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Plant species diversity and the role of soil nutrients in the semiarid area of District Bannu, KPK, Pakistan

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Abstract

Communities are the result of species interactions for the resources. Plant species compete for the resources above and below the soil and ameliorate the environment for neighboring species. In this way superior competitor eliminate the inferior competitive species and affect the diversity of an area. As a result those species sustain which are well adapted to the prevailing environmental conditions. Therefore, considering the relative influence of species interactions and an environment on the diversity, we expected changes in the diversity of plant species along the edaphic gradients. We investigated eastern, western and northern sites in the semi-arid zone of District Bannu, KPK, Pakistan, to know the plant species diversity and its relation with the variation in the selected edaphic variables. We analyzed the soil samples of the three sites for the micro and macro-elements. We used quadrate method to collect the quantitative data of the plant species. We calculated shanoon`s diversity index and similarities among the sites of the plant species and analyzed the correlation between the diversity and the edaphic variables. We observed high importance value index for tree species as compared to shrubs and herbs and less diversity among the three sites in which western and northern sites have more similarities. We did not find the significant relation of the edaphic variables for the macro-elements. However few micro-elements have shown strong correlation with the diversity. We argued that less diversity may be the result of environmental filtering and anthropogenic activities prevailing in the area.

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Introduction

Current debate on the importance of neutral and deterministic processes (Hubbell, 2001 and Morlon *et al.*, 2009) in generating species relative abundances within communities is a central question in ecology (McGill, 2010; Murrell, 2010). Neutral theory has successfully predicted that species functional differences are not needed to generate the observed patterns of diversity in nature (Chave, 2004). However, habitat filtering imposes ecological filters that select individual species because they possess a trait syndrome suitable for a given habitat (Keddy, 1992; Diaz *et al.*, 1998). Functionally dissimilar species are excluded because they cannot cope with local environmental stress or competition (Grime, 1973; Mayfield & Levine, 2010). The productive meadows tend to be dominated by tall, fast growing species that can develop a disproportionately large competitive effect on local resources and act themselves as a habitat filter by excluding less competitive species (Grime *et al.*, 1997; Grime, 2006).

However, intensity and importance of competition vary spatially along gradients of environmental stress or resource availability (Greenlee and Callaway, 1996; Goldberg and Novoplansky, 1997). In plant communities, for instance, competition and facilitation are supposed to occur simultaneously among different species and to change as the age of the community advances. Seedlings may use larger individuals as 'nurses', but compete with them when they become adults (Valiente Banuet and Verdú, 2008). As a consequence, the distribution of plant species at small spatial scale is also expected to change when the environmental conditions change (Collins and Klahr, 1991).

Species diversity assessments based on the number of species and/or their relative abundance; often provide little indication of spatial and temporal changes of community structure (Swenson, 2011). For this purpose phytosociology is an invaluable method for vegetation survey and assessment involving investigation of characteristics of plant communities using simple and rapidly employing field techniques (Rieley and Page, 1990). The current study is planned to explore the diversity of plant species in the semi-arid region of District Bannu along with abiotic factors. It also addresses how much is the similarity of vegetation in different stands of District Bannu.

Materials and methods

Study site

The present project was based on the study of plant diversity of the semi-arid zone of District Bannu covering an area of about 1,227Km^2. Bannu is the oldest and important District of Khyber Pakhtunkhwa, Pakistan.

It is located in between 32.43° to 33.06° North latitude and from 70.22° to 70.57° East longitude. According to Kopppen (1948) climate classification Bannu is located in BSh regions of the world. The average annual temperature is 23.6°C with highest in June on average at around 33.6°C and January is the coldest month with temperature averaging 11.7 °C.

The rainfall here averages 327mm with least amount of rainfall occurs in November about 4 mm and most of the precipitation here falls in July, averaging 69mm. We classified the area into three stands on the basis of direction from the main city of the District Bannu. We surveyed many sites on the eastern side of District Bannu such as Landi Jhalander, Bandaar killa, Azim killa, Barmi khel, Topen killa, Umer zai, Sirki khel, Marghalie Peerba khel and Oligie Mosa khel (Hereafter Eastern Stand), Baka khel, Sardi khel and Jani khel (Hereafter Western Stand) and Painda khel, Sada khel, Spark waziran, Amal khel, Nadar Bodin khel, Domel area, Tazeree Benzen khel, Saed khel, Jhando khel (Hereafter Northern Stand).

Sampling

Quadrat method was used to study and analyze the vegetation dynamics as well as to collect the primary data for statistical analysis. We placed randomly 10 plots of 100m × 100m, in each stand having best representation of floral biodiversity and geographic extent of the area. We sampled species with DBH (diameter of bresat height) ≥ 1cm.

Soil Analysis

Soil samples were collected from 0-6 cm depth at 3 multiple of 3 different sites and analysed for elemental composition and physio-chemical characteristics (Bao, 1999; Collison, 1977). A soil texture was determined by Hydrometer method (Bouyoucos, 1936) and textural classes were determined with the help of textural triangle (Brady, 1999). Soil organic matter was determined by oxidation with potassium dichromate in sulphuric acid medium under standard wet burning method (Rayan *et al.*, 1997). Total Nitrogen was determined by the Kjeldahl method (Bremner and Mulvaney, 1982). Phosphorus was determined after Olsen & Sommers (1982). Potassium was determined by flame emission spectroscopy (Rhoades, 1982). Soil pH was measured in 1:5 soil water suspensions with a pH meter (Jackson, 1962). Electrical conductivity of the soil was determined in 1: 5 soil water interruptions with EC meter.

Data Analysis

Quantitative Analysis

Phytosociological survey, an important tool of ecology for vegetation assessment was conducted in 3 representative designated sites. Density, cover and frequency of each species were measured and values were changed to relative values following Cain and Castro (1956) and Qadir and Shetvy (1986). After the calculation of above mentioned parameters, Importance Value Index (I. V. I.) for each species in each sample was calculated as under:

I.V. I = Relevant Cover + Relative Frequency + Relative Density

On the basis of Importance Value Index (IVI.), sampled vegetation was described into different plant communities. The community within each stand was named with the first three of the species having highest Importance Value Index irrespective of its habit. When two or more species closely approached each other in order of Importance Value, the community shared the names of these dominants. The name of the species with highest I.V appeared first followed by other dominant species.

The generic names of the dominant species were used for naming the community. Species other than the dominants were classified into co-dominants, associates and rare. The plant communities established on the basis of highest importance values according to Hussain (1989).

Diversity Analysis

We used Shanoon's index (H) to characterize species diversity in a community. Shannon's index accounts for both abundance and evenness of the species present. The proportion of species i relative to the total number of species (p_i) is calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product is summed across species, and multiplied by -1:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Shannon's equitability (E_H) can be calculated by dividing H by $H_{\max}$ (here $H_{\max}$ = $\ln S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

We also tested whether the communities have similar composition or different from one another. We used Bray-Crutis method of dissimilarity index which is bound between 0 and 1, where 0 means that the two communities have the same composition or species are present in both communities, and 1 means that the species composition in two communities is different or both communities do not share any species (Bloom, 1981). Bray-Crutis method is one of the good methods of calculating the dissimilarity among the sites or different communities (Faith *et al.*, 1987). It is also known as Steinhaus, Czekanowski and Sørensen index (R Documentation Vegdist "Vegan Package"). First we calculated dissimilarity and then subtracted from 1 to calculate the similarity.

To calculate the similarity (Bray-Crutis) between the three different communities we used the 'vegan' package (Oksanen *et al.*, 2011) in the R environment (R development core team 2012). We clustered those communities that are more similar using an agglomerative hierarchical clustering algorithm.

Results

Phytosociology

Eastern Stand (Calligonum- Prosopis- Tamarix Community)

In general we found that trees and shrubs are the dominant plant of this stand based on high IVI values. However, *Calligonum polygonoides* was the dominant shrub among the community of this stand. Among the shrubs we observed *Calligonum polygonoides* with highest (87.4) IVI value followed by *Periploca aphylla* (52.03), *Tamarix dioica* (44.85), *Rhazya stricta* (44.18), *Cistanche tubulosa* (37.89) and *Echinops echinatus* (33.63). While among the trees *Prosopis cineraria* had the high IVI value of (77.55) followed by *Tamarix aphylla* (62.44), *Zizyphus jujube* (61.20), *Acacia nilotica* (56.19), and *Cappris decidua* (42.62). However we also observed herbaceous plants with comparatively less IVI values in stand 1. We found *Cymbopogon distense* with IVI value (32.96) followed by *Chenrus cilairus* (19.72, *Cynodon dactylon* (18.5) and *Astragalus scorpiurus* (16.58) (Table 1).

Table 1. Plant species of the Eastern stand from the semi-arid zone of District Bannu, KP, Pakistan.

SN	Name of plant	Family	IVI
1	*Acacia nilotica* (L.) Wild.ex Delile	Mimosaceae	56.19
2	*Cappris decidua* (Frossk.) Edgew.	Cappridaceae	42.62
3	*Prosopis cineraria* L.	Mimosaceae	77.55
4	*Tamarix aphylla* (L.) Karst	Tamaricaceae	62.44
5	*Ziziphus jujuba* Mill	Rhamnaceae	61.2
6	*Calligonum polygonoides* L.	Polygonaceae	87.4
7	*Periploca aphylla* Decne.	Asclepiadaceae	52.03
8	*Tamarix dioica* Roxb. Ex Roth.	Tamaricaceae	44.85
9	*Rhazya stricta* Decne.	Apocynaceae	44.18
10	*Echinops echinatus* L.	Asteraceae	33.63
11	*Cistanche tubulosa* (Shehenk.)	Orobancheaceae	37.89
12	*Arnebia hispidissima* (Lehm.) A. DC.	Boraginaceae	13.12
13	*Astragalus scorpiurus* Bunge.	Papilionaceae	16.58
14	*Boerhavia procumbens* Banks ex Roxb	Nyctaginaceae	14.23
15	*Cenchrus ciliaris* L.	Poaceae	19.72
16	*Chenopodium album* L.	Chenopodiaceae	15.38
17	*Convolvulus arvensis* L.	Convolvulaceae	11.8
18	*Cymbopogon distanse* Schutt.	Poaceae	32.96
19	*Cynodon dactylon* (L.) Pers.	Poaceae	18.5
20	*Euphobia dracunculoides* Lam.	Euphorbiaceae	11.37
21	*Farsetia jacquemontii* (Hook. F. & thoms.) Jafri	Brassicaceae	8.61
22	*Heliotropium europaeum* (F. & M.) Kazmi	Boraginaceae	8.87
23	*Hypecoum pendulum* L.	Papaveraceae	9.26
24	*Launaea procumbens* Pravin Kawale.	Asteraceae	12.61
25	*Melilotus indica* (L.) All.	Papilionaceae	9.68
26	*Oligomeris linifolia* (Vahl.) Macbride	Resedaceae	6.29
27	*Plantago lanceolata* L.	Plantaginaceae	9.19
28	*Plantago ovata* Frossk.	Plantaginaceae	7.98
29	*Psammogeton biternatum* Edgew.	Apiaceae	9.32
30	*Rostraria cristata* Linn.	Poaceae	14.13
31	*Rumex dentatus* (Meisn.) Rech.f.	Polygonaceae	9.85
32	*Silene vulgaris* (Moench) Garcke.	Caryophyllaceae	12.48
33	*Sisymbrium irio* L	Brassicaceae	12.14
34	*Trigonella crassipes* Boiss.	Papilionaceae	15.46
35	*Alhagi maurorum* Medic.	Papilionaceae	24.94
36	*Amaranthus viridis* L.	Amaranthaceae	21.92
37	*Aristida cynantha* L.	Poaceae	28.57
38	*Carthamus persicus* Willd.	Asteraceae	20.26
39	*Chrozophora plicata* (Vahl) A. Juss. Ex Spreng	Euphorbiaceae	18.51
40	*Citrullus colocynthis* (L.) Shred.	Cucurbitaceae	17.61
41	*Cyperus rotundus* L.	Cyperaceae	18.87
42	*Eragrostis pilosa* (L.)P. Beauv.	Poaceae	26.72
43	*Eragrostis minor* Host.	Poaceae	20.98
44	*Euphorbia prostrata* Ait.	Euphorbiaceae	18.22
45	*Fagonia indica* L.	Zygophyllaceae	21.92
46	*Plantago ovata* Frossk.	Plantaginaceae	14.2
47	*Portulaca oleraceae* Linn.	Aizoaceae	13.97

SN	Name of plant	Family	IVI
48	*Cenchrus bifolrus* Roxb.	Poaceae	73.4
49	*Aristida adscensionis* L.	Poaceae	38.16
50	*Dichanthium annulatum* Frossk	Poaceae	38.91
51	*Launaea angustifolia* (Desf.) Kuntze	Asteraceae	27.35
52	*Malva neglecta* Wallr.	Malvaceae	38.76

Western Stand (Prosopis- Tamarix- Acacia Community)

Except only one shrub, most of the trees were dominant in the whole community of this stand. Among the trees, we found *Tamarix aphylla* with high IVI value of (81.17) followed by *Acacia nilotica* with (76.60), *Acacia modesta* with (61.42), *Ziziphus jujube* with (55.29) and *Prosopis cineraria* with (25.50). Among the shrubs we observed *Prosopis juliflora* as the dominant plant in this stand with (103.61) IVI value followed by *Aerva javanica* with (51.14), *Calotropis procera* with (47.96) and *Rhazya stricta* (41.65). Among the herbs *Alhagi maurorum* had the high IVI value with (52.15) followed by *Cynodon dactylon* with (50.7), *Chenopodium murale* (43.22), *Polypogon pectinatusi* with (41.31), *Amaranthus viridus* (39.14) and *Achyranthes aspera* (38.07) (Table 2).

Table 2. Plant species of the Western stand from the semi-arid zone of District Bannu, KP, Pakistan.

SN	Name of Plants	Family	IVI
1	*Acacia modesta* Wall.	Mimosaceae	61.42
2	*Acacia nilotica* (L.) Wild.ex Delile	Mimosaceae	76.6
3	*Tamarix aphylla* (L.) Karst	Tamariaceae	81.17
4	*Ziziphus jujuba* Mill.	Rhamnaceae	55.29
5	*Prosopis cineraria* L.	Mimosaceae	25.5
6	*Aerva javanica* (Burm. F.) Juss.	Amaranthaceae	51.14
7	*Calotropis procera* (willd.) R. Br.	Capparidaceae	47.96
8	*Prosopis juliflora* Swartz.	Mimosaceae	103.61
9	*Rhazya stricta* Decne.	Apocynaceae	41.65
10	*Withania coagulans* Dunal.	Solanaceae	55.65
11	*Alopecurus nepalensis* Trin.Ex Steud.	Poaceae	5.45
12	*Anagallis arvensis* L.	Primulaceae	9.03
13	*Atriplex stocksii* Boiss	Chenopodiaceae	6.5
14	*Calendula officinalis* L.	Asteraceae	10.04
15	*Carduus argentatus* L.	Asteraceae	5.41
16	*Cirsium arvense* (L.) Scop.	Asteraceae	6.55
	Cymbopogon distanse Schutt.	Poaceae	8.06
21	*Datura alba* Nees.	Solanaceae	6.01
22	*Dinebra retroflexa* (Vahl) Panzer.	Poaceae	3.43
23	*Echinochloa crus-galli* (L.) P. Beauv.	Poaceae	4.37
24	*Euphorbia helioscopia* L.	Euphorbiaceae	15.24
25	*Euphorbia prostrata* Ait.	Euphorbiaceae	8.09
26	*Fagonia indica* L.	Zygophyllaceae	8.02
27	*Filago pyramidata* L.	Asteraceae	3.39
28	*Fumeria indica* Hausskn.	Fumariaceae	9.09
29	*Heliotropium crispum* Desf.	Boraginaceae	3.83
30	*Lactuca serriola* L.	Asteraceae	5.29
31	*Lathyrus aphaca* L.	Papilionaceae	3.89
32	*Launaea procumbens* Pravin Kawale	Asteraceae	3.18
33	*Leptochloa panacea* Retz	Poaceae	4.4
34	*Malva neglecta* Wallr.	Malvaceae	3.85
35	*Medicago polymorpha* L.	Papilionaceae	6.93
36	*Melilotus alba* Desr.	Papilionaceae	3.52
37	*Melilotus indica* (L.) All.	Papilionaceae	5.41
38	*Neslia apiculata* Fisch.	Brassicaceae	3.43
39	*Nicotiana plumbaginifolia* Viv.	Solanaceae	4.01
40	*Oxalis corniculata* L.	Oxalidaceae	4.69
41	*Phalaris minor* Retz.	Poaceae	4.6
42	*Plantago lanceolata* L.	Plantaginaceae	7.27
43	*Poa annua* L.	Poaceae	12.95
44	*Poa botryoides* (Trin. Ex Griseb.) Kom.	Poaceae	5.18
45	*Polygonum plebejum* R.Br	Polygonaceae	4.7

SN	Name of Plants	Family	IVI
46	*Ranunculus sceleratus* L.	Ranunculaceae	3.79
47	*Rumex dentatus* (Meisn.) Rech.f.	Polygonaceae	4.12
48	*Polypogon monspeliensis* (L.) Desf.	Poaceae	9.4
49	*Sisymbrium irio* L	Brassicaceae	8.42
50	*Sonchus asper* (L.) Hill.	Asteraceae	7.9
51	*Solanum nigrum* L.	Solanaceae	3.8
52	*Taraxacum officinale* F.H. Wiggers	Asteraceae	8.97
53	*Torilis nodosa* (L.) Gaertn.	Apiaceae	5.9
54	*Trigonella crassipes* Boiss.	Papilionaceae	7.32
55	*Verbena officinalis* L.	Verbenaceae	5.05
56	*Xanthium strumarium* L.	Asteraceae	6.6
57	*Alhagi maurorum* Medic.	Papilionaceae	52.15
58	*Aristida cyanantha* Nees ex Steud.	Poaceae	22.75
59	*Cenchrus ciliaris* L.	Poaceae	29.83
60	*Conyza bonariensis* (L.) Cronquist	Asteraceae	26.21
62	*Cyperus rotundus* L.	Cyperaceae	30.39
63	*Fagonia cretica* L.	Zygophyllaceae	27.85
64	*Heliotropium strigosum* Wild	Boraginaceae	18.68
66	*Achyranthes aspera* L.	Amaranthaceae	38.07
67	*Amaranthus viridis* L.	Amaranthaceae	39.21
68	*Boerhavia procumbens* Banks ex Roxb	Nyctaginaceae	21.19
69	*Chenopodium murale* L.	Chenopodiaceae	43.22
70	*Corchorus depressus* (L.)	Tiliaceae	17.06
74	*Solanum surattense* Burm.f.	Solanaceae	20.7
75	*Tribulus terrestris* L.	Zygophyllaceae	20.31
76	*Avena fatua* L.	Poaceae	23.97
77	*Convolvulus arvensis* L.	Convolvulaceae	29.32
78	*Cynodon dactylon* (L.) Pers.	Poaceae	45.37
79	*Dichanthium annulatum* Forssk.	Poaceae	39.17
85	*Setaria pumila* (Poir.) Roem.	Poaceae	22.4

Northern Stand (Prosopis- Tamarix- Phoenix Community)

We observed that northern stand has also the prevalence of trees and shrubs. Among the trees we found *Tamarix aphylla* as the dominant plant with high (66.96) importance values followed by *Prosopis cineraria* with (57.26), *Phoenix dactylifera* with (52.55), *Ziziphus jujube* with (43.64), *Acacia nilotica* with (41.72) and *Acacia modesta* with (37.87). Among the shrubs *Prosopis juliflora* was the dominant plant with high importance value of (69.22) followed by *Tamarix dioica* with (44.81), *Rhazya stricta* with (34.81) and *Aerva javanica* with (32.05).

IVI values of herbaceous plants were generally less than trees and shrubs. Among the herbs *Cymobopogon distance* was the dominant with importance value (31.66) followed by *Cynodon dactylon* with (24.57), *Cenchrus ciliaris* with (20.66) and *Malcolmia africana* (20.37) (Table 3).

Table 3. Plant species of the Northern stand from the semi-arid zone of District Bannu, KP, Pakistan.

SN	Name of plants	Family	IVI
1	*Acacia modesta* Wall.	Mimosaceae	37.87
2	*Acacia nilotica* (L.) Wild.ex Delile	Mimosaceae	41.72
3	*Phoenix dactylifera* L.	Araceae	52.55
4	*Prosopis cineraria* L.	Mimosaceae	57.26
5	*Tamarix aphylla* (L.) Karst	Tamaricaceae	66.96
6	*Ziziphus jujube* Mill.	Rhamnaceae	43.64
7	*Aerva javanica* (Burm. F.) Juss.	Amaranthaceae	32.05
8	*Calotropis procera* (Willd.) R. Br.	Asclepiadaceae	31.74
9	*Cistanche tubulosa* (Shehenk.)	Orobanchaceae	28.77
10	*Prosopis juliflora* Swartz.	Mimosaceae	69.22
11	*Rhazya stricta* Decne.	Apocynaceae	34.84
12	*Tamarix dioica* Roxb. Ex Roth.	Tamaricaceae	44.81
13	*Vitus negundo* L.	Vitaceae	24.24
14	*Withania coagulans* Dunal.	Solanaceae	34.31
15	*Anagallis arvensis* L.	Primulaceae	14.08
16	*Avena fatua* L.	Poaceae	10.24

17	*Calendula officinalis* L.	Asteraceae	10.64
18	*Carthamus persicus* Willd.	Asteraceae	11.98
19	*Cenchrus ciliaris* L.	Poaceae	20.66
22	*Cymbopogon distanse* Schutt.	Poaceae	31.66
24	*Datura alba* Nees.	Solanaceae	13.33
25	*Euphorbia helioscopia* L.	Euphorbiaceae	9.35
26	*Heliotropium europaeum* (F. & M.) Kazmi	Boraginaceae	10.83
27	*Malcolmia Africana* (L.) R.Br.	Malvaceae	20.37
28	*Onosma chitralicum* I.M.Johnston	Boraginaceae	9.12
29	*Pegnum harmala* L.	Zygophyllaceae	16.26
30	*Polygonum plebejum* R.Br	Polygonaceae	8.83
31	*Rumex dentatus* (Meisn.) Rech.f.	Polygonaceae	13.15
32	*Sisymbrium irio* L	Brassicaceae	14.43
33	*Sonchus asper* (L.) Hill.	Asteraceae	12.74
34	*Spergula fallax* (Lowe) E.H.L. Krause	Caryophyllaceae	5.15
35	*Taraxacum officinale* F.H. Wiggers	Asteraceae	14.33
36	*Alhagi maurorum* Medic.	Papilionaceae	25.33
37	*Avena fatua* L.	Poaceae	14.16
38	*Bromus pectinatus* Thunb.	Poaceae	29.4
40	*Cenchrus biflorus* Roxb.	Poaceae	23.33
42	*Cyperus rotundus* L.	Cyperaceae	12.86
43	*Eleusine indica* (L.) Gaertn.	Poaceae	31.32
44	*Fagonia cretica* L.	Zygophyllaceae	11.73
46	*Poa annua* L.	Poaceae	23.48
49	*Achyranthes aspera* L.	Amaranthaceae	34.47
50	*Amaranthus viridis* L.	Amaranthaceae	28.04
51	*Boerhavia procumbens* Banks ex Roxb	Nyctaginaceae	28.47
52	*Bromus pectinatus* thumb.	Poaceae	40.61
53	*Chenopodium murale* L.	Chenopodiaceae	29.63
54	*Citrullus colocynthis* (L.) Shred.	Cucurbitaceae	34.53
57	*Solanum surattense* Burm.f.	Solanaceae	27.42
58	*Aristida adscensionis* L.	Poaceae	33.85
59	*Chenopodium album* L.	Chenopodiaceae	51.52
60	*Convolvulus arvensis* L.	Convolvulaceae	34.17
61	*Cynodon dactylon* (L.) Pers.	Poaceae	42.27
62	*Dichanthium annulatum* Forssk.	Poaceae	32.5

Diversity and Similarity

We observed 52, 85 and 62 plant species in eastern, western and northern stands respectively. Species diversity index was 3.814, 4.083 and 3.74 in eastern, western and northern stands respectively (Table 4). Most of the edaphic variables showed non-significant relation with the diversity.

However Fe, Ca, Cd, Mn have positive and Zn, Ni showed negative correlation with the diversity in all the three stands (Table 5).We found high similarity of plant species in western and northern stands than eastern (Fig. 1).

Table 4. Plant species richness and diversity of the three sites in semi-arid zone of District Bannu, Kp, Pakistan.

Sites	Species richness	Shanoon`s Diversity index
Eastern	52	3.81
Western	85	4.08
Northern	62	3.74

Table 5. Correlation of plant species diversity index of the three sites along edaphic variables in the semi-arid zone of District Bannu, KP, Pakistan. Significant values at α = 0.05 are in bold. PH = Power of Hydrogen, EC = Electric conductance, OM = Organic matter, N = Nitrogen, P = Phosphorus, K = Potassium, S = Sulphur, Si = Silicon, Fe = Ferrous, Cu = Copper, Zn = Zinc, Ca = Calcium, Mg = Magnesium, Pb = Lead, Cd = Cadmium, Ni = Nickle, Cr = Chromium, Mn = Manganese.

Edaphic variables	*P* values	Co-efficient
PH	0.29	-0.5
EC in (dScm-1)	0.81	0.5
OM in %	0.6	0.5
N	0.49	-0.5
P	0.33	-0.5
K	0.34	-0.5
S	0.77	0.5
Si	0.24	-0.5
Fe	0.01	1
Cu	0.01	1
Zn	0.01	-0.5
Ca	0.01	1
Mg	0.14	0.5
Pb	0.13	-1

Edaphic variables	*P* values	Co-efficient
Cd	0.03	0.5
Ni	0.01	-1
Cr	0.32	-0.5
Mn	0.01	1

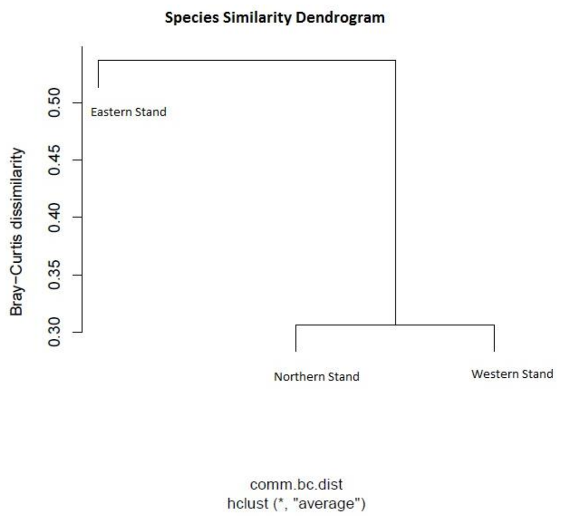

Fig. 1. The species similarity dendrogram among the stands in the semi-arid zone of District Bannu, KP, Pakistan.

Discussion

The present study revealed the importance of conservation practices and provided a baseline data of this ecologically important area. Edaphic factors showed weak role to ameliorate the environment and effect interactions among the plants for the soil resources. We argued that less diversity is the result of human involvement in the area and disturbances due to grazing and land utilization practices. Environmental adaptations of the plants are the important characteristics for the establishment of species and prevalence in the area.

Phytosociological survey

In general semi-arid climate represent scrubby vegetation in which shrubs and herbs are the dominant habits of the plants. However, the high relative density of few trees in our study may be due to their allelopatheic behaviour and better adaptations which leads them as the dominant plants of the area. For example the dropped leaves of *Tamarix* plant have high contents of salts which make the soil saline around their vicinity preventing the seed germination of other plants (Morris *et al.*, 2009; Natale *et al.*, 2010). Similarly *Prosopis* and *Ziziphus* species have also well adapted roots for the absorption of water and minerals in water stress conditions and thick barks to withstand the extreme environment (Elfadl and Luukkanen, 2003; Arndt *et al.*, 2001).

We also observed the presence of few dominant shrubs in all the stands. For example *Calligonum* and *Rhazya* species are usually non-palatable due to the presence of certain chemicals which give bitter taste and un-pleasant smell for the animals (Samejo *et al.*, 2013; Quets *et al.*, 2014). The presence of odour volatile oils in *Rhazya* also reduces their fuel consumption among the people of the area. Moreover, the vegetative propagation in *Calligonum* also help in an increasing the density of the plant (Samejo *et al.*, 2013; Quets *et al.*, 2014).

We have observed that constant and continuous grazing in the area is also responsible for the less diversity of plant species. The livestock totally depend on the grasses and wild herbs due to less cultivation of fodder. Due to poverty and less ownership of the lands, the local people are confined to cultivate only a few crop plants only for themselves. Therefore, the absence of cultivated fodder confined the livestock to graze wild herbs. Irregular and uncontrolled grazing of the livestock also has laid negative impact on the diversity of the plants.

Diversity and similarity

We observed less diversity and high similarity among the stands. Diversity among the sites and within the stands may be related to vulnerability of the plants to the people and environmental disturbances. Generally, habitat and land use change is expected to drive non-random changes in diversity (Mace *et al.*, 2003). Disturbance is thought to reduce the impact of interspecific competition through local extinction of disturbance-vulnerable species and can change local habitat conditions, which may lead to environmental filtering of species in community assembly with increasing disturbance (Winter *et al.*, 2009). Similarity among the stands may be due to the general climate of the semi-arid environment is harsh which is not suitable for the plants and only those plants can survive best which are best adapted with the environment (Luzuriaga *et al*., 2012; Keddy,1992; Diaz *et al*.,1998). As a consequence of habitat filtering, a positive relationship between species traits and abundance is expected (Shipley *et al*., 2006).

Our findings also revealed the higher density of those plants which are good adapted with the environment. For example *Tamarix* has thick bark and spiny leaves which reduce the transpiration rate of the plants. Similarly *Prosopis* and *Acacia* have also thick bark, deep roots and small leaves which are the suitable characteristics to the semi-arid environment (Natale *et al*., 2010; Arndt *et al*., 2001).

Diversity along the edaphic variables

We did not find significant correlation of the plant diversity with the edaphic abiotic variables in all the three studied sites. Our results explained that edaphic factors are not as influential in the studied stands. However little effect of the micro-elements on the vegetation may be due the edaphic elemental spatial heterogeneity. Spatial heterogeneity can influence diversity both by increasing the number of habitats types and by affecting ecological processes such as dispersal and competition (Dufour *et al*., 2006) through the spatial configuration of habitats.

Heterogenic biotic and abiotic microenvironment provides equal opportunity to every species for the growth and development. (Lundholm and Larson, 2003; Pausas *et al*., 2003; Leigh *et al*., 2004; Dufour *et al*., 2006). For example, in South Africa Thuiller *et al*., (2006) showed that topographic heterogeneity could improve plant richness both by increasing the number of niches in space and by keeping the number of niches relatively stable in time.

Conclusion

The diversity of plants in semi-arid zone of District Bannu is affected with anthropogenic activities. Therefore extensive conservation practises are needed to protect the diversity of plants.

The future study will explore the plant species co-occurrence, phylogenetic and functional characteristics of this zone to determine the relation of plants and environment aspects of plant species diversity.

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