

Phytosociological Attributes of Trees in Sal (*Shorea robusta*)-dominated Forests of Buffer Zone of Bandhavgarh Tiger Reserve, Madhya Pradesh, India

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Abstract Phytosociological attributes viz, density, dominance, frequency, Importance Value Index (IVI) and regeneration status of tree community were assessed in Sal (*Shorea robusta*)-dominated forests of buffer zone of Bandhavgarh Tiger Reserve during the year 2016. A total of 31 tree species belonging to 19 families were evaluated. The study area is dominated by *Shorea robusta* in terms of density and IVI. Regeneration of four species viz, *Chloroxylon swietenia*, *Wrightia tinctoria*, *Flacourtia indica* and *Diospyros melanoxylon* was good. The study area exhibited fair regeneration status despite of the high anthropogenic pressure on the woody species.

Keywords: Phytosociological, Sal, IVI, Bandhavgarh, regeneration

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1. Introduction

Trees are well known to be regulating and maintaining the temperature and oxygen level of the atmosphere, preserving soil, promoting sustenance of wildlife and benefitting the human race. Upper storey (trees) plays a crucial role in the holistic health of any forested region. India contributes to 1.8% (72 million hectares) of the 4.06 billion hectares of global forests. A wide array of forest types, viz, deciduous, semi-evergreen, subtropical and thorn forests in the lower montane zone; temperate forests in higher montane zones; up to thorn and tropical dry deciduous forests in the semi-arid regions (Gujarat and Rajasthan) are characteristic of Indian forests. The tropical forests accommodate more than 50% of the global faunal as well as floral diversity [1]. Moreover, tropical forests are the most complex in nature and the most exploited terrestrial ecosystems of the biosphere [2].

With the escalating development in the country, the forest cover experienced rapid decline over past decades along with associated loss of biodiversity; for the developmental activities promote increased deforestation (primarily for the purpose of agricultural expansion as well as conversion into pastures and urban land) and forest degradation (severe repercussion of unsustainable harvesting, pests, fire, pollution as well as climate change). However, due to the imposition of legislations in terms of forest conservation in the past few years, the rate of deforestation has reduced to 10 million hectares per year as compared to 16 million hectares per year in the 1990s

as per the report published by FAO and UNEP in 2020 [3]. In order to implement such forest conservation-oriented laws/legislations, a thorough understanding of the phytosociological attributes of an area is the chief requirement.

The study area is a human-dominated landscape with associated anthropogenic pressure on its forests in terms of deforestation, non-timber forest produce (NTFP) collection, competition of food resource among wild and domestic herbivores as well as modified feeding habits of carnivores. Assemblage of such factors often results in increasing conflicts and severe retaliatory actions putting the biodiversity in adverse conditions. The aim of this paper is to assess the phytosociological attributes i.e., density, importance value index (IVI) and regeneration status of trees in the Sal (*Shorea robusta*)-dominated forests of the study area as an attempt to facilitate preparation of further management practices and conservation efforts in the reserve.

2. Material and Methods

2.1. Study Area

The study was carried in the buffer zone of Bandhavgarh Tiger Reserve (BTR). The Reserve lies between 23° 27' 00" to 23° 59' 50" North latitude and 80° 47' 75" to 81° 15' 45" East longitude (Figure 1). The core zone of BTR consists of Bandhavgarh National Park and Panpatha Wildlife Sanctuary covering 716 km² and the surrounding buffer includes 820 km², adding up to

1536 km² as the total area of the reserve. The buffer zone has three administrative zones - Manpur, Dhamokhar, and Panpatha. The reserve falls in the districts of Umaria, Katni and Shahdol of Madhya Pradesh. The reserve comprises of five major forest types, viz, moist peninsular low-level Sal forest, northern dry mixed deciduous forest, dry deciduous scrub, dry grassland and West Gangetic moist mixed deciduous forest [4]. The dominant tree species of the forest is Sal (*Shorea robusta*). The forested areas of the buffer zone of the reserve are interspersed with Bamboo patches, meadows as well as scrub lands with universal presence of a noxious weed viz., *Lantana camara*. The study area also consists of degraded forests due to the presence of human settlements as well as agricultural lands. The terrain is the mosaic of both the flat and hilly surfaces which leads to the horizontal heterogeneity in habitat features. The elevation ranges from 324-815 meters above mean sea level (MSL) with a mean elevation of 570m MSL. The reserve has two major river systems, Son and Johila. Son River flows from North to South and lies in the eastern part of the reserve. The average rainfall is 1,173 mm, most of which occurs during the monsoon.

2.2. Methodology

10 transects of two kilometre length each, were laid in four habitat types viz, mixed, Sal, Sal-miscellaneous forest and scrubland. Circular plots of radius 10 m were laid on the transects, at an equidistance of 250 m, resulting in 80 circular plots. In 10 m radius of each circular plot, tree species were recorded along with their number of individuals and girth at breast height (GBH). Plants with

height of >3 m and GBH >30 cm were identified as trees. In the nested plot of radius 5 m, regenerating class was enumerated. Plants with height < 30 cm were identified as seedlings. Plants with 3 m > height > 30 cm were identified as saplings. Density of trees and regenerating class was calculated as follows:

$$\text{Density} = \frac{\text{Number of individuals}}{\text{Area sampled}}$$

IVI of tree species was calculated with the help of following formulae [5]:

$$\text{Relative density} = \frac{\text{Density of species A}}{\text{Total density of all species}} * 100$$

$$\text{Dominance} = \frac{\text{Total basal area of species A}}{\text{Total basal area of all species}}$$

Relative dominance

$$= \frac{\text{Dominance of species A}}{\text{Total dominance of all species}} * 100$$

$$\text{Frequency} = \frac{\text{Number of plots in which species A occur}}{\text{Total number of plots sampled}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of species A}}{\text{Total frequency of all species}} * 100$$

Importance Value Index (IVI)

$$= \text{Relative density} + \text{Relative dominance} + \text{Relative frequency}$$

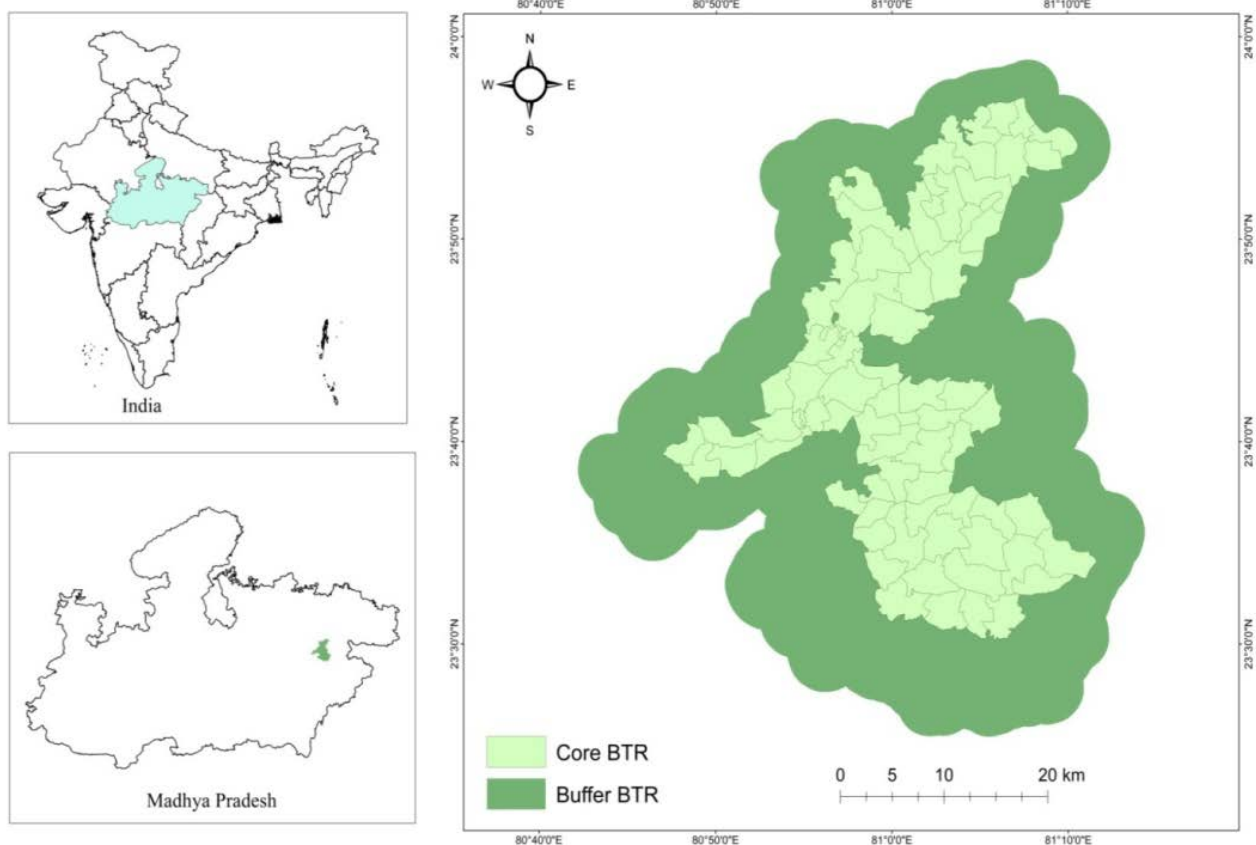


Figure 1. Location map of the study area

Regeneration of tree species was categorized under following categories [6]:

GOOD = seedling > sapling > adult

FAIR = seedling > sapling ≤ adult

POOR = species surviving in only sapling stage, but not as seedlings (sapling may be <, > or = adult)

NONE = species only present as adults

NEW

= species surviving only as sapling and / or seedling

3. Results and Discussion

Phytosociological assessment described a total of 702 individuals described among 31 tree species under 19 families. Similar species richness from another tropical dry deciduous forest of central India (29 tree species

represented by 17 families with Fabaceae being the most dominant) was reported by [7]. However, the species richness in the examined forest was found to be comparatively lower than the Sal-dominated forests of Gorakhpur division of eastern terai region (208 species) [8], eastern Himalayas (87 species) [9], North-east (71 species) [10] and central India (56 species) [11] as well as Nepal (68 species) [12] and Bangladesh (94 species) [13]. Family Fabaceae showed dominance with highest number of tree species (five) followed by Combretaceae and Anacardiaceae with three tree species each; as well as Salicaceae, Rubiaceae, Myrtaceae and Ebenaceae with two tree species each. Abundance of the Fabaceae family attests to the old age and maturity of the surveyed forest [14]. Remaining families viz, Phyllanthaceae, Rutaceae, Apocynaceae, Rhamnaceae, Lecythidaceae, Sapindaceae, Sapotaceae, Ebenaceae, Meliaceae, Dipterocarpaceae, Burseraceae, Lythraceae and Malvaceae were represented by one tree species each. The result is similar to research findings [15,16] demonstrating that although the forest consisted of several families, many of them are represented by only one tree species.

Table 1. Phytosociological attributes (density, importance value index and regeneration status of tree community) evaluated during 2016 in buffer zone of Bandhavgarh Tiger Reserve, Madhya Pradesh, India

S.No.	Tree species	Family	Mean density (ha)	Relative density	Relative dominance	Relative frequency	IVI	Regeneration status
1	<i>Cassia fistula</i>	Fabaceae	36.37	2.34	0.75	2.56	5.66	FAIR
2	<i>Phyllanthus emblica</i>	Phyllanthaceae	54.56	3.51	1.33	2.56	7.40	POOR
3	<i>Pterocarpus marsupium</i>	Fabaceae	31.83	2.05	0.55	0.73	3.33	NONE
4	<i>Casearia elliptica</i>	Salicaceae	54.97	3.54	2.17	4.02	9.73	POOR
5	<i>Semecarpus anacardium</i>	Anacardiaceae	37.13	2.39	1.10	2.20	5.69	NONE
6	<i>Chloroxylon swietenia</i>	Rutaceae	100.38	6.46	4.58	4.76	15.80	GOOD
7	<i>Buchanania cochinchinensis</i>	Anacardiaceae	54.22	3.49	5.78	9.88	19.15	POOR
8	<i>Mitragyna parviflora</i>	Rubiaceae	31.83	2.05	0.56	0.73	3.34	FAIR
9	<i>Anogeissus latifolia</i>	Combretaceae	47.74	3.07	0.89	1.46	5.43	FAIR
10	<i>Dalbergia lanceolaria</i>	Fabaceae	47.74	3.07	2.64	2.93	8.64	POOR
11	<i>Wrightia tinctoria</i>	Apocynaceae	42.44	2.73	0.30	1.10	4.13	GOOD
12	<i>Eucalyptus hybrid</i>	Myrtaceae	31.83	2.05	0.10	0.37	2.52	NONE
13	<i>Ziziphus xylopyrus</i>	Rhamnaceae	63.65	4.10	0.19	0.37	4.65	POOR
14	<i>Lannea coromandelica</i>	Anacardiaceae	43.19	2.78	4.02	5.12	11.93	NONE
15	<i>Haldina cordifolia</i>	Rubiaceae	31.83	2.05	0.29	0.73	3.07	NONE
16	<i>Terminalia chebula</i>	Combretaceae	31.83	2.05	0.23	0.37	2.65	NONE
17	<i>Syzygium cumini</i>	Myrtaceae	45.47	2.93	1.76	2.56	7.24	FAIR
18	<i>Flacourtia indica</i>	Salicaceae	47.74	3.07	0.26	0.73	4.07	GOOD
19	<i>Acacia catechu</i>	Fabaceae	74.26	4.78	0.65	1.16	6.59	NONE
20	<i>Careya arborea</i>	Lecythidaceae	31.83	2.05	0.11	0.37	2.53	NONE
21	<i>Schleichera oleosa</i>	Sapindaceae	47.74	3.07	0.54	0.73	4.35	NONE
22	<i>Madhuca indica</i>	Sapotaceae	48.80	3.14	4.75	5.49	13.39	FAIR
23	<i>Butea monosperma</i>	Fabaceae	31.83	2.05	0.83	1.83	4.71	NONE
24	<i>Diospyros montana</i>	Ebenaceae	31.83	2.05	0.09	0.37	2.50	NONE
25	<i>Soymdia febrifuga</i>	Meliaceae	31.83	2.05	0.07	0.37	2.48	POOR
26	<i>Terminalia elliptica</i>	Combretaceae	54.97	3.54	3.64	4.02	11.21	POOR
27	<i>Shorea robusta</i>	Dipterocarpaceae	168.37	10.84	49.20	22.68	82.73	FAIR
28	<i>Boswellia serrata</i>	Burseraceae	31.83	2.05	0.49	0.37	2.90	NONE
29	<i>Lagerstroemia parviflora</i>	Lythraceae	49.33	3.18	3.46	7.38	14.02	POOR
30	<i>Bombax ceiba</i>	Malvaceae	31.83	2.05	0.31	0.37	2.72	NONE
31	<i>Diospyros melanoxylon</i>	Ebenaceae	83.55	5.38	8.35	11.71	25.43	GOOD

Mean density/ha along with the relative density, relative dominance, relative frequency, IVI and regeneration status of each tree species has been summarized under Table 1. The dominant tree species with highest IVI and mean density in the human-dominated buffer zone of BTR is *Shorea robusta*. Mean density of *Shorea robusta* was calculated to be 168.37 (mean density/ha). The tree species were segregated into three classes A, B and C: 3.23% (one species) had ≥ 100 individuals, 35.48% (11 species) had >10 and <100 individuals and the rest of the 61.29% (19 species) had <10 individuals respectively. Sal belonged to Group A with 328 individuals. The forested area of the buffer zone of the reserve is primarily characteristic of tropical moist deciduous forest dominated by *Shorea robusta* interspersed with patches of *Dendrocalamus strictus*, scrub land and thickets of *Lantana camara*, *Phyllanthus emblica*, *Casearia elliptica*, *Chloroxylon swietenia*, *Buchanania cochinchinensis*, *Dalbergia lanceolaria*, *Syzygium cumini*, *Madhuca indica*, *Terminalia elliptica*, *Lagerstroemia parviflora*, *Diospyros melanoxylon* and *Lannea coromandelica* described group B. Species belonging to group B are found in large numbers as they are economically important to the local people residing in the buffer zone in terms of timber, fuel wood and several NTFP purposes and are therefore, experience selective logging which stimulates their regeneration. Tree species viz, *Phyllanthus emblica*, *Buchanania cochinchinensis*, *Syzygium cumini* and *Diospyros melanoxylon* are utilized by the local people in terms of timber and fuel wood as well as for their seasonal fruits. Fruits of *Buchanania cochinchinensis* bear single seed which is an edible nut called *Chironji*. Flowers and fruits of *Madhuca indica* are collected by the local people as the flowers are used in liquor-making and vegetable oil extracted from the fruits is used in cooking. Group C consists of species with individuals less than 10.

Importance value index of *Shorea robusta* was calculated to be highest (82.73) followed by *Diospyros melanoxylon* (25.43). High importance value index suggests that the tree species are ecologically important in terms of better regenerating tendency as well as good adaptability. Importance value index of six tree species viz, *Chloroxylon swietenia*, *Buchanania cochinchinensis*, *Lannea coromandelica*, *Madhuca indica*, *Terminalia elliptica* and *Lagerstroemia parviflora* was calculated to be in the range of >10 and <20 . Remaining 23 tree species were evaluated to have lesser importance value indices.

A total of 810 seedlings and 965 saplings have been recorded from the study area during the survey. Out of 31 tree species, 10 species showed good to fair regeneration; eight species showed poor regeneration and 41.94% (13 species) lacked regeneration. The regeneration of tree species is influenced by edaphic factors, light intensity and anthropogenic pressure of varying nature [17,18,19,20,21]. Summer season of the reserve experiences significant amount of anthropogenic pressure in terms of Mahua's flowers and fruits collection, forest fires, Tendu's leaves harvesting along with the fuel wood collection throughout the year. However, regeneration of tree species is still sustained in the study area. 6 out of 31 species (*Cassia fistula*, *Mitragyna parviflora*, *Anogeissus latifolia*, *Syzygium cumini*, *Madhuca indica* and *Shorea robusta*) showed fair regeneration; whereas, *Diospyros melanoxylon*, *Chloroxylon*

swietenia, *Wrightia tinctoria* and *Flacourtia indica* showed good regeneration. *Diospyros melanoxylon* showed good regeneration despite of the harvesting of its leaves from the saplings for *beedi-making*. In the presence of moderate human disturbance, many species tend to benefit in terms of their regeneration, as per the intermediate disturbance hypothesis. As the disturbance (selective logging and lopping) results in canopy gaps which enable increased penetration of light and elevated soil temperature along with reduced competition for nutrients and water, making the environmental conditions favorable. Moreover, the herbivores (domestic and wild) facilitate seed dispersion and germination.

Chloroxylon swietenia is categorized as Vulnerable (VU) by the IUCN red data list [22]. Density of the tree species was calculated to be 100.38 (mean density/ha) in the study area and it showed good regeneration too. Moreover, *Pterocarpus marsupium* is categorized as Near Threatened (NT) by the IUCN red data list with 'decreasing' population trend [23]. Density of the tree species was calculated to be 31.83 (mean density/ha) with no regeneration. *Phyllanthus emblica* and *Acacia catechu* had decreasing population trend according to the IUCN red data list [24,25]. Remaining tree species were either categorized as Least Concern (LC) or were not evaluated of their conservation status.

4. Conclusion

The survey covered small area of the buffer zone but the quantification of the vegetation attributes provided an insight into the better understanding of Sal-dominated forest of BTR. Despite of the anthropogenic pressure, the buffer zone of the reserve is characterized by rich floral community along with fair amount of regeneration. However, further estimation of biomass and carbon sequestration potential may facilitate supplementary understanding regarding the sustainability and productivity of the forest.

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Statement of Competing Interests

The authors have no competing interests.

List of Abbreviations

NTFP – Non-Timber Forest Products
IVI – Importance Value Index

BTR – Bandhavgarh Tiger Reserve
MSL – Mean Sea Level
GBH – Girth at Breast Height

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