Forest Community Structure and Composition Along an Elevational Gradient of Parshuram Kund Area in Lohit District of Arunachal Pradesh, India.

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Abstract: The present study was conducted in natural Himalayan forests of Parsuram Kund area in Lohit district of Arunachal Pradesh to understand the effect of altitudinal variation on structure and composition of the vegetation. Three altitudinal zones viz., upper zone (U) = 550-850 m asl, middle zone (M) = 500-700 m asl and lower zone (L) = 350-450 m asl were selected for the study. Tree Species richness (SR) was recorded to be highest (26) on the middle altitude followed by lower (21) and upper altitude (13). Species diversity (richness) and dominance (Simpson Concentration of dominance index) were found to be inversely related to each other. Shrub and herb species richness were also recorded to be higher on middle altitude followed by lower and upper altitudes. [Nature and Science 2010;8(1):44-52]. (ISSN: 1545-0740).

Key words: Phytosociology, species richness, diversity indices, altitude.

1. Introduction

The Indian Himalayan region occupies a special place in the mountain ecosystems of the world. These geodynamically young mountains are not only important from the stand point of climate and as a provider of life, giving water to a large part of the Indian subcontinent, but they also harbor a rich variety of flora, fauna, human communities and cultural diversity (Singh, 2006). Understanding of forest structure is a pre-requisite to describe various ecological processes and also to model the functioning and dynamics of forests (Elourard et al., 1997). Species diversity has functional consequences, because the number and kinds of species present in any area determine the organismal traits, which influence ecosystem processes. The components of species diversity that determine the expression of traits include the number of species present (species richness), their relative abundance (species evenness), presence of the particular species (species composition), the interactions among species (non-additive effects), and the temporal and spatial variation in these properties. In addition to its effects on current functioning of ecosystems, species diversity influences the resilience and resistance of ecosystems to environmental changes (Chapin et al., 2000).

The altitude and aspect play a key role in determining the temperature regime and atmospheric pressure of any site. Within one altitude the cofactors like topography, aspect, inclination of slope and soil type affect the forest composition (Shank and Noorie, 1950). Ellu and Obua (2005) have suggested that different altitudes and slopes influence the species richness and dispersion behavior of tree species. Moreover, Kharkwal et al. (2005) have pointed out that altitude and climatic variables like temperature and rainfall are the determinants of species richness. The distribution and species richness pattern of different species are largely regulated by altitude and physiographic factors (Sharma et al., 2009a, 2009b). The micro-environment of different aspects of hill slopes is influenced by the intensity and duration of available sunlight (Yadav and Gupta, 2006). This type of ecological knowledge is fundamental for conservation and sustainable utilization, and may provide important information for the policy makers for drafting management plans of fragile mountain ecosystems. Under the backdrop of the aforesaid facts, the present study was undertaken in natural Himalayan forests of Parsuram Kund area of Lohit district in Arunachal Pradesh to understand the effect of altitude on the structure and composition of the vegetation of natural forests.

2. Material and methods

The study was conducted in the natural Himalayan forest of Parsuram Kund area of Lohit district in Arunachal Pradesh. The Lohit district is one of the districts of the state of Arunachal Pradesh in India. The Lohit District is located at the north-eastern edge of the state. The district stretches from 97° 24' E longitude to 95° 15' E longitude and 29° 22' N latitude to 27° 33' N latitude. The main ethnic groups that inhabit the place are Tai Khamti, Mishmi and Singpho. This river originates from the eastern part of Tibet and becomes a part of India at a place called Kibithoo. The district headquarters are located at Tezu. According to Indian census of 2001, it has a total area of 11402 Km^2 and a population of 143,478. The district is named after one of the important river of the state, Lohit River, from the Sanskrit Louhitya, reddish- or rust-coloured, and consists of the river valley and hills/mountains to the North and South. The area is highly inaccessible, and it is only in 2004 that a permanent bridge has been made operational across the Lohit at the holy site of Parashuram Kund, giving round-the-year connection to Tezu.

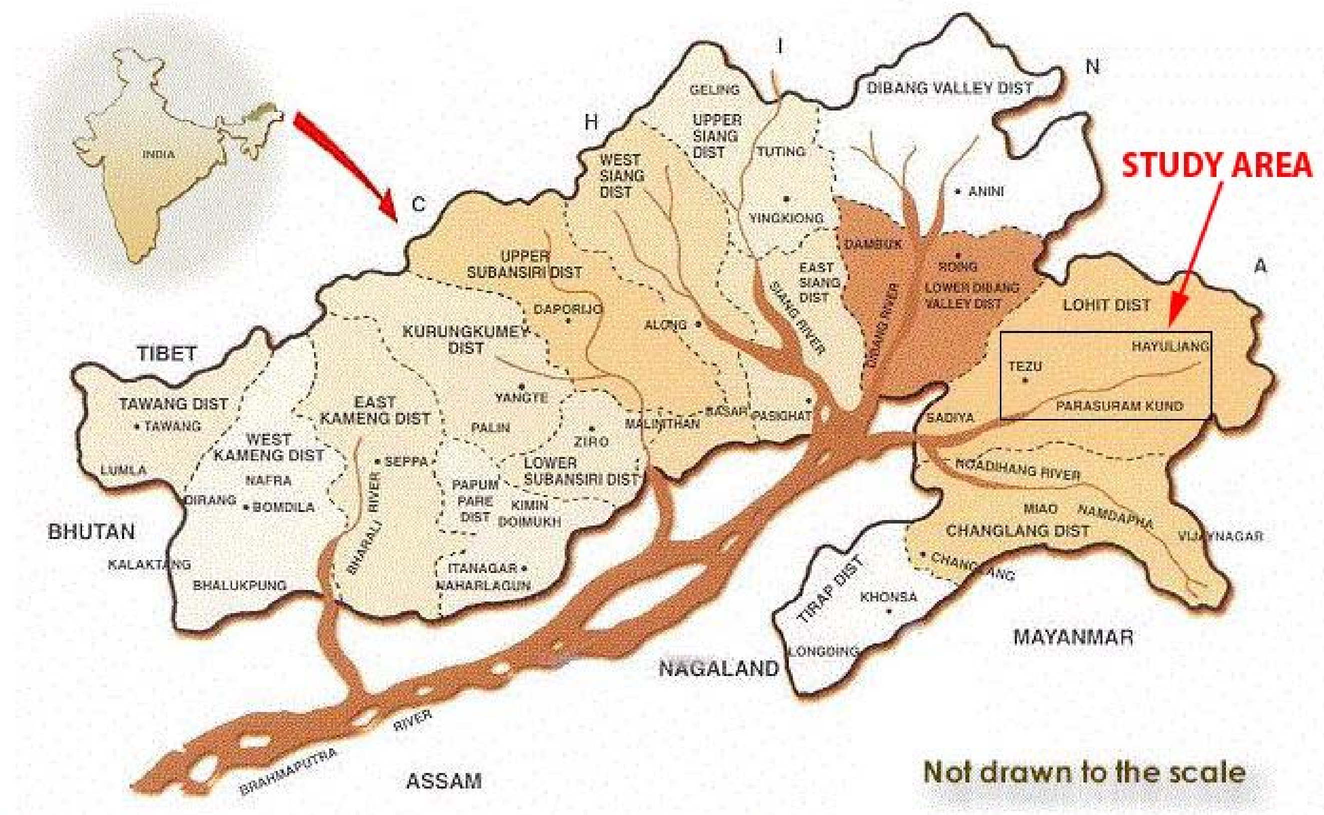

Figure 1: Map of the study area.

The climate of this place is mainly of two types. The high-altitude places are slightly cold, while the low-altitude places as well as the valleys are quite humid and hot. The period between the later part of November to the early part of March is winter time. The rainy season is experienced by the place between June and October. The climate is hot and highly humid in the lower elevations and in the Valleys and mildly cold in the higher elevations. The winter prevails during the months from late November to early March. The period from March to May is the pre-monsoon season. It is followed by monsoon from June to October. After the reconnaissance survey three altitudinal zones viz., upper zone (U) = 550-850 m asl, middle zone (M) = 500-700 m asl and lower zone (L) = 350-450 m asl were identified to study the effect of altitudinal variation on structure and composition of the vegetation.

The composition of the forest along the altitudinal gradient was analysed by using nested quadrat method or centre point quadrat method for trees, shrubs and herbs species as per Kent and Coker (1992). Three vegetation layers, (i.e., trees, shrubs and herbs) were analyzed for species richness, density and diversity. A total of 60 plots (twenty plots in each forest type) measuring 10m × 10m each were sampled. Trees (≥10cm dbh) were analyzed by 10m × 10m sized quadrats, whereas shrubs by 5m × 5m sized quadrats. Further, quadrats of 1m × 1m size were randomly laid out with in each 10m × 10m sized quadrat at each site, to study plants in the herbaceous layer. Circumference at breast height (cbh= 1.37m) was taken for the determination of tree basal area and was calculated as πr^2, where r is the radius. Total basal area is the sum of basal area of all species present in the forest. Species Richness was simply taken as a count of number of species present in that forest type. Basal area (m^2/ha) was used to determine the relative dominance of a tree species. The diversity ($\overline{H}$) was determined by using Shannon-Wiener information index (Shannon and Weaver, 1963) as: $\overline{H} = -\sum n_i/n \log_2 n_i/n$; where, n_i was the density of a species and n was the sum of total density of all species in that forest type. The Simpson's concentration of dominance (Simpson, 1949) was measured as: $Cd = \sum Pi^2$, where, $\sum Pi = \sum n_i/n$, where, ni and n are same as in Shannon-Wiener diversity index. Simpson's diversity index (Simpson, 1949) was calculated as: D = 1-Cd, where, D = Simpson's diversity and Cd = Simpson's concentration of dominance.

3. Results

Results of forest community structure and composition are given in tables 1 to 4.

Trees: At upper altitude *Albizia lucida* was the dominant tree species with highest density (240 ind/ha) and TBC (8.19 m^2/ha). At middle altitude *Artocarpus chaplasha* had highest density (120 ind/ha) and TBC was highest in *Terminalia myriocarpa* (28.12 m^2/ha). At lower altitude *Albizia lucida* had highest density (120 ind/ha) and *Dubanga grandiflora* had highest TBC (9.62 m^2/ha). Tree Species richness (SR) was recorded to be highest at middle altitude (26) followed by lower (21) and upper (13) altitudes. Highest tree density was recorded at middle zone (860 ind/ha) followed by upper (600 ind/ha) and lower (550 ind/ha) altitudinal zone. Cd was found to be highest (0.2078) on upper altitude followed by lower (0.1094) and middle (0.0719) altitude. Value $\overline{H}$ was found to be highest (4.171) at middle altitude followed by lower (3.740) and upper (2.893) altitude.

Table 1: Phytosociology and diversity of tree strata.

Species	Density (ind/ha)			Basal Area (m^2/ha)			Cd			Shannon-Wiener ($\overline{H}$)		
	U	M	L	U	M	L	U	M	L	U	M	L
Actinodaphne obovata	-	20	-	-	0.07	-	-	0.0005	-	-	0.126	-
Ailanthus excelsa	-	10	-	-	2.58	-	-	0.0001	-	-	0.075	-
Alangium begoniaefolia	50	20	-	0.78	0.09	-	0.0069	0.0005	-	0.299	0.126	-
Albizia lucida	240	-	120	8.19	-	7.21	0.1600	0.0000	0.0476	0.529	-	0.479
Albizia sp.	-	80	-	-	3.03		-	0.0087	-	-	0.319	-
Artocarpus chaplasha	-	120	20	-	1.15	0.01	-	0.0195	0.0013	-	0.396	0.174
Bombax ceiba	-	-	10	-	-	8.60	-	0.0000	0.0003	-	-	0.105
Brassiopsis glomerulata	10	10	-	0.1	0.05	-	0.0003	0.0001	-	0.098	0.075	-
Callicarpa arborea	-	-	10	-	-	1.08	-	-	0.0003	-	-	0.105
Cinnamomum sp.	-	-	10	-	-	0.01	-	-	0.0003	-	-	0.105
Cyanometra polyandra	-	-	10	-	-	4.03	-	-	0.0003	-	-	0.105
Dalbergia sisso	80	20	50	6.8	3.2	5.60	0.0178	0.0005	0.0083	0.387	0.126	0.314
Dalbergia sp.	10	-	-	0.39	-	-	0.0003	-	-	0.098	-	-
Dendrocalamus hamiltonii	-	80	-	-	0.56	-	-	0.0087	-	-	0.319	-

Dilenia indica	-	-	10	-	-	3.20	-	0.0000	0.0003	-	-	0.105
Duabanga grandiflora	70	20	100	3.45	1.94	9.62	0.0136	0.0005	0.0331	0.362	0.126	0.447
Dysoxylon hamiltonii	-	20	-	-	1.26	-	-	0.0005	-	-	0.126	-
Engelhardtia spicata	-	-	50	-	-	6.80	-	-	0.0083	-	-	0.314
Ficus cunia	-	10	-	-	0.16	-	-	0.0001	-	-	0.075	-
Ficus roxburghii	-	10	-	-	0.39	-	-	0.0001	-	-	0.075	-
Ficus semecordata	-	40	10	-	15.81	3.56	-	0.0022	0.0003	-	0.206	0.105
Garuga gamblei	-	-	20	-	-	9.60	-	-	0.0013	-	0.126	0.174
Gynocardia odorata	10	20	10	0.29	1.3	2.20	0.0003	0.0005	0.0003	0.098	-	0.105
Knema angustifolia	-	10	-	-	0.07	-	-	0.0001	-	-	0.075	-
Kydia calycina	-	10	20	-	0.96	4.38	-	0.0001	0.0013	-	0.075	0.174
Laportea sp.	-	-	10	-	-	2.13	-	-	0.0003	-	-	0.105
Leea sp.	-	10	-	-	0.15	-	-	0.0001	-	-	0.075	-
Macaranga denticulata	20	90	20	0.9	3.39	2.00	0.0011	0.0110	0.0013	0.164	0.341	0.174
Macropanax dispermus	-	10	10	-	0.07	0.72	-	0.0001	0.0003	-	0.075	0.105
Mallotus tetracoccus	20	-	-	0.3	-	-	0.0011	-	-	0.164	-	-
Ostodes paniculata	-	20	-	-	0.26	-	-	0.0005	-	-	0.126	-
Pandanas odoratissima	30	40	-	0.19	0.39	-	0.0025	0.0022	-	0.216	0.206	-
Pterospermum acerifolium	20	60	10	1.36	8.84	2.30	0.0011	0.0049	0.0003	0.164	0.268	0.105
Sapindus rarak	-	-	30	-	-	4.50	-	-	0.0030	-	-	0.229
Sarcosperma griffithii	-	30	-	-	0.51	-	-	0.0012	-	-	0.169	-
Saurauria nepalensis	-	10	-	-	0.05	-	-	0.0001	-	-	0.075	-
Stercularia villosa	30	-	-	0.31	-	-	0.0025	-	-	0.216	-	-
Talauma hodgsonii	-	-	10	-	-	0.78	-	-	0.0003	-	-	0.105
Terminalia myriocarpa	10	80	-	1.15	25.12	-	0.0003	0.0087	-	0.098	0.319	-
Toona ciliata	-	10	-	-	3.51	-	-	0.0001	-	-	0.075	-
Trema orientalis	-	-	10	-	-	0.01	-	-	0.0003	-	-	0.105
	600	860	550	19.61	74.91	78.32	0.2078	0.0719	0.1094	2.893	4.171	3.740

Shrubs: At upper altitude *Musa nagensium* was the dominant shrub species with highest density (680 ind/ha) and TBC (16.24 m^2/ha). At middle altitude also Musa nagensium was the dominant shrub species with highest density (560 ind/ha) and TBC (4.24 m^2/ha). At lower altitude *Piper peepuloides* was the dominant shrub species with highest density (540 ind/ha) and highest TBC was recorded for *Grewia disperma* (1.45 m^2/ha). Shrub Species richness (SR) decreased from upper altitude to lower altitude with highest SR at upper (12) altitude followed by middle (10) and lower (10) altitude. Highest (3180 ind/ha) density was recorded at upper altitude followed by lower (2640 ind/ha) and middle (2380 ind/ha) altitudinal zone, where as highest TBC (17.45 m^2/ha) was recorded at upper altitude followed by middle (9.31 m^2/ha) and lower (1.93 m^2/ha) altitudes. Cd was found to be highest (0.143) on middle altitude followed by upper (0.120) and lower (0.118) altitude, whereas $\bar{H}$ was found to be highest (3.27) at upper altitude followed by lower (3.21) and middle (2.99) altitude.

Table 2: Phytosociology and diversity of shrub strata.

Species	Density (ind/ha)			Basal Area (m^2/ha)			Cd			Shannon-Wiener ($\overline{H}$)		
	U	M	L	U	M	L	U	M	L	U	M	L
Acacia pinnata	40	280	-	0.03	0.02	-	0.0002	0.0138	-	0.079	0.363	-
Artemisia nelagirca	160	-	200	0.01	-	0.02	0.0025	-	0.0057	0.217	-	0.282
Bambusa pallida	-	60	-	-	2.17	-	-	0.0006	-	-	0.134	-
Boehmeria longifolia	360	-	220	0.04	-	0.02	0.0128	-	0.0069	0.356	-	0.299
Boehmeria macrophylla	240	-	-	0.4	-	-	0.0057	-	-	0.281	-	-
Calamus leptospadix	440	-	-	0.38	-	-	0.0191	-	-	0.395	-	-
C. floribundus	120	-	340	0.02	-	0.09	0.0014	-	0.0166	0.178	-	0.381
Debregeasia longifolia	160	240	120	0.19	0.62	0.12	0.0025	0.0102	0.0021	0.217	0.334	0.203
Dendrocalamous gignteus	-	40	-	-	0.35	-	-	0.0003	-	-	0.099	-
Ficus urophylla	-	100	-	-	0.22	-	-	0.0018	-	-	0.192	-
Girardinia diversifolia	180	-	280	0.02	-	0.06	0.0032	-	0.0112	0.234	-	0.343
Grewia disperma	-	-	240	-	-	1.45	-	-	0.0083	-	-	0.314
Jasminium sp.	300	-	-	0.03	-	-	0.0089	-	-	0.321	-	-
Mesea indica	420	-	-	0.05	-	-	0.0174	-	-	0.386	-	-
Murraya paniculata	-	120	-	-	0.17	-	-	0.0025	-	-	0.217	-
Musa nagensium	680	560	-	16.24	4.24	-	0.0457	0.0554	-	0.476	0.491	-
Piper peepuloides	-	-	540	-	-	0.12	-	-	0.0418	-	-	0.468
P. griffithii	-	340	240	-	1.44	0.01	-	0.0204	0.0083	-	0.401	0.314
Rubus ellipticus	-	400	-	-	0.06	-	-	0.0282	-	-	0.432	-
Sida rhombifolia	-	-	160	-	-	0.01	-	-	0.0037	-	-	0.245
Trevesia palmata	80	-	-	0.04	-	-	0.0006	-	-	0.134	-	-
Triumfetta bartramia	-	240	-	-	0.02	-	-	0.0102	-	-	0.334	-
Zanthoxylum nepalensis	-	-	300	-	-	0.03	-	-	0.0129	-	-	0.356
	3180	2380	2640	17.45	9.31	1.93	0.1202	0.1434	0.1175	3.274	2.997	3.206

Monsoon Herbs: At upper altitude *Imperata cylindrica* was the dominant herb species with highest density (3300 ind/ha) followed by *Equisetum* sp. (2100 ind/ha) and *Saccharum spontaneum* (1400 ind/ha). At lower altitude *Bidens pilosa* was the dominant herb species with highest density (4000 ind/ha) followed by *Elatostemma* sp. (1800 ind/ha) and *Imperata cylindrical* (1600 ind/ha). At middle altitude *Elatostemma* sp. was the dominant herb species with highest density (1900 ind/ha) followed by *Pilea* sp. (1800 ind/ha) and *Phyrinum pubinerve* (1600 ind/ha). Herb Species richness (SR) was found to be higher at middle altitude (29) followed by upper and lower altitude with 21 species each. Highest (14200 ind/ha) density was recorded at upper altitude followed by middle (13100 ind/ha) and lower (13800 ind/ha) altitudinal zone. Cd was found to be highest (0.133) on lower altitude followed by upper (0.105) and lower (0.077) altitude, whereas $\overline{H}$ was found to be highest (4.21) at middle altitude followed by upper (3.78) and lower (3.55) altitude.

Table 3: Phytosociology and diversity of herb strata in monsoon and post monsoon seasons.

Species	**Density (ind/ha)**			**Cd**			**Shannon-Wiener ($\overline{H}$)**		
Monsoon Season Herbs	**U**	**M**	**L**	**U**	**M**	**L**	**U**	**M**	**L**
Begonia sp.	400	100	100	0.0008	0.0001	0.0001	0.145	0.054	0.051
Bidens pilosa	-	-	4000	-	-	0.0840	-	-	0.518
Colocossia sp.	-	300	-	-	0.0005	-	-	0.125	-
Commelina bengalensis	-	200	-	-	0.0002	-	-	0.092	-
Cyanotis vaga	-	200	400	-	0.0002	0.0008	-	0.092	0.148
Cyperus sp.	-	200	200	-	0.0002	0.0002	-	0.092	0.089
Elatostemma sp.	1100	1900	1800	0.0060	0.0210	0.0170	0.286	0.404	0.383
Equisetum sp.	2100	400	-	0.0219	0.0009	-	0.408	0.154	-
Eupatorium adenophorum	-	-	1000	-	-	0.0053	-	-	0.274
Eupatorium odoratum	200	200	-	0.0002	0.0002	-	0.087	0.092	-
Forrestica sp.	-	200	-	-	0.0002	-	-	0.092	-
Imperata cylindrica	3300	500	1600	0.0540	0.0015	0.0134	0.489	0.180	0.360
Lygodium flexuosum	300	100	-	0.0004	0.0001	-	0.118	0.054	-
Mastersia sp.	-	200	-	-	0.0002	-	-	0.092	-
Mikania micrantha	600	300	100	0.0018	0.0005	0.0001	0.193	0.125	0.051
Molinera cucurboides	100	200	200	-	0.0002	0.0002	0.050	0.092	0.089
Nephrolepis cordifolia	400	200	300	0.0008	0.0002	0.0005	0.145	0.092	0.120
Ophiopogon intermedius	200	300	300	0.0002	0.0005	0.0005	0.087	0.125	0.120
Paederia foetida	500	100	500	0.0012	0.0001	0.0013	0.170	0.054	0.173
Paspalam sp.	600	300	300	0.0018	0.0005	0.0005	0.193	0.125	0.120
Photos scandens	700	200	200	0.0024	0.0002	0.0002	0.214	0.092	0.089
Phyrnium pubinerve	500	1600	-	0.0012	0.0149	-	0.170	0.370	-
Pilea sp.	-	1800	-	-	0.0189	-	-	0.393	-
Polygonum capitatum	-	-	200	-	-	0.0002	-	-	0.089
Polypodium sp.	400	300	200	0.0008	0.0005	0.0002	0.145	0.125	0.089
Pteris sp.	300	700	300	0.0004	0.0029	0.0005	0.118	0.226	0.120
Saccharum spontaneum	1400	1200	1000	0.0097	0.0084	0.0053	0.329	0.316	0.274
Senecio cappa	200	200	-	0.0002	0.0002	-	0.087	0.092	-
Sonchus oleraceus	300	200	200	0.0004	0.0002	0.0002	0.118	0.092	0.089
Thladiantha calcarata	300	100	-	0.0004	0.0001	-	0.118	0.054	-
Thysanolaena maxima	300	200	200	0.0004	0.0002	0.0002	0.118	0.092	0.089
Urtica dioica	-	700	700	-	0.0029	0.0026	-	0.226	0.218
	14200	13100	13800	0.1053	0.0770	0.1332	3.784	4.212	3.552

Post-monsoon Season Herbs	U	M	L	U	M	L	U	M	L
Begonia sp.	100	100	200	0.0001	0.0001	0.0002	0.052	0.055	0.089
Bidens pilosa	-	-	3800	-	-	0.0781	-	-	0.514
Colocossia sp.	-	100	-	-	0.0001	-	-	0.055	-
Commelina bengalensis	-	200	-	-	0.0002	-	-	0.094	-
Cyanotis cappa	200	-	-	0.0002	-	-	0.089	-	-
Cyanotis vaga	-	200	300	-	0.0002	0.0005	-	0.094	0.121
Elatostemma sp.	1200	2100	1600	0.0078	0.0269	0.0138	0.309	0.428	0.363
Equisetum sp.	2200	700	-	0.0262	0.0030	-	0.425	0.229	-
Eupatorium adenophorum	-	-	800	-	-	0.0035	-	-	0.240
Eupatorium odoratum	400	200	-	0.0009	0.0002	-	0.150	0.094	-
Forrestica sp.	-	200	-	-	0.0002	-	-	0.094	-
Imperata cylindrica	2900	700	1400	0.0455	0.0030	0.0106	0.475	0.229	0.338
Lygodium flexuosum.	200	100	-	0.0002	0.0001	-	0.089	0.055	-
Mastersia sp.	-	200	-	-	0.0002	-	-	0.094	-
Mikania micrantha	500	300	300	0.0014	0.0005	0.0005	0.175	0.127	0.121
Molinera cucurboides	-	100	200	-	0.0001	0.0002	-	0.055	0.089
Nephrolepis cordifolia	400	200	200	0.0009	0.0002	0.0002	0.150	0.094	0.089
Ophiopogon intermedius	300	300	500	0.0005	0.0005	0.0014	0.121	0.127	0.175
Paederia foetida	400	200	600	0.0009	0.0002	0.0019	0.150	0.094	0.199
Paspalam sp.	800	400	200	0.0035	0.0010	0.0002	0.240	0.156	0.089
Photos scandens	500	200	800	0.0014	0.0002	0.0035	0.175	0.094	0.240
Phyrnium pubinerve	800	1000	-	0.0035	0.0061	-	0.240	0.287	-
Pilea sp.	-	1900	-	-	0.0220	-	-	0.408	-
Pogonetum sp.	-	200	100	-	0.0002	0.0001	-	0.094	0.052
Polygonum capitatum	-	-	100	-	-	0.0001	-	-	0.052
Polypodium sp.	200	0	100	0.0002	-	0.0001	0.089	-	0.052
Pteris sp.	500	800	400	0.0014	0.0039	0.0005	0.175	0.250	0.121
Saccharum spontaneum	1000	1000	1000	0.0054	0.0061	0.0054	0.277	0.287	0.277
Senecio cappa	300	100	-	0.0005	0.0001	-	0.121	0.055	-
Sonchus oleraceus	100	300	200	0.0001	0.0005	0.0002	0.052	0.127	0.089
Thladiantha calcarata	200	100	-	0.0002	0.0001	-	0.089	0.055	-
Thysanolaena maxima	400	200	300	0.0009	0.0002	0.0005	0.150	0.094	0.121
Urtica dioica	-	700	600	-	0.0030	0.0019	-	0.229	0.199
	13600	12800	13700	0.1012	0.0795	0.1233	3.795	4.150	3.634

Post-monsoon Herbs: At upper altitude *Imperata cylindrica* was the dominant herb species with highest density (2900 ind/ha) followed by *Equisetum* sp. (2200 ind/ha) and *Saccharum spontaneum* (1000 ind/ha). At middle altitude *Elatostemma* sp. was the dominant herb species with highest density (2100 ind/ha) followed by Pilea sp. (1900 ind/ha). At lower altitude *Bidens pilosa* was the dominant herb species with highest density (3800 ind/ha) followed by *Elatostemma* sp. (1600 ind/ha) and *Saccharum spontaneum* (1000 ind/ha). Post-monsoon Herb Species richness (SR) was found to higher on middle altitude (28) followed by lower and upper altitude both with 21 species each. Highest (13700 ind/ha) density was recorded at lower altitude followed by upper (13600 ind/ha) and middle (12800 ind/ha) altitudinal zone. Cd was found to be highest (0.123) on lower altitude followed by upper (0.101) and middle (0.079) altitude, whereas $\bar{H}$ was found to be highest (4.15) at middle altitude followed by upper (3.79) and lower (3.63) altitude.

Table 4: Total diversity indices of different forest strata at different altitudes.

Variable	Site	Trees	Shrubs	Herbs	
				Monsoon	Post-monsoon
Density (Ind/ha)	Upper	600	3180	14200	13600
	Middle	860	2380	13100	12800
	Lower	550	2640	13800	13700
Cd	Upper	0.208	0.12	0.105	0.101
	Middle	0.072	0.1434	0.077	0.079
	Lower	0.109	0.118	0.133	0.123
$\bar{H}$	Upper	2.89	3.27	3.78	3.79
	Middle	4.17	2.99	4.21	4.15
	Lower	3.74	3.21	3.55	3.63
SR	Upper	13	12	21	21
	Middle	26	10	29	28
	Lower	21	10	21	21

4. Discussion

The diversity of trees is fundamental to total forest biodiversity, because trees provide resources and habitat for almost all other forest species (Huang et al., 2003). At large scales, species diversity generally was found related to climate and productivity (Rahbek, 2005). Franklin et al. (1989) proposed that long-term productivity of natural forest ecosystems with high tree species diversity may be greater than that of forests with low diversity as a result of increased ecosystem resilience to disturbance. Slobodkin and Sanders (1969) opined that species richness of any community is a function of severity, variability and predictability of the environment in which it develops. Therefore, diversity tends to increase as the environment becomes more favourable and more predictable (Putman, 1994). Tree species diversity varied greatly from place to place mainly due to variation in biogeography, habitat and disturbance (Sagar et al., 2003), which have also been considered as the important factors for structuring the forest communities (Burslem and Whitmore, 1999). Srivastava et al. (2005) reported that the community characters differ among aspect, slope and altitude even in the same vegetation type. In our study we found that tree diversity decreased from lower altitude to higher altitude which means in our study area the environment at lower altitude was favourable for increasing tree diversity as compared to higher altitude.

In many other studies, the mean $\bar{H}$ values for the other forests of temperate Himalaya varied from 0.4 to 2.8 (Singh et al., 1994), 0.08 to 1.29 (Shivnath et al., 1993) and 1.55 to 1.97 (Mishra et al., 2000), whereas in our study values reported by us are bit higher. Whittaker (1965) and Risser and Rice (1971) have reported the range of values of Cd for certain temperate vegetation from 0.19 to 0.99. The values of concentration of dominance (Cd) of the present study were more or less similar to the earlier reported values for temperate forests. Mean Cd values of 0.31 to 0.42 (Mishra et al., 2000) and 0.07 to 0.25 (Shivnath et al., 1993) were reported earlier from other parts of Indian Himalaya. The higher value of Cd in the forest growing on upper altitude was due to lower species richness. According to Baduni and Sharma (1997) the Cd or Simpson's index was strongly affected by the IVI of the first three relatively important species in a community. Species diversity (richness) and dominance (Simpson index) are inversely related to each other (Zobel et al., 1976). The Himalayan region is bestowed with a variety of natural resources which have been exploited by mankind since time immemorial. The link between forest management and the well-being of communities in forested areas has traditionally been defined by forest sector employment opportunities (Sharma and Gairola, 2007). The reported values of diversity and density in these forests can be utilized for management purposes and in the future for technological advancement, economic prosperity and providing employment opportunity to the local people.

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