Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 3, No. 10, p. 86-99, 2013
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Phytosociological attributes of a tropical dry deciduous forest of Bundelkhand region of Uttar Pradesh, India

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Article published on October 12, 2013

Key words: Bundelkhand, biodiversity, phytosociology, species richness, vegetation analysis.

Abstract

The present investigation reflects the findings of phytosociological attributes which have been undertaken in the forests of Mahoba district of Bundelkhand region of Uttar Pradesh, India. The vegetation types of district Mahoba is mainly Tropical dry mixed deciduous forest, consist of scrubs and thorn forest and grasslands. Vegetation analysis was conducted during 2007 to 2012. The survey documentation of the plant species in the different forests areas of Mahoba recorded 50 species of tree and 31 species of shrubs/herbs/climbers. Among the trees *Anogeissus pendula* and *Butea monosperma* showed maximum density (0.33/100 m2) and *Flacourtia indica* showed maximum density (7.3326/100 m2) among lower group. The basal area of different tree species varied between 4.9230 to 0.0134 m2/ha and *Anogeissus pendula* showed maximum basal area (4.9230 m2/ha) and the basal area of different shrub/herb/climber species varied between 0.3802 to 0.0004 m2/ha where *Zizyphus nummularia* showed maximum basal area (0.3802 m2/ha). The dominant tree species *Anogeissus pendula* exhibited higher IVI value (23.6317) and among shrub/herb/climber species *Flacourtia indica* exhibited higher IVI value (54.7403).

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Introduction

The conspicuous element of the earth is the existence of life, and the salient feature of life is its diversity (Dahlberg, 1989; Tilman, 2000; Wardle *et al*., 2011; Sharma and Sarkar, 2013). Biodiversity is way of describing the diversity of life on earth; it includes all life forms and the ecosystem of which they are part (Ewing, 1990). It forms the foundation for sustainable development, constitutes the basis for the environmental health of our land and is the source of economic and ecological security for our future generations. In the developing country, biodiversity provides the assurance of food, many raw materials such as fiber for clothing, materials, for shelter, fertilizer, fuel and medicines, as well as source of work energy in the form of animal traction (Parveen and Hussain, 2007). In addition, biodiversity maintains balance for planetary and human survival (Jafferies, 1997). The current contraction of biodiversity is cause for alarm, while disappearance is most serious. Biodiversity is continuously declining due to the activities of human kind (Krishnmurthy, 2003).

Forests are repository of the biodiversity, gene pool resources, sequester carbon dioxide and provide lot of other environmental services. They play a vital role in sustaining the life of people and are crucial for the food and water security. The first and foremost objective of forest management in any country is to ensure livelihood security. This is ensured through better management practices and sustainable utilization of forestlands (Anderson-Teixeira *et al*. 2013). In India, the sustained flow of water in our rivers, streams and rivulets and recharge of ground water is necessary for the food security and drinking water availability. The hydrological functions of forests include interception of rainfall and regulating the stem flows, binding soil to prevent soil erosion and conserving the soil moisture. The Forests are the source of major water resource both surface, subsoil and ground water in the country. Forests supply nutrients to agriculture crops through runoff water with much other complementariness with agriculture ecosystem (Godfrey, 2011).

In the absence of operation planning and convergence degradation of forests and adjoining lands continued which seriously affected the sustainability of crops and natural vegetation. Due to continuous degradation of land resources, depletion of precious biodiversity and conservation functions of forests the resource is getting reduced gradually causing serious ecological concerns in many parts of the country (Rai, 2012).

Several researchers (Mishra *et al*., 1993; Awasthi *et al*., 2001; Bhadra *et al*., 2010; Misra and Sharma, 2010; Das and Menon, 2011; Hegde *et al*., 2011; Jaykumar and Nair, 2012; Bajpai *et al*., 2012; Ahmed, 2012; Sahu *et al*., 2012) worked on phytosociology in different part of the country but literature about Bundelkhand region are limited.
Present investigation have been carried out in the forests of Mahoba district of Uttar Pradesh, Bundelkhand region, India to assess the plant biodiversity (especially phyto-sociological analysis) of forest of Mahoba district which are belongs to Tropical Dry Deciduous Forest (Champion and Seth, 1968) with the following objectives:

- to determine the density, basal area and population structure of trees and shrubs/herbs/climbers species.
- to assess the species richness and diversity of plant species.

Materials and methods

Study areas

Forest of Mahoba district lies between 25° 01' to 25° 39' N latitude and 79° 15' to 80° 10' E longitude (Fig.1.). Total geographical area of the district is 2884 sq. km. Geologically the area comprises Precambrian Bundelkhand massif dolerites, granites and quartz reefs unconfirmavely overlain by quaternary alluvium. The main and major rivers of the district are Dhasan, Urmil, Birma and Arjun. The

average annual rainfall is 580 mm. The climate is typical subtropical punctuated by long and intense summer. About 87% of the annual rainfall is received from south-west monsoon. May is the hottest month with mean average temperature shooting upto 44.5°C. With the advance of monsoon by about mid-June, temperature starts decreasing. January is usually the coldest month with the mean average temperature fall upto 4.0°C. The relative humidity is highest during south-west monsoon ranging between 80% to 85% with its lowest around 30% during peak summer months of April and May. Average rain fall is 600 - 700 mm but concentrated only during July – August. Most of the rain fall is run-off due to rocky nature of the soil.

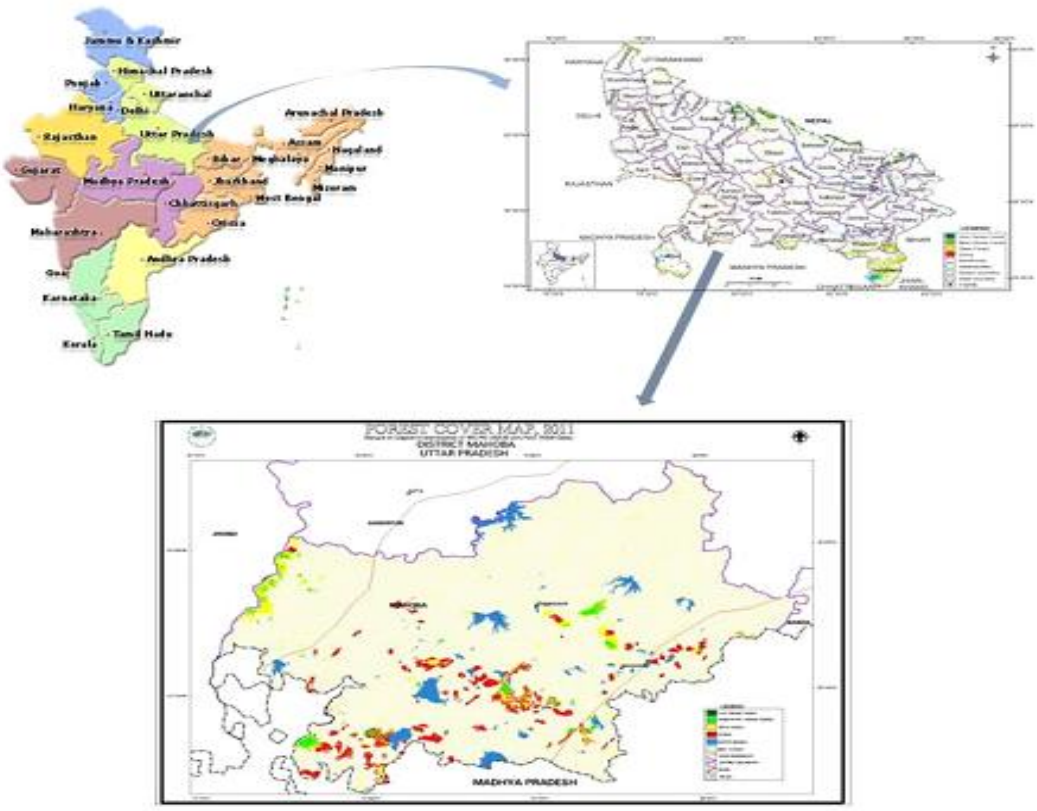

Fig. 1. Vegetation covers of District Mahoba.

The district is characterized by presence of Bundelkhand massif terrains. The master slope of the area is mainly towards northeast. The district can be broadly classified into two physiographic units. I. Southern part, having high relief and II. Northern part is having relatively low relief with low hillocks. In Mahoba district soil has been produced by the weathering of granites. Well known Bundelkhand varieties are Mar, Kafur, Parana and Rakar. Clayey and loamy soil is dominant in the district. The forest of Mahoba district includes 4 ranges viz. Mahoba, Charkhari, Panwari and Jaitpur. This forest spreads in 15,731.43 hactare (Fig.2.)

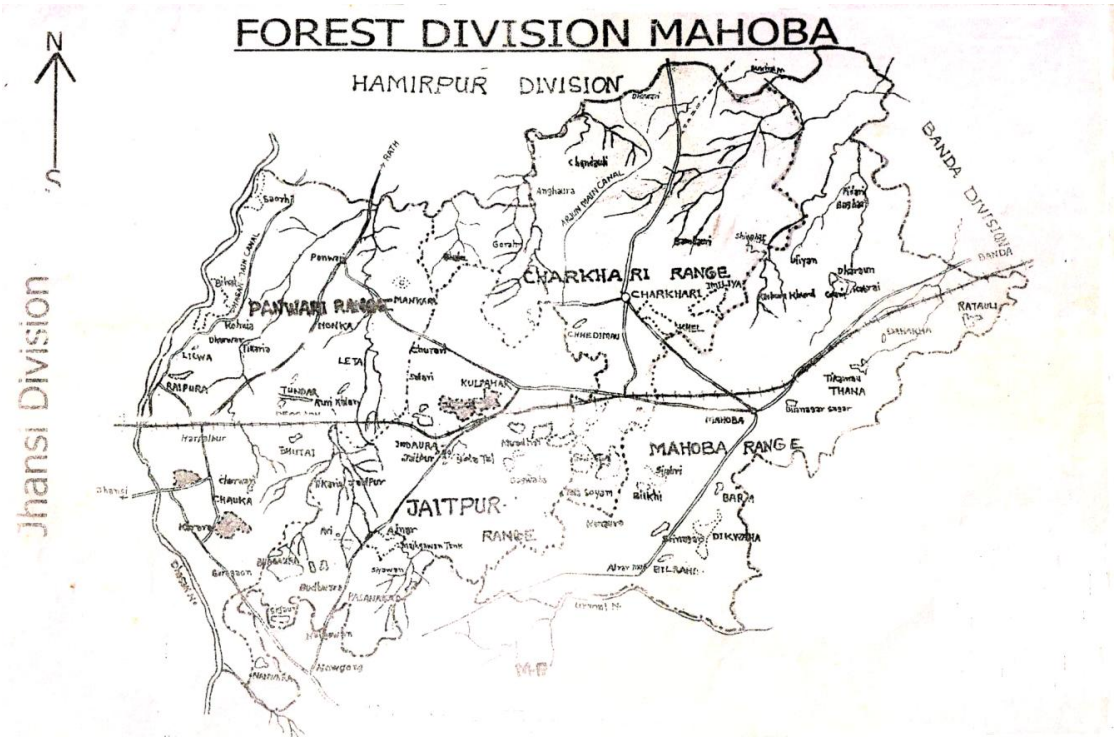

Fig. 2. Forest Ranges of District Mahoba.

Floristic survey

Selected forest areas were visited during the year of 2007 to 2012, when the plants growth almost ceased and most of the foliage of the plant was still intact. Sampling of vegetation was done by quadrate methods (Misra, 1968).

Vegetation analysis

The surveys of area have been done by sampling method. Size of the unit sample (quadrate) and minimum number of samples have been determined by species-area curve and minimum quadrate–number method, respectively.

Analytical characters were obtained mostly by vegetation analysis with the help of *nested quadrate method*. The quadrate size for trees, shrubs, and herbs was 10m x 10m, 3m x 3m and 1m x 1m respectively.

Phyto-sociological analysis

During phyto-sociological analysis, trees and ground vegetation was differentiated by measuring the girth at breast height (gbh). Only stems ≥ 20 cm gbh (1.3 m above ground level) were considered "woody trees" and phyto sociological analyses were limited to them. Girth was measured using 2 m tape. Height of small trees and shrubs was measured using a 5 m graded pole. When the height exceeded 5 m it was estimated visually. For calculating the basal area of multi-stemmed trees, the girth of each stem was measured individually and added up. Phyto-sociological parameters indicated below were analyzed by the following methods and formulas –

% Frequency =

$$\frac{\text{Number of qudrats of occurrence of a species}}{\text{Total number of quadrats studied}} \times 100$$

Density =

$$\frac{\text{Total number of individual of a species}}{\text{Total number of quadrats studied}}$$

$$Abundance = \frac{\text{Total number of individual of a species}}{\text{Total number of quadrats in which the species occurred}}$$

$$Basal\ area = \frac{C^2}{4\pi}$$

Where, C = Circumference at Breast Height

Basal area is an index of dominance. The total basal area is the sum of individual basal areas of all trees calculated from the gbh of each tree.

Importance Value Index (*IVI*)

Species Importance Value Index IVI was computed by adding the figures of relative density, relative frequency and relative basal area for that species. It gives the total picture or the sociological structure of a species in a community.

Importance Value Index (IVI) = Rel. Freq + Rel. Den + Rel. Dom

Relative Frequency =

$$\frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

Relative Density =

$$\frac{\text{Number of individuals of a species}}{\text{Number of individuals of all species}} \times 100$$

Relative Dominance =

$$\frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$$

Species diversity analysis

Species diversity was calculated using the Simpson index (Simpson, 1949) and Shannon-Wiener index (Shannon and Wiener, 1949). The pooled data of important value index were used to calculate the species richness and general diversity in selected forest of Bundelkhand region.

Simpson index (probability measures)

D = 1-c

Where $c = \sum_{i=1}^{s} Pi^2$

Pi = importance of its species in the stand (proportion of number, biomass etc.)

S = number of species present, and

$\sum_{i=1}^{s}$ denotes summation of Pi^2 values for i=1 all species·

The value of 'D' varies from zero (low diversity) to a maximum of 1-1/s, where s is the number of the species. The index gives relatively little weight to the rare species and more weight to the common species.

Shannon-Wiener's index (information measures)

$$H = \sum_{i=1}^{s} Pi \log Pi$$

Where, Pi is the proportion of the total number of individuals consisting its species and s is the number of species.

The index is influenced by the number of species and the equitability of evenness of allotment of individuals among the species.

Equitability or Evenness

The equitability (range 0-1) is found by the following formula:

$$E = H/\log s$$

Where, log s = value of species diversity index under condition of maximal equitability.

Results and discussion

Species composition and their density (*Plant/100 m²*)

A total of 50 species of tree were recorded from this forest area during the study period (Table 1.).

Table 1. Phytosociological observation of Tree species in Mahoba forest (Species arranged in descending order of IVI).

S. No.	Trees	Family	Frequency (%)	Density (100 m²)	Basal Area (m²/ha)	Reletive Frequency	Reletive Density	Reletive Dominance	IVI
1	*Anogeissus pendula* Edgew.	Combretaceae	29.0000	0.3300	4.9230	6.1181	5.6122	11.9013	23.6317
2	*Butea monosperma* (Lam.) Taub.	Fabaceae	30.0000	0.3300	3.8236	6.3291	5.6122	9.2435	21.1849
3	*Anogeissus latifolia* (Roxb. ex DC) Wall. Ex Guill. & Perr.	Combretaceae	29.0000	0.3000	3.0276	6.1181	5.1020	7.3193	18.5395
4	*Diospyrous melanoxylon* Roxb.	Ebenaceae	28.0000	0.3000	2.9071	5.9072	5.1020	7.0278	18.0371
5	*Acacia catechu* (L.f.) Willd.	Fabaceae	26.0000	0.2700	2.4701	5.4852	4.5918	5.9715	16.0485
6	*Madhuca indica* Gmel.	Sapotaceae	24.0000	0.2700	2.5836	5.0633	4.5918	6.2458	15.9010
7	*Acacia nilotica* (Linn.) Willd. ex Delile	Fabaceae	20.0000	0.2200	1.6957	4.2194	3.7415	4.0993	12.0602
8	*Lagerstromia parviflora* Roxb.	Lythraceae	18.0000	0.1900	1.5356	3.7975	3.2313	3.7123	10.7411
9	*Ailanthus excelsa* Roxb.	Xanthoxylaceae	17.0000	0.1900	1.4213	3.5865	3.2313	3.4359	10.2537
10	*Adina cardifolia* Hook. f.	Rubiaceae	14.0000	0.1700	1.4764	2.9536	2.8912	3.5691	9.4139
11	*Acacia leucophloea* Willd.	Fabaceae	13.0000	0.1600	1.4793	2.7426	2.7211	3.5763	9.0400
12	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae	11.0000	0.1600	1.2459	2.3207	2.7211	3.0119	8.0537
13	*Terminalia tomentosa* (Roxb.) Wight & Arn.	Combretaceae	12.0000	0.1500	0.9318	2.5316	2.5510	2.2526	7.3352
14	*Cassia fistula* Linn.	Caesalpinaceae	13.0000	0.1500	0.8332	2.7426	2.5510	2.0143	7.3080
15	*Azadirachta indica* Ad. de Juss.	Meliaceae	10.0000	0.1400	0.8940	2.1097	2.3810	2.1613	6.6520
16	*Albizzia lebbek* (Linn.) Benth.	Fabaceae	11.0000	0.1500	0.7343	2.3207	2.5510	1.7752	6.6469
17	*Wrightia tomentosa* Roem. & Schult.	Apocynaceae	12.0000	0.1700	0.4870	2.5316	2.8912	1.1774	6.6002
18	*Dalbergia sissoo* Roxb.	Fabaceae	12.0000	0.1400	0.6595	2.5316	2.3810	1.5944	6.5070
19	*Albizzia odoretissima* Willd.	Fabaceae	11.0000	0.1500	0.5672	2.3207	2.5510	1.3711	6.2428
20	*Feronia limonia* (Linn.) Swingle	Rutaceae	8.0000	0.1600	0.7279	1.6878	2.7211	1.7597	6.1686
21	*Zizyphus xylopyra* Willd.	Rhamnaceae	9.0000	0.1400	0.7118	1.8987	2.3810	1.7207	6.0004
22	*Tamarindus indica* Linn.	Fabaceae	7.0000	0.1300	0.7897	1.4768	2.2109	1.9091	5.5968
23	*Syzygium cuminii* (Linn.) Skeels	Myrtaceae	8.0000	0.1100	0.3858	1.6878	1.8707	0.9328	4.4913
24	*Mangifera indica* Linn.	Anacardiadiaceae	7.0000	0.1000	0.4957	1.4768	1.7007	1.1983	4.3758
25	*Pterocarpus marsupium* Roxb.	Fabaceae	7.0000	0.0900	0.3604	1.4768	1.5306	0.8712	3.8786
26	*Emblica officinalis* Gaertn. Fruct.	Euphorbiaceae	7.0000	0.0900	0.3203	1.4768	1.5306	0.7742	3.7816
27	*Tectona grandis* Linn. f.	Verbenaceae	7.0000	0.0700	0.3312	1.4768	1.1905	0.8006	3.4679
28	*Grewia tilaefolia* Vahl.	Tiliaceae	6.0000	0.0700	0.3789	1.2658	1.1905	0.9161	3.3724
29	*Casearia tomentosa* Roxb.	Flacourtiaceae	5.0000	0.0600	0.5053	1.0549	1.0204	1.2217	3.2969
30	*Ficus glomerata* Roxb.	Moraceae	5.0000	0.0800	0.3275	1.0549	1.3605	0.7918	3.2072
31	*Holarrhena antidysentrica* Wall.	Apocynaceae	5.0000	0.0900	0.1427	1.0549	1.5306	0.3451	2.9305
32	*Miliusa tomentosa* (Roxb.) J.Sinclair	Annonaceae	5.0000	0.0700	0.1724	1.0549	1.1905	0.4167	2.6620
33	*Pongamia pinnata* (Linn.) Pierre	Papilionaceae	5.0000	0.0600	0.2058	1.0549	1.0204	0.4974	2.5727
34	*Erythrina suberosa* Roxb.	Fabaceae	3.0000	0.0500	0.3852	0.6329	0.8503	0.9311	2.4144
35	*Sterculia urens* Roxb.	Sterculiaceae	4.0000	0.0600	0.1242	0.8439	1.0204	0.3003	2.1646
36	*Hardwickia binnata* Roxb.	Fabaceae	3.0000	0.0500	0.2281	0.6329	0.8503	0.5515	2.0347
37	*Gardenia turgida* Roxb.	Rubiaceae	3.0000	0.0500	0.1424	0.6329	0.8503	0.3443	1.8275
38	*Bauhinia racemosa* Lam.	Fabaceae	3.0000	0.0500	0.1218	0.6329	0.8503	0.2943	1.7776
39	*Terminalia chebula* Retz.	Combretaceae	3.0000	0.0400	0.1472	0.6329	0.6803	0.3558	1.6690

40	*Carissa spinarum* Linn.	Apocynaceae	4.0000	0.0400	0.0120	0.8439	0.6803	0.0290	1.5532
41	*Prosopis spicigera* Linn.	Fabaceae	2.0000	0.0400	0.1743	0.4219	0.6803	0.4214	1.5236
42	*Holoptelia integrifolia* Planch.	Urticaceae	3.0000	0.0400	0.0580	0.6329	0.6803	0.1403	1.4535
43	*Aegle marmelos* (Linn.) Correa ex Roxb.	Rutaceae	3.0000	0.0300	0.0510	0.6329	0.5102	0.1233	1.2664
44	*Lannea coromandelica* (Houtt.) Merr.	Anacardiadiaceae	2.0000	0.0400	0.0474	0.4219	0.6803	0.1146	1.2168
45	*Cochlospermum religiosum* (Linn.) Alston	Cochlospermaceae	2.0000	0.0300	0.0928	0.4219	0.5102	0.2244	1.1565
46	*Mitragyna parviflora* (Roxb.) Korth.	Rubiaceae	2.0000	0.0300	0.0688	0.4219	0.5102	0.1664	1.0985
47	*Buchanania lanzan* Spreng.	Terebinthaceae	2.0000	0.0200	0.0645	0.4219	0.3401	0.1558	0.9179
48	*Alangium salvifolium* (L.F.) WANG.	Alangiaceae	2.0000	0.0200	0.0413	0.4219	0.3401	0.0997	0.8618
49	*Terminalia bellerica* Roxb.	Combretaceae	1.0000	0.0200	0.0413	0.2110	0.3401	0.0997	0.6508
50	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	1.0000	0.0100	0.0134	0.2110	0.1701	0.0323	0.4134

Anogeissus pendula and *Butea monosperma* showed maximum density (0.33/100 m²) which was followed by *Anogeissus latifolia* (0.3/100 m²), *Diospyrous melanoxylon* (0.3/100 m²) respectively and *Schleichera oleosa* (0.01/100 m²) showed the lowest density cover among trees. Whereas, a total of 31 species of shrubs/herbs/climbers were recorded from this forest in which *Flacourtia indica* showed maximum density (7.3326/100 m²) followed by *Convolvulus microphullus* (3.9996/100 m²), *Lantana camara* (2.8886/100 m²), and *Asparagus racemosus* and *Piper longum* recorded lowest density (0.2222/100 m²) as shown in Table 2 .

Table 2. Phytosociological observations of Shrub/Herb/Climber species in Mahoba forest (Species arranged in descending order of IVI).

S. No.	Shrubs/Hurbs/ Climbers	Family	Frequency (%)	Density (100 m²)	Basal Area (m²/ha)	Reletive Frequency	Reletive Density	Reletive Dominance	IVI
1	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	29.0000	7.3326	0.2200	17.4699	18.6969	18.5735	54.7403
2	*Zizyphus nummularia* (Burm.f.) Wight & Arn.	Rhamnaceae	15.0000	2.5553	0.3802	9.0361	6.5156	32.0940	47.6458
3	*Carissa spinarum* Linn.	Apocynaceae	7.0000	1.4443	0.1499	4.2169	3.6827	12.6585	20.5581
4	*Zizyphus mauritiana* Lamk.	Rhamnaceae	7.0000	0.9999	0.0917	4.2169	2.5496	7.7399	14.5063
5	*Convolvulus microphullus* Sieb. ex Spreng.	Convolvulaceae	5.0000	3.9996	0.0040	3.0120	10.1983	0.3413	13.5517
6	*Solanum indicum* Linn.	Solanaceae	9.0000	2.1109	0.0318	5.4217	5.3824	2.6869	13.4911
7	*Echinops echinatus* Roxb.	Asteraceae	9.0000	2.3331	0.0148	5.4217	5.9490	1.2464	12.6171
8	*Lantana camara* Linn.	Verbenaceae	7.0000	2.8886	0.0079	4.2169	7.3654	0.6689	12.2512
9	*Tinospora cardifolia* Hook.f .& Thoms.	Menispermaceae	9.0000	1.6665	0.0158	5.4217	4.2493	1.3300	11.0010
10	*Calotropis procera* (Ait.) Ait. f.	Asclepiadaceae	8.0000	1.3332	0.0201	4.8193	3.3994	1.6929	9.9116
11	*Ichnocarpus frutescens* Ait. & Ait.	Apocynaceae	4.0000	0.8888	0.0569	2.4096	2.2663	4.8066	9.4826
12	*Curcuma amada* Roxb.	Zingiberaceae	7.0000	1.1110	0.0149	4.2169	2.8329	1.2614	8.3111
13	*Helicteres isora* Linn.	Sterculiaceae	4.0000	0.7777	0.0354	2.4096	1.9830	2.9855	7.3781
14	*Ocimum basilicum* Linn.	Lamiaceae	5.0000	1.2221	0.0134	3.0120	3.1161	1.1345	7.2627
15	*Cocculus hirsutus* (Linn.) Diels	Menispermaceae	5.0000	0.9999	0.0145	3.0120	2.5496	1.2241	6.7857
16	*Gymnma sylvestre* (Retz.) Schult. R.Br.	Asclepiadaceae	6.0000	0.8888	0.0035	3.6145	2.2663	0.2985	6.1793
17	*Balanites aegyptica* (Linn.)	Zygophyllaceae	4.0000	0.8888	0.0110	2.4096	2.2663	0.9293	5.6052

	Delile								
18	*Dendrocalamus strictus* (Roxb.) Nees	Poaceae	1.0000	0.5555	0.0354	0.6024	1.4164	2.9855	5.0043
19	*Datura alba* (Nees. Ab. Esenb.)	Solanaceae	4.0000	0.6666	0.0079	2.4096	1.6997	0.6643	4.7736
20	*Andrographis paniculata* (Burm.f.) Wall.ex. Nees	Acanthaceae	2.0000	0.6666	0.0050	1.2048	1.6997	0.4198	3.3244
21	*Rauwolfia serpentina* (Linn.) Benth. ex Kunz.	Apocynaceae	2.0000	0.6666	0.0041	1.2048	1.6997	0.3453	3.2498
22	*Zizyphus oenoplia* (Linn.) Mill.	Rhamnaceae	2.0000	0.4444	0.0057	1.2048	1.1331	0.4777	2.8156
23	*Woodfordia fruticosa* Kurz.	Lythraceae	2.0000	0.2222	0.0113	1.2048	0.5666	0.9554	2.7267
24	*Abrus precatorius* Linn.	Fabaceae	2.0000	0.3333	0.0072	1.2048	0.8499	0.6046	2.6592
25	*Aloe barbadensis* Mill.	Liliaceae	2.0000	0.3333	0.0072	1.2048	0.8499	0.6046	2.6592
26	*Withania somnifera* (Linn.) Dunal	Solanaceae	2.0000	0.4444	0.0028	1.2048	1.1331	0.2388	2.5768
27	*Capparis decidua* (Forsk.) Pax.	Capparaceae	2.0000	0.4444	0.0014	1.2048	1.1331	0.1194	2.4574
28	*Opuntia dilloni* Benson	Cactaceae	1.0000	0.3333	0.0072	0.6024	0.8499	0.6046	2.0568
29	*Caesalpinia dicapetala* (Roth) Alston.	Caesalpiniaceae	2.0000	0.2222	0.0022	1.2048	0.5666	0.1866	1.9580
30	*Asparagus racemosus* (Willd.) Oberm.	Asparagaceae	1.0000	0.2222	0.0011	0.6024	0.5666	0.0914	1.2604
31	*Piper longum* Linn.	Piperaceae	1.0000	0.2222	0.0004	0.6024	0.5666	0.0299	1.1988

A diagrammatic representation of distribution of density classes of tree species found in this forest has been shown in Fig.3. And distribution classes of shrubs/herbs/climbers species shown in Fig. 4.

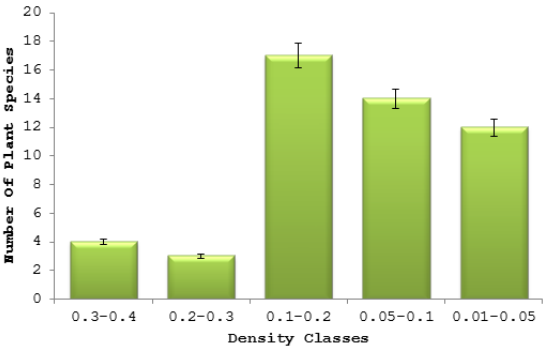

Fig.3. Distribution of Tree species (plant/100 m²) with density classes.

Basal Area of Plant Species (m²/ha)

The basal area of different tree species varied between 4.9230 to 0.0134 m²/ha. *Anogeissus pendula* showed maximum basal area (4.9230 m²/ha) and *Carissa spinarum* (0.0120 m²/ha) showed the lowest basal area cover.

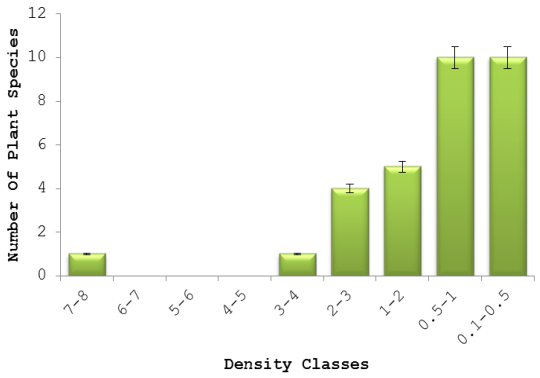

Fig.4. Distribution of shrubs/herbs/climbers species (plant/100 m²) with density classes.

The basal area of different shrub/herb/climber species varied between 0.3802 to 0.0004 m²/ha. *Zizyphus nummularia* showed maximum basal area (0.3802 m²/ha and *Piper longum* (0.0004 m²/ha) showed the lowest basal area cover. Fig.5. and Fig.6. represent the distribution pattern of different basal area classes of tree species (m²/ha) and shrub/herb/climber species (m²/ha) respectively.

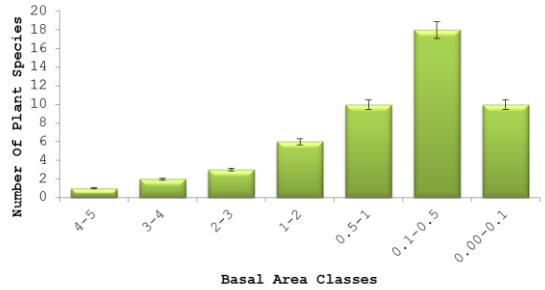

Fig.5. Distribution of Tree species (m²/ha) with Basal Area classes.

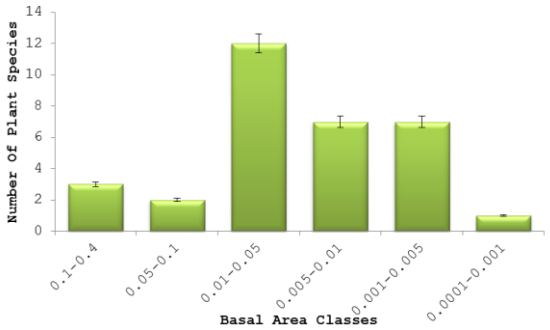

Fig.6. Distribution of shrub/herb/climber species (m²/ha) with Basal Area classes.

IVI of Plant Species

Among Eleven dominant tree species Anogeissus *pendula* exhibited higher IVI value of (23.6317) followed by *Butea monosperma* (21.1849), *Anogeissus latifolia* (18.5395), *Diospyrous melanoxylon* (18.0371), and all the species showed IVI values in the range of 3 to 5 (Fig.7.).

The calculated values of IVI were observed between 1 to 3 for sixteen plant species and *Holarrhena antidysentrica* (2.9305), showed the highest IVI. The values of IVI were less than one for *Buchanania lanzan* (0.9179), *Alangium salvifolium* (0.8618), *Terminalia bellerica* (0.6508) and *Schleichera oleosa* (0.4134).

On the basis of IVI values this forest communities could be considered as *Anogeissus pendula* - *Butea monosperma* community of forest.

Among Eleven dominant shrub/herb/climber species *Flacourtia indica* exhibited higher IVI value of (54.7403) followed by *Zizyphus nummularia* (47.6458), *Carissa spinarum* (20.5581), *Zizyphus mauritiana* (14.5063) and showed IVI value between 7 to 9. The value varied between 5 to 7 for *Cocculus hirsutus* (6.7857), *Gymnma sylvestre* (6.1793), *Balanites aegyptica* (5.6052) and *Dendrocalamus strictus* (5.0043). *Datura alba* (4.7736), *Andrographis paniculata* (3.3244) and *Rauwolfia serpentina* (3.2498) showed IVI values in the range of 3 to 5. *Zizyphus oenoplia* (2.8156), *Woodfordia fruticosa* (2.7267), *Abrus precatorius* (2.6592), *Aloe barbadensis* (2.6592), *Withania somnifera* (2.5768), *Capparis decidua* (2.4574), *Opuntia dilloni* (2.0568), *Caesalpinia dicapetala* (1.9580), *Asparagus racemosus* (1.2604) and *Piper longum* (1.1988) showed IVI values in the range of 1 to 3 (Fig.8.).

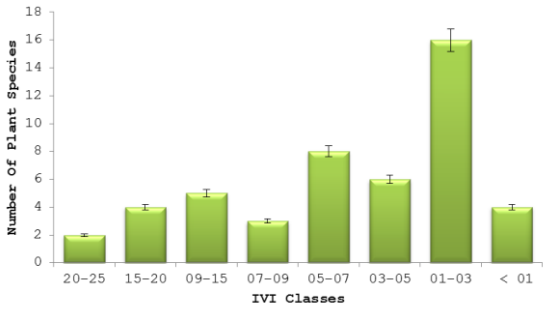

Fig.7. Distribution of Tree species with IVI classes in Mahoba district Forest.

On the basis of IVI values this forest communities of shrubs/herbs/climbers could be considered as dominated by *Flacourtia indica* and *Zizyphus nummularia* forest. Only few shrubs/herbs/climbers species were with higher IVI values and maximum number of shrubs/herbs/climbers species with lower values.

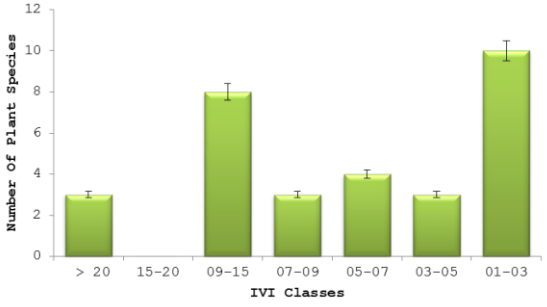

Fig.8. Distribution of Shrub/Herb/Climber species with IVI classes.

Species Diversity, Dominace and Equitability

Plants species Diversity (*H'*), concentration of Dominance (D) and Equitability (Evenness) of Mohaba forest communities have been determined. Result indicates that there was higher species diversity of trees in *Anogeissus pendula* and *Butea monosperma* dominated Mahoba district forest (3.6535) and exhibited concentration of Dominanc was 0.970854 and Eqitability have been recoreded 0.9339 (Table 3. and Table 4.).

Table 3. Species Diversity, Dominance and Equitability of Trees of forest communities.

Forest	Species Richness (R)	Species Diversity (*H'*)	Equitability (E)	Concentration of Dominance (D)
Mahoba District Forest	50	3.6535	0.9339	0.970854

Table 4. Species Diversity, Dominance and Equitability of shrubs/herbs/climbers of forest communities.

Forest	Species Richness (R)	Species Diversity (*H'*)	Equitability (E)	Concentration of Dominance (D)
Mahoba District Forest	31	3.0028	0.8744	0.930048

Result also indicates that there was higher species diversity of shrubs/herbs/climbers in *Flacourtia indica* and *Zizyphus nummularia* dominated Mahoba district forest (3.0028). The Mohaba forest exhibited higher values of concentration of Dominanc (0.930048) and values of Eqitability (0.8744). The dominance-Diversity curves for tree and shrubs/herbs/climbers species of Mahoba forest have been depicted in Fig.9. and Fig.10 which have been determined from the basic data. The Dominance-Diversity curves for the forests are characterized with lesser number of species in higher IVI range and more of species in lower IVI range.

The tropical Dry deciduous forests of Bundelkhand region are under tremendous pressure of biotic interferences and climate change. There has been significant reduction in rainfall of the area due to climate change. The increase in intensity and frequency of droughts could lead the forests to lose their self-maintenance capabilities against the changes already brought in due to biotic interferences.

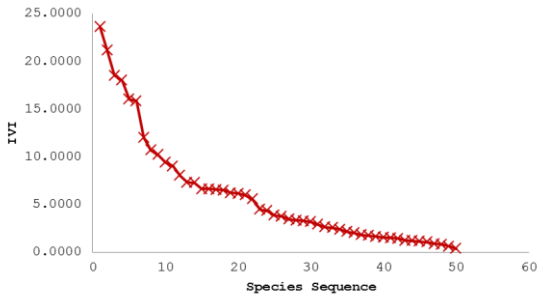

Fig.9. Dominance – Diversity curve for tree species of Mahoba District Forest.

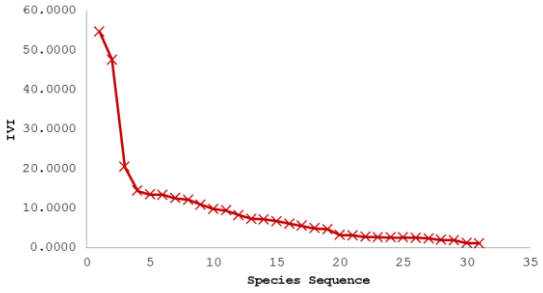

Fig.10. Dominance–Diversity curve for shrubs/herbs/climbers species of Mahoba district forest.

The species richness of tree species were observed under present investigation 50 and shrub/herbs/climbers species have been observed as 31 in Mahoba District Forest are comparable with other forest communities of India. Rao and Mishra

(1994) observed 61 tree and shrub species in tropical forest of Chitrakoot. 53 and 57 tree and shrub species have been reported for tropical semi-evergreen forest of Manipur, North-East India. Tropical Evergreen forest of Courtallum reserve forest of Western Ghats by Devi and Yadav (2006) and Parthasarathy and Karthikeyan (1997); Tropical forests of Andaman Islands (Tripathi *et al*, 2006); Bala forest in Alwar of Rajasthan (Yadav and Yadav, 2006); Shivaliks, Doon Valley and outer Himalaya (Rawat and Bhainsore, 1999) and tropical forests of Sidhi (Saxena 1988) have shown species richness in the range of present study. However, the species richness of studied forest communities are lower than those reported by Elouard *et al* (1997) for moist evergreen forest of Western Ghats of Karnataka, Kadavul and Parthasarathy (1999) for semi-evergreen forest of Kalrayan hills, Eastern Ghat.

The tree density in the sanctuary areas has been found higher than the tropical evergreen forests of Western as well as Eastern Ghats where it ranges from 419-716 stem ha^{-1} (Singh *et al*, 1984; Ganesh *et al*, 1996; Ghate *et al*, 1998; Parthasarathy, 1999; Chittibabu and Parthasarathy, 2000) and some tropical deciduous forests were recorded 150-627 stem ha^{-1} (Jha and Singh, 1990; Singh and Singh, 1991; Varghese and Menon, 1998; Shrestha and Jha, 1997; Pandey and Shukla, 2003).

The species richness in the study area has been found higher than the tropical dry forests of Mirzapur (Singh and Singh, 1991), Similipal Biosphare Reserve (Mishra *et al*, 2008) and tropical dry evergreen forest of Tanil Nadu (Venkateshwaran and Parthasarathy, 2005; Mani and Parthasarathy, 2005) but lower than tropical dry deciduous forest of Andhra Pradesh (Reddy *et al*, 2008) and tropical wet evergreen forest of Kalakad (Parthasarathy, 1999). More significantly, the mean species richness has been found greater than the earlier report from the area made by Tripathi and Singh, (2009).

Conclusion

Tropical dry deciduous forests are enriched with economically important species. Vegetation composition, diversity of species and their habitats are well understood for other tropical forest types and compared also to dry deciduous forests. Dry deciduous forests are among the most exploited and endangered ecosystems of the biosphere.

Calculations of IVI have helped in understanding the ecological significance of the species in the tropical dry deciduous forest type. Species diversity and stem density were observed to decrease with increasing girth class. The present study will serve as a primary input towards monitoring and sustaining the phyto-diversity of tropical dry deciduous forests in the state of Uttar Pradesh as well as other part of the world having similar kind of forest areas. Study on floristic composition and diversity will be useful to the conservation researchers and scientists and also to the forest managers for effective management of the forest ecosystem.

The mixed forests are not adequately stocked. Due to drier conditions prevailing, the forests are open and poor in growth. Due to over increasing biotic interference like recurring fires, unrestricted heavy grazing, over exploitation and indiscriminate felling under nectar, fast retrogression has set in the forests, tree growth is winding down at an alarming speed. It is suggested that -

- Soil conservation measures, afforestation in degraded forest land, and participation of people in joint forest management measures have been widely adopted as effective management tools in all the forest ecosystem restoration projects.
- Environmental education and awareness among the people of Bundelkhand region for conservation/management of forest.
- Enrich the research works in the field of forest management, biodiversity and traditional/indigenous knowledge.

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