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Plant Diversity Patterns and Tree Population Structure in Tropical Dry Deciduous Forests in Semiarid region of North Western India

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Abstract

This paper analyzed plant diversity patterns and tree population structure in tropical dry deciduous forests in the Reserved Bir forest (located at Hisar 29° 10'N longitude and 75° 44'E latitude at an altitude of 240 m above mean sea level) and the Protected forest at Jind (29° 17'42" N latitude and 76° 17'16" longitude at 210 m above sea level). The climate of the study area is semi-arid and tropical. The mixed dry deciduous forest at Jind was dominated by Dalbergia sissoo (IVI= 167.90) and co-dominated by Azadirachta indica (IVI= 31.58), whereas at Bir forest, Hisar was dominated by Salvadora oleoides (IVI= 122.06) and co-dominated by Prosopis juliflora (IVI=109.46). A total of 87 species of plants (trees, shrubs, climbers and herbs) belonging to 29 families were recorded in the two forests. Population structure of dominant tree species showed that most of the individual were in intermediate girth classes ranging from 30 to 60 cm and 61 to 90cm, and lower number of seedlings and saplings. The Shannon's diversity index of trees for the two forests was 1.286 to 1.40. The Pielou's Index of equitability varied from 0.639 to 0.801. Most of herbaceous species showed a contagious distribution (A/F ratio ranged from 0.059 to 0.516) because of patchy growth of plants. The Simpson's index of diversity for herbaceous plants was 0.023 to 0.135. There was appreciable diversity of the herbaceous plants in the forests.

Keywords: Basal area, Dominance-Diversity Curves, Diversity indices, Contagious distribution, Shannon's diversity index.

Introduction

Forests are the chief bio-resources and repositories of natural wealth that support human well-being and ecological sustainability. The tropical forests are the home to 78% of the land biodiversity, and are among the most bio-diverse terrestrial ecosystems ¹⁻². The long term sustainability of forest ecosystems is greatly concerned with plant diversity³. Studies dealing with the structure (plant height, density), functioning and composition of the tropical forests have been reported by several workers at a local and regional level in Central America and the Caribbean⁴⁻⁵, Brazilian caatinga⁶, Africa⁷, Thailand⁸, Costa Rica⁹. Biodiversity conservation and ecosystem services of forests in Siwaliks have been discussed with emphasis on patterns of plant biodiversity, non-timber forest produce, and carbon sequestration¹⁰.

Community structure, composition and diversity patterns in forest ecosystems are significant ecological parameters correlated with and affected by prevailing environmental as well as anthropogenic variables¹¹⁻¹³. The information on tropical plant diversity is needed because of its potential usefulness for conservation and management of the protected forests. Quantitative analysis of forest vegetation of southern Haryana is lacking, although some information is available on flora and life-form classes of plants¹⁴⁻¹⁵. This paper provides quantitative information on the floristic composition, plant diversity patterns

and tree population structure of mixed dry deciduous forest ecosystems of the two protected forests in Haryana.

Materials and Methods

Study sites: The study sites are located at Bir Forest Hisar, and the Protected Forest at Jind, in Haryana. Haryana is predominantly an agriculture state with a forest cover of 1586 sq. km, which is 3.90% of the state's geographical area. Tree cover in the state is 1286 sq.km, which is 2.90% of the geographical area, thus making the total forest and tree cover as $6.49\%^{16}$. The Protected forest of Jind (Bir Bara Ban Wildlife Sanctuary) lies at 29⁰ 17'42" N latitude and 76⁰ 17'16" longitudes at 210 m above sea level. This protected forest is spread over an area of 419.26 ha. The Bir forest of Hisar is located at 29° 10'N longitude and 75° 44'E latitude with an altitude of 240 m above mean sea level (MSL).

Climate and Rainfall: The climate of the study area is tropical and semi-arid. There are three seasons in a year. Average annual rainfall of the district Jind is 515 mm which is unevenly distributed over the year. About, 84% of annual rainfall is received during the rainy season from July to August. Rest of rainfall is received during winter and summer seasons from western disturbances and thunder storms. Mean maximum temperature of area is in May and June is 41°C and mean minimum temperature is 6°C in the month of January. The climate of the study area at Hisar is semi-arid. Average annual rainfall is 499 mm of which 70-80% occurs during July-September¹⁷.

The soils of the study sites are old alluvium, sandy loam to loam in texture¹⁸. The soil pH of 7.4 to 7.8 indicated a slightly alkaline soil reaction.

Methodology

Floristic Composition of Vegetation: The sampling was conducted during June to December, 2009. Floristic composition of vegetation and plant diversity was analyzed by sampling 12 randomly placed quadrats of 20×20 m. All the trees in the sampling plots were identified and their CBH (Circumference at Breast Height) was measured at 1.37 m height from the ground. Sixteen sample plot of 5×5 m were observations for determining the density of shrubs and climbers. Density of herbaceous plants was studied using twenty four quadrats of 1×1 m marked within 20×20 m quadrats.

Phytosociological analysis of Functional Groups of Plants: The quantitative vegetation characteristics like plant density, abundance, frequency, and basal area were studied¹⁹⁻²⁰. Importance value index (IVI) of trees and shrubs were calculated as: Relative density (%) + Relative frequency (%) + Relative basal area (%)²¹. Whitford index (abundance/ frequency ratio, A/F) was used to study the dispersion pattern of plant species²². The dispersion pattern of the species will be regular, if the value of A/F ratio is <0.025, random (0.025–0.05), and clumped or contagious if value is > 0.05²³.

Population Structure of Tree Species: The population structure of trees was prepared on the basis of girth measurement (cbh), according to NRSA Manual²⁴ which recognized following classes:

Class	Range in cbh (cm)
А	0 to 10.4
В	10.5 to 30
С	31to 60
D	61 to 90
Е	91 to 120
F	121 to 150
G	151 to180
Н	181-210
Ι	221-240
J	241-270

Percent proportion of each girth class was calculated for various tree species as:

Percent	No. of individuals in each girth class
Proportion=	Total no. of individuals in all the girth classes

Analysis of Species Diversity Indices: The dominancediversity curves²⁵ of species for each site were plotted using log values of importance value index (IVI) and species sequence.

The species diversity (\overline{H}) for trees and shrubs was determined using the following Shannon and Wiener equation²⁶:

$$H = \sum_{i=1}^{s} (Ni/N) \ln (Ni/N)$$

Where: Ni = Importance value of one species, N = Total of importance value of all species, Concentration of dominance (C) was measured by Simpson's index as follows²⁷:

$$C = \sum_{i=1}^{s} (Ni/N)^2$$

Where: Ni = Importance value of one species, N = Total of importance value of all species, Equitability (e) was calculated²⁸ as:

$$E = H/ln S$$

Where: \overline{H} = Shannon index, S = number of species. Margalef's index of Species richness (d)²⁹ was calculated using the following equation:

$$D = (S - 1) / \ln N$$

Where: S = total number of species, N = total density of all species.

Results and Discussion

Floristic composition and Diversity: A total of 87 species of different functional groups of plants belonging to 74 genera of 29 families were recorded in the forest ecosystems at Reserved Bir Forest, Hisar and Protected forest at Jind. Floristic composition of studied forest ecosystems are given in Table-1. The mixed dry deciduous forest at Jind was found to be more diverse and species rich as compared to that of the forest ecosystem at Bir forest Hisar. A total of 9 tree species were recorded, dominant among them are Dalbergia sissoo, Azadirachta indica and Acacia leucophloea. Shrub layer in the forest consist of six species including Brevnia rhamboides, Capparis sepiaria L., Capparis zeylanica L., Carrisa spinarum L., Phyllanthus reticulatus Poir, Zizyphus nummularia Burm.f., whereas 8 species of climbers were found to be associated with trees. There was high diversity of herbaceous plants on the ground floor in the mixed forest Jind as compared to that of the Bir forest Hisar. The number of herbaceous and shrub species recorded in the forests was 52 and nine respectively.

Functional groups of Plants	No. of Species	No. of Genus	No. of Family			
	Mixed dry decidue	ous forest at Jind				
Trees	Trees 9 7 6					
Shrubs	6	5	4			
Climbers	8	8	4			
Herbaceous layer	52	47	17			
	Bir fores	st Hisar				
Trees	5	3	2			
Shrubs	4	4	4			
Climbers	8	8	4			
Herbaceous layer	9	9	7			

 Table 1

 Floristic composition of the two mixed dry deciduous forests at Jind and Hisar

In the case of Bir forest Hisar, the tree layer consists of five species and dominated by *Salvadora oleoides*, *Prosopis juliflora* and *Prosopis cineraria* (L) Druce. The shrub species in the mixed forest at Hisar are: *Capparis decidua* (Forsk) Edgew, *Lycium europaeum* L., *Phyllanthus reticulatus* Poir, *Grewia tenax* (Table-6). The various species of climbers in the forest includes *Asparagus racemosus* Willd, *Cissampelos glabra* Roxb, *Coccinia grandis* L., *Tinospora cordifolia* Miers, *Ichnocarpus frutescens* L., *Cocculus hirsutus* L., *Pergularia daemia* Forsk, *Telosma pallida* Roxb (Table-6). Ground floor herbaceous vegetation consists of only a few species during the study period.

Phytosociological Analysis of Functional Groups of Plants: Mixed dry deciduous forest at Jind: The mixed forest was dominated by Dalbergia sissoo with an Importance Value Index (IVI) of 168. The importance value index of Azadirachta indica and Prosopis cineraria varied from 31.58 to 27.0 (Table-2). The basal of trees was in the order (m² ha⁻¹): 18.434 Dalbergia sissoo, >2.35 Azadirachta indica, >0.76 Prosopis cineraria, >0.30 Acacia nilotica, > 0.26 Acacia senegal, >0.067 Ficus rumphii, >0.045 Cordia dichotoma, >0.037 Diospyros cordifolia (Table-2). Predominant tree species showed an A/F ratio from 0.118 to 0.083.

The shrub layer in the forest was dominated by *Capparis* sepiaria with an IVI of 91.65 and *Carrisa spinarum* with an IVI of 56.02. The shrubs showed an aggregated (contagious)

distribution with A/F ratio ranging from 0.13 to 0.06 (Table-3). A total of eight climber species were found to occur in the forest (Table-3). There was abundant growth of *Cissampelos pareira* and *Coccinia grandis* in the forest on shrubs and trees. *Pergularia daemia* was the most predominant climber in the shrub layer. Excepting *Cocculus hirsutus*, most of the plants showed a contagious distribution as there were multiple stems of the climbers emerging from the ground.

The various grass species in the ground floor vegetation were represented by *Bothriochloea pertusa*, *Cenchrus setigirus*, *Cynodon dactylon Desmostachya bipinnata*, *Dichanthium annulatum*, *Echinochloa colonum Panicum antidotale*, *Setaria glauca* having IVI values ranging from 14.94 to 1.84 (Table-4). Most of herbaceous plants showed a contagious distribution because of patchy growth of plants on the ground- floor.

Mixed Forest, Bir Reserved forest, Hisar: The mixed forest was dominated by *Salvadora oleoides* with an Importance Value Index (IVI) of 122.06 and co dominated by *Prosopis juliflora* (IVI, 109.54). The IVI of *Acacia leucophloea, Acacia nilotica*, and *Prosopis cineraria* varied from 32.28 to 7.67 (Table-2). The basal of trees (m² ha⁻¹) was in the order: 3.61 *Salvadora oleoides,* >2.79 *Prosopis juliflora,* > 0.74 and *Prosopis cineraria,* >0.75 *Acacia leucophloea,* >0.61 *Prosopis cineraria,* >0.108 *Acacia nilotica* (Table-2). The A/F ratio of trees varied from 0.368 to 0.018.

Analytical characters of tree species in mixed dry deciduous forests at Jind and Hisar						
Tree Species	Density (trees ha ⁻¹)	Basal Area (m ² ha ⁻¹)	A/F ratio	IVI		
Mixed dry deciduous forest at Jind						
Acacia leucophloea Roxb.	22.5	0.5908	0.049	17.64		
Acacia nilotica L.	12.5	0.2996	0.20	09.75		
Acacia senegal L.	12.5	0.2621	0.083	09.72		
Azadirachta indica A. Juss.	45	2.3517	0.018	31.58		
Cordia dichotoma G. Forst.	7.5	0.0457	0.033	05.71		
Dalbergia sissoo Roxb.	205	18.343	0.089	167.90		
Diospyros cordifolia Roxb.	7.5	0.0375	0.033	05.70		
Ficus rumphii Blume	10	0.0673	0.044	06.41		
Prosopis cineraria (L.) Druce.	47.5	0.7623	0.118	27.00		
	Bir Reser	ve Forest at Hisar				
Acacia leucophloea Roxb.	27.5	0.7460	0.120	28.37		
Acacia nilotica L.	7.5	0.108	0.10	7.67		
Prosopis cineraria (L.) Druce.	32.5	0.611	0.018	32.28		
Prosopis juliflora DC.	150	2.79	0.368	109.54		
Salvadora oleoides Decne.	142.5	3.6066	0.108	122.06		

 Table-2

 Analytical characters of tree species in mixed dry deciduous forests at Jind and Hisar

IVI = Importance Value Index

There was a moderately high diversity of climbers in the mixed forest (Table-5). The three most abundant climbers in the forest were represented by *Asparagus racemosus*, *Cissampelos pariera* and *Coccinia grandis* with IVI values ranging from 41.48 to 80.06. *Asparagus racemosus* was found only in dry deciduous reserve forest Hisar in natural habitation. Other climbers recorded in the forest included *Cocculus citrullus*, Ichnocarpus frutescens, Pergularia daemia, Telosma pallida, and Tinospora cordifolia. Asparagus racemesus Cissampelos glabra, Telosma pallida, and Tinospora cordifolia showed a contiguous distribution as there were multiple stems of the plant emerging from the base. Cocculus hirsutus, Ichnocarpus frutescens, Pergularia daemia showed random distribution in forest (Table-5).

Phytosociological characters of shrubs and climbers in the mixed dry deciduous forest at Jind				
Plant species	ΙVΙ	A/F ratio	Distribution	
	Shrubs			
Breynia rhamnoides (Retz.) Muell.	47.40	0.19	Contagious	
Capparis sepiaria L.	91.65	0.13	Contagious	
Capparis zeylanica L.	23.04	0.06	Contagious	
Carrisa spinarum L.	56.02	0.08	Contagious	
Phyllanthus reticulatus Poir.	38.33	0.07	Contagious	
Zizyphus nummularia Burm.f.	42.74	0.09	Contagious	
	Climbers			
Abrus precatorius L.	23.94	0.057	Contagious	
Cissampelos pareira Roxb.	78.01	0.109	Contagious	
Coccinia grandis L.	61.08	0.095	Contagious	
Cocculus hirsutus L.	11.79	0.031	Random	
Ichnocarpus frutescens (L.) R.Br.	22.46	0.068	Contagious	
Pergularia daemia Forsk.	50.56	0.059	Contagious	
Telosma pallida Roxb.	22.60	0.090	Contagious	
Tinospora cordifolia (Willd) Miers.	22.46	0.068	Contagious	

Table-3

IVI = Importance Value Index

The shrubs species of Capparis *decidua* (IVI= 77.45), *Grewia tenax* (IVI= 83.35) *Lycium europaeum* (IVI= 84.17), and *Phyllanthus reticulatus* (IVI = 54.99) were recorded in the mixed forest (Table-5). The shrubs of *Capparis decidua* formed a distinct association with the trees in the mixed deciduous forest of Bir reserve forest, Hisar. The shrubs showed an aggregated distribution with A/F ratios ranging from 0.40 to 0.055 (Table-5).

The ground floor vegetation was found to be composed of *Aristida adscensionis Cenchrus setigirus, Cynodon dactylon Dactyloctenium aegyptium* having IVI values ranging from 72.61 to 20.75 (Table-6). Other herbaceous species recorded in the forest included *Peristophe paniculata, Pupalia lappacea, Evolvulus alsinoides, Trianthema portulacastrum, Tribulus terrestris* and *Vernonia cinerea.* Most of herbaceous plants showed a contagious distribution because of patchy growth of plants on the ground- floor excepting *Evolvulus alsinoides.*

Table	-4
Phytosociological characters of herbaceous	plant species in the mixed forest at Jind

Plant Species	IVI	A/F ratio	Distribution
Abutilon indicum Sweat	3.77	0.165	Contagious
Achyranthes aspera L	1.84	0.112	Contagious
Alternanthera pungens H.B.K.	7.49	0.058	Contagious
Alysicarpus vaginalis (L.)DC.	4.01	0.375	Contagious
Barleria cristata L.	4.92	0.133	Contagious
Blepheris maderaspatensis (L.) Roth	6.82	0.714	Contagious
Boerrhavia diffusa L.	6.73	0.067	Contagious
Bothriochloea pertusa A. Camus	8.63	0.310	Contagious
Cassia tora L.	5.54	0.169	Contagious
Cenchrus setigirus Vahl	7.39	0.253	Contagious
Chenopodium album L.	5.06	0.090	Contagious
Commelina benghalensis L.	5.98	0.120	Contagious
Corchorus aestuans L.	5.54	0.169	Contagious
Corchorus olitorius L.	5.10	0.075	Contagious
Crotalaria medicaginea Lamk.	6.52	0.676	Contagious
Cynodon dactylon (L.) Pers	9.05	0.328	Contagious
Cyperus rotundus L.	4.19	0.150	Contagious
Dactyloctenium aegyptium (L.) P. Beauv	4.99	0.250	Contagious
Desmodium giganticum (L.) DC.	4.70	0.131	Contagious
Desmodium triflorum (L.)DC.	4.08	0.103	Contagious
Desmostachya bipinnata (L.) Stapf	9.67	0.357	Contagious
Dichanthium annulatum (Forssk.) Stapf.	14.94	1.691	Contagious
Digera arvensis Forssk.	5.31	0.062	Contagious
Echinochloa colonum (L.) Link.	4.01	0.375	Contagious
Elytraria crenata Vahl.	5.47	0.283	Contagious
Erigeron leucanthus D.Don	4.27	0.200	Contagious

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Plant Species	IVI	A/F ratio	Distribution
Euphorbia hirta L.	4.49	0.122	Contagious
Euphorbia prostrata Aiton.	3.77	0.166	Contagious
Ipomoea pertigridis L.	5.50	0.028	Random
Ipomoea sindica Stapf.	9.15	0.048	Random
Leucas cephalotes (Roth) Spreng	4.95	0.488	Contagious
Malvastrum coromandelianum L.	3.54	0.150	Contagious
Oxalis corniculata L.	6.54	0.138	Contagious
Panicum antidotale Retz.	9.08	0.154	Contagious
Peristophe bicalyculata (Retz) Nees	13.6	0.094	Contagious
Phyllanthus niruri auct.pl (non L.)	5.62	0.108	Contagious
Phyllanthus simplex Retz.	2.46	0.187	Contagious
Physalis minima L.	3.46	0.075	Contagious
Pupalia lappacea L.	6.89	0.070	Contagious
Rhynchosia minima (L.) DC.	5.61	0.045	Random
Rungia pectinata (L.) Nees	3.77	0.166	Contagious
Setaria glauca (L.) Beauv.	14.04	0.099	Contagious
Sida cordifolia L.	4.95	0.488	Contagious
Solanum nigram L.	3.94	0.054	Contagious
Tribulus terrestris L.	4.49	0.122	Contagious
Trichosanthes cumumerina L.	2.56	0.083	Contagious
Tridax procumbens L.	4.08	0.103	Contagious
Triumfeta rhomboidea Jacq.	5.58	0.563	Contagious
Urena lobata L.	3.67	0.084	Contagious
Vernonia cinerea (L.) Less	5.06	0.090	Contagious
Vitis carnosa (Lamk.)	2.78	0.225	Contagious
Xanthium indicum Koen.	3.77	0.166	Contagious

IVI= Importance Value Index

Table-5
hytosociological characters of shrubs and climbers in Bir Reserve forest at Hisar

Phytosociological characters of shrubs and climbers in Bir Reserve forest at Hisar			
Plant Species	ΙVΙ	A/F ratio	Distribution
	Shrubs		
Capparis decidua Forssk.	77.45	0.102	Contagious
Grewia tenax (Forssk.)Fiori	83.35	0.40	Contagious
Lycium europaeum L.	84.17	0.107	Contagious
Phyllanthus reticulatus Poir.	54.99	0.055	Contagious
	Climbers		
Asparagus racemesus Willd.	41.48	0.116	Contagious
Cissampelos pariera Roxb.	62.93	0.055	Contagious
Coccinia grandis L.	80.06	0.096	Contagious
Cocculus citrullus (L.) Diels	12.35	0.044	Random
Ichnocarpus frutescens L.	14.73	0.031	Random
Pergularia daemia Forsk.	21.41	0.040	Random
Telosma pallida Roxb.	37.53	0.093	Contagious
Tinospora cordifolia Miers.	28.80	0.068	Contagious

IVI = Importance Value Index

Plant Species	I V I	A/F ratio	Distribution
Aristida adscensionis L.	47.32	0.33	Contagious
Cenchrus biflorus Roxb.	72.61	0.55	Contagious
Dactyloctenium aegyptium (L.) P.	25.64	0.075	Contagious
Evolvulus alsinoides. (L.)L	26.86	0.15	Contagious
Peristrophe paniculata Forssk.	20.75	0.1	Contagious
Pupalia lappacea (L.) Juss.	27.61	0.048	Random
Trianthema portulacastrum L.	30.08	0.1	Contagious
Tribulus terrestris L.	26.79	0.081	Contagious
Vernonia cinerea (L.) Less	22.01	0.111	Contagious

IVI = Importance Value Index

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Population Structure of tree: Tree Population structure was prepared according to the Manual of NRSA (2008) which showed that most of the individuals were present in intermediate girth classes in the mixed forest at Jind (Figure-1). *Dalbergia sissoo, Acacia nilotica, Azadirachta indica* showed 27.77 to 40 % individuals in higher girth class of 91 -120 cm (Figure-3).

In the Bir forest at Hisar, *Salvadora oleoides* and *Prosopis juliflora* showed the saplings as the 12.5% and 20% trees showed <30cm girth. Most of the individuals of *Salvadora oleoides* and *Prosopis juliflora* were in girth class of 30-60cm. There were 7.5 to 37.5% of trees in girth class ranging from 61to 90 cm. *Salvadora oleoides* showed 12.5% of trees in higher girth class of 91-120cm (Figure-2).

Dominance diversity Curves and Diversity Indices: The dominance diversity curves of various functional groups of plants in the mixed forest at Jind and Bir forest Hisar are shown

in Figures-3 and 4. Trees, shrubs, climbers and herbaceous plants showed a lognormal distribution because of apportionment of resources among several species in the forest. The Shannon's diversity index was found to be greater for the mixed-forest, Jind (1.40), followed by that of Bir forest, Hisar (1.286). For the mixed deciduous forest at Jind, equitability index (Pielou's index) for tree layer was 0.639. Species richness (Margalef's index) for the trees was higher for the mixed forest, Jind (1.352), followed by that of the Bir forest, Hisar (0.679). The Shannon's diversity index of herbaceous species was greater in the mixed forest at Jind (3.84) than in the mixed forest, Hisar. The equitability index for the shrubs was higher for mixed forest, Hisar (0.989) than the mixed forest Jind. The number of herbaceous species (52) was higher in the mixed forest, Jind. Therefore, the Simpson's index was lowest with a value of 0.031 as compared to mixed forest Hisar. The values for various diversity indices for various functional groups of plants are given in Table-7.



Girth Classes

DS = Dalbergia sissoo; PC = Prosopis cineraria; AL = Acacia leucophloea, AN = Acacia nilotica; CD = Cordia dichotoma; FR = Ficus rumphii;





Girth Classes

SO = Salvadora Oleoides; PJ = Prosopis juliflora ; PC = Prosopis cineraria; AL = Acacia leucophloea ; AN = Acacia nilotica Figure-2

Tree Population structure in the mixed dry deciduous forest at Hisar

Discussion: Floristic study of these forests recorded a moderately high diversity of the plant species. Some of the dominant species like Dalbergia sissoo, Azadirachta indica, Salvadora oleoides and Prosopis juliflora exhibited the population structure with most of the individuals in higher and intermediate girth classes. Generally, diversity of forest depends on ecosystem processes and functions like soil formation, nutrient cycling, maintenance of hydrological cycle and organic matter decomposition. The lognormal distribution of trees, shrubs, climbers and herbs was observed due to apportionment of resources among several species in these forests. The lognormal dominance-distribution curves signify equitability and stability of the community, exhibits abundance of species having intermediate dominance values in the community²⁵ and also indicates maturity and complexity of natural community. In this study most of the shrubs and herbaceous species showed a contagious distribution because of patchy growth of plants on the groundfloor excepting Evolvulus alsinoides. Contagious/clumped distribution pattern and low frequency of most species made the community highly heterogeneous and patchy³⁰. This type of distribution pattern of species is usually associated with inefficient mode of seed dispersal³¹. Random distribution of species in the community was an outcome of frequent disturbance³². Contagious distribution has also been reported by several workers³³⁻³⁵ and it is the commonest pattern in nature³⁶. This distribution pattern was also reported in foothills forests of Garhwal Himalaya³⁷. An overview of forest biodiversity, its conservation and the very need for people's participation in biodiversity conservation and rehabilitation in India was given by some workers³⁸. The importance value index has quantified the ecological significance of the species in the tropical dry deciduous forest type.



Figure-3 Dominance diversity curves of different functional groups of plants in the mixed forest at Jind

Number of plant species and various diversity indices in mixed forest Jind and Bir forest Hisar						
Plant funcional group site	Plant Species (n)	Shannon's index (H)	Margalef's index (D)	Simpson's index (Cd)	Pielou index (e)	
		Mixed for	est Jind			
Trees	9	1.400	1.353	0.385	0.639	
Shrubs	6	1.705	0.527	0.195	0.951	
Climbers	8	1.886	0.718	1.623	0.858	
Herbaceous layer	52	3.849	3.823	0.031	0.974	
	Mixed forest Hisar					
Trees	5	1.286	0.679	0.801	0.679	
Shrubs	4	1.373	0.343	0.256	0.989	
Climbers	8	1.907	0.770	0.168	0.917	
Herbaceous layer	9	2.103	0.665	0.135	0.957	

Table-7



Dominance diversity curves of different functional groups of plants in the Bir forest at Hisar

Conclusion

This study reported 87 species of 29 families in two forest ecosystems. Mixed forest at Jind was more species divers as compared to Bir forest Hisar. Most of the shrubs and herbaceous plants showed a contiguous distribution because of patchy growth of plants on the ground- floor excepting *Evolvulus alsinoides*. The lognormal distribution of trees, shrubs, climbers and herbs suggested that resources were apportioned by several species. A very few number of seedlings saplings showed less regenerative potential of the forest ecosystems.

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