Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 7, No. 1, p. 46-53, 2015
http://www.innspub.net

INNSPUB
RESEARCH PAPER
OPEN ACCESS

Altitudinal variation in plant species richness and diversity at Thandiani sub forests division, Abbottabad, Pakistan

Waqas Khan[1], Shujaul Mulk Khan[1,2] and Habib Ahmad[3]

[1]*Department of Botany, Hazara University Mansehra, Pakistan*

[2]*Department of Plant Sciences, Quaid-i-Azam University Islamabad, Pakistan*

[3]*Department of Genetics, Hazara University Mansehra, Pakistan*

Article published on July 4, 2015

Key words: Thandiani, Species diversity, Species richness, Equatiability, Deforestation.

Abstract

The present study reveals species diversity and its components along the altitudinal gradient ranged from 1290m to 2626m at Thandiani sub Forests Division. A Thandiani sub Forests division including the forests of Mandroach, Neelor, Kakul, Qalandarabad, Kala pani, Larri, Riala and Sikher, was explored to assess the vegetation structure and conservation status of economically important species. The vegetation was studied by the Shannon – Weaver index method during 2012-13. A total of 252 species belonging to 97 families were recorded from the area. Species diversity and its component values were high in the tree layer (*Pinus* communities) in the middle and upper regions of the altitudinal gradient. It decreases both towards the upper and lower altitude, which was due to different environmental and anthropogenic factors such as deforestation, human interaction, encroachment pressure, low number of species and soil erosion. There is great need of reforestation in the area. Alternate sources of fuel must be provided to local inhabitants to minimize the pressure on wealth of wild plants.

***Corresponding Author:** Waqas Khan ✉ shuja60@gmail.com; waqaskhan1985@yahoo.com

Introduction

Species diversity is considered to be an indicator of the health of an ecosystem (McGard-Steed and Morin, 2000). Climate, productivity, biotic interaction, habitat and heterogeneity are the different variables which correspond to variation in diversity (Givnnish, 1999; Willig *et al.*, 2003 and Currie and Francis, 2004). Diversity is the direct measure of the impact of human and livestock disturbances on the forest ecosystem. In degraded ecosystems by overexploitation and pollution, loss of biodiversity and ecosystem functioningis directly correlated to intensity of disturbance. The purpose of study is to co-relate diversity of plants among different altitudinal stations. Species richness is a simple, easy and most widely used measure of biological diversity determined by various biotic as well as abiotic factors (Peet, 1974; Stirling and Wilsey, 2001 and Schuster and Diekmann, 2005). Some work on the species diversity has been done by different workers in various parts of the world (i.e. Adhikari *et al.*, 1991; Franklin and Merlin, 1992; West, 1993; Planty-Tabbachi *et al.*, 1995; Green and Kaufman, 1995; Willoughby, 1996; Al-Faraj *et al.*, 1997; Raizada *et al.*, 1998; Khan *et al.*, 1999; Khan *et al.*, 2011, 2012a,b,c, 2013a,b, 2014; Townsend *et al.*, 2000; Spehn *et al.*, 2000; Vujnovic *et al.*, 2002; Hurka and Heinrich, 2004; Schuster and Diekmann, 2005; Malik, 2005, Habib *et al.*, 2011: Amjad, 2013).

Materials and methods

Study area

The study was conducted in Thandiani Sub Forests Division (73°53¢5.316"E, 33°32¢9.925"N) at an altitude between 1290m to 2626m during 2012-13. It is a mountainous region with sparsely distributed vegetation. The mountains are well within the reach of monsoon. The area has variable climate. The average annual rainfall of the area is 1424.1mm. The maximum rainfall occurs during July amounting to 305.5 mm, while least rainfall occurs during November amounting to 33.3 mm. The hottest months of the year are June and July, with mean daily maximum temperature of 36.4 and 33.2°C respectively, and minimum temperature of 13.8 and 16.6°C respectively. The average maximum and minimum relative humidity is 79-83 and 65-.72% in July and August respectively.

Methodology

We selected a study area in a traditionally managed mountain woody pasture. The area was sampled by quadrat method. The quadrats were laid down at regular intervals of 100 m. The size of quadrats was kept 10×2, 5×2 and 1×1 (m×m) for trees, shrubs and herbs respectively. Density, frequency and cover were recorded (Mueller-Dombois and Ellenberg, 1974). Importance value index of each plant species was calculated and plant communities were named after the plant species having the highest IV (Hussain, 1989; Malik, 2005). Species diversity was measured by Shannon-Wiener (1949) methods.

Shannon – Weaver index

$$D = \sum\left[\frac{\sum n (n-1)}{N (N-1)} \right]$$

The components of diversity as species richness and equitability were measured after Menhinick (1964) and Pielou (1975), respectively.

Menhinick index:-

$$d = \frac{S}{\sqrt{N}}$$

Pielou index:-

$$E = \frac{\text{Natural log of Diversity Index}}{\text{Natural log of Total Species}}$$

Results

The Shannon's diversity in the investigated area ranged from 11.01 to 39.441. Highest diversity value 39.441 was recorded in Lower Ballolia the *Themeda, Zizyphus* and *Olea* community at 1785m with GPS Reading N34 12 56.3 E73 17 35.2. It was followed by *Abies, Aquilegia* and *Pinus* community at 2391m, GPS Reading N34 14 21.5 E73 20 50.7, *Pinus, Achillea* and *Cedrus* at 2330m, GPS Reading N34 14 53.1 E73 20 51.4 and *Zizyphus, Ailenthus* and *Rumex* community 1661m, GPS Reading N34 12 44.0 E73 17 41.4, which were 35.4993, 34.7604 and 34.2242 respectively. The lowest species diversity (11.01) was recorded for *Pinus, Viola* and *Rumex* community at 1523m elavation with GPS Reading N34 11 36.9 E73

17 53.3, it was followed by *Themeda, Pinus* and *Zizyphus* community (11.1) at 1321m, GPS Reading N34 11 10.0 E73 16 30.8 and *Themeda, Robenia* and *Pinus* community (11.31) at 1299m, GPS Reading N34 11 03.0 E73 16 35.4, other communities showed valuable variation in the diversity (Table 1). The value of species richness ranged from 1.100963765 to 2.477767101 (Table 1).

Table 1. Diversity index and its components recorded from Thandiani Sub Forests Division, Abbottabad, Pakistan.

S. No	Stations	Communities	GPS Readings	Elevation	D.I	T.S	Equetibility or Eveness	S.R
1	Mandroch	*Themeda, Robenia & Pinus*	N34 11 03.0 E73 16 35.4	1299 m	11.31	19	0.823819854	1.137500246
2	Mandroch Darra	*Poa, Pinus & Cyanodon*	N34 11 29.5 E73 17 36.3	1396 m	20.2	33	0.859624225	1.509384867
3	Barri Bahk	*Pinus, Viola & Rumex*	N34 11 36.9 E73 17 53.3	1523 m	11.01	18	0.82992921	1.10158211
4	Lower Danna	*Pinus, Eucliptus & Poa*	N34 11 30.7 E73 17 52.6	1582 m	16.44	38	0.769663526	1.876686234
5	Danna	*Pinus, Rumex & Tagetus*	N34 11 41.9 E73 18 24.8	1697 m	25.28	48	0.834369892	1.949866713
6	Upper Danna	*Pinus, Rumex & Rumex*	N34 11 13.0 E73 18 18.5	1775 m	30.33	51	0.867825189	1.869750717
7	Neelor	*Themeda, Pinus & Zizyphus*	N34 11 10.0 E73 16 30.8	1321 m	11.1	20	0.803671464	1.100963765
8	Battanga	*Pinus, Cyanodon & Ajuga*	N34 11 25.0 E73 16 44.1	1428 m	14.12	20	0.883787999	1.172420764
9	Pkheer Bandi	*Pinus, Cyanodon & Verbescum*	N34 11 19.7 E73 16 57.3	1551 m	26.2929	41	0.880365018	2.027319523
10	Pejjo	*Zizyphus, Ailenthus & Rumex*	N34 12 44.0 E73 17 41.4	1661 m	34.2242	55	0.881616984	2.182608423
11	Lower Ballolia	*Themeda, Zizyphus & Olea*	N34 12 56.3 E73 17 35.2	1785 m	39.441	54	0.921238551	2.200875694
12	Upper Ballolia	*Pinus, Medicago & Podophyllum*	N34 12 53.8 E73 17 42.0	1849 m	32.8926	59	0.856705243	2.477767101
13	Malach Lower	*Pinus, Themeda & Cyanodon*	N34 12 29.0 E73 17 16.1	1496 m	26.4876	39	0.894396496	1.5356235
14	Malach Upper	*Pinus, Pyrus & Ranunculus*	N34 12 50.7 E73 17 18.4	1591 m	32.8317	43	0.928266087	1.87310942
15	Kakul Reserve Forests Cathment	*Pinus, Valeriana &Plantago*	N34 12 31.7 E73 17 40.2	1722 m	28.1844	46	0.872050497	1.731232838
16	Mathrikka	*Abies, Pinus &Caryopteris*	N34 13 09.0 E73 17 32.4	1829 m	31.888	56	0.860106155	2.086996779
17	Mathrikka Top	*Pinus, Abies & Bistorta*	N34 13 14.3 E73 17 34.1	1919 m	31.0034	52	0.869117959	1.870310003
18	Jabbra	*Pinus, Achillea & Abies*	N34 13 22.6 E73 17 43.8	2027 m	31.2695	53	0.867100772	1.8374444
19	Pallu Ziarat	*Cedrus, Pinus & Impetiens*	N34 13 58.2 E73 18 02.3	2171 m	30.9114	55	0.856211572	1.855103958
20	Qalandarabad	*Pinus, Cannabus & Poa*	N34 15 53.5 E73 14 15.7	1290 m	24.2158	36	0.889350766	1.592546239
21	Bandi Toondan Cathment	*Pinus, Rumex & Poa*	N34 15 53.6 E73 15 49.1	1417 m	26.3611	43	0.869905705	1.771784133
22	Mera Bunn	*Pinus, Poa & Valeriana*	N34 15 50.6 E73 16 45.0	1532 m	29.4749	44	0.894125131	1.576463601
23	Loonrr Pattian	*Pinus, Ranunculus & Themeda*	N34 15 38.4 E73 17 30.3	1668 m	29.46	47	0.87867629	1.598972471
24	Gali Bannian	*Pinus, Rumex & Verbescum*	N34 10 19.7 E73 17 32.9	1535 m	24.1375	43	0.846476271	1.710448161
S. No	**Stations**	**Communities**	**GPS Readings**	**Elevation**	**D.I**	**T.S**	**Equetibility or Eveness**	**S.R**
25	Upper Gali Bannian	*Cedrus, Medicago & Abies*	N34 11 35.6 E73 19 02.7	1637 m	25.0589	43	0.856436498	1.542616407
26	Chatrri	*Pinus, Rumex & Abies*	N34 12 15.1 E73 19 41.2	1715 m	25.0527	45	0.846143207	1.58999682

27	Lower Kala Pani	*Abies, Pinus & Potentilla*	N34 13 02.0 E73 19 59.2	1860 m	26.3076	43	0.869365567	1.501625136
28	Upper Kala Pani	*Cedrus, Pinus & Achilles*	N34 13 43.5 E73 20 13.8	2017 m	28.5369	49	0.861087545	1.663168372
29	Reserve Forests Cathment	*Cedrus, Pinus & Impetiens*	N34 13 16.3 E73 20 19.0	2177 m	28.5149	52	0.847942318	1.741088778
30	Lower Thandiani	*Pinus, Cedrus & Bergenia*	N34 14 20.7 E73 20 45.8	2281 m	29.5744	53	0.853062998	1.691297963
31	Upper Thandiani Catchment	*Pinus, Cedrus & Impetiens*	N34 13 16.4 E73 20 42.5	2400 m	34.2128	62	0.855944952	1.938446738
32	Larri Track	*Pinus, Euphorbia & Cedrus*	N34 13 23.3 E73 20 08.4	2012 m	25.1993	41	0.868925164	1.591108578
33	Larri	*Cedrus, Abies & Pinus*	N34 13 48.0 E73 20 29.8	2124 m	31.9665	48	0.894990591	1.751544876
34	Sawan Gali	*Pinus, Achillea & Cedrus*	N34 14 53.1 E73 20 51.4	2330 m	34.7604	53	0.893757659	1.834140632
35	Larri Top	*Abies, Aquilegia & Pinus*	N34 14 21.5 E73 20 50.7	2391 m	35.4993	58	0.879094465	1.959638397
36	Riala	*Pinus, Cyanodon & Galium*	N34 16 14.6 E73 18 15.7	1526 m	19.6073	36	0.83044125	1.480842126
37	Riala Cathment	*Pinus, Cedrus & Rumex*	N34 15 50.2 E73 17 33.6	1617 m	26.2017	42	0.873759489	1.6719936
38	Upper Riala	*Cedrus, Pinus & Bistorta*	N34 16 27.7 E73 19 01.7	1707 m	23.4941	43	0.839293106	1.684009967
39	Terarri	*Pinus, Cedrus & Ajuga*	N34 16 30.3 E73 19 09.3	1815 m	27.3462	48	0.854664372	1.753881829
40	Terarri Cathment	*Abies, Pinus & Achillea*	N34 16 30.0 E73 19 33.6	1918 m	29.284	49	0.867727961	1.744446194
41	Darral	*Abies, Pinus & Bistorta*	N34 16 27.3 E73 19 32.3	2001 m	25.599	49	0.83317138	1.705961028
42	Makali	*Pinus, Euphorbia & Potentilla*	N34 16 18.1 E73 19 41.3	2131 m	25.284	48	0.834410762	1.657144031
43	Ladrri	*Pinus, Abies & Plantago*	N34 16 30.5 E73 19 54.2	2219 m	23.4589	48	0.815056791	1.643488698
44	Parringa	*Pinus, Euphorbia & Nepeta*	N34 16 42.4 E73 20 02.0	2292 m	26.0928	51	0.829553423	1.707606302
45	Sattu Top	*Pinus, Abies & Cedrus*	N34 16 46.2 E73 20 06.3	2382 m	30.2628	51	0.867261052	1.682334768
46	Mera Rehmat Khan Cathment	*Rumex, Abies & Polygonum*	N34 1401.7 E73 2025.7	2194m	13.4007	30	0.763056845	1.666666667
47	Mera Rehmat Khan Top	*Pinus, Impetiens & Quercus*	N34 14 45.8 E73 20 04.4	2309 m	25.7532	44	0.858455629	2.348546256
48	Lower Nammal	*Pinus, Potetilla & Cedrus*	N34 15 04.5 E73 20 22.4	2407 m	13.6161	30	0.767745186	1.50565684
49	Upper Nammal	*Pinus, Frageria & Cedrus*	N34 14 47.5 E73 20 25.5	2539 m	18.5241	30	0.858248511	1.409522957
50	Sikher	*Pinus, Potentilla & Abies*	N34 14 54.1 E73 20 35.0	2626 m	15.8911	39	0.754937264	1.596163743

The highest value of species richness was recorded in *Pinus, Medicago* and *Podophyllum* (2.477767101) at 1849m, with GPS Reading N34 12 53.8 E73 17 42.0, followed by *Themeda, Zizyphus* and *Olea* (2.200875694) and *zizyphus, ailenthus* and *Rumex* (2.182608423) communities at 1785 m, GPS Reading N34 12 56.3 E73 17 35.2 and 1661m, GPS Reading N34 12 44.0 E73 17 41.4, respectively. *Themeda, Pinus* and *Zizyphus* community at 1321m, GPS Reading N34 11 10.0 E73 16 30.8 has least species richness value i.e 1.100963765, followed by *Pinus, Viola* and *Rumex* community (1.10158211) at 1523m, GPS Reading N34 11 36.9 E73 17 53.3, (Table 1). The value of equitability or evenness ranged from 0.754937264 to 0.928266087. The highest equitability or evenness value 0.928266087 was recorded for *Pinus, Pyrus* and *Ranunculus* community at 1591m, GPS Reading N34 12 50.7 E73 17 18.4, whereas the lowest equitability or evenness value 0.754937264 was for *Pinus, Potentilla* and *Abies* community at 2626m with GPS Reading N34 14 54.1 E73 20 35.0. Other communities showed little variation of equitability or evenness among them (Table 1).

Discussion

Species diversity is measures of complexity in form and structure. Diversity can be correlated with different variables such as productivity, stability, maturity, predation pressure, evolutionary time and spatial heterogeneity (Hills, 1973). It is important for protection and conservation of natural vegetation which is increasingly threatened due to forest cutting for industrial and urban expansion. (Naveh and Whittaker, 1980) Temperate forest can be regarded as highly valuable habitat in term of biodiversity. The shanon diversity value ranges from 11.01 to 39.441. The recorded value lies within the reported range for other Himalayan forests (Pande, 2001; Mishra *et al.*, 2003; Kunwar and Sharma, 2004) in the investigated area species diversity value were low at bases of different Stations. It increases with the increase of altitudenal ranges, similar findings were reported by Malik (2005) and Colinvaux (1993). The low species diversity in Kotli may be due to deforestation, human interactions (Kumar and Bhutt, 2006), collection of medicinal plants and quick disappearance of annual plants because of cold conditions (Ram *et al.*, 2004). In some communities, very high species diversity was recorded in the investigated area. The high species diversity was observed in *Pinus* I, *Pinus* III, *Pinus* VII and *Rubus-Quercus-Pinus* communities at 1661, 1785, 2330 and 2391 m in moist temperate zone. Habib *et al.* (2011) and Malik *et al.* (2001) reported similar vegetation in Daukhan and Gari dubata area, where high species diversity was found in upper reaches, while low diversity in low altitude. Similarly, Khan *et al.* (1999) reported low species diversity due to environmental stress. In over case species diversity was low due to less number of species at lower altitude and high diversity due to high number of species at high altitude. The diversity of species was high in the tree layer in the middle and upper regions (1661, 1785, 2330 and 2391). It decreases both toward lower and upper most altitudenal regions. *P. roxburghaii* and *P. walliciana* communities occupying the middle altitudinal zone had high diversity. The results are in agreement with Saxena *et al.* (1987) who reported that in Kuman Himalaya the species diversity at tree layer was higher, which decreased both toward lower and upper most altitudenal regions. Kharkwal *et al.* (2005) reported the same pattern of species diversity and richness in Kuman, India. Species richness is the number of species per unit area. Richness is mainly controlled by the fertility and episodic removal of leaves typically by grazing and forest fire. This regional pattern of species richness is the product of many intermingling factors such as environmental variables, geography, topography, species pool, productivity and competition (Criddle *et al.*, 2003). This may also due to high degree of variations in soil differentiation and altitude (Lomolinon, 2001). However moisture, temperature and nutrient availability affect the distribution and bulk of species in any area (Korner, 1998).

Species richness was low in lower reaches, it increases according to altitude from 1300m to 2000m, however, from 2000m to 2626 m species richness decreased with the increasing altitude.. In the investigated area, there was abundance of annuals due to which species richness increased. In the monsoon most of annuals disappeared that decreased species richness. The higher value of species richness was recorded for communities of moist habitat that had relatively optimum climatic conditions. Equitability or evenness was high in the middle at 1700m to 1900m m and decreased both toward top and bottom. A higher equitability may result a highly stable environment or a prolonged period of time (Shoukat and Khan, 1999). The high total species diversity at the high level of disturbance resulted from high equitability of relatively small number of species.

References

Adhikari BS. 1991. High altitude forest composition diversity and profile structure in a part of Kaumaun Himalaya. Tropical Ecology journal **32(1),** 86-97.

Al-Farraj MM, Al-.Rarhan A, Al-Yemeni A. 1997. Ecological studies on Rawdhat system in Saudi Arabia 1- Rawdhat khorim. Pakistan Journal of Botany **29(1),** 75-88.

Colinvaux P. 1993. Ecology. John Wiley and Sons Inc. New York 648-684.

Cardillo M, Orme CDL, Owens IPF. 2005. Testing for latitudinal bias in diversification rates: An example using New World birds. Ecology **86,** 2278-2287.

Currie DJ, Francis AP. 2004. Regional versus climate effect on taxon richness in angiosperms; reply to Qian and Ricklefs. American Naturalist **163,** 780-785.

Franklen J, Merlin M. 1992. Species environmental patterns of forest vegetation on the uplifted reef limestone of Atiu, Mongaia, Mauke and Mitiaro, Cookisland, West central Pacific Ocean. Journal of Vegetation Science **3(1),** 3-14.

Givnish TJ. 1999. On the causes of gradients in tropical tree dversity. Journal of Ecology **87,** 193-210.

Green DM, Kaufman JB. 1995. Succession and livestock grazing in a Northeastern Oregon riparian Ecosystem. Journal of Range Management **48(4),** 307-313.

Habib T, Malik ZH, Hussain MA, Khan MQ. 2011. Plant species diversity along the altitudinal gradient at Garhi Dopatta Hills, Muzaffarabad., Journal of Medicinal Plants Research **5(20),** pp. 5194.5196.

Hill MO. 1973. Dversity and evenness: a unifying notation and its consequences. Ecology **54,** 427–432.

Hurka H, Heinrich A. 2004. Species richness and composition during Sylvigenesis in a tropical dry forest in North Western Costa Rica. Tropical Ecology **45,** 43-57.

Hussain M, Ali A. 2006. Spatial and Seasonal variation in the species composition of herbaceous vegetation indigenous to soone valley in the salt range of Pakistan. Pakistan Journal of Agricultural Science **43**, 43-49.

Khan D, Alam MM, Feheemuddin M. 1999. Structure Composition and above ground Standing phytomass of some grass dominated communities of Karachi: Summer aspects. Hamdard Medicus **42**, 19-52.

Khan SM, Harper DM, Page S, Ahmad H. 2011. Species and community diversity of vascular flora along environmental gradient in Naran Valley: a multivariate approach through indicator species analysis. Pakistan Journal Botany **43,** 2337–2346.

Khan SM. 2012a. Plant communities and vegetation ecosystem services in the Naran Valley, Western Himalaya, PhD Thesis, University of Leicester. University of Leicester.

Khan SM, Page S, Ahmad H, Harper D. 2012b. Identifying plant species and communities across environmental gradients in the Western Himalayas: method development and conservation use. Ecolgical Informatics.
http://dx.doi.org/10.1016/j.ecoinf.2012.11.010.

Khan SM, Page S, Ahmad H, Shaheen H, Harper DM. 2012c. Vegetation dynamics in the Western Himalayas, diversity indices and climate change. J. Sci. Technol. Development **31 (3),** 232–243.

Khan SM, Page S, Ahmad H, Ullah Z, Shaheen H, Ahmad M, Harper DM. 2013a. Phyto-climatic gradient of vegetation and habitat specificity in the high elevation Western Himalayas. Pakistan Journal Botany **45,** 223–230.

Khan SM, Page S, Ahmad H, Harper DM. 2013b. Sustainable utilization and conservation of plant biodiversity in montane ecosystems; using the Western Himalayas as a case study. Annals of Botany **112,** 479–501.
http://dx.doi.org/10.1093/aob/mct125

Kharkwal G, Mehrotra P, Rawat YS, Pangetey YPS. 2005. Phtodiversity and growth form in relation to altitudinal gradient in the Central Himalaya (Kumaun) region of India. Current Science **89(5),** 873-878.

Korner C. 1998. A re-assessment of high elevation treeline positions and their explanation. Oecologia **115**, 445–459.

Lomolino MV. 2001. Elevation gradients of species-density: historical and prospective views. Global Ecology and Biogeography **10**, 3–13.

Malik H, Malik NZ, Bashir S, Gorsi MS. 2001. Phytosociological studies on the vegetation of Dao Khan Hillls. Journal of Science &Technology **25,** 35-41.

Margalef R. 1958. Informational theory in Ecology, Gen. Syst. 5: 36-71. McGrady-Steed, J., & Morin, P. J., Biodiversity, density compensation and the dynamics of populations and functional groups. Ecology **81**, 361-373.

Mueller-Dombois D, Ellenberg H. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons. Inc.

Naveh Z, Whittaker RH. 1980. Structural and floristic diversity of shrublands and woodlands in Northern Israel and other Mediterranean areas. Plant Ecology **41(3),** 171190.

Parthasarthy N, Karthikeyan R. 1997. Biodiversity and population density of Woody species in a tropical evergreen forest in Coutallum Reserve Forests, Western Ghats, Ind.Trop. Ecology **38(2),** 297-306.

Peet RK. 1974. The measurement of species diversity. Annual Review of Ecology and Systematics **5**, 285–307.

Pichi-Sermolli RE. 1948. An index for establishing the degree of maturity in plant communities. Journal of Ecology **36**, 85-90.

Planty-Tabacchi A, Tabacchi E, Naiman RJ, Defessasi C, Decamps H. 1995. Invisibility of species – rich communities in riparian Zones. Conservation Biology **10,** 598-607.

Raizada S, Joshi P, Srivastiva MM. 1988. Composition and vegetational diversity in an alpine grassland in the Garhwal Himalaya. Tropical Ecology **39(1),** 133-141.

Saxina AK, Panday TP, Singh JS. 1987. Altitudinal Variation in the Vegetation of Kuman Himalaya, Prespective in Environmental Botany 44-66.

Schuster B, Diekmann M. 2005. Species richness and environmental correlates in deciduous forests of Northwest Germany, Forest Ecology and Management 206-213.

Shannon CE, Wiener W. 1949. The Mathematical theory of Communication, University of Illinois Press Urgana 117.

Sheldon AL. 1969. Equitability indices: dependence on the species account. Ecology **50**, 466-467.

Shoukat SS, Khan D. 1999. A Comparative study of the Statistical behavior of diversity and equitability indices with reference to desert vegetation. Pakistan Journal of Botany **11,** 155-165.

Spehn EM, Joshi J, Schmid B, Diemer M, Korner C. 2000. Above ground resource use increases with plant species richness in experimental grassland ecosystem. Functional Ecology **14(3),** 326-337.

Stirling G, Wilsey B. 2001. Empirical Relationships between Species Richness, Evenness, and Proportional Diversity. American Naturalist **158(3),** 286–299.

Townsend CR, Harper JL, Begon M. 2000. Essentials of Ecology. Blackwell Sci, Inc. USA **2000,** 354-387.

Vujnovic K, Wein RW, Dale MRT. 2002. Predicting plant species diversity in response to disturbance magnitude in grassland remnants of central Alberta. Canadian Journal of Botany **80(5),** 504-511.

West NE. 1993. Biodiversity of Rangelands. Journal of Range Management **46,** 2-13.

Willig MR, Kaufman DM, Stevens RD. 2003. Latitudinal gradients of biodiversity: pattern, process, scale, and synthesis. Annual Review of Ecology, Evolution, and Systematics **34,** 273-309.

Willough MG. 1995. Species diversity and how it is affected by livestock grazing on Alberta's Eastern Slopes. In West, N.E. (ed). Proc. Rangelands. In a sustainable biosphere, 5thInternational Congress 1995, Salt Lake City Utah pp. 610-611.