basal area values are lower when compared with other tropical forest ecosystems (Murphy and Lugo 1986; Singh and Singh 1991; Ravan 1994; Verghese and Menon 1998; Sunderpandian and Swamy 2000). Singh and Singh (1991) reported 349 to 627 trees density, 9 to 14.79 m^2/ha basal area and 9 to 14 species in dry tropical forests of Mirzapur district, Uttar Pradesh, India whereas in the present study, the maximum tree density was recorded as 292 tree/ha. In a study, Verghese and Menon (1998) also reported a stand density of 535 trees/ha, species density 12 per 0.1 ha and basal area of 26.57 m^2/ha in southern moist mixed deciduous forests of Agasthyamalai region of Kerala, India. The lower tree density in the present study was a result of poor natural regeneration and poor moisture condition which was also evident by the poor status of understorey layer. Other than this there were no means of supplementation of natural regene-ration by artificial stump planting in gaps.

The diversity parameters of degraded forest are lower than the diversity indices reported in different tropical forests (Singh and Singh 1991; Ramprasad and Pandey 1992; Verghese and Menon 1998). Ramprasad and Pandey (1992) in a tropical forest of Madhya Pradesh found species diversity from 0.32 to 3.76 and concentration of dominance from 0.07 to 0.63 at

Table 5: Aspect wise diversity in degraded forest types (overstorey and understorey)

Aspect	Shannon Index		Simpson Index		Richness		Equitability		Beta Diversity	
	O.S.	U.S.	O.S.	U.S.	O.S.	U.S.	O.S.	U.S.	O.S.	U.S.
Northern	1.90	1.75	0.15	0.12	2.84	2.75	0.97	0.87	3.71	5.20
Southern	1.96	1.63	0.24	0.20	3.47	3.14	0.94	0.88	4.33	5.21
Eastern	1.69	1.72	0.19	0.28	2.51	2.13	0.81	0.80	3.25	2.88
Western	1.85	1.92	0.17	0.15	3.25	3.12	0.88	0.78	3.71	3.71

OS- overstorey
US- understorey

different distances from habitation in Bilaspur, Mandla, Balaghat and Jabalpur districts of Madhya Pradesh, India which indicated the present study in its disturbed domain or in the area of high interference by human beings.

The Shannon index values of the present study area were comparatively lower than those values reported by Singh et al. (1984) and Swamy (1998) for other tropical forests of India. According to Pant and Samant (2007), the diverse habitat and suitable climatic factors can support the growth and survival of the species which in general lack in the present study. The lower diversity of dry tropical ecosystem in this study is attributed to sharing of large proportion of resources by only a few species, while in tropical evergreen forests more number of species efficiently shared the resources. Therefore the higher diversity was found in those forests (Pascal 1992; Swamy 1998). The species diversity also correlated with species richness. Moreover, the higher rate of species turnover resulted in higher beta diversity value.

RECOMMENDATIONS

The study indicated that some parts of the dry tropical ecosystems of Chhattisgarh are severely degraded due to increased biotic interferences and thus affected the structure, composition and diversity of forest. The study reflected that these forests were not ecologically as rich diverse as other dry tropical forests of the world. The immediate implications of this study suggested to adopt the intensive conservation measures through practice of suitable silvicultural management practices especially in degraded and immature under-stocked areas. The rotational grazing practices should be adopted in grazing lands. It is also suggested to practice alternative land management/agrislvicultural practices in marginal and degraded wastelands. Similarly, the farmers should be encouraged to grow multi-purpose trees on field bunds in agriculture lands to meet their domestic needs of fuel, fodder and timber. All these strategies will help in reducing the biotic pressure and also restoring and conserving the fragile dry tropical forest ecosystems of Chhattisgarh.

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