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Phyto-diversity and Population Structure in Southern Moist Mixed Deciduous Forest ($3B/C_2$) of Bori Wild Life Sanctuary (WLS) in Madhya Pradesh, India

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Abstract

The present study deals with the phyto-diversity, population structure including regeneration of un-established seedlings, established saplings and mature trees and physico-chemical properties of soil in southern moist mixed deciduous forest of Bori Wild Life Sanctuary in Madhya Pradesh, India. The results indicated that the average number of un-established and established regeneration of tree seedlings per hectare worked out to be 30,000 ha^{-1}, and 2,778 ha^{-1}, respectively, which were quite adequate. The dominant species in the stand were Tectona grandis, Saccopetalum tomentosum and Lagerstroemia parviflora. The distribution pattern of individuals of tree species in different girth classes was also seemed to be uninterrupted in the stand studied. This trend of uninterrupted distribution of in different growth phases with plenty of established regeneration was the healthy sign of establishment. Other associates showed different growth patterns. The dominant ground flora species were Achyranthes aspera, Zingiber roseum and Flemingia nana. The total density of tree and ground flora species was 247.37 ha^{-1} and 74,665 ha^{-1}, respectively. The level of organic matter in soil was high, which was greater than 1.29 percent. The level of available nitrogen was low, which was less than 280 kg ha^{-1}.

Keywords: *Phyto-diversity, population structure, natural regeneration, stand structure, soil properties*

1. Introduction

The preservation plot Southern moist mixed deciduous forest was established in 1947 for studies on natural development of vegetation and since then no forestry operation was done in the plot. The topography of the area was undulating. The soil color was dark brown due to humus incorporation. The longitude and latitude of the preservation plot were 78°30'E and 21°0' N, respectively. The area of the preservation plot was 31.60 ha.

Ecology of natural regeneration of Southern moist mixed deciduous forest with special reference to crop composition and community types was attempted by Champion and Seth (1968). Due to overexploitation, lack of *ex-situ* conservation, increase human and cattle population, fire incidence, depleting moisture regime, the bio-diversity resources have constantly been under pressure. Thus, on the recommendation of all India Silviculture Conference (Anon, 1929, 1939, 1961) followed by NCA (1976), a large number of preservation plots were laid all over the country (including Madhya Pradesh and Chhatisgarh states) with the objective of *in-situ* conservation of different forest types for regular ecological studies. It was very essential to protect the plot from grazing, fire and illicit cuttings, preservation plots were valuable assets to conduct ecological and growth studies. The present paper deals with the structural composition and population dynamics studies in southern moist mixed deciduous forest ($3B/C_2$) of Bori Wild Life Sanctuary (WLS) in Madhya Pradesh, India.

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2. Materials and Methods

Vegetation structure of preservation plot was studies using quadrat method. For tree, regeneration and ground flora, the numbers of quadrats laid out were 25 quadrats of size 20x20m, 25 quadrats of size 10x10m and 100 quadrats of size 1x1m, respectively. The quantitative analysis of vegetation for frequency, density and basal area was calculated adopting standard method of Mishra (1968). Their relative value were calculated and summed to get importance value index (IVI) following Curtis and Cottom (1956). Biodiversity index was calculated adopting standard method of Shannon-Wiener (1963) using IVI values. In order to assess the status of regeneration and population structure of standing crop, the compartment number 45 was studied adopting standard ecological methods (Mishra, 1989; Philips, 1959). In order to represent the population structure of each species and to determine the distribution pattern of density of different tree species following girth at breast height (GBH)/collar girth classes were established (Ralhan *et. al.* 1982).

Girth Class	Range
A	0-10 collar girth in cm (Un-established regeneration of Seedlings)
B	> 10-20 collar girth in cm (Established regeneration Saplings)
C	> 20-30 gbh in cm
D	> 30-45 gbh in cm
E	> 45-60 gbh in cm
F	> 60-90 gbh in cm
G	> 90-120 gbh in cm
H	> 120-150 gbh in cm
I	> 150-180 gbh in cm
J	>1 80-200 gbh in cm and above

The total numbers of individuals belonging to above girth classes were computed for each species. The database was useful for determining the trend of establishment and growth of each species. The number of individuals in each girth class, for each species, was divided by the total number of individuals in all girth classes of that species. The resultant value was multiplied by 100 to yield per cent density for each girth class for each species.

Five samples from four corners and one center were collected and mixed thoroughly to get a composite sample for analysis of physico-chemical properties of soil. Soil organic carbon was determined by Black (1956) method. The physico-chemical and nutritional properties (N, P, K) of soil were analyzed using soil testing methods by Jackson (1976) and Piper (1950).

3. Results

3.1. Phyto-sociology of Standing Crop

There were 20 tree species viz; *Adina cordifolia, Anogeissus latifolia, Cassia fistula, Diospyros melanoxylon, Ficus glomereta, Grewia tiliaefolia, Lagerstroemia parviflora, Mallotus philippinensis, Mitragyna parvifolia, Ougeinia oojeinensis, Saccopetalum tomentosum, Sapindus mukorossi, Schleichera oleosa, Stereospermum suaveolens, Syzygium cumini, Tectona grandis, Terminalia bellirica, Terminalia tomentosa, Wrightia tinctoria* and *Ziziphus xylopyrus* found in the stand structure (Table-1). On the basis of Importance Value Index (IVI) and diversity index (H), the dominant species, viz, *Tectona grandis* (IVI-73.33, H-0.344), *Saccopetalum tomentosum* (IVI-36.74, H-0.257) and *Lagerstroemia parviflora* (IVI-23.43, H-0.199) were found in the preservation plot

representing southern moist mixed deciduous forests. Total density of tree species, frequency, basal area, and total biodiversity index value were found to be 247.37 ha^{-1}, 900, 19.58 m^2 ha^{-1}, and 2.485, respectively.

3.2. Population Structure and Regeneration of Standing Crop

The status of standing crop of Southern moist mixed deciduous and its associates, pertaining to crop composition, average density of standing trees per ha, average percent composition of crop and its associates in different girth classes, un-established and established regeneration of Bori Wild Life Sanctuary (Table-2). Adequate un-established regeneration of tree seedlings (per ha) with 0 to 10 cm collar girth were found to be *Cassia fistula* (2500), *Schleichera oleosa* (2500), *Ziziphus xylopyrus* (2500), *Saccopetalum tomentosum* (3500), *Diospyros melanoxylon* (4000), *Mallotus philippinensis* (5500), and *Tectona grandis* (5500). Adequate established regeneration of tree saplings (per ha) with > 10 to 20 cm collar girth were found to be *Mallotus philippinensis* (565), *Cassia fistula* (447), *Syzygium cumini* (400), *Saccopetalum tomentosum* (330), *Ziziphus xylopyrus* (283), *Anogeissus latifolia* (188), *Schleichera oleosa* (188), *Tectona grandis* (165), *Terminalia tomentosa* (118), and *Wrightia tinctoria* (94). In the lower and middle girth classes with > 20 to 120 cm girth at breast height (gbh) following tree species (in descending order) viz; *Saccopetalum tomentosum, Tectona grandis, Sapindus mukorossi, Mallotus philippinensis, Wrightia tinctoria, Grewia tiliaefolia, Ficus glomerate, Lagerstroemia parviflora, Schleichera oleosa, Syzygium cumini, Cassia fistula, Ziziphus xylopyrus,Diospyros melanoxylon, Anogeissus latifolia,* and *Ougeinia oojeinensis* were found. In the higher girth classes with > 120 to 200 cm and above girth at breast height (gbh) following tree species (in descending order) viz; *Tectona grandis, Lagerstroemia parviflora, Anogeissus latifolia, Schleichera oleosa, Stereospermum suaveolens, Cassia fistula, Ougeinia oojeinensis, Syzygium cumini, Adina cordifolia, Grewia tiliaefolia, Terminalia bellirica,* and *Terminalia tomentosa* were found.

3.3. Population Structure and Regeneration of Standing Crop

The regeneration of ground flora species in descending order were *Achyranthes aspera, Zingiber roseum, Flemingia nana, Hemidesmus indicus, Smilax macrophylla, Ventilago calyculata, Tridax procumbens, Helicteres isora, Asparagus racemosus, Cyperus rotundus, Grewia tiliaefolia, Phoenix acaulis, Sida rhombifolia, Ziziphus oenoplia, Dioscorea daemona, Urena lobata,* and *Hebiscus ficulenues* (Table-3).

3.4. Physical and Chemical Properties of Soil

The soil texture was sandy loam and sandy clay loam in different soil horizons, respectively. Mechanical analysis in 0-10 cm horizon was sand (56%), silt (26%) and clay (18%). Similarly, in 11-30 cm horizon, it was sand (54%), silt (24%) and clay (22%). Soil nutrients can be taken as a functional index of soil development (Table-4). The slightly acidic pH was suitable for greater availability of nutrients and soil organic matter. The electrical conductivity in 0-10 cm and 11-30 cm horizons were found to be 0.041 ms cm^{-1} and 0.094 ms cm^{-1}, respectively. Available Nutrients in 0-10 cm horizon were N (260 kg ha^{-1}), P (12.2 kg ha^{-1}) and K (32.3 kg ha^{-1}). Similarly, in 11-30 cm horizon the soil nutrients were N (233 kg ha^{-1}) P (11.6 kg ha^{-1}) and K (28.1 kg ha^{-1}).

Table 1. Phyto-sociology of Tree Species ha^{-1} in the Preservation Plot Representing Density, Frequency, Basal Area, Importance Value Index (IVI), Biodiversity Index (H) in Bori WLS

S. N.	Species	Density of trees (ha^{-1})	Frequency of trees	Basal area (m^2 ha^{-1})	Importance Value Index (IVI)	Shannon-Wiener Index of Diversity (H)
1.	*Adina cordifolia* (Roxb.) Hook. f.	1.38	12.50	0.28	3.35	0.050
2.	*Anogeissus latifolia* (R. ex DC.) Wall. ex Bedd.	8.32	50.00	1.24	15.08	0.150
3.	*Cassia fistula* L.	8.30	50.00	0.36	10.59	0.001
4.	*Diospyros melanoxylon* Roxb.	4.76	25.00	0.41	6.48	0.082
5.	*Ficus glomerata* Roxb.	4.14	25.00	0.09	4.85	0.066
6.	Grewia tiliaefolia Vahl.	11.08	62.50	0.38	13.19	0.137
7.	*Lagerstroemia parviflora* Roxb.	11.06	62.50	2.39	23.43	0.199
8.	*Mallotus philippinensis* Muell. Arg	15.26	50.00	0.11	12.16	0.129
9.	*Mitragyna parvifolia* (Roxb.) Korth.	1.38	12.50	0.16	2.73	0.042
10.	*Ougeinia oojeinensis* (Roxb.) Hochr.	12.48	75.00	1.56	21.14	0.186
11.	*Saccopetalum tomentosum* (Roxb.) H. f. & T.	55.53	100.00	0.68	36.74	0.257
12.	*Sapindus mukorossi* Gaertn.	5.52	25.00	0.25	8.90	0.104
13.	*Schleichera oleosa* (Lour.) Oken	12.47	37.50	0.44	11.37	0.124
14.	*Stereospermum suaveolens* (Roxb)DC.	4.15	25.00	0.87	8.82	0.103
15.	*Syzygium cumini* (L.) Skeels	13.86	62.50	1.30	19.02	0.174
16.	*Tectona grandis* L. f.	59.68	100.00	7.51	73.33	0.344
17.	*Terminalia bellirica* (Gaertn.) Roxb.	1.38	12.50	0.99	6.96	0.087
18.	*Terminalia tomentosa* R. (ex DC) Wight & Arn.	1.38	12.50	0.37	3.80	0.055
19.	*Wrightia tinctoria* R.Br.	12.48	87.50	0.14	15.28	0.151
20.	*Ziziphus xylopyrus* (Retz) Willd.	2.76	12.50	0.06	2.78	0.043
Total		**247.37**	**900**	**19.58**	**300**	**2.485**

Table 2. Population Structure of Tree Species ha^{-1} in the Preservation Plot Representing Regeneration of un-established Seedlings, Established Saplings and Mature Trees in Bori WLS

S. N.	Species name	Un-established regeneration of Seedlings (0-10 cm)	Established regeneration Saplings (>10-20 cm)	Population structure of mature tree species (gbh)								Density ha^{-1}
				> 20-30 cm	> 30-45 cm	> 45-60 cm	> 60-90 cm	> 90-120 cm	> 120-150 cm	> 150-180 cm	>1 80-200 cm and above	
		A	B	C	D	E	F	G	H	I	J	
1.	*Adina cordifolia* (Roxb.) Hook. f.	-	-	-	-	-	-	-	-	1.38	-	**1.38**
2.	*Anogeissus latifolia* (R. ex DC.) Wall. ex Bedd.	2000	188	2.77	-	-	-	-	1.38	-	4.17	**8.32**
3.	*Cassia fistula* L.	2500	447	2.77	2.77	-	-	-	1.38	1.38	-	**8.30**
4.	*Diospyros melanoxylon* Roxb.	4000	-	-	-	-	-	4.76	-	-	-	**4.76**
5.	*Ficus glomerata* Roxb.	-	-	1.38	-	1.38	1.38	-	-	-	-	**4.14**
6.	Grewia tiliaefolia Vahl.	-	-	-	2.77	5.55	1.38	-	-	1.38	-	**11.08**
7.	*Lagerstroemia parviflora* Roxb.	-	-	-	-	1.38	1.38	1.38	1.38	2.77	2.77	**11.06**
8.	*Mallotus philippinensis* Muell. Arg	5500	565	12.50	1.38	1.38	-	-	-	-	-	**15.26**
9.	*Mitragyna parvifolia* (Roxb.) Korth.	-	-	-	-	-	-	-	1.38	-	-	**1.38**
10.	*Ougeinia oojeinensis* (Roxb.) Hochr.	-	-	1.38	-	-	-	-	9.72	1.38	-	**12.48**
11.	*Saccopetalum tomentosum* (Roxb.) H. f. & T.	3500	330	25.00	18.05	5.55	5.55	1.38	-	-	-	**55.53**
12.	*Sapindus mukorossi* Gaertn.	-	-	-	1.38	1.38	1.38	1.38	-	-	-	**5.52**
13.	*Schleichera oleosa* (Lour.) Oken	2500	188	5.55	-	-	1.38	-	2.77	2.77	-	**12.47**
14.	*Stereospermum suaveolens* (Roxb)DC.	-	-	-	-	-	-	-	1.38	2.77	-	**4.15**
15.	*Syzygium cumini* (L.) Skeels	-	400	2.77	-	-	-	4.16	5.55	1.38	-	**13.86**
16.	*Tectona grandis* L. f.	5500	165	5.55	6.94	1.38	1.38	8.33	16.66	11.11	8.33	**59.68**
17.	*Terminalia bellirica* (Gaertn.) Roxb.	-	-	-	-	-	-	-	-	-	1.38	**1.38**
18.	*Terminalia tomentosa* R. (ex DC) Wight & Arn.	-	118	-	-	-	-	-	-	-	1.38	**1.38**
19.	*Wrightia tinctoria* R.Br.	2000	94	6.94	4.16	-	1.38	-	-	-	-	**12.48**
20.	*Ziziphus xylopyrus* (Retz) Willd.	2500	283	-	1.38	-	1.38	-	-	-	-	**2.76**
Total		**30000**	**2778**	**66.61**	**38.83**	**18.00**	**16.59**	**21.39**	**41.60**	**26.32**	**18.03**	**247.37**

Table 3. Regeneration of Ground Flora Species ha^{-1} in the Preservation Plot in Bori WLS

S.N.	*Species*	No. of plants ha^{-1}
1.	*Achyranthes aspera* L.	14000
2.	*Asparagus racemosus* Willd.	3000
3.	*Cyperus rotundus* L.	3000
4.	*Dioscorea daemona* Roxb.	1500
5.	*Flemingia nana* Roxb.	6500
6.	*Grewia tiliaefolia* Vahl.	2000
7.	*Hebiscus ficulenues* L.	165
8.	*Helicteres isora* Linn.	3500
9.	*Hemidesmus indicus* R. Br.	6000
10.	*Phoenix acaulis* Roxb.	2000
11.	*Sida rhombifolia* L.	2000
12.	*Smilax macrophylla* Roxb. ex D.Don	6000
13.	*Tridax procumbens* Linn.	4500
14.	*Urena lobata* L.	1500
15.	*Ventilago calyculata* Tul.	5500
16.	*Zingiber roseum* (Roxb.) Roscoe	11500
17.	*Ziziphus oenoplia* (L.) Mill.	2000
Total		**74665**

Table 4. Physico-chemical Properties of Soil in the Preservation Plot in Bori WLS

SN	Soil properties	Soil depth	
		0-10 cm	11-30 cm
Physical properties			
1.	Texture class	SL (Sandy Loam)	SCL (Sandy Clay Loam)
2.	Mechanical Analysis (%)		
2.1.	Sand	56	54
2.2.	Silt	26	24
2.3.	Clay	18	22
Chemical Properties			
3.	pH	6.3	6.2
4.	EC (ms cm^{-1})	0.041	0.094
5.	Organic Matter (%)	2.51	2.25
6.	Available Nutrients		
6.1.	N (kg ha^{-1})	260	233
6.2.	P (kg ha^{-1})	12.2	11.6
6.3.	K (kg ha^{-1})	32.3	28.1

4. Discussion

As per the Champion and Seth (1968) the presence of teak, in this forest type was an indicator of secondary succession. Many workers had previously done arrangement of population structure by size class distribution. The information derived from them, had been used to understand regeneration and the intensity of disturbances and future sustainability of tree species population in forest communities (Schmelz and Lindsey 1965; Robertson 1978; Upreti, 1982). Following patterns of population structures were recognized in different species:

1. Greater proportion of individuals in the lower girth classes (adequate un-established and established regeneration) viz; *Mallotus philippinensis, Tectona grandis, Diospyros melanoxylon, Saccopetalum tomentosum, Cassia fistula, Schleichera oleosa* and *Ziziphus xylopyrus*. This pattern of population structure was indicative of progressive regeneration and frequent reproduction.
2. Gap phase type, having absence of individuals in certain girth classes viz; *Anogeissus latifolia, Ficus glomerate, Mallotus philippinensis, Ougeinia oojeinensis, Wrightia tinctoria, Stereospermum suaveolens, Ziziphus xylopyrus, Adina cordifolia, Diospyros melanoxylon, Mitragyna parvifolia, Terminalia bellirica* and *Terminalia tomentosa.* This pattern of population structure related with alternate periods of stressful periods.
3. More individuals in sapling stage and in higher girth classes viz; *Tectona grandis, Lagerstroemia parviflora, Saccopetalum tomentosum, Cassia fistula, Grewia tiliaefolia, Sapindus mukorossi, Schleichera oleosa* and *Syzygium cumini.* This pattern of population structure is indicative of progressive trends in terms of regeneration and mature trees.
4. Greater proportion of individuals in intermediate stage and absence in regeneration viz; *Adina cordifolia, Ficus glomerata, Grewia tiliaefolia, Lagerstroemia parviflora, Mitragyna parvifolia, Ougeinia oojeinensis, Sapindus mukorossi, Stereospermum suaveolens, Syzygium cumini, Terminalia bellirica* and *Terminalia tomentosa*. This pattern was indicating of inhibition of regeneration for certain period of time.

The dominant ground flora species were *Achyranthes aspera, Zingiber roseum, Flemingia nana, Hemidesmus indicus, Smilax macrophylla* and *Ventilago calyculata.* Ground flora forms an important structural component of forest ecosystem. Although, good deal of information was available regarding the various tree stands of southern moist mixed deciduous forests. The study of the development and succession of ground flora communities in a forest was of practical importance to forestry. The ground flora community not only indicative the fertility status of the forests, but also given an idea of the growth and development of forest floor (Prasad, 1976; Rajavanshi *et al*, 1983; Mathur and Soni, 1983; Chaubey, 1986; Jha and Singh, 1990; Prasad and Srivastava, 1991; Banerjee *et al.*, 1996, 2001).

The soil texture was sandy loam and sandy clay loam with the depth of 0-10 and 11-30 cm, respectively. By increasing the depth of soil, nitrogen and organic matter were found decreased. This was due to less humus in the lower level of soil depth. An organic matter and nitrogen contents of soils with increasing the soil depth was an indication of soil degradation (Barrow, 1991; Heluf and Wakene, 2006).

5. Conclusions

Keeping the status of standing crop and regeneration of different species concluded that though, the crop condition is quite good and regeneration is adequate, yet biotic influences, fire and other hazards could be strictly controlled for the sustainable development of population structure. The following conclusions were drawn:

1. The dominant tree species in the stand were *Tectona grandis*, *Saccopetalum tomentosum* and *Lagerstroemia parviflora*.
2. The distribution pattern of individuals of tree species in different girth classes was also seemed to be uninterrupted in the stand.
3. In most of the tree species adequate regeneration was found.
4. The ground flora was quite adequate showing important structural component of forest ecosystem.
5. The level of organic matter in soil was high and the level of available nitrogen was low.

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