Species diversity, dominance and equitability in tropical dry deciduous forest of Bundelkhand region, India

Abstract

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. Present investigation has under taken aims to assess the phyto-sociological analysis i.e. species diversity, dominance and equitability, etc. of three different forest of Lalitpur, Mahoba and Chitrakoot district of Bundelkhand region of Uttar Pradesh, India. The forest of Mahoba district is dominated by Anogeissus pendula and Butea monosperma, having forest of Chitrakoot district is dominated by Diospyros melanoxylon and Lagerstromia parviflora whereas forest of Lalitpur district is dominated by Butea monosperma and Tectona grandis. Result indicates that there was higher species diversity of trees in B. monosperma and T. grandis dominated Lalitpur district forest (3.6556) to be followed by A. pendula and B. monosperma dominated Mahoba district forest (3.6535) and D. melanoxylon and L. parviflora dominated Chitrakoot district forest (3.5039). Mahoba district forest exhibited higher values of concentration of Dominance (0.970854) to be followed by Lalitpur district forest (0.967797) and Chitrakoot district forest (0.963256). Mahoba district forest showed higher values of Equitability (0.9339) to be followed by Lalitpur district forest (0.8928) and Chitrakoot district forest (0.8784).

Keywords: Bundelkhand region, chitrakoot, lalitpur, mahoba, butea monosperma, tectona grandis

Introduction

India is a large developing country known for its diverse forest ecosystems and is also a mega-biodiversity nation of the World. Forest ecosystems in India are critical for biodiversity, watershed protection and livelihoods of indigenous and rural communities. India is a country with a high population density and low forest area per capita. The livestock population density is among the highest in the world. Further, nearly 70% of the population residing in rural areas depends on forest and other biomass resources for fuel-wood, timber and non-timber forest products for its energy needs and livelihood. Fuel-wood is a dominant source of cooking energy for the Ethnic population with forests contributing significantly to this. 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.1 Forests supply nutrients to agricultural crops through runoff water with much other complementariness in agriculture ecosystems.2 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.3 As forests disappeared, the possibilities of natural resources being conserved decreased and the possibilities of conservation also decreased. 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. An obvious approach to conserve plant biodiversity is to map distributional patterns and look for concentrations of diversity. Further, management of forest requires understanding of its composition in relation to other forests. On this background the present study has undertaken aims to assess the phyto-sociological analysis i.e. species diversity, dominance and equitability, etc. of three different forest of Lalitpur, Mahoba and Chitrakoot district of Uttar Pradesh, India which are belongs to Tropical Dry Deciduous Forest.3

Materials and methods

Study area

Bundelkhnd region of Uttar Pradesh is having 29,418Km² of geographical area and only 6.61% its forest which is rich in dry deciduous mixed in nature. Present investigations have been carried out in selected forest of three districts of Bundelkhand region (Figure 1) namely Lalitpur, Mahoba and Chitrakoot for their phytosociological attributes (e.g. density, dominance, similarity of species between forest communities, etc.) of plant communities.

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 1mx1m respectively.

Phytosociological study

The term vegetation ecology is also equated to phytosociology or community ecology. Trees and ground vegetation were differentiated by measuring the girth at breast height (gbh). Only stems ≥20cm gbh (1.3m above ground level) were considered “woody trees” and phytosociological analyses were limited to them. Girth was measured using 2m tape. Height of small trees and shrubs was measured using a 5m graded pole. When the height exceeded 5m it was estimated visually. For calculating the basal area of multi-stemmed trees, the girth of each stem was measured individually and added up phytosociological parameters were analyzed the following the methods and formulas.

Species diversity analysis

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

Equitability or evenness

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

\[ E = \frac{H}{\log s} \]

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

Similarity index

The mathematical expressions of community similarity are variously referred as indices of similarity. The similarity of plant species of forest was determined according to Sorenson.

Results and discussions

It is obvious from this study that out of three forest communities of trees the forest of Mahoba district is dominated by *Anogeissus pendula* and *Butea monosperma*, forest of Chitrakoot district is dominated by *Diospyrous melanoxylon* and *Lagerstromia parviflora* whereas forest of Lalitpur district is dominated by *Butea monosperma* and *Tectona grandis*.
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A Forest community of shrubs/herbs/climbers in Mahoba district forest is dominated by Flacourtia indica and Zizyphus nummularia whereas forest communities of shrubs/herbs/climbers in Chitrakoot and Lalitpur district forest is dominated by Flacourtia indica and Zizyphus mauritiana. The B. monosperma and T. grandis dominated tree forest community of Lalitpur district forest is composed of maximum number of 59 tree species and 40 shrubs/herbs/climbers species followed by D. melanoxylon and L. parviflora dominated tree forest community of Chitrakoot district forest is composed of 54 tree species and 38 shrubs/herbs/climbers species and A. pendula and B. monosperma dominated tree forest community of Mahoba district forest is composed of 50 tree species and 31 shrubs/herbs/climbers species. It is also evident from the result that the dominance of these forest communities is shared by only few species whereas majority of trees and shrubs/herbs/climbers species are with lower values of IVI.

Total density plant per 100m² of different tree species and shrubs/herbs/climbers species have been determine for three forest communities (Table 1). Result reveals that there was higher density of trees is the Lalitpur forest followed by Chitrakoot and Mahoba district forest whereas higher density of shrubs/herbs/climbers is the Lalitpur district forest followed by Chitrakoot and Mahoba district forest (Table 2).

### Table 1 Total density (plant/100m²) and Basal Area (m²/ha) of trees of three forest communities

| Forest              | Total density | Total basal area |
|---------------------|---------------|------------------|
| Lalitpur district forest | 7.15          | 59.784           |
| Chitrakoot district forest | 6.53          | 48.352           |
| Mahoba district forest | 5.88          | 41.365           |

### Table 2 Total density (plant/100m²) and basal area (m²/ha) of shrubs/herbs/ climbers of three forest communities

| Forest              | Total density | Total basal area |
|---------------------|---------------|------------------|
| Lalitpur district forest | 49.21         | 1.523            |
| Chitrakoot district forest | 46.88         | 1.63             |
| Mahoba district forest | 39.22         | 1.184            |

Plants species Diversity ($H'$), concentration of Dominance (D) and Equitability (E) of three forest communities have been presented in the Tables 3 & 4. Result indicates that there was higher species diversity of trees in B. monosperma and T. grandis dominated Lalitpur district forest (3.6556) to be followed by A. pendula and B. monosperma dominated Mahoba district forest (3.6535) and D. melanoxylon and L. parviflora dominated Chitrakoot district forest (3.5039). Mahoba district forest exhibited higher values of concentration of Dominance (53 and 57 tree and shrub species have been reported for tropical semi-evergreen forest of Manipur, North-East India and tropical evergreen forest of Courtallam reserve forest of Western Ghats respectively. Tropical forests of Andaman Islands,18 Bala forest in Alwar of Rajasthan,17 Shivaliks, Doon Valley and outer Himalaya,18 have shown species richness in the range of present study. It is also nearly similar to the values obtained in some rainforest of Africa,19,20 However, the species richness of studied forest communities are lower than those reported for moist evergreen forest of Western Ghats of Karnataka (91 species),21 semi-evergreen forest of Kalrayan hills, Eastern Ghat (73 species),22 south-eastern Asian evergreen forest of Sabah (198 species),23 for Sarawak (214 species)24 and for Peninsular Malaysia (244 species).25

These values of species richness have been found within the range of tropics i.e. 20-307 spp. ha⁻¹.26-27 These values of the species richness have been found lower in comparison with the humid tropical evergreen forest (61 species ha⁻¹),25 but higher than the tropical rain forest (43 species ha⁻¹).26 The species richness in the study area has been found higher than the tropical dry forests of Mizapur (9-14),20 Similipal Biosphere Reserve (19-36)28 and tropical dry evergreen forest of Tanil Nadu (19-35)29,30 but lower than tropical dry deciduous forest of Andhra Pradesh (69)31 and tropical wet evergreen forest of Kalakad (80-85).32 More significantly, the mean species richness has been found greater than the earlier report from the area in which they have recorded only 44 tree species in 7.02 hectares.30

Total density (Plant/100m²) of tree species have been observed as 7.15 plant/100m² (Lalitpur District Forest), 6.53 plant/100m² (Chitrakoot District Forest) and 5.88 plant/100m² (Mahoba District Forest) and shrub/herbs/climbers species have been observed as 49.22 plant/100m² (Lalitpur District Forest), 46.88 plant/100m² (Chitrakoot District Forest) and 39.22 plant/100m² (Mahoba District Forest). These values of tree density have been found within the range of tropics i.e. 276-935 stem ha⁻¹.33-37-39 The tree density in the sanctuary area has been found higher than the tropical evergreen forests of Western as well as Eastern Ghats where it ranges from 419-716 stem ha⁻¹39,40 and tropical deciduous forests (150-627 stem ha⁻¹).30,41-43 Tropical moist forest of Singapore (604 stem ha⁻¹)44 and tropical rain forest of Costa Rica (391-617 stem ha⁻¹)44 also have the lower tree density than that of the sanctuary area. Some tropical deciduous forest of Eastern Ghats ranging from 735-810 stem ha⁻¹,31,34 tropical evergreen forest

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of Eastern Ghats and North-East India ranging from 750-935 stem ha\textsuperscript{−1} \cite{31,32,14} and tropical rain forest of Amazon and Malaysia ranging from 1054-1420 stem ha\textsuperscript{−1} \cite{32,41} show the higher tree density than the sanctuary area.

The recorded stem densities of three forests are well within range of 245 to 859 stems ha\textsuperscript{−1} reported for trees in the tropics.\textsuperscript{33,34} However, the observed total densities (ha\textsuperscript{−1}) are lower when compared with 610-635 stems ha\textsuperscript{−1} in Uppangala sites of Karnataka,\textsuperscript{42} 482 stem ha\textsuperscript{−1} in tropical evergreen forest in Courtallum reserve forest of Western Ghats,\textsuperscript{43} 938-1476 stems ha\textsuperscript{−1} in subtropical humid forest of North-east India,\textsuperscript{44} 1176-1496 stems ha\textsuperscript{−1} in subhumid forest of Jaintia hills of Meghalaya,\textsuperscript{45} 367 to 667 stems ha\textsuperscript{−1} in tropical semi-evergreen forest of Kalryan hills, Eastern Ghats.\textsuperscript{46}

The stem density in the present study is also average than other tropical forests such as those of Bolivia (649 trees ha\textsuperscript{−1}),\textsuperscript{47} Costa Rica (448-617 stems ha\textsuperscript{−1}),\textsuperscript{48} and Lowland tropical forests in Kurupukari, Guayana (716-1440 stem ha\textsuperscript{−1}).\textsuperscript{49} The values of total density in several other tropical forests ranged from 5.5 to 18 trees ha\textsuperscript{−1} while for temperate forests, the same is ranged from 3.2 to 21 trees ha\textsuperscript{−1}.\textsuperscript{50,51} The tree basal cover was measured as 59.784 m\textsuperscript{2} ha\textsuperscript{−1} (Lalitpur Distric Forest), 48.352 m\textsuperscript{2} ha\textsuperscript{−1} (Chitrakoot Forest) and 41.365 m\textsuperscript{2} ha\textsuperscript{−1} (Mahoba Forest) and shrub/herbs/climbers species basal cover was measured as 1.523 m\textsuperscript{2} ha\textsuperscript{−1} (Lalitpur Distric Forest), 1.630 m\textsuperscript{2} ha\textsuperscript{−1} (Chitrakoot Forest) and 1.184 m\textsuperscript{2} ha\textsuperscript{−1} (Mahoba Forest). These values of basal area have been found within the range of tropical i.e. 7-104 m\textsuperscript{2} ha\textsuperscript{−1}.\textsuperscript{31,40,43}

The basal area has been found higher than the tropical evergreen forests ranging from 11.82-76 m\textsuperscript{2} ha\textsuperscript{−1} \cite{30,35,40,42,51} and tropical deciduous forest ranging from 7-61 m\textsuperscript{2} ha\textsuperscript{−1} \cite{30,36,41,42} in India. The basal area of tropical rain forest of Malaysia i.e. 26-46 m\textsuperscript{2} ha\textsuperscript{−1},\textsuperscript{14} also has the lower basal area than the sanctuary area. The basal cover of some evergreen forests of Western Ghats ranging from 29-103 m\textsuperscript{2} ha\textsuperscript{−1},\textsuperscript{31,40} Similipal Biosphere Reserve 48.7-10.9 m\textsuperscript{2} ha\textsuperscript{−1} and the tropical rain forest of Amazonia 28 to 68 m\textsuperscript{2} ha\textsuperscript{−1},\textsuperscript{52} have been found higher than the forest of sanctuary area. More significantly, the basal area of the adjacent forests ranging from 16-61 m\textsuperscript{2} ha\textsuperscript{−1} \cite{30,36,41} has been found lower than the basal cover of the study area.

These values are lower to the tropical rain forest (78 m\textsuperscript{2} ha\textsuperscript{−1}) of Amazonia,\textsuperscript{53} tropical dry deciduous forest (75.9 m\textsuperscript{2} ha\textsuperscript{−1}) in Chitrakoot of Madhya Pradesh,\textsuperscript{54} tropical forests (12.44-77.4 m\textsuperscript{2} ha\textsuperscript{−1}) of Andaman islands\textsuperscript{55} and subtropical humid forests (36-71 m\textsuperscript{2} ha\textsuperscript{−1}) in Maghlaya.\textsuperscript{56} However, the observed basal cover values under present study are higher than the moist evergreen forest (39.7 m\textsuperscript{2} ha\textsuperscript{−1}) in Western Ghats of Karnataka,\textsuperscript{57} tropical forest evergreen forest (42.61 m\textsuperscript{2} ha\textsuperscript{−1}) in Courtallum reserve forest, Western Ghats,\textsuperscript{58} sal forests (23.24-37.75 m\textsuperscript{2} ha\textsuperscript{−1}) in Doon valley,\textsuperscript{59} tropical semi-evergreen forest (18.9-19.58 m\textsuperscript{2} ha\textsuperscript{−1}) in Manipur, north-east India,\textsuperscript{60} tropical semi-evergreen forest (25.8-41.2 m\textsuperscript{2} ha\textsuperscript{−1}) of Kalryan hills, Eastern Ghats,\textsuperscript{61} tropical forests (39.7 m\textsuperscript{2} ha\textsuperscript{−1}) in Uppagala of Central Western Ghats.\textsuperscript{62}

These forest communities have been also investigated in present study for their tree (Table 3) and shrub/herbs/climbers species diversity (Table 4). Results indicated that for tree species, B. monosperma and T. grandis dominated Lalitpur district forest exhibited higher species diversity (H’ =3.6535) than A. pendula and B. monosperma dominated Mahoba district forest (H’ =3.6535) and D. melanoxylon and L. parviflora dominated Chitrakoot district forest (H’ =3.5039) and for shrub/herbs/climbers species, F. indica and Z. mauritiana dominated Lalitpur district forest exhibited higher species diversity (H’ =3.1952) than F. indica and Z. mauritiana dominated Chitrakoot district forest (H’ =3.1563) and F. indica and Z. nummularia dominated Mahoba district forest (H’ =3.0028). Species diversity is one of the most important characteristics of a community. It is a mechanism which generates stability.\textsuperscript{63} Results indicate that there is a narrow variation in species diversity among these three forest community. The diversity of the three forests is positively related to the number of species. In a deciduous forest community, Monk\textsuperscript{64} observed that diversity tended to reach a maximum level after a community is composed of 12-15 species.

The species diversity values were reported between 1.16 to 3.40 for temperate forests.\textsuperscript{65-67} The diversity index is generally higher for tropical forests, which is reported as 5.06 and 5.40 for young and old stand respectively.\textsuperscript{68} The values of species diversity under present investigation are much less than those reported for tropical forests.\textsuperscript{69} However, these are comparable with the values generally reported for other tropical forests.\textsuperscript{70-72} The species diversity values of studied forests are average than those reported as 1.855 to 2.029 for Rampara forest in Saurashtra, Gujarat,\textsuperscript{73} 3.42 to 3.87 for subtropical humid forest, Meghalaya,\textsuperscript{74} 3.069 for tropical evergreen forest in Courtallum reserve forest of Western Ghats,\textsuperscript{14} 4.56 for moist evergreen forest in Western Ghats\textsuperscript{57} and 2.305 to 2.869 for tropical semi evergreen forest of Kalryan hills, Eastern Ghats.\textsuperscript{21} Some other forests of Madhya Pradesh such as Seoni, Balaghan and Mandla also exhibited higher species diversity than those of this study.\textsuperscript{74}

The concentration of dominance for tree species on density basis was higher in Mahoba followed by Lalitpur and Chitrakoot district forest (Table 3) but the concentration of dominance for shrub/herbs/climbers species on density basis was higher in Lalitpur followed by Mahoba and Chitrakoot district forest (Table 4). Risser and Rice\textsuperscript{67} have reported concentration of dominance values in the range of 0.10 to 0.99 for temperate vegetation. For a tropical forest, Knight\textsuperscript{70} reported an average value of 0.06. The observed values under present investigation are higher than average value of tropical forests reported by Knight.\textsuperscript{70} There was a narrow variation in values obtained for three forests. The higher value of CD in Mahoba District forest could be attributed to the environmental stress.\textsuperscript{75} These relatively high values for concentration of dominance in this study than reported average value (0.06) of tropical forests are in accordance with low species diversity at the studied sites because species diversity (H) behaves inversely to the index of dominance.\textsuperscript{76} The observed CD values of studied forests are comparable with the value obtained (0.92) for moist evergreen forest of Western Ghats,\textsuperscript{57} but are higher to those of tropical evergreen forest in Courtallum reserve forest of Western Ghats\textsuperscript{13} and Rampura forest in Saurashtra, Gujarat.\textsuperscript{77}

Dominance increases as a function of stress,\textsuperscript{78} due to past damage,\textsuperscript{79} poor drainage\textsuperscript{80} etc. Species represented by one or two individuals were considered rare.\textsuperscript{81} It is evident that many widespread tropical species tend to be locally abundant in certain areas and relatively rare in others.\textsuperscript{82} The numbers of individuals of such rare species are kept low by a combination of unfavorable regeneration conditions, lack of appropriate habitat or both.\textsuperscript{82} In this respect also, the studied forests are similar to tropical forests, which are known to possess large number of tree species that have few individuals. However, with disturbance number of such species decreased as there was an increase in number of individuals of those species which are resistant to damage or to death caused by physical extremes or natural enemies that eventually fill much of the space after disturbances.\textsuperscript{82}
Table 3: Species diversity, dominance and equitability of trees of three forest communities

| Forest              | Species richness (R) | Species diversity (H') | Equitability (E) | Concentration of dominance (D) |
|---------------------|----------------------|------------------------|------------------|-------------------------------|
| Lalitpur district forest | 59                   | 3.6556                 | 0.8928           | 0.967797                      |
| Chitrakoot district forest | 54                   | 3.5039                 | 0.8784           | 0.963256                      |
| Mahoba district forest         | 50                   | 3.6535                 | 0.9339           | 0.970854                      |

Table 4: Species diversity, dominance and equitability of shrubs/herbs/climbers of three forest communities

| Forest              | Species richness (R) | Species diversity (H') | Equitability (E) | Concentration of dominance |
|---------------------|----------------------|------------------------|------------------|---------------------------|
| Lalitpur district forest | 40                   | 3.1952                 | 0.8662           | 0.934721                  |
| Chitrakoot district forest | 38                   | 3.1563                 | 0.8677           | 0.928583                  |
| Mahoba district forest         | 31                   | 3.0028                 | 0.8744           | 0.930048                  |

Table 5: Common tree species of three forest communities

| S No | Lalitpur-Chitrakoot forest | Chitrakoot-Mahoba forest | Lalitpur-Mahoba forest |
|------|----------------------------|--------------------------|-------------------------|
| 1    | Acacia catechu             | Acacia catechu           | Acacia catechu          |
| 2    | Acacia leucaphloea         | Acacia leucaphloea       | Acacia leucaphloea      |
| 3    | Acacia nilotica            | Acacia nilotica          | Acacia nilotica         |
| 4    | Adina cardifolia           | Adina cardifolia         | Adina cardifolia        |
| 5    | Aegle marmelos             | Aegle marmelos           | Aegle marmelos          |
| 6    | Albizia lebbek             | Alanthus excels          | Alangium salviolatum    |
| 7    | Albizia procera            | Albizia lebbek           | Albizia lebbek          |
| 8    | Anogeissus latifolia       | Anogeissus latifolia     | Anogeissus latifolia    |
| 9    | Anogeissus pendula         | Anogeissus pendula       | Anogeissus latifolia    |
| 10   | Azadirachta indica         | Azadirachta indica       | Azadirachta indica      |
| 11   | Bauhinia racemosa          | Bauhinia racemosa        | Bauhinia racemosa       |
| 12   | Bombax ceiba               | Buchanania lanzan        | Buchanania racemosa     |
| 13   | Baswellia serrata          | Butea monosperma         | Butea monosperma        |
| 14   | Buchanania lanzan          | Carissa spinarum         | Butea monosperma        |
| 15   | Butea monosperma           | Casearia tomentosa       | Casearia tomentosa      |
| 16   | Casearia tomentosa         | Cassia fistula           | Cassia fistula          |
| 17   | Cassia fistula             | Cochlospermum religiosum | Cochlospermum religiosum |
| 18   | Cochlospermum religiosum   | Dalbergia sisse          | Dalbergia sisse         |
| 19   | Dalbergia sisse            | Diospyrous melanoxylon   | Diospyrous melanoxylon  |
| 20   | Diospyrous melanoxylon     | Emblica officinalis      | Emblica officinalis     |
| 21   | Emblica officinalis        | Feronia limonia          | Erythrina suberosa      |
| 22   | Elaeocodendron glaucum     | Gardenia turgid          | Feronia limonia         |
| 23   | Eugenia heymeanum          | Grewia tiloeifolia       | Ficus glomerata         |
| 24   | Feronia limonia            | Holarrhena antidysentrica| Grewia tiloeifolia     |
| 25   | Ficus religiosa            | Holoptelia integrifolia  | Holarrhena antidysentrica |
### Table 6: Common Herbs/shrubs/Climbers species of three forest communities

| S No | Lalitpur-Chitrakoot forest | Chitrakoot-Mahoba forest | Lalitpur-Mahoba forest |
|------|-----------------------------|--------------------------|------------------------|
| 1    | Aloe barbadensis            | Aloe barbadensis         | Aloe barbadensis       |
| 2    | Andrographis paniculata     | Andrographis paniculata  | Andrographis paniculata|
| 3    | Asparagus racemosus         | Asparagus racemosus      | Asparagus racemosus    |
| 4    | Butea superba               | Calotropis procera       | Calotropis procera    |
| 5    | Caesalpinia dicapetala      | Cocculus hirsutus        | Cocculus hirsutus     |
| 6    | Carissa spinarum            | Curcuma amada            | Curcuma amada         |
| 7    | Centella asiatica           | Datura alba              | Datura alba           |
| 8    | Cocculus hirsutus           | Dendralamus strictus     | Dendralamus strictus  |
| 9    | Convolvulus microphullus    | Echinops echinatus       | Echinops echinatus    |
| 10   | Curcuma amada               | Flacourtia indica        | Flacourtia indica     |
| 11   | Datura alba                 | Gymnma sylvestre         | Gymnma sylvestre     |
| 12   | Dendralamus strictus        | Helicteres isora         | Helicteres isora     |
| 13   | Echinops echinatus          | Ichneocarpus frutescens  | Ichneocarpus frutescens|
| 14   | Flacourtia indica           | Lantana camara           | Lantana camara       |
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| S No | Lalitpur-Chitrakoot forest | Chitrakoot-Mahoba forest | Lalitpur-Mahoba forest |
|------|----------------------------|--------------------------|------------------------|
| 18   | Grewia hirsute             | Ocimum basilicum         | Lantana camara         |
| 19   | Gymnema sylvestre          | Opuntia dilloni          | Ocimum basilicum       |
| 20   | Helicteres isora           | Piper longum             | Opuntia dilloni        |
| 21   | Hemidesmus indicus         | Rauwolfia serpentina     | Piper longum           |
| 22   | Ichnocarpus frutescens     | Solanum indicum         | Rauwolfia serpentina   |
| 23   | Lantana camara             | Tinospora cardiophlia    | Solanum indicum       |
| 24   | Mimosa holarayana          | Vitex nigundo            | Tinospora cardiophlia  |
| 25   | Nyctanthes Arbortrista     | Withania somnifera       | Vitex nigundo          |
| 26   | Ocimum basilicum           | Woodfordia fruticosa     | Withania somnifera     |
| 27   | Operculina turpenthus      | Zizyphus mauritiana      | Woodfordia fruticosa   |
| 28   | Opuntia dilloni            | Zizyphus nummularia      | Zizyphus mauritiana   |
| 29   | Piper longum               | Zizyphus oenoplia        | Zizyphus nummularia    |
| 30   | Rauwolfia serpentina       |                          |                        |
| 31   | Solanum indicum            |                          |                        |
| 32   | Tinospora cardiophlia      |                          |                        |
| 33   | Vitex nigundo              |                          |                        |
| 34   | Withania somnifera         |                          |                        |
| 35   | Woodfordia fruticosa       |                          |                        |
| 36   | Zizyphus mauritiana        |                          |                        |
| 37   | Zizyphus nummularia        |                          |                        |
| 38   | Zizyphus oenoplia          |                          |                        |

Table 7 Similarity(%) of tree species between three forest communities

| Forest communities | Number of common tree species | Similarity (%) |
|--------------------|------------------------------|----------------|
| Lalitpur vs Chitrakoot forest | 44                           | 77.19          |
| Chitrakoot vs Mahoba forest  | 41                           | 78.84          |
| Lalitpur vs Mahoba forest   | 45                           | 81.81          |

Table 8 Similarity(%) of shrubs/herbs/climbers species between three forest communities

| Forest communities | Number of Common Shrubs/ Herbs/ Climbers species | Similarity (%) |
|--------------------|--------------------------------------------------|----------------|
| Lalitpur vs Chitrakoot forest | 38                           | 97.43          |
| Chitrakoot vs Mahoba forest  | 29                           | 84.05          |
| Lalitpur vs Mahoba forest   | 30                           | 84.5           |

Conclusions

At present, the biodiversity of Bundelkhand region are declining fast due to the degradation of habitats by heckles and indiscriminate cutting of forests for timber, fuel wood, and expansion of agriculture, construction of roads, querying of stones, grazing, invasion of alien weeds, over exploitation of plants for medicines etc., the rich biodiversity of Bundelkhand region has reduced to a great extent. 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. 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. The high species diversity and low basal cover in miscellaneous forest clearly indicate the growing nature of this forest types with maximum number of species having younger individuals. 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.

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Conflicts of interest

The author declares there are no conflicts of interest.

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