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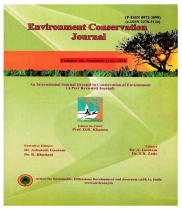

Tree species diversity in Kalidhar forest of western Shiwaliks, Jammu, JK (UT)

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ABSTRACT

The present study was conducted in Kalidhar forest of western Shiwaliks, Jammu, JK (UT), to assess the tree diversity and undertake phytosociological analysis in three major land use (LU) classes i.e. Forest, Agriculture and Scrub area. A total of 70, 50 and 50 sample plots of 0.1 ha were laid respectively in forests, scrub and agriculture LU classes. The study revealed that in forests possess a total 39 tree species belonging to 19 families and 31 genera, whereas, in scrub and agriculture lands a total of 9 tree species (8 families and 9 genera) and 60 tree species (26 families and 46 genera) were recorded respectively. *Mallotus philippensis* was the most dense tree species with 2.85 individuals per ha in forests followed by *Pinus roxburghii* 2.06 per hectare. In scrub and agriculture land *Acacia modesta* and Grewia *optiva* were found the densest species respectively. The value of Importance value index (IVI) was found highest for *Pinus roxburhii* (44.63) in forests, whereas, respective values were recorded highest for *Syzygium cumini* (82.64) and *Grewia optiva* (29.0) in scrub and agriculture lands. *Flacourtia indica* and *Pinus roxburghii* showed random distribution in forest and *Syzygium cumini* was also found to have random distribution in the scrub lands. Contiguous distribution was found for all tree species encountered in agriculture (LU) class. The diversity values of Shannon Wiener and Simpson indices showed highest tree diversity in agriculture lands with the values of 3.19 and 0.07 respectively followed by that in forests (2.47 and 0.14). Tree species richness was found high in agriculture area with Margalef's (59.86) and Menhinick's (1.80).

Introduction

India is a land of diverse nation with respect to its natural resources and traditions. Vegetation, especially trees are the most precious resource the nature has provided to us, as it caters to the essential requirements/needs of the human. The Indian Himalayan region is considered as the repository of biological and cultural diversity and supports about 18,440 species of plant, includes 1748 species of medicinal plants and 675 species of wild edibles (Negi and Gaur, 1994). Forests are one of the major sources of biodiversity and it is essential for human survival and economic well being and for the ecosystem function and stability. Forests of Himalaya play significant role for sustainable development of the region as they not only provide timber and resin to industries but also fulfills the basic needs of villagers such as fuel, small timber, fodder, and other minor products residing nearby areas. The knowledge of the floristic composition of a plant community is a prerequisite to understand the overall structure and function of any ecosystem (Gairola *et al*., 2010). Varied topographical features of Himalayan region supports unique and rich biodiversity elements ranging from genes and ecosystems. Significant work in the field of phytosociology and phytodiversity has also been done in the past few decades in the Himalayan state of Jammu and

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Kashmir by many workers including Sharma *et al*. (2008); Dangwal *et al*. (2012); Sharma and Raina (2013), Ahmed and Sharma (2014), Ghazal (2015), Sharma and Raina (2018). Sub tropical forest of Kalidhar region rich in floral wealth lie in the Shiwaliks hills of Jammu district in the Union Territory of Jammu and Kashmir. The rapid depletion of floristic diversity and changing pattern of vegetation due to various biotic and abiotic factors has promoted to carry out the qualitative and quantitative assessment of vegetation (Sharma *et al*., 2014). A sound understanding of phytosociology and the richness of species is necessary for appropriate conservation and restoration of the biological diversity. Thus keeping in view the present study has been carried out to analyze the composition, distribution and diversity of tree species in Kalidhar forest, western Shiwaliks, Jammu, J&K.

Material and Methods

The detailed study was carried out Kalidhar range of Jammu Forest Division, a part of Western Shiwaliks, J&K. It is located between 32^0 47' to 33^0 30' N latitude and $74^0$22' to 74^0 48'E longitudes. The study area is about 30 km away from Jammu city and is surrounded by Rajouri district in north, Reasi district in east and International border with Pakistan in west (Figure 1). In the study, stratified random sampling was carried out. For sampling and data collection regarding trees in the three land use classes viz forest, scrub and agriculture land sample plots of size 0.1 ha were laid. In each sample plot plants with circumference at breast height (CBH) greater than 30 cm (at 1.37 m from the ground) were considered as trees. The circumference of individual tree species was measured at breast height (1.37 m) above ground level by using measuring tape and height was measured with hypsometer. For the forest, Scrub and agriculture class total 70, 50 and 50 sample plots were laid respectively. The importance value index (IVI) was determined as the sum of the relative frequency, relative density and relative dominance (Curtis 1959).

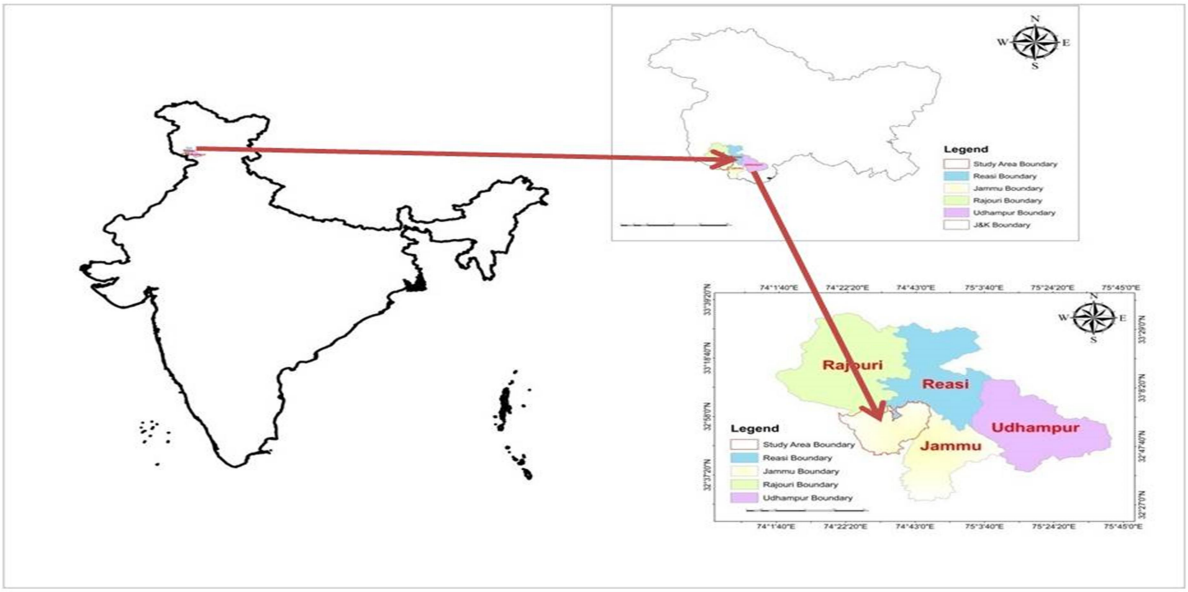

Figure 1: Location map of Kalidhar forest.

Basal area: Basal area refers to the ground actually penetrated by the stems and was used to calculate dominance of the tree species.

Basal area = (CBH) ²/4π

Abundance to frequency ratio (A/F ratio) for different species was calculated to know the distribution pattern of the species. If, <0.025 it showed regular distribution, between 0.025 – 0.05 indicates random distribution and >0.05 indicates contiguous distribution. Shannon-Wiener Index was used to calculate the species diversity in the

community and was represented by H (Shannon and Wiener, 1963).

$$H = - \Sigma Pi \ lnPi$$

Where Pi = ni/N
ni is number of the individuals of the species.
N is total number of individuals of all species.

Concentration of dominance (Cd), Simpson's Index, was measured according to Simpson (1949).

$$Ds = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2$$

Where, n = number of individuals of the species.
N = total number of individuals of all species.

Richness was calculated by Margalef's Index (Da) (1968) and Menhinik's Index (Db) (1964) as given by Whittaker (1977).

$$Da = s - 1/ln(n)$$

Where, s = number of species.
n= number of individuals.

$$Db = s/\sqrt{n}$$

Where, s = number of species
n = number of individuals

Species diversity and concentration of dominance was computed by using Shannon-Weaver (1949) and Simpson indices (1949), respectively. Species richness was calculated using Menhinick's Index (1964) and Margalef's Index (1968).

Results and Discussion

Phytosociological analysis of tree species in forest area

The assessment of trees was carried out in three land use classes of the study area viz. forests, scrub and agriculture lands. The results of the study revealed that in forest a total of 39 tree species belonging to 19 families and 31 genera were recorded. The study showed that *Mallotus philippensis* was the most dense tree species with density of 2.85 individuals per hectare followed by *Pinus roxburghii* (2.06/ha). Although *Mallotus philippensis* is an associate of *Pinus roxburghii* but in the study area density of the former was found higher than the *Pinus roxburghii*. Some open patches of pine are found in the study area which indicates that there must be good population of Pine trees, which have reduced over the years due to anthropogenic pressure on these trees as pine is the most exploited species. A study conducted by Sharma and Kant (2014) in Jammu kandi shiwaliks have reported *Mallotus philippensis* as denser tree species as compared to *Pinus rosburghii*. According to them man made disturbances have impacted the vegetation pattern and distribution of tree species. The other tree species observed in the study with lesser density were *Acacia modesta*, *Broussonetia papyrifera*, *Ficus religiosa*, *Oroxylum indicum*, *Psidium guajava Terminalia bellirica* and *Terminalia chebula*. The Important Value Index (IVI) for *Pinus roxburghii* was observed (Table 1) to be highest (44.63) in the forest area followed closely by *Mallotus philippensis* (41.78). It has also been reported by Kumar (2010), Dangwal *et al*. (2012) and Sharma and Raina (2018) that the *Pinus roxburghii* and *Mallotus philippensis* are the dominant or co-dominant tree species.

Phytosociological analysis of tree species in scrub area

In the scrub areas, which are restricted to dry parts of the study area dominated by shrubs and with sparse population of trees such as *Acacia modesta, Bombax ceiba, Syzygium cumini, Grewia optiva, etc*. A total of 9 tree species belonging to 8 families and 9 genera were recorded. Sharma (2008) also observed 9 tree species in sub-tropical scrub in Birhun watershed. In the present study *Acacia modesta* was found the most dense tree species with value of 1.42 trees/2ha followed by *Syzygium cumini* 0.61 trees/ha. In a similar study carried out by Sharma and Kant (2014) also observed *Acacia modesta* as the most dense species with very density of 84.64 trees /ha. Whereas in a study conducted by Sharma (2008) observed *Dalbergia sisoo* most dense tree species followed by *Acacia modesta* with 0.57 and 0.42 trees /ha respectively. The importance value index among the tree species in scrub class was recorded highest

for *Syzygium cumini* with IVI value of 82.64 followed by *Acacia modesta* (76.93) (Table 2).

Phytosociological analysis of tree in agriculture area

The prevalence of trees in the agriculture lands is there in the study area. The results of the study show that in agriculture fields of the study area there are total 60 trees species belonging to 26 families and 46 genera. The *Grewia optiva* was found the most dense tree species with density of 0.86 trees/ ha followed by *Dalbergia sisso* (0.33 trees/ ha). A study conducted by Sharma and Kour

Table 1: Phytosociological parameters for trees in forest class of the study area

SN	Name of sps	TBA (m^2/ha)	ABA ± STDV	Density Trees/ha	A/F ratio	IVI
1	*Acacia catechu*	0.98	0.02 ±0.01	0.51	0.37	9.37
2	*Acacia modesta*	0.02	0.02 ±0.00	0.01	0.70	1.91
3	*Acacia nilotica*	0.09	0.01 ±0.01	0.06	0.54	2.56
4	*Aegle marmelos*	0.03	0.02 ±0.00	0.02	0.52	2.34
5	*Albizzia lebbeck*	0.05	0.01 ±0.00	0.04	0.87	1.90
6	*Bauhinia purpurea*	0.03	0.01 ±0.01	0.02	1.40	1.86
7	*Bauhinia variegata*	0.12	0.01 ±0.00	0.11	0.61	3.00
8	*Bombax ceiba*	0.25	0.01 ±0.01	0.19	0.14	5.89
9	*Broussonetia papyrifera*	0.02	0.02 ±0.00	0.01	0.60	1.97
10	*Butea monosperma*	0.37	0.05 ±0.06	0.06	0.20	7.14
11	*Casearia tomentosa*	0.50	0.01 ±0.02	0.27	0.14	7.59
12	*Cassia fistula*	2.16	0.01 ±0.01	1.51	0.06	28.66
13	*Dalbergia sissoo*	0.20	0.02±0.03	0.09	0.21	4.28
14	*Desmodium oojeinense*	0.09	0.01 ±0.00	0.07	0.70	2.49
15	*Emblica officinalis*	0.32	0.02 ±0.01	0.12	0.42	4.58
16	*Ficus benghalensis*	1.25	0.21 ±0.26	0.05	0.26	21.84
17	*Ficus palmata*	0.01	0.01 ±0.00	0.02	1.40	0.97
18	*Ficus recemosa*	0.34	0.02 ±0.01	0.16	0.39	4.82
19	*Ficus religiosa*	0.03	0.03 ±0.00	0.01	0.70	3.13
20	*Flacourtia indica*	0.51	0.01 ±0.01	0.46	0.05	13.26
21	*Glochidion velutinum*	0.05	0.01 ±0.00	0.03	0.70	2.02
22	*Lannea coromandelica*	0.86	0.02 ±0.02	0.39	0.12	10.12
23	*Leucaena leucocephala*	0.19	0.01 ±0.01	0.17	0.41	4.12
24	*Mallotus philippensis*	3.46	0.01 ±0.01	2.85	0.10	41.78
25	*Mangifera indica*	0.42	0.11 ±0.11	0.03	0.18	11.71
26	*Mitragyna parvifolia*	0.04	0.02 ±0.00	0.02	0.52	2.62
27	*Olea cuspidate*	0.01	0.01 ±0.00	0.02	1.40	1.04
28	*Oroxylum indicum*	0.004	0.004 ±0.00	0.01	0.70	0.74
29	*Phoenix sylvestris*	0.13	0.01 ±0.01	0.09	0.85	2.80
30	*Pinus roxburghii*	18.24	0.07 ±0.07	2.06	0.04	44.63
31	*Psidium guajava*	0.01	0.01 ±0.00	0.01	0.70	0.98
32	*Syzgium cumini*	1.24	0.03 ±0.03	0.29	0.09	10.77
33	*Tectona grandis*	0.47	0.02 ±0.01	0.22	0.76	5.12
34	*Terminalia arjuna*	0.29	0.10 ±0.12	0.02	0.52	10.34
35	*Terminalia bellirica*	0.04	0.04 ±0.00	0.01	0.70	4.69
36	*Terminalia chebula*	0.01	0.01 ±0.00	0.01	0.70	1.55
37	*Toona ciliate*	0.07	0.01 ±0.00	0.06	0.31	2.60
38	*Trema politoria*	0.03	0.01 ±0.00	0.03	0.70	1.50
39	*Wenlandia heynei*	0.91	0.01 ±0.02	0.49	0.12	11.31
	Total	**33.82**	**1.02 ±0.87**	**10.57**	**---------**	**300**

(2014) revealed that *Mangifera indica* was the most dense tree species in agriculture land (2.1 trees/ ha) followed by *Acacia nilotica* (1.3 trees/ ha). In the Agriculture land the density values of tree species were less as compared to the forest area similar result was also reported by Ahmed and Sharma,2014. The IVI among the tree species in agriculture land was recorded highest for *Grewia optiva* withvalue of 29.0 followed by IVI of *Leucaena leucocephala* with the value of 21.21 (Table 3). A study carried out in Poonch by Manzoor and Jazib, 2020 also found *Grewia optiva* as the most dense and dominant tree species with the density and IVI value of 3.88 and 16 respectively. Another study conducted by Sharma and Kour (2014) in Vijaypur, Samba, JK(UT) found maximum value of IVI (78.61) for *Mangifera indica.*

Table 2: Phytosociological parameters for tress in Scrub class of the study area

SN	Name of species	TBA (m^2/ha)	ABA ± Stdv	Density (Trees/ha)	A/F ratio	IVI
1	*Acacia modesta*	*0.75*	0.016 ±0.018	1.420	0.08	76.93
2	*Bombax ceiba*	*0.0094*	0.0047 ±0.0010	0.061	0.09	10.34
3	*Cassia fistula*	*0.023*	0.0058 ±0.0011	0.123	0.05	17.48
4	*Dalbergia sisso*	*0.090*	0.0075 ±0.0030	0.370	0.06	30.37
5	*Flacourtia indica*	*0.035*	0.0059 ±0.0023	0.185	0.07	19.33
6	*Grewia optiva*	*0.0094*	0.0047 ±0.0010	0.061	0.09	10.34
7	*Lannea coromandelica*	*0.198*	0.0123 ±0.0092	0.493	0.08	38.24
8	*Syzygium cumini*	*0.96*	0.0480 ±0.080	0.617	0.04	82.64
9	*Wendlandia heynei*	*0.031*	0.0051 ±0.0012	0.185	0.27	14.28
Total		**2.11**	**0.110 ±0.117**	**3.519**	**-------**	**300**

Table 3: Phytosociological parameters for trees in Agriculture class of the study area

SN	Name of species	TBA (m^2/ha)	ABA ±STDV	Density (Trees/ha)	A/F ratio	IVI
1	*Acacia catechu*	0.051	0.005±0.003	0.036	0.281	3.006
2	*Acacia modesta*	0.034	0.017±0.008	0.008	0.250	3.619
3	*Acacia nilotica*	0.108	0.009±0.006	0.044	0.220	4.174
4	*Aegle marmelos*	0.010	0.010±0	0.004	0.500	2.195
5	*Albizia lebbeck*	0.304	0.010±0.006	0.120	0.104	8.136
6	*Alstonia scholaris*	0.035	0.011±0.003	0.012	0.375	2.807
7	*Artocarpus lakucha*	0.114	0.022±0.014	0.020	0.625	4.821
8	*Azadirchta indica*	0.019	0.019±0	0.004	0.500	3.548
9	*Bauhinia purpurea*	0.249	0.006±0.005	0.152	4.750	5.118
10	*Bauhinia variegata*	0.021	0.010±0.011	0.008	1.000	2.274
11	*Bombax ceiba*	0.247	0.006±0.006	0.148	0.072	9.466
12	*Broussonetia papyrifera*	0.038	0.007±0.003	0.020	0.625	2.351
13	*Butea monosperma*	0.810	0.018±0.022	0.180	0.900	8.560
14	*Callistemon lanceolatus*	0.010	0.010±00	0.004	0.500	2.195
15	*Carica papya*	0.007	0.001±00	0.020	2.500	1.024
16	*Casearia tomentosa*	0.040	0.006±0.010	0.024	0.333	2.587
17	*Cassia fistula*	0.070	0.005±0.004	0.056	0.143	4.288

18	*Celtis australis*	0.013	0.006±0.001	0.008	0.250	1.914
19	*Citrus limetta*	0.005	0.001±0.0002	0.012	1.500	0.857
20	*Citrus limon*	0.003	0.001±0.0002	0.008	1.000	0.787
21	*Citrus medica*	0.011	0.002±0.0008	0.016	0.500	1.451
22	*Citrus pseudolimon*	0.013	0.002±0.0012	0.024	0.188	2.168
23	*Citrus sinensis*	0.069	0.002±0.0010	0.112	0.875	4.181
24	*Citrus nobilis*	0.001	0.001±00	0.004	0.500	0.723
25	*Cordia dichotoma*	0.020	0.006±0.0016	0.012	0.375	2.009
26	*Dalbergia sisso*	1.049	0.012±0.0146	0.336	0.145	14.953
27	*Eriobotrya japonica*	0.006	0.001±0.0002	0.016	0.222	1.585
28	*Eucalyptus citriodora*	0.091	0.013±0.0126	0.028	0.219	4.026
29	*Ficus auriculata*	0.019	0.009±0.0030	0.008	1.000	2.114
30	*Ficus benghalensis*	0.222	0.111±0.1189	0.008	0.250	18.917
31	*Ficus carica*	0.005	0.001±0.0002	0.012	0.375	1.226
32	*Ficus palmata*	0.098	0.003±0.0019	0.112	0.115	6.562
33	*Ficus recemosa*	0.037	0.018±0.0243	0.008	0.250	3.850
34	*Ficus religiosa*	0.171	0.021±0.0292	0.032	0.250	5.481
35	*Flacourtia indica*	0.100	0.003±0.0030	0.108	0.080	7.138
36	*Gmelina arborea*	0.008	0.008±00	0.004	0.500	1.827
37	*Grewia optiva*	1.403	0.006±0.0054	0.864	0.148	29.000
38	*Lannea coromandelica*	0.289	0.008±0.0055	0.136	0.118	8.231
39	*Leucaena leucocephala*	0.649	0.004±0.0049	0.544	0.101	21.210
40	*Litchi chinensis*	0.001	0.001±00	0.004	0.500	0.671
41	*Litsea chinensis*	0.026	0.006±0.0023	0.016	0.500	2.051
42	*Mallotus philippensis*	0.083	0.003±0.0026	0.084	0.105	5.660
43	*Mangifera indica*	1.935	0.030±0.0240	0.252	0.079	16.983
44	*Manilkara zapota*	0.003	0.003±00	0.004	0.500	0.979
45	*Melia azadirachta*	0.165	0.011±0.0030	0.056	0.109	5.711
46	*Morus alba*	0.227	0.009±0.0068	0.100	0.195	6.253
47	*Phoenix sylvestris*	0.016	0.005±0.0040	0.012	0.375	1.809
48	*Phyllanthus emblica*	0.169	0.010±0.0068	0.064	0.500	4.425
49	*Populus ciliata*	0.003	0.001±0.0003	0.008	0.250	1.086
50	*Prunus domestica*	0.002	0.002±00	0.004	0.500	0.821
51	*Prunus persica*	0.003	0.001±0.0003	0.008	0.250	1.086
52	*Psidium guajava*	0.050	0.002±0.0007	0.072	0.250	3.964
53	*Punica granatum*	0.005	0.001±0.0005	0.012	0.375	1.223

54	*Syzygium cumini*	0.362	0.014±0.0151	0.100	0.074	8.709
55	*Tectona grandis*	0.089	0.005±0.0049	0.060	7.500	2.639
56	*Terminalia bellirica*	0.311	0.025±0.0144	0.048	0.375	6.573
57	*Toona ciliata*	0.349	0.016±0.0083	0.084	0.105	7.758
58	*Wendlandia heynei*	0.007	0.003±0.0030	0.008	1.000	1.079
59	*Ziziphus maurtiana*	0.092	0.009±0.0064	0.040	1.250	3.043
60	*Ziziphus nummularia*	0.299	0.008±0.0052	0.140	0.273	7.067
	Total	**10.679**	**0.613 ±0.446**	**4.451597**	**-------**	**300**

Table 4: Diversity Indices for Trees in Forest, Scrub and Agricultural area

Land form	Margalef's index (Da)	Menhinick's index (Db)	Shannon-Wiener's index (H)	Simpson's index (Ds)
Forest	38.86	1.07	2.47	0.14
Scrub	8.79	0.84	1.75	0.23
Agriculture	59.86	1.80	3.19	0.07

Distribution Pattern of tree species

Distribution pattern of tree species in the study area was mainly contagious in all the three classes viz. forest, scrub and agriculture. Odum (1971) also observed that contiguous is the most common pattern in nature and it is due to small significant variations in the environment. Among tree species in forest of the study area, *Flacourtia indica* and *Pinus roxburghii* show random distribution. In contrary the study conducted elsewhere by Ahmed and Sharma (2014) reported *Ficus recemosa* and *Pyrus pashia* were randomly distributed in the forest. In the scrub of the study area only *Syzygium cumini* was randomly distributed. In case of agricultural class of the study area all the species showed contagious distribution pattern. Whereas regular distribution is rare due to severe competition between the individuals exists.

Diversity analysis

The study regarding tree diversity using Shannon-Wiener and Simpson indices and species richness using Margalef's and Menhinick's indices was carried out. The results showed that the tree diversity in agriculture land use was highest with Shannon-Wiener and Simpson indices values of 3.19 and 0.07 respectively. The high value of Shannon Wiener index in agriculture land can be attributed to cultivation of various trees especially fruit and other multipurpose tree species (Ahmed and Sharma, 2014). The Shannon- Wiener index values for trees in the forest and scrub were found to be 2.47 and 1.75 respectively, whereas the respective values of Simpson index for the forest and scrub classes were observed as 0.14 and 0.23. The Shannon Wiener index values obtained in the present study are comparable to the value of 2.78 reported by Kumar and Raina (2012) in forests of Kishtwar J&K, 3.16 in Lamberi forest range, Rajouri (Sharma, 2012) and 2.62 by in Ramnagar Wildlife sactuary, Jammu (Ghazal, 2015). The Simpson Index values found in the study are in accordance with the findings i.e. 0.17 observed by Dangwal *et al*., (2012) in Nowshera block of Rajouri district and in range of 0.07 to 0.63 found by Bijalwan, (2010) in different districts of Madhya Pradesh, India, in the areas of high interference by human beings. In case of scrub class the values of Simpson index was observed to be 0.23 (Table 4).

The values of Margalef and Menhinick indices for tree species richness were also found highest for agriculture class with the values of 59.86 and 1.80, respectively, followed by values of 38.86 and 1.07 for trees in forest class The observation made by

Ahmed and Sharma (2014) in Ponda watershed also showed the maximum values of tree species richness in the agriculture area. In scrub class the respective values of Margalef and Menhinick indices found were 8.79 and 0.84 for trees respectively. In similar studies conducted by various authors such as Sharma and Kant, 2014; Ahmed and Sharma, 2014 and Ghazal, 2015 obtained value of 16.46 and 1.21; 7.13 and 2.16; 3.68 and 1.86 respectively.

Conclusion

The phytosociological and tree diversity analysis of three land use classes in the study area i.e. forests, scrub and agriculture lands, revealed that there is a big gap between the values of various parameters like IVI, density, A/F ratio among these classes. The diversity was found highest in agriculture lands because of plantation of different multipurpose tree species. There are many tree species having very low values of IVI and other parameters and these species deserve more attention for conservation. Thus the phytodiversity studied is in under great anthropogenic pressure.

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