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RELATIONSHIP OF FOREST VEGETATION AND ENVIRONMENTAL GRADIENTS (ADAPHIC, TOPOGRAPHIC AND SOIL NUTRIENTS) FROM SOME FROSTED AREAS OF HIMALAYAN, HINDU KUSH AND KARAKORAM RANGES OF GILGIT-BALTSITAN, PAKISTAN- (A MULTIVARIATE APPROACH)

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Abstract

The present study was conducted to investigate the relationship between forest vegetation and environmental gradients from some forested area of Himalayan, Hindu Kush and Karakoram ranges of Pakistan. Forty stands were sampled from three districts of Gilgit-Baltistan. Ward's cluster analysis for classification and Detrended Correspondence Analysis (DCA) for ordination were applied to seek the vegetation distribution and composition. Ward's cluster analysis when applied on tree species data and understory species data each give five groups and these five groups distinctly distributed on ordination plan. In cluster groups of trees Group I (a) and Group II are dominated by *Pinus wallichiana*, Group I (b) mono specific group of *Pinus wallichiana*, Group III *Picea smithiana*, Group IV *Betula utilis* and group V is consist on two mono specific stands of *Abies pindrow and Juniperus macropoda*. In cluster of ground flora Group I dominated by *Potentilla anserine*, Group II *Urtica dioica*, Group III *Viola rupestris*, and *Fragaria nubicola*, Group IV *Cicer songaricum* and Group V *Bergenia stracheyi* consequently. The groups of tree and understory vegetation are readily superimposed on DCA ordination plane. Classification and ordination showed similar distribution pattern of tree species as well as understory vegetation. Relationships between the ordination axes with topographic (elevation and slope) and edaphic variables (pH, TDS, Salinity, conductivity and water holding capacity) also employed. In case of tree vegetation data cluster groups among the environmental factors only edaphic factor salinity ($P < 0.05$) and soil nutrient K^+ ($P < 0.05$), ($P < 0.05$) showed positively correlated with axes 1, and axes 2, 3 correspondingly while in case of understory data cluster groups between the topographic variables elevation ($P < 0.05$) was found positively correlated with axes 1. While among the edaphic factors only pH ($P < 0.05$), ($P < 0.01$) was showed positively correlated with axes 2 and 3 respectively. Whereas among the soil nutrients only Fe^{++} was recorded ($P < 0.05$) positively correlated with ordination axes 3. Both cases most of the environmental variables did not show significant correlation this may due to the anthropogenic disturbances however further studies are needed to explore the rest of parts of the said regions.

Key Words: DCA, Environmental Gradients, PCQ, Multivariate, Skardu, Astore, Gilgit

Introduction:

Complete description about the study was briefly described by Akbar *et al.,* (2010, 2011). In Pakistan many workers applied multivariate technique in different areas to investigate the vegetation classification and distribution Shaukat & Qadir, (1971), Ahmed (1973;1976), Shaukat *et al.,* (1980), Shaukat (1988), Shaukat & Uddin (1989a), Shaukat & Uddin (1989b), Shaukat (1994), Shaukat *et al.,* (2005), Malik & Hussain (2006; 2007), Peer *et al.,* (2007), Dasti *et al.,* (2007), Wazir *et al.,* (2008), Saima *et al.,* (2009), Ahmed *et al.,* (2009), Ahmed *et al.,* (2010), Siddiqui *et al.,* (2010a; 2010b).

Recently Ahmed *et al.,* (2011) used TWINSPAN and DCA ordination to classify and ordinate the vegetation of *Cedrus deodara* dominating forests from mountainous areas of Pakistan. Siddiqui (2011) described vegetation pattern of conifer forest of moist temperate area of Himalayan range applying the modern multivariate techniques. Khan (2011) and Wahab (2011) classified the vegetation of Chitral and Dir district respectively by using TWINSPAN, Ward's cluster analysis and DCA ordination. Khan (2012) described applied cluster analysis and DCA during the community analysis of *Quercus baloot* from Dir. In Gilgit-Baltistan before this research any other researcher did not conduct such kinds of investigation, so this is the first information and investigation regarding vegetation environment relationship and the study may be provide preliminary base line information.

In the light of the above research no quantitative work has been done on the vegetation of forested area of Gilgit, Astore and Skardu district, so this study provide detail information about the forest vegetation of these three districts.

Material and Methods:

Forty stands were sampled applying Point Centered Quarter (PCQ) method (Cottam & Curtis, 1956) from the fifteen forested valleys of study area. The detailed sampling methods also described by Akber *et al.,* (2010; 2011; 2013; 2014a; 2014b).

To investigate the relationship between the vegetations and environmental factors Ward's Hierarchical Agglomerative clustering techniques (McCune & Grace, 2002) was used. The importance values index of trees were used, as it provides the degree of dominance and abundance of given species in relation to other species in the area. (Kent & Coker, 1992; Song *et al*. 2009). To categorize the vegetation into groups the importance value of trees and frequency of understory vegetation was taken. The understory species that attained > 6% frequency are considered for multivariate analysis. Therefore, the importance value index (IVI) of 7 tree species and frequency of 37 understory species were used to perform the ordination and classification analysis. From the 83 ground flora a total of 37 species including herb, shrub, and seedling of tree species were selected to perform multivariate analysis. The rare species (that found in less than 6 stands) were ignored, when applying multivariate techniques. Similar method also applied by Shaukat (1989), McCune *et al.,* (2000), Khan *et al*., (2011a; 2012), Siddiqui *et al.,* (2010a'b) and Ahmed *et al.,* (2011b). The vegetation species on the forest floor were stated as rare, occasional, frequent, abundant, and most abundant following Tansely & Chipp (1926), Tansely (1946, 1926) and Khan *et al.,* (2011). These classes based on actual frequency as follows; (1) 1-20% rare, (2) 21- 40 Occasional, (3) 41-60 Frequent, (4) 61-80% Abundant, (5) 81-100 most abundant.

The environmental characteristics elevation and slope were used to check the response of vegetation groups with the environmental factor. Slope angle were categorized into 4 classes i.e. Plain – 15° gentle, 16°-30° moderate, 31°-45° steep, 46°-60° very steep.

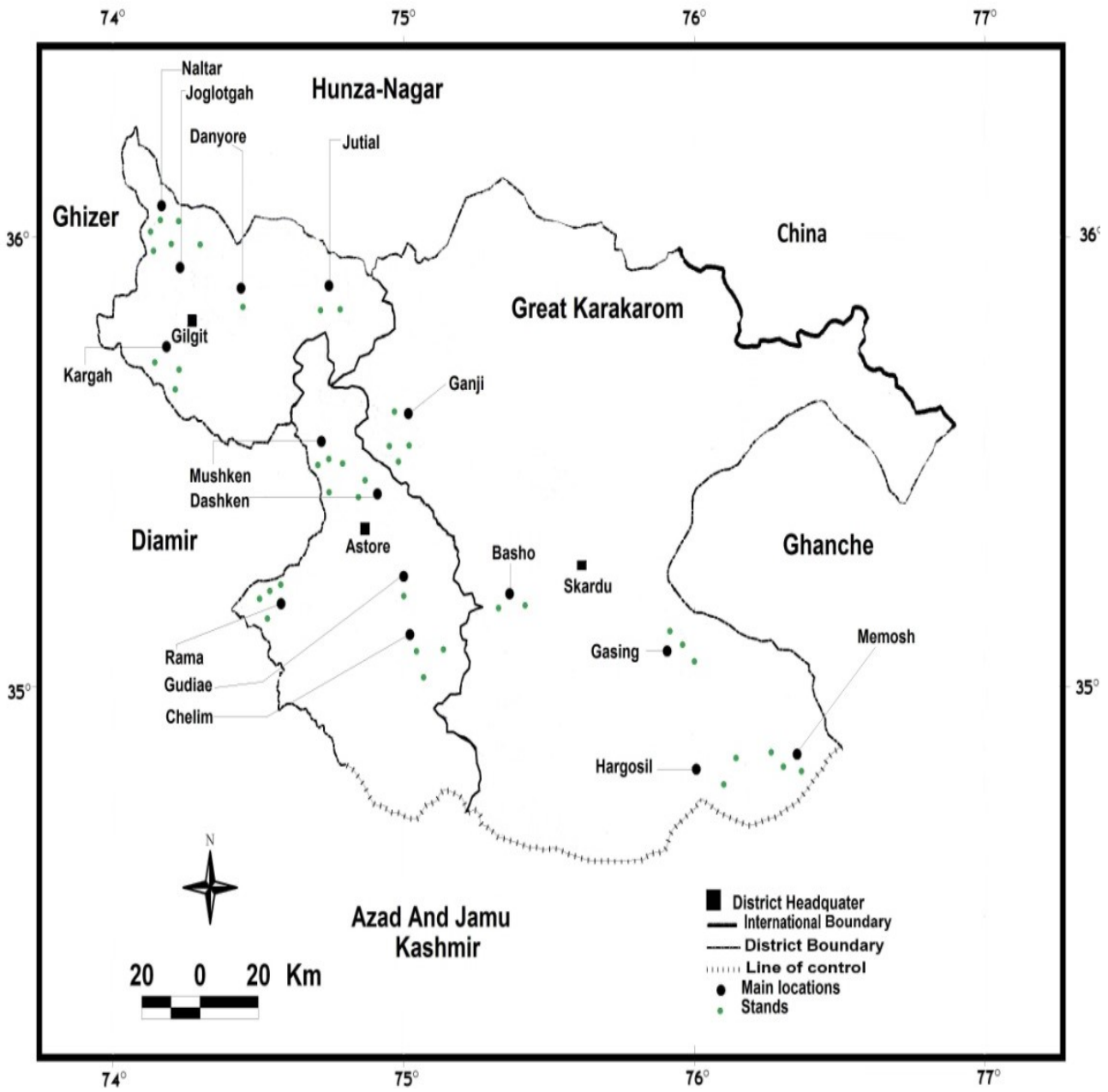


Fig. 1. Map of the study area

Table: 1 Characteristics of sampling sites of Skardu, Gilgit and Astore Districts.

Stn	Main Location and sites	Lat (N)	Long (E)	Ele (M)	Aspect	Slope (°)	Canopy
1	Basho-A	35°17	75°38	3700	NE	35	Mdr
2	Basho-B	35°17	75°38	3550	NE	30	Opn
3	Gasing-A	35°09	75°98	3500	E	25	Mdr
4	Gasing-B	35°09	75°98	3400	W	20	cls
5	Gasing-C	35°09	75°98	3600	N	27	Opn
6	Hargosil-A	34°43	76°06	3586	E	20	Sct
7	Hargosil-B	34°44	76°06	3463	N	15	Opn
8	Memosh-A	34°42	76°06	3463	NE	35	Opn
9	Memosh-B	34°42	76°06	3414	E	30	Opn
10	Memosh-C	34°42	76°06	3477	E	23	Mdr
11	Ganji-A	35° 56	74° 98	3310	SE	15	cls
12	Ganji-B	35° 56	74° 98	3472	SW	35	cls
13	Ganji-C	35° 56	74° 98	3585	SE	37	cls
14	Ganji-D	35° 34	74° 59	3374	SE	35	cls
15	Kargah-A	35° 55	74° 05	3255	NE	43	Mdr
16	Kargah-B	35° 56	74° 04	3427	E	33	Opn
17	Kargah-C	35° 52	74° 02	3216	SE	25	Opn
18	Jutial-A	35° 50	74° 20	3250	N	40	Mdr
19	Jutial-B	35° 50	74° 20	3250	N	40	Mdr
20	Naltar-A	36° 09	74° 11	2930	S	36	Mdr
21	Naltar-B	36° 08	74° 11	3401	S	40	Mdr
22	Naltar-C	36° 11	74° 18	2893	pln	5	Mdr
23	Naltar-D	36° 11	74° 18	2893	pln	5	Mdr
24	Danyore	35° 56	74° 28	3736	NE	45	Opn
25	Joglotgah-A	36° 07	74° 24	3523	W	35	Mdr
26	Joglotgah-B	36° 07	74° 22	3055	pln	5	Mdr
27	Rama-A	35° 20	74° 48	3508	NE	40	Opn
28	Rama-B	35° 20	74° 48	3464	NW	45	Mdr
29	Rama-C	35° 20	74° 48	3275	S	35	Opn
30	Rama-D	35° 20	74° 48	3016	S	15	Mdr
31	Mushken-A	35° 49	74° 72	2691	E	40	Mdr
32	Mushken-B	35° 48	74° 73	2719	SE	35	cls
33	Mushken-C	35° 48	74° 74	2659	NE	25	cls
34	Mushken-D	35° 48	74° 74	3078	NE	40	Mdr
35	Mushken-E	35° 49	74° 75	2639	NE	30	Opn
36	Dashken	35° 46	74° 77	2616	E	45	Mdr
37	Gudaie	35° 17	74° 97	3775	N	50	cls
38	Chelim-A	35° 03	75° 10	3458	SE	45	cls
39	Chelim-B	35° 01	75° 07	3559	E	40	Mdr
40	Chelim-C	35° 00	75° 06	3596	E	20	sct

Key to abbreviations: stn=Number of stand, Lat=Latitude, Long=Longitude, Ele=Elevation, Opn=open, Mdr=Moderate, Sct=Scatted, cls=Close

Results:

The locations of study area where sampling was perform shown in Fig. 1 while the site characteristics are presented in Table 1.

(1) Classification:

(a) **Ward's Cluster analysis of Stands (Tree vegetation data):** The dendrogram was prepared using Ward's Clustering Method, (Fig. 2) clearly separate out the five major groups of vegetation and on the basis of these groups environmental variables are also divided into five groups. Characteristics of vegetation groups (mean ± SE) are presented in Table 2 while the environmental features (mean ± SE) of each group are given in Table 3.

Group I: (a) *Pinus wallichiana* mix group: The sub group of Group I consist of total 9 stands was predominantly *Pinus wallichiana* with (80.77% average importance value) while *Juniperus excelsa* showed second dominant species with (11.88% average IVI) whereas the angiospermic associated tree species *Betula utilis* present with the very low (3.20% average importance value). The *Pinus gerardiana* also attained very low (average importance i.e.4%).

Total thirty one plant species including herbs, shrubs and seedlings of trees were also associated with this tree species as understory vegetation. Among theses *Anaphalis virgata*, *Potentilla anserina* ,*Pinus wallichiana* and *Leontopodium himalayanum* found as occasional, while *Anaphalis nepalensis, Anaphalis virgata*, *Artemisia brevifolium*, *Hieracium lanceolatum*, *Berberis orthobotrys*, *Bergenia stracheyi*, *Betula utilis*, *Bistorta affinis*, *Cicer songaricum*, *Fragaria nubicola*, *Geranium partens, Inula rhizocephala*, *Juniperus communis*, *Myostis asiatica*, *Nepeta discolor*, *Oxyria digyna*, *Ribes orientale*, *Urtica dioica*, *Rubus irritans*, *Rumex hastatus*, *Taraxacum baltistanicum*, *Trifolium partense, Trifolium repens*, *Rosa webbiana* and *Astragalus zanskarensis* attempted rare position, where as only *Taraxacum baltistanicum* found as frequent species with 60% frequency in this group no any other species recorded in the category of abundant and very abundant. These results showed that the understory vegetation of these stands is under the anthropogenic disturbances.

This group of vegetation was recorded on high elevation 3519±117 m and moderate 27° slope angle. The edaphic feature of this group showed mean value of total dissolved salts (TDS) 18.1±3.1, water holding capacity (WHC) 45.52±5, salinity 00±00, conductivity 42.46±7.1 and Organic matter 5.5±0.6. The soil of this group was strongly acidic in nature having the man value of pH 5.5±0.1. While in case of the soil nutrients this group showed the mean value of Ca^{++} 171±16.1, Mg^{++}130±95, K^{+} 202±15.6, Co^{++} 0.7±00, MN^{++} 8.7±1.5, Zn^{++} 1.2±0.1 and Fe^{++} 91.6±19.2 ppm respectively (Table 3).

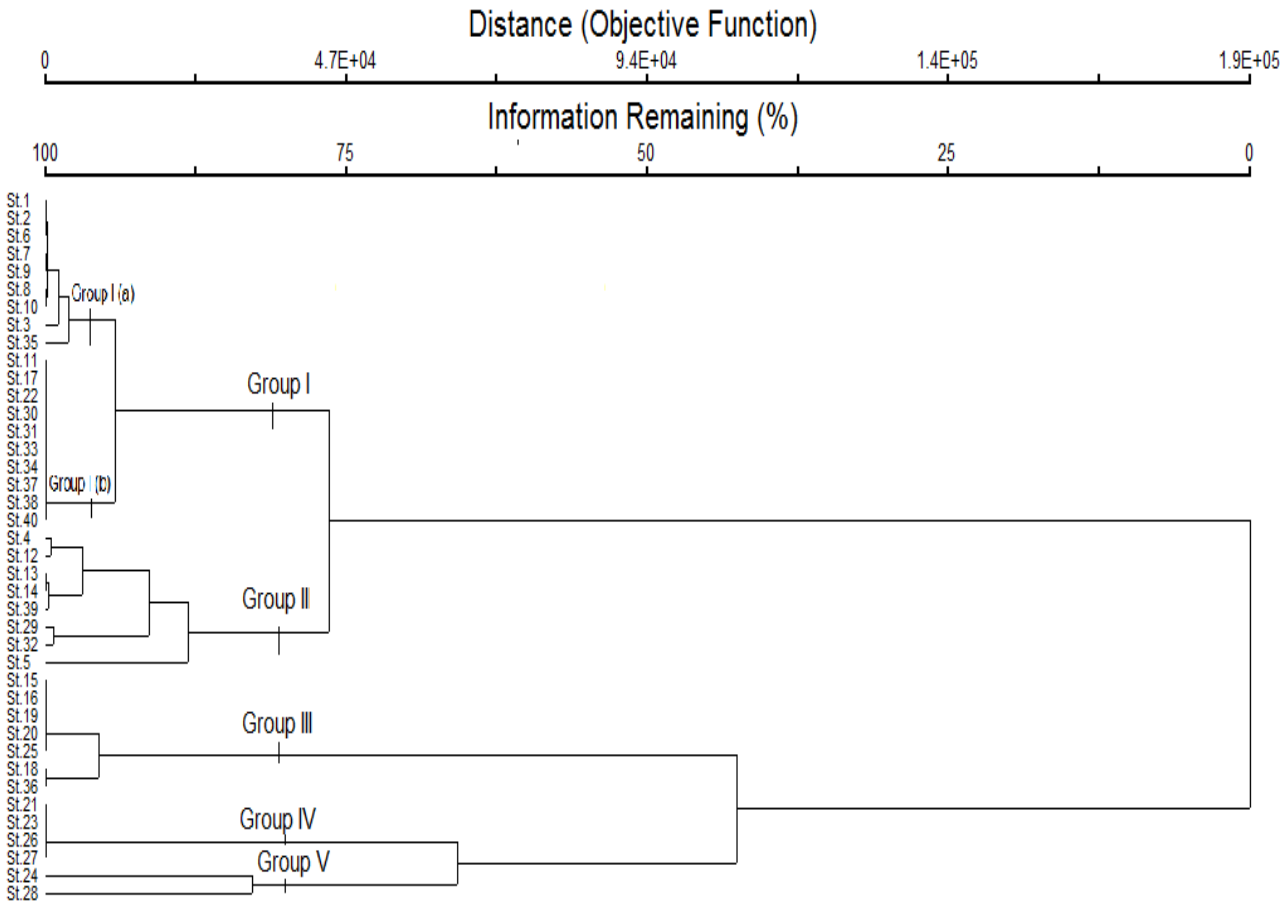


Fig. 2. Dendrogram obtained from Ward's Cluster Analysis, using importance value of tree species, showing five distinct groups.

Group I: (b) pure *Pinus wallichiana* group: This is also the sub group of group I .The cluster analysis agglomerate 10 pure stands of *Pinus wallichiana* that shared (100 ± 00% average importance value) in this group. There was no any co-dominant tree species in this group. Among all the groups this is one of the large groups.

Many ground flora also associated in this group in which *Anaphalis nepalensis*, *Artemisia brevifolium*, *Astragalus zanskarensis*, *Berberis orthobotrys*, *Bergenia stracheyi*, *Bistorta affinis*, *Fragaria nubicola*, *Geranium partens*, *Leontopodium leontopodinum*, *Myostis asiatica*, *Potentilla anserine*, *Rosa webbiana*, *Rubus irritans*, *Viola rupestris*, *Thymus serpyllum*, *Trifolium partense*, *Trifolium repens*, *Urtica dioica, Tanacetum artemisioides* and *Taraxacum baltistanicum* are occasionally occurring species where some species i.e. *Anaphalis virgata*, *Hieracium lanceolatum*, *Pinus wallichiana*, *Juniperus communis*, *Nepeta discolor*, *Oxyria digyna, Inula rhizocephala, Ribes alpestre*, *Rheum tibeticum*, *Ribes orientale*, *Rumex hastatus, Spiraea canescens, Verbascum Thapsus* and *Taraxacum sp.* are showing rare position in this cluster group however only *Cicer songaricum* is occurring as frequent species with 42% mean frequency whereas no any other species attempted abundant and very abundant position. Ground flora is mostly present occasionally where as in Group I (a) most of the understory vegetation represented rare position.

The topographic characteristics of this group reveled comparatively low elevation 3169±117 m and low slope angle (280) as compare to the Group I (a). Low concentration of salts (TDS) 18.4±3.5, high WHC 50.97±5, high salinity 0.04±0.2, high conductivity 42.7±7.8 and low organic matter 8.3±1.5% are the characteristics of this group. The soil of this group was slightly acidic in nature having the mean value of PH 6.2±0.2 while in case of the soil nutrients this group showed the mean value of Ca^{++} 192±11.9, Mg^{++}144.9±8.5, K^{+} 202±21.7, Co^{++} 0.8±00, MN^{++} 13.6±1.6, Zn^{++} 1.2±0.2 and Fe^{++} 165.7±17 ppm respectively (Table 3).

Group II: *Pinus wallichiana* and *Picea smithiana* group: This group consists of eight stands having three coniferous tree species i.e. *Pinus wallichiana* with (52.54 ±7.5%), *Picea smithiana* (49.6± 11%), *Juniperus excelsa* (36.59±17%) and an angiospermic tree *Betula utilis* with (28.46±3%) average importance values. *Pinus wallichiana* species is common in group I (a) and (b).

The understory vegetation of this group comprise of thirty five species among them *Berberis orthobotrys*, *Bergenia stracheyi*, *Bistorta affinis, Fragaria nubicola*, *Geranium partens*, *Inula rhizocephala, Leontopodium leontopodinum*, *Myostis asiatica, Oxyria digyna, Potentilla anserine*, *Rosa webbiana, Rubus irritans*, *Tanacetum artemisioides, Viola rupestris, Trifolium partense, Trifolium repens, Urtica dioica* and *Thymus serpyllumare* are occasionally occurring species where as *Anaphalis nepalensis, Astragalus zanskarensis, Cicer songaricum*, *Betula utilis*, *Hieracium lanceolatum, Juniperus communis*, *Leontopodium himalayanum, Nepeta discolor*, *Pinus wallichiana* (seedling), *Rheum tibeticum* , *Ribes alpestre, Ribes orientale, Verbascum thapsus, Spiraea canescens, Taraxacum sp.*, *Taraxacum baltistanicum* and *Rumex hastatus* are rare species. In this group no any species was occurring in frequent, abundant and very abundant category. The results indicated that most of the species were getting pressure due to the natural and human induced disturbances therefore most of the species distributed rarely.

The environmental properties showing considerably same elevation 3178±116 m and slope angle 29^{0} with group I (b) while little bit difference to Group I (a).

The Edaphic feature of this group showed mean value of TDS 25.6±3.4, water holding capacity 41.14±5, salinity 0.01±0.1, conductivity 58.4±7.6 and Organic matter 7.7±1.3 percent respectively. The soil of this group was neutral in nature having the mean value of pH 6.9±0.2. While in case of the soil nutrients this group showed the mean value of Ca^{++} 177±14, Mg^{++}127±8.4,K^{+} 206±15.5, Co^{++} 0.7±00,Mn^{++} 13.6±1.9, Zn^{++} 1.2±0.1 and Fe^{++} 125.7±14.6ppm respectively (Table 3).

Table 2. five groups derived from Ward's cluster analysis of 40 stands and their average tree species composition (average importance value for each group):

S. No	Species Name	Group I (a)	Group I (b)	Group II	Group III	Group IV	Group V
1	*P. w*	82.95± 3.16	100±00	52.54±7.5	-	-	-
2	*P. s*	-	-	49.6±11.4	91.61±5.4	-	-
3	*B. u*	3.6± 1.59	-	28.46±3.6	-	100±00	-
4	*J. e*	13.37± 1.8	-	36.59±17.9	29.4± 0.4	-	-
5	*J. m*	-	-	-	-	-	100±00
6	*A. p*	-	-	-	-	-	100±00
7	*P. g*	36.6±00	-	-	-	-	-

Note: - Absent*, *Pinus wallichiana (P.w)*, *Pinus gerardiana (P.g)*, *Betula utilis (B.u)*, *Juniperus excelsa (J.e)*, *Juniperus macropoda (J.m)*, *Abies pindrow (A.p)*, *Picea smithiana (P.s)*

Group III: *Picea smithiana* and *Juniperus excelsa* group: Having seven stands this cluster group has two coniferous tree species i.e. *Picea smithinana* as leading specie with (91.61±5.4% average importance value) while co-dominant *Juniperus excelsa* contributed (29.4±04% average importance value).

In this group the ground flora comprises of twenty eight species including seedlings of trees, herbs and shrubs among them *Anaphalis nepalensis, Astragalus zanskarensis, Bistorta affinis*, *Cicer songaricum*, *Geranium partens*, *Leontopodium leontopodinum, Potentilla anserine*, *Urtica dioica, Viola rupestris, Thymus serpyllum* and *Rumex hastatus are* Occasionally occurring species. Moreover some species i.e.*Rosa webbiana, Anaphalis virgata*, *Artemisia brevifolium*, *Bergenia stracheyi, Juniperus communis*, *Oxyria digyna, Rheum tibeticum, Ribes alpestre, Ribes orientale*, *Rubus irritans*, *Verbascum Thapsus, Tanacetum artemisioides, Taraxacum sp.*, *Trifolium partense, Trifolium repens* and *Spiraea canescens* were showing rare position. Whereas only one species *Fragaria nubicola* was recorded as frequent with 43% frequency. The frequency of any species not reached at the level of abundant and very abundant. This indicates there should be pay special consideration to the forest understory vegetation in this area.

The characteristics of environmental variable of this group have considerably similar to the group I (b) while at low elevation as compare to the other cluster groups. This group located on an average of 3178±116 meter elevation with 39^0 steep slopes.

The Edaphic feature of this group showed mean value of TDS 32.9±10, water holding capacity 46.5±3.7, salinity 0.05±0.02, conductivity 75.8±22 and Organic matter 6.8±1.3 percent respectively. The soil of this group III was slightly acidic in nature having the mean value of pH 6.4±0.6. Soil nutrients of this group showed the mean value of Ca^{++} 231±22, Mg^{++}117±4.6, K^{+} 206±19, Co^{++} 0.8±00, MN^{++} 14±1.9, Zn^{++}1.4±0.2 and Fe^{++} 127±19.2 ppm respectively (Table 3).

Group IV: Pure *Betula utilis* group: This is a smallest group as compare to the earlier groups having a single angiospermic tree species *Betula utilis* with (100±00% average importance value) and 22±10 moderate slope.

The understory vegetation shared twenty three species including seedlings of *Betula utilis* among these *Anaphalis nepalensis, Rumex hastatus, Geranium partens*, *Potentilla anserine*, *Fragaria nubicola, Viola rupestris, Urtica dioica, Thymus serpyllum* are occasionally occurring species while *Betula utilis*, *Anaphalis virgata*, *Inula rhizocephala, Juniperus communis*, *Oxyria digyna, Rheum tibeticum, Taraxacum sp.*, *Ribes orientale, Rosa webbiana, Rubus irritans* and *Ribes alpestre are* rare species. Some species also found as frequent in this group i.e. *Bistorta affinis* 47%, *Bergenia stracheyi* 43%, *Trifolium partense* 47% and *Leontopodium leontopodinum* 45% with mean frequency whereas no any species attempted very abundant position.

With the respect of the topographic feature this group is situated on an average elevation of 3214±144 with 22^0 moderate slope.

The Edaphic feature of this group showed mean value of TDS 32.9±10, water holding capacity 46.5±3.7, salinity 0.05±0.2, conductivity 75.82±22 and organic matter 13.4±5.8 percent respectively. The soil of this group was slightly acidic in nature having the mean value of pH 6.4±0.6. While in case of the soil nutrients this group showed the mean value of Ca^{++} 213±20.7, Mg^{++}125±3.9,K^{+} 277±37.9, Co^{++} 0.7±00,Mn^{++} 14.8±2.3, Zn^{++} 0.8±0.1 and Fe^{++} 132±6.3ppm respectively (Table 3).

Group V: *Abies pindrow* and *Juniperus macropoda* group: Among all the cluster groups this group is the smallest group having only two stands. The coniferous tree species *Abies pindrow* shared (100±00 importance value) while the *Juniperus macropoda* also contributed (100±00 importance value) for this group.

The forest ground flora comprises of sixteen species among them *Bergenia stracheyi*, *Geranium partens*, *Leontopodium leontopodinum, Rubus irritans*, *Rosa webbiana and Potentilla anserina* are occasionally occurring species, while *Urtica dioica, Trifolium repens, Taraxacum sp.*, *Ribes alpestre* and *Juniperus communis* are recorded as rare species, whereas some species present frequently i. e. *Anaphalis virgata* 45%, *Artemisia brevifolium* 50%, *Bistorta affinis* 45%, *Fragaria nubicola* 55% and *Nepeta discolor* 45%. There is no presence of a species with the position of abundant in this group.

As compared to the other cluster groups, this group is entirely different because this group located on highest elevation 3600± 136 m with 45 steep slopes.

The Edaphic feature of this group showed mean value of TDS 20.9±0.9, water holding capacity 32.5±7, salinity 0.1±0.1, conductivity 46.2±2.2 and Organic matter 4.2±0.3 percent respectively. The soil of this group-V was also slightly acidic in nature having the mean value of pH 6.2±0.6. While in case of the soil nutrients this group showed the mean value of Ca^{++} 237±21.3, Mg^{++}132±13.5,K^{+} 250±94.5, Co^{++} 0.7±00,Mn^{++} 12.4±1.5, Zn^{++} 0.9±0.1 and Fe^{++} 130±26ppm respectively (Table 3).

A. Univariate Analysis of Variance (ANOVA): Five main groups of tree vegetation data were derived using by Ward's Cluster Analysis where as using univariate analysis of variance (ANOVA) the environmental characteristics i.e. topographic factors and edaphic factors (Table 4) of each groups were analyzed. Both of the topographic variables (elevation and slope) were found non-significant with 1.3 and 2.3 F ratio respectively. Among the five edaphic variables i.e. TDS, pH, water holding capacity, salinity and conductivity all found non-significant except pH with 3.6 F ration. While on the other hand in case of soil nutrients all showed non-significant (Table 4).

Table 3. Average frequency of understory species in the five groups derived from Ward's cluster analysis of the tree vegetation data.

S. No.	Name of species	Group I (a)	Group I (b)	Group II	Group III	Group IV	Group V
1	*Anaphalis nepalensis*	18	26	20	25	27	45
2	*Anaphalis virgata*	22	18	-	17	5	-
3	*Artemisia brevifolium*	20	22	-	15	-	50
4	*Astragalus zanskarensis*	17	31	20	30	-	-
5	*Berberis orthobotrys*	12	30	28	-	-	-
6	*Bergenia stracheyi*	14	33	39	5	43	30
7	*Betula utilis*	15	-	5	-	20	-
8	*Bistorta affinis*	15	36	36	32	47	45
9	*Cicer songaricum*	14	42	15	32	-	-
10	*Fragaria nubicola*	20	34	34	43	32	55
11	*Geranium partens*	9	27	34	34	28	25
12	*Hieracium lanceolatum*	16	15	7	-	-	-
13	*Inula rhizocephala*	7	15	29	-	18	-
14	*Juniperus communis*	7	19	17	14	7	20
15	*Leontopodium himalayanum*	30	-	12	-	-	-
16	*Leontopodium leontopodinum*	-	36	28	25	42	30
17	*Myostis asiatica*	5	23	40	-	-	-
18	*Nepeta discolor*	7	17	15	-	-	45
19	*Oxyria digyna*	16	10	39	15	20	-
20	*Pinus wallichiana*	35	17	10	-	-	-
21	*Potentilla anserina*	40	27	28	22	35	25
22	*Rheum tibeticum*	-	15	15	13	12	-
23	*Ribes alpestre*	-	17	17	18	20	10
24	*Ribes orientale*	10	17	11	5	10	-
25	*Rosa webbiana*	18	19	22	12	12	22
26	*Rubus irritans*	5	37	35	20	15	25
27	*Rumex hastatus*	8	15	15	21	30	-
28	*Spiraea canescens*	6	13	10	5	-	-
29	*Tanacetum artemisioides*	31	20	32	5	-	-
30	*Taraxacum sp*	-	19	17	20	20	20
31	*Taraxacum baltistanicum*	16	35	8	-	-	-
32	*Thymus serpyllum*	60	40	26	33	37	-
33	*Trifolium partense*	12	-	35	14	45	-
34	*Trifolium repens*	9	23	35	15	-	10
35	*Urtica dioica*	12	37	35	40	27	10
36	*Verbascum thapsus*	-	20	20	13	-	-
37	*Viola rupestris*	-	32	26	37	33	-

Note: - is Absent

Table 4. Mean values ± SE of environmental variables (topographic, edaphic and Soil nutrient) based on five groups derived from Ward's cluster analysis using tree vegetation data of 40 stands form three districts of Gilgit-Baltistan.

Variable	Group I (a)	Group I(b)	Group II	Group III	Group IV	Group V
1- Topographic variables						
1-Elevation (m)	3421±101	3169±117	3373±101	3178±116	3214±144	3600±136
2-Slope^{o}	27±2.2	28±4.7	33±2.5	39±1.6	22±10	45±00
2- Edaphic variables						
1-TDS	18.1±3.1	18.4±3.5	25.6±3.4	32.9±10	32.9±10	20±0.9
2-pH	5.5±0.1	6.2±0.2	6.9±0.2	6.4±0.6	6.4±0.6	6.3±0.6
3-WHC	45.52±5	50.97±5	41.14±5	46.5±3.7	46.5±3.7	32.5±7
4-Salinity	00±00	0.04±0.2	0.01±0.1	0.05±0.02	0.05±0.02	0.1±0.1
5-Conductivity	42.46±7.1	42.7±7.8	58.4±7.6	75.8±22	75.82±22	46.2±2.2
6-OM	5.5±0.6	8.3±1.5	7.7±1.3	6.8±1.3	13.4±5.8	4.2±0.3
3-Soil Nutrients						
1-Ca	171±16.1	192±11.9	177±14	231±22	213±20.7	237±21.3
2-Mg	130±9.5	144.9±8.5	127±8.4	117±4.6	125±3.9	132±13.5
3-K	202±15.6	205±21.7	206±15.5	206±19	277±37.9	250±94.5
4-Co	0.7±00	0.8±00	0.7±00	0.8±00	0.7±00	0.7±00
5-Mn	8.7±1.5	13.6±1.6	13.6±1.9	14±1.9	14.8±2.3	12.4±1.5
6-Zn	1.2±0.1	1.2±0.2	1.2±0.1	1.4±0.2	0.8±0.1	0.9±0.1
7-Fe	91.6±19.2	165.7±17	125±14.6	127±19.2	132±6.3	130±26.3

SE = Standard error, (Mean ± SE).

B. **Ward's Cluster Analysis of Stands (Understory vegetation data):** The Dendrogram of Cluster Analysis of understory vegetation based on frequency applying ward's method is presented in Fig. 3 while the frequencies of groups are given in Table 4. Environmental groups based on cluster analysis are presented in Table 5.

On the basis of frequency and two environmental characteristics i.e. slope and elevation, the ground flora divided in to five main groups these groups are briefly described in the following.

Group I: This is a largest group as compare to the other cluster groups which comprises of 10 stands. In this cluster groups, a total of thirty species were recorded among them *Potentilla anserine* showed 36%, *Tanacetum artemisioides* attained 33.48% and the seedling of coniferous tree species *Pinus wallichiana* occupied 31%, *Leontopodium himalayanum* 27.14%, *Bistorta affinis* 27%, *Anaphalis virgata* 23.21% average frequency. Most of the plants in this group i.e. *Anaphalis nepalensis, Artemisia brevifolium, Astragalus zanskarensis*, *Berberis orthobotrys*, *Bergenia stracheyi*, *Betula utilis*, *Cicer songaricum*, *Fragaria nubicola*, *Geranium partens*, *Hieracium lanceolatum*, *Inula rhizocephala*, *Juniperus communis*, *Myostis asiatica*, *Nepeta discolor, Oxyria digyna*, *Ribes orientale*, *Rosa webbiana*, *Rubus irritans*, *Rumex hastatus*, *Spiraea canescens*, *Urtica dioica*, *Trifolium partense*, *Trifolium repens, Taraxacum baltistanicum* are found as rare species.

The Topographic characteristics of this group recorded highest mean value 3515±29 m and with low mean slope 26±2.1 angle as compare to the other cluster groups of ground vegetation data.

Edaphic variables of this cluster group were recorded i.e. TDS 18.7±2.7, water holding capacity 46.14±4.5, salinity 0.0, conductivity 43.6±6.2 and Organic matter 6.2±0.5 percent recorded. The soil of this group was recorded moderately acidic in nature having the mean value of PH 5.6±6.0 while in case of the soil nutrients this group showed the mean value of Ca^{++} 174±14.2, Mg^{++} 125±7.4, K^{+} 207±16, Co^{++}0.7±00, MN^{++} 9.9±1.5, Zn^{++} 1.2±0.1 and Fe^{++} 79.8±14.1ppm respectively (Table 6).

Group II: This group attempts the second position among the all cluster groups having nine stands. The leading species *Urtica dioica* and, *Fragaria nubicola* recorded with 44.44% and 41% average frequency respectively. Most of the plant species i.e. *Astragalus zanskarensis*, *Cicer songaricum*, *Geranium partens*, *Inula rhizocephala*, *Juniperus communis*, *Oxyria digyna*, *Potentilla anserina*, *Ribes alpestre, Viola rupestris, Rumex hastatus*, *Taraxacum sp.*, *Trifolium partense, Trifolium repens,* and *Rubus irritans* are found occasionally with the frequency ranging from 21% to 36% while some are recorded as rare i.e. *Artemisia brevifolium, Verbascum Thapsus, Hieracium lanceolatum, Leontopodium leontopodinum, Pinus wallichiana* (seedlings), *Rheum tibeticum, Ribes*

orientale, Rosa webbiana, Spiraea canescens, Thymus serpyllum, and *Betula utilis* (seedlings) with 7% to 20% average frequency.

According to the environmental variables, this group recorded at low mean value of elevation i.e. 3026±29 m and with low mean slope 29±4.7 angle as compare to the other cluster groups of ground vegetation data.

On the basis of soil physical characteristics this cluster groups were recorded TDS 26.9±2.8, water holding capacity 37.33±3.4, high salinity level 0.04±0.02, conductivity 61.66±6 and Organic matter 7.2±1 percent respectively. The soil of this group was recorded neutral in nature having the mean value of PH 6.7±0.2. Soil nutrients of this group showed the mean value of Ca^{++} 198±15.9, Mg^{++} 123±7, K^{+} 236±18.6, Co^{++} 0.7±00, MN^{++} 13.9±1.9, Zn^{++} 1±0.2 and Fe^{++} 117±11.8 ppm respectively (Table 6).

Group III: This group includes eight stands and was composed of twenty six species among these fourteen species are common in group I and group II. The dominant species were *Nepeta discolor*, *Viola rupestris*, and *Fragaria nubicola* having 42%, 45% and 45% average frequency respectively representing frequent position. Other associated species found in this group were *Anaphalis nepalensis*, *Artemisia brevifolium, Bergenia stracheyi, Geranium partens*, *Leontopodium leontopodinum, Myostis asiatica, Potentilla anserine*, *Ribes orientale, Rosa webbiana, Rubus irritans*, *Thymus serpyllum*, *Urtica dioica, Trifolium repens,* and *Tanacetum artemisioides* showing 23 % to 39% average frequency representing the occasional category. Few species were rare i.e.*Anaphalis virgata*, *Astragalus zanskarensis, Juniperus communis*, *Ribes alpestre, Oxyria digyna* and *Betula utilis* (seedlings) having 10% to 20% average frequency.

On the basis of the topographic characteristics this group was recorded mean elevation 3122±170 m and with mean steep slope 36±4.3 angle. The slope of this group was high as compare to the other cluster groups.

Soil edaphic variables of this cluster group were recorded i.e. TDS 16.06±2.08, water holding capacity 49.25±6.5, slightly high salinity 0.3±0.2, conductivity 37.57±4.7 and low organic matter 4.3±0.7 percent respectively. The soil of this group was recorded neutral in nature having the mean value of PH 6.6±0.2. Soil nutrients of this group showed the mean value of Ca^{++} 195±14.1, Mg^{++} 150±8.1, K^{+} 225±27, Co^{++} 0.7±00, MN^{++} 10±1.6, Zn^{++} 1.3±0.3 and Fe^{++} 187±18.3 ppm respectively (Table 6)

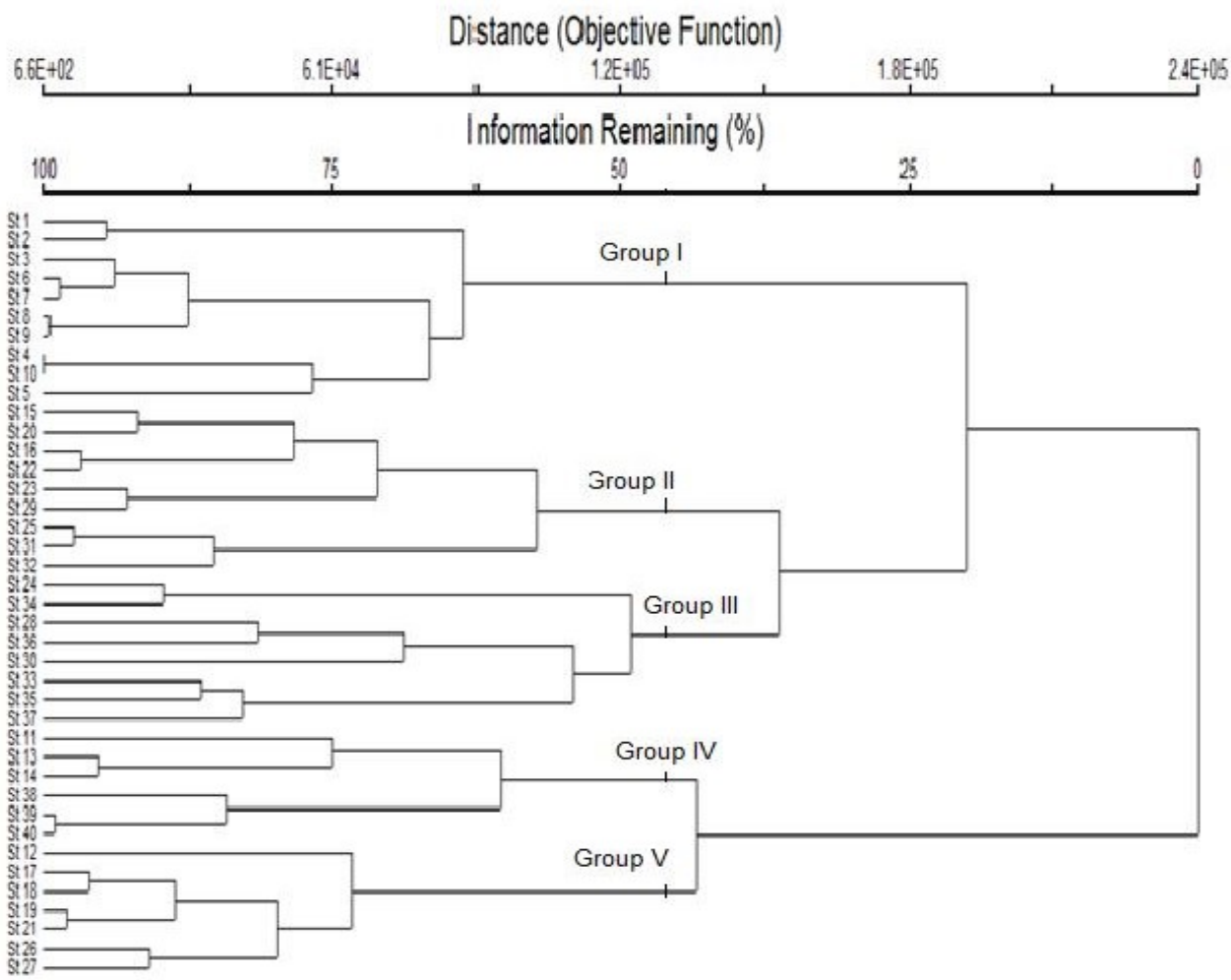


Fig. 3. Dendrogram obtained from Ward's Cluster Analysis of understory species on the basis of frequency, showing five distinct groups.

Table 5. Analysis of variance of individual environmental variables (topographic, edaphic five groups were derived by Ward's cluster analysis using tree vegetation data of 40 stands.

Source of Variation		SS	df	MS	F	P-level
1- Topographic Variables						
1-Elevation	Between Groups	657343.8	5	131468.8	1.300113	ns
	Within Groups	3438116	34	101121.1		
	Total	4095460	39			
2-Slope	Between Groups	1379.118	5	275.8236	2.342242	ns
	Within Groups	4003.857	34	117.7605		
	Total	5382.975	39			
2- Edaphic Variables						
1-TDS	Between Groups	921.7948	5	184.359	1.50731	ns
	Within Groups	4036.228	33	122.3099		
	Total	4958.023	38			
2-pH	Between Groups	9.930164	5	1.986033	3.69951	P < 0.05
	Within Groups	18.44973	34	0.542639		
	Total	28.3799	39			
3-WHC	Between Groups	831.7013	5	166.3403	0.813813	ns
	Within Groups	6949.473	34	204.3963		
	Total	7781.174	39			
4-Salinity	Between Groups	0.027179	5	0.005436	2.238235	ns
	Within Groups	0.082571	34	0.002429		
	Total	0.10975	39			
5-Conductivity	Between Groups	4834.794	5	966.9589	1.67244	ns
	Within Groups	19657.86	34	578.1725		
	Total	24492.66	39			
6-OM	Between Groups	205.16147	5	41.032294	1.8133551	ns
	Within Groups	769.34628	34	22.627832		
	Total	974.50775	39			
3-Soil Nutrients						
1-Ca	Between Groups	23133.273	4	5783.3182	2.5295187	ns
	Within Groups	75448.938	33	2286.3314		
	Total	98582.211	37			
2-Mg	Between Groups	3555.204	5	711.04079	1.3159702	ns
	Within Groups	18370.771	34	540.3168		
	Total	21925.975	39			
3-K	Between Groups	197.64424	5	39.528847	1.5963257	ns
	Within Groups	841.9214	34	24.762394		
	Total	1039.5656	39			
4-Co	Between Groups	0.0230831	5	0.0046166	0.6668908	ns
	Within Groups	0.2353688	34	0.0069226		
	Total	0.2584519	39			
5-Mn	Between Groups	197.64424	5	39.528847	1.5963257	ns
	Within Groups	841.9214	34	24.762394		
	Total	1039.5656	39			
6-Zn	Between Groups	1.1185376	5	0.2237075	0.9796535	ns
	Within Groups	7.7640268	34	0.2283537		
7-Fe	Total	8.8825644	39			
	Between Groups	26337.835	5	5267.5671	2.1895925	ns
	Within Groups	81794.8	34	2405.7294		
	Total	108132.64	39			

Note: SS = Sum of square, MS = Mean square, F = F ratio, df = Degree of freedom, P level = Probability level and ns = Non significant.

Table 6. Average frequency of understory species in the five groups derived from Ward's cluster analysis of the understory vegetation data.

S. No	Name of Plant Species	SP cod	Group 1	Group 2	Group 3	Group 4	Group 5
1	*Anaphalis nepalensis*	ANE	14.28	0	33.33	23.33	25
2	*Anaphalis virgata*	AVI	23.21	0	15	0	20
3	*Artemisia brevifolium*	ABR	11	17.5	27	15	0
4	*Astragalus zanskarensis*	AZA	16.42	30	20	27	0
5	*Berberis orthobotrys*	BOR	15	0	0	27	0
6	*Bergenia stracheyi*	BST	15.24	0	30	39	45
7	*Betula utilis*	BUT	5.35	20	15	0	20
8	*Bistorta affinis*	BAF	27	0	40	36	43
9	*Cicer songaricum*	CSO	14.28	32	0	41	0
10	*Fragaria nubicola*	FNU	16	44.44	42	0	27
11	*Geranium partens*	GPA	9.27	36	27	30	27
12	*Hieracium lanceolatum*	HLA	16.49	15	0	0	0
13	*Inula rhizocephala*	IRH	6.24	32	0	0	12
14	*Juniperus communis*	JCO	7.19	32	16	17	12
15	*Leontopodium himalayanum*	LHI	27.14	0	0	0	0
16	*Leontopodium leontopodinum*	LLE	0	20	31.43	33.33	36.42
17	*Myostis asiatica*	MAS	6	0	30	20	40
18	*Nepeta discolor*	NDI	12	0	45	15	20
19	*Oxyria digyna*	ODI	20	22	10	0	20
20	*Pinus wallichiana*	PWA	31	15	0	0	20
21	*Potentilla anserina*	PAN	36	25	28.33	27	26
22	*Rheum tibeticum*	RTI	0	15	0	17	11
23	*Ribes alpestre*	RAL	0	21	17	15	15
24	*Ribes orientale*	ROR	11	12	22	10	13.33
25	*Rosa webbiana*	RWE	18	16	23	16.25	10
26	*Rubus irritans*	RIR	5	29	30	0	7
27	*Rumex hastatus*	RHA	9	21	10	0	0
28	*Spiraea canescens*	SCA	9	7	0	20	7
29	*Tanacetum artemisioides*	TAR	33.48	0	22	12	0
30	*Taraxacum sp*	TSP	0	22	20	15	12
31	*Taraxacum baltistanicum*	TBA	18.32	0	0	22	0
32	*Thymus serpyllum*	TSE	0	20	38	34	40
33	*Trifolium partense*	TPA	12.49	30	0	30	10
34	*Trifolium repens*	TRE	12	22	21	0	0
35	*Urtica dioica*	UDI	13	41	22	0	22
36	*Verbascum thapsus*	VTH	0	17	0	25	5
37	*Viola rupestris*	VRU	0	30	45	17	35

Group IV: Among the entire cluster group this was the smallest group including six stands. In this group a total of twenty five species are present, floristic composition more or less similar to the group I. Among these *Cicer songaricum*, *Bergenia stracheyi, and Bistorta affinis* are dominant species with 41%, 39% and 36% average frequency respectively. Other associated species i.e. *Anaphalis nepalensis* 23.33%, *Astragalus zanskarensis* 27%, *Berberis orthobotrys* 27%, *Geranium partens*30%, *Leontopodium leontopodinum* 33.33%, *Potentilla anserina* 27% were recorded with average frequency. The rare species i.e. *Artemisia brevifolium, Juniperus communis*, *Myostis asiatica*, *Nepeta discolor, Rheum tibeticum, Ribes alpestre, Ribes orientale, Rosa webbiana, Spiraea*

canescens, Viola rupestris, Taraxacum sp., *Tanacetum artemisioides* associated with low average frequency.

On the basis of the topographic characteristics, this group was recorded at mean elevation 3480±48 m and with mean slope 32±4.8 angle.

The Physical characteristics were recorded i.e. TDS 11.48±1.7, water holding capacity 48.95±6.1, salinity 0.0, conductivity 27.16±3.9 and organic matter 9.7±1.3 percent respectively. The soil of this group was showed strongly acidic in nature having the mean value of pH 5.5±0.09.While in case of the soil chemical properties this group showed the mean value of Ca^{++} 199±20.9, Mg^{++}137±12.7, K^{+}177±18.3, Co^{++}0.8±00, MN^{++}16±1.5, Zn^{++}1.5±0.1 and Fe^{++} 138±12.9ppm respectively (Table 6).

Group V: This group consists of seven stands having twenty six species, predominantly *Bergenia stracheyi*, *Bistorta affinis*, *Myostis asiatica* and *Thymus serpyllum* with 45%, 43%, 40% and 40% average frequency respectively. *Anaphalis nepalensis, Fragaria nubicola, Geranium partens*, *Potentilla anserina*, and *Leontopodium leontopodinum* are recorded occasionally from range of 23% to 36% average frequency. Some species are dispersed with the range of average frequency from 10% to 20% i.e. *Inula rhizocephala*, *Juniperus communis*, *Nepeta discolor, Rosa webbiana*, *Rheum tibeticum*, *Ribes alpestre*, *Oxyria digyna* and *Pinus wallichiana* (seedlings).

On the basis of the environmental properties this group was recorded at mean elevation 3307±60 m and with mean slope 32±4.9 angle.

Soil edaphic variables of this cluster group were recorded i.e. TDS 30.38±5.9, water holding capacity 44.85±40, salinity 0.02±0.01, conductivity 69.24±13 and Organic matter 12±3.5 percent respectively. The soil of this group was recorded slightly acidic in nature having the mean value of pH 6.2±0.4.While in case of the soil nutrients this group showed the mean value of Ca^{++} 220±21.7, Mg^{++} 120±3.9, K^{+} 215±27.9, Co^{++} 0.8±00, Mn^{++} 16±1.6, Zn^{++} 1.1±0.2 and Fe^{++} 139±8.2ppm respectively (Table 6).

Univariate Analysis of Variance Ground Vegetation Data (ANAVA): Five main groups of ground flora vegetation data were derived using by Ward's cluster analysis where as using univariate analysis of variance (ANOVA) the environmental characteristics i.e. topographic factors and Edaphic factors (Table 7) of each groups were analyzed. Between the topographic variables i.e. Elevation and slope the elevation was found significant difference in group means with 4.5 F ratio while the slope was non-significant with 1.0 F ratio. Among the five edaphic variable i.e. TDS, water holding capacity, salinity and all found non-significant except PH, conductivity and organic matter were recorded significantly correlation with 7.79, 4.64 and 3.617 F-ratio respectively. While in case of the soil chemical properties of cluster groups of tree vegetation data MN^{++} and Fe^{++} were showed significantly correlation with F- ration 3.23 and 8.65 respectively (Table 7).

Table 7. Mean values of the environmental variables based on the five groups obtained from Ward's method of cluster analysis using understory vegetation data of 40 stands from forested areas of Gilgit-Baltistan. (Mean ± SE):

Variable	Group I	Group II	Group III	Group IV	Group V
1- Topographic variables					
1-Elevation (m)	3515±29	3026±102	3122±170	3480±48	3307±60
2-Slope^{o}	26±2.1	29±4.7	36±4.3	32±4.8	32±4.9
2- Edaphic variables					
1-TDS	18.7±2.7	26.9±2.8	16.06±2.08	11.48±1.7	30.38±5.9
2-pH	5.4±0.05	6.7±0.2	6.6±02	5.5±0.09	6.28±0.4
3-WHC	46.14±4.5	37.33±3.4	49.25±6.5	48.95±6.1	44.85±40
4-Salinity	00±00	0.04±0.02	0.30±0.2	00±00	0.02±0.01
5-Conductivity	43.6±6.2	61.66±6	37.57±4.7	27.16±3.9	69.24±13
6-OM	6.2±0.5	7.2±1	4.3±0.7	9.7±1.3	12±3.5
3-Soil Nutrients					
1-Ca	174±14.2	198±15.9	195±14.1	199±20.9	220±21.7
2-Mg	125±7	123±7	150±8.1	137±12.7	120±3.9
3-K	207±16	236±18.6	225±27	177±18.3	215±27.9
4-Co	0.7±0	0.7±00	0.7±00	0.8±00	0.8±00
5-Mn	9.9±1.5	13±1.9	10±1.6	16±1.5	16±1.6
6-Zn	1.2±0.1	1±0.2	1.3±0.3	1.5±0.1	1.1±0.2
7-Fe	79.8±14.1	117±11.8	187±18.3	138±12.9	139±8.2

Table 8. Analysis of variance of individual environmental variables (topographic, edaphic five groups were derived by Ward's cluster analysis using circular plot data of 40 stands.

Source of Variation		SS	DF	MS	F	P-level
1- Topographic Variables						
1-Elevation	Between Groups	1395984	4	348995.9	4.524899	P < 0.05
	Within Groups	2699476	35	77127.89		
	Total	4095460	39			
2-Slope	Between Groups	557.2429	4	139.3107	1.010391	ns
	Within Groups	4825.732	35	137.8781		
	Total	5382.975	39			
2- Edaphic Variables						
1-TDS	Between Groups	1184.096	4	296.024	2.949503	ns
	Within Groups	3512.742	35	100.364		
	Total	4696.838	39			
2-pH	Between Groups	13.37163	4	3.342908	7.795824	P < 0.001
	Within Groups	15.00826	35	0.428808		
	Total	28.3799	39			
3-WHC	Between Groups	780.7475	4	195.1869	0.975875	ns
	Within Groups	7000.426	35	200.0122		
	Total	7781.174	39			
4-Salinity	Between Groups	0.014492	4	0.003623	1.331181	ns
	Within Groups	0.095258	35	0.002722		
	Total	0.10975	39			
5-Conductivity	Between Groups	8492.849	4	2123.212	4.644582	P < 0.05
	Within Groups	15999.81	35	457.1374		
	Total	24492.66	39			
6-OM	Between Groups	285.0378	4	71.25944	3.617388	P < 0.05
	Within Groups	689.47	35	19.69914		
	Total	974.5078	39			
3-Soil Nutrients						
1-Ca	Between Groups	9269.605	4	2317.401	1.012163	ns
	Within Groups	80134.37	35	2289.553		
	Total	89403.98	39			
2-Mg	Between Groups	4809.491	4	1202.373	2.458627	ns
	Within Groups	17116.48	35	489.0424		
	Total	21925.98	39			
3-K	Between Groups	13756.79	4	3439.196	0.915388	ns
	Within Groups	131498.2	35	3757.091		
	Total	145255	39			
4-Co	Between Groups	0.021054	4	0.005263	0.776	ns
	Within Groups	0.237398	35	0.006783		
	Total	0.258452	39			
5-Mn	Between Groups	280.8672	4	70.2168	3.239216	P < 0.05
	Within Groups	758.6984	35	21.6771		
	Total	1039.566	39			
6-Zn	Between Groups	0.912663	4	0.228166	1.001995	ns
	Within Groups	7.969902	35	0.227711		
	Total	8.882564	39			
7-Fe	Between Groups	53777.8	4	13444.45	8.65711	P < 0.001
	Within Groups	54354.83	35	1552.995		
	Total	108132.6	39			

Note: SS = Sum of Square, MS = Mean Square, F = F ratio, DF = Degree of Freedom, P level = Probability level and ns = Non significant.

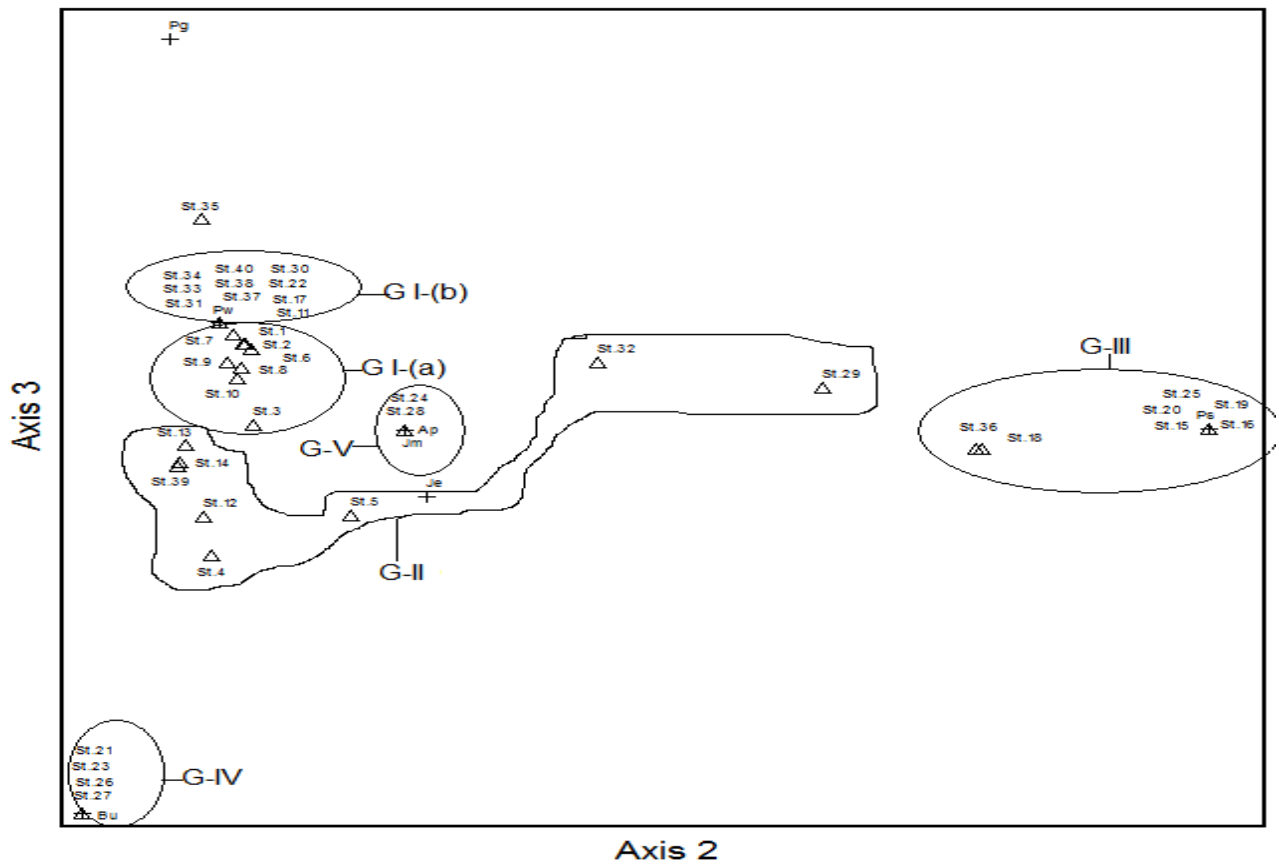


Fig. 4. DCA ordination of stands, using tree species data of 40 stands of forested areas from three districts of Gilgit-Baltistan

C. ORDINATION:

(a) **DCA ordination of tree vegetation data:** Importance value of tree species and topographic variables (elevation and slope) are in DCA ordination to find out the correlation between the vegetation composition and topographic variables. Five main groups are differentiated by Ward's cluster analysis are clearly superimposed on DCA ordination (axes 1,2 ; 1,3 & 2,3), no overlapping was seen on ordination axis 1.2 and 1,3 where as on ordination axis 2,3 five groups separate out clearly. Having 9 stands Group I is the largest group among all five groups. This group is further divided into two sub groups i.e. group I (a) and group I (b) due to the different species composition. In all the nineteen stands *Pinus wallichiana* is dominated.

Group I (a) consists of 9 stands dominated by *Pinus wallichiana* but some other species are also associated with this group i.e. *Juniperus excelsa, Betula utilis* and *Pinus gerardiana* while Group I (b) consists of 10 stands in which *Pinus wallichiana* found as mono specific order. Group I (a) was located on the elevation of 2639 to 3700 meters and 15 to 35° slope angle while the Group I (b) located on the elevation of 2669 to 3596 meters with plain to 45° slope angle.

Group II is composed of (stands, 4, 5, 12, 13, 14, 29, 32, 39) in which stand 4 is dominated by *Betula utilis* while *Pinus wallichiana* and *Juniperus excelsa* are also associated.

Stand 5 is dominated by *Juniperus excelsa* while *Pinus wallichiana* is found as co-dominant species whereas *Betula utilis* is also found in this stand as associated species. In Stand 12, 13, 14 and 39 are occupied *Pinus wallichiana* as first dominant species while *Betula utilis* found as co-dominant. *Picea smithiana* is first dominant species in stand 29 while in this stand *Pinus wallichiana* is recorded as second dominant species. In stand 32 *Pinus wallichiana* contributed highest importance value being first dominate and *Picea smithiana* occupied second leading species. This group was recorded on the elevation range between 2719 to3600 with the 20 to 40 slope angle.

Seven stands of group III are dominated by *Picea smithiana* among these stands stand 15, 16, 19 and 25 are monospecific *Picea smithiana* stand while in stand 18, 20 and 36 *Juniperus excelsa* found as co-dominant species.

Group IV is separated on the basis of monospecific condition of an angiospermic species *Betula utilis*. In this group 4 stand i.e. stand 21, 23, 26 and 27 were recorded as pure *Betula utilis* species. The elevation and slope is ranged between 2616 to3523 and 33 to 45 respectively. The environmental variables varies in this group i.e. elevation and slope from 2893 to 3508 meters and plain to 40 angles respectively. This species also found in Group I (a) as third dominant and in Group II as second leading species

The last group is the smallest group among all the groups which composed of only two stands i.e.24 and 28 Stand no 24 is monospecific stands of *Juniperus macropoda* while stand 28 is monospecific *Abies pindrow* species. These two species never found with any other species in any groups or stands as co-dominant as well as

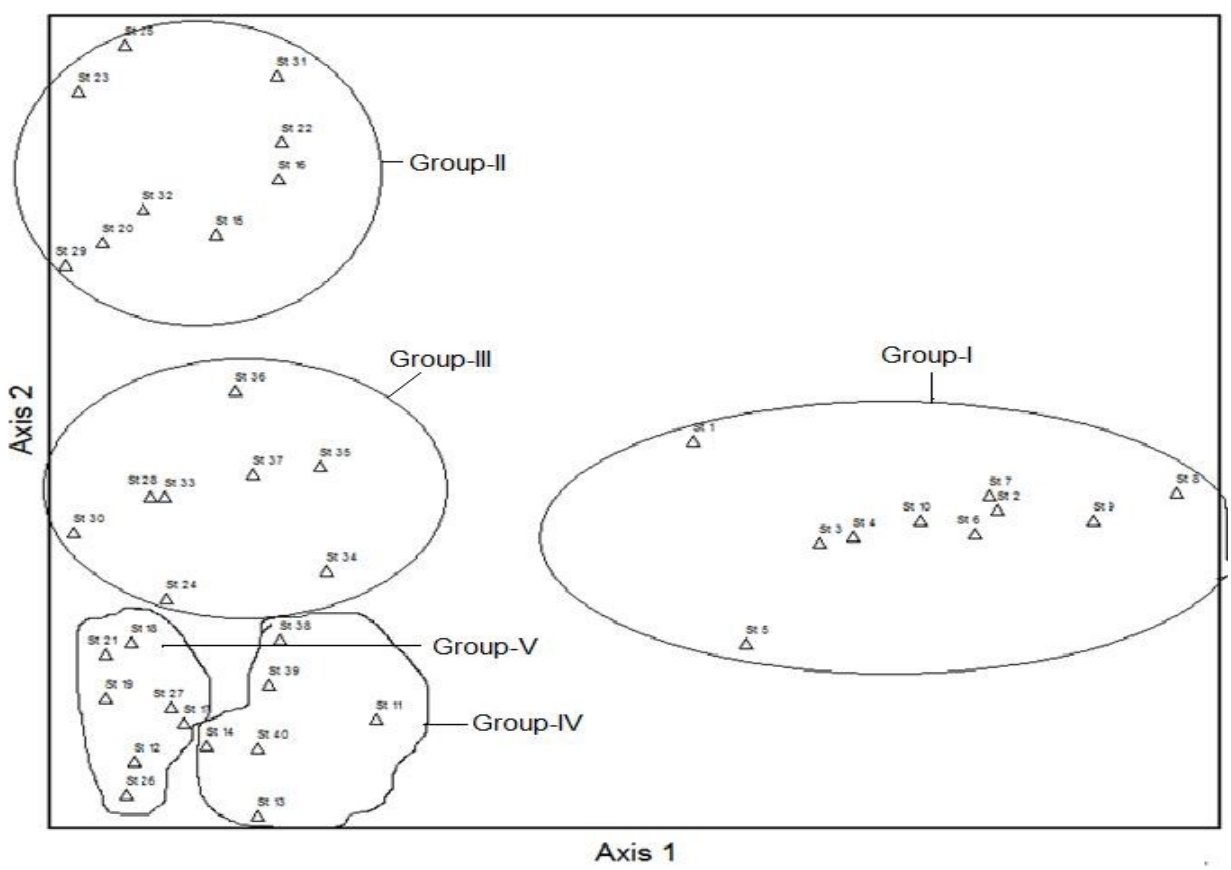
associated form. The elevation and slope ranges is high as compare to the other groups because this groups is lie on the elevation ranged from 3464 to 3736 meters and 45° slope angle.

Relationship (correlation coefficient) of three ordination axes with Topographic, Edaphic and Soil nutrients of tree vegetation data:
The Results between three Ordination axes with the different variables are presented in Table-8. Among the environmental factors only edaphic factor salinity ($P < 0.05$) and soil nutrient K^+ ($P < 0.05$), ($P < 0.05$) showed positively correlated with ordination axes 1, and ordination axes 2,3 correspondingly (Table-8).

(b) **DCA ordination of understory vegetation data:** The two dimensional DCA ordinations of all three axes i.e. 1and 2, 1 and 3 and 2 derived using the mean frequency of 37 understory vegetation with their corresponding environmental characteristics. The stands on ordination axis 1, 3 and 2 and 3 were overlapping to each other therefore there were no any clear grouping is occurring while the stands clearly spate out five groups only on the ordination axis 1 and 2. These groups were matched to the ward's cluster groups of understory vegetation.

Group-I was the largest group as compare to the other cluster groups which comprises of 10 stands. In this ordination group total thirty species were recorded among them *Potentilla anserine, Tanacetum artemisioides* and the seedling of coniferous tree species *Pinus wallichiana* were recorded as dominant species. Group-II attempts the second position among the all ordination groups having nine stands. This group was separate out due to the abundance of *Urtica dioica* and *Fragaria nubicola.* Group-III includes eight stands and was composed of twenty six species among these fourteen species are common in group I and group II. The dominant species were *Nepeta discolor*, *Viola rupestris*, and *Fragaria nubicola.* Among the entire ordination groups this is the smallest group consist of six stands. In this group total twenty five species were present the floristic composition more or less similar to the group I. Among these *Cicer songaricum*, *Bergenia stracheyi, and Bistorta affinis* were recorded as leading species. Group-V was consist of seven stands having twenty six species predominantly *Bergenia stracheyi*, *Bistorta affinis*, *Myostis asiatica* and *Thymus serpyllum*.

Relationship (correlation coefficient) of three ordination axes with Topographic, Edaphic and Soil nutrients of understory vegetation data:
Results of different environmental factors relationship with the three ordination axes was presented in table-9. Between the topographic variables Elevation ($P < 0.05$) was found positively correlated with axes 1. While among the edaphic factors only pH ($P < 0.05$), ($P < 0.01$) was showed positively correlated with axes 2 and 3 respectively. Whereas among the soil nutrients only Fe^{++} was recorded ($P < 0.05$) positively correlated with ordination axes 3.



. 5 Showing DCA stands ordination on axis 1 and 2 of ground flora.

Table 9. Relationship (correlation coefficients) of environmental variables (topographic and edaphic variables) with 3 DCA ordination axes obtained by tree vegetation data based on importance value of tree species.

S. No.	Variables	Axis 1		Axis 2		Axis 3	
		r	Prob. Level	r	Prob. Level	r	Prob. Level
	1- Topographic variables						
1	Elevation	0.218	Ns	0.095	Ns	0.0665	ns
2	Slope	0.277	Ns	0.012	Ns	-0.078	ns
	2- Edaphic variables						
1	TDS	-0.01	Ns	-0.01	Ns	0.31	ns
2	PH	0.045	Ns	0.16	Ns	0.07	ns
3	WHC	-0.2	Ns	-0.12	Ns	-0.06	ns
4	Salinity	0.345	P < 0.05	-0.42	Ns	0.14	ns
5	Conductivity	-0.02	Ns	-0.02	Ns	0.31	ns
6	OM	-0.16	Ns	-0.016	Ns	0.32	ns
	3- Soil Nutrients						
1	Ca	0.201	Ns	0	Ns	0.154	
2	Mg	0.021	Ns	-0.129	Ns	-0.230	
3	K	0.133	Ns	0.351	P < 0.05	0.384	P < 0.05
4	Co	-0.123	Ns	-0.081	Ns	-0.062	ns
5	Mn	-0.010	Ns	-0.066	Ns	0.227	ns
6	Zn	-0.155	ns	0.028	Ns	-0.243	ns
7	Fe	0.002	Ns	0.113	Ns	-0.062	ns

r = Correlation coefficient, ns = Non significant, Prob. Level = Probability level.

Table 10. Relationship (correlation coefficients) of environmental (topographic and edaphic variables) with 3 DCA ordination axes obtained by understory vegetation data based on frequency of understory species:

S. No.	Variables	Axis 1		Axis 2		Axis 3	
		r	Prob. Level	r	Prob. Level	r	Prob. Level
	1- Topographic variables						
1	Elevation	0.38	P < 0.05	-0.41	ns	-0.27	ns
2	Slope	-0.21	ns	-0.03	ns	0.16	ns
	2- Edaphic variables						
1	TDS	-0.23	ns	0.236	ns	-0.138	ns
2	PH	-0.52	ns	0.399	P < 0.05	0.423	P < 0.01
3	WHC	0.046	ns	-0.174	ns	-0.074	ns
4	Salinity	-0.26	ns	0.24	ns	-0.27	ns
5	Conductivity	-0.22	ns	0.23	ns	-0.13	ns
6	OM	-0.190		-0.254		-0.179	ns
	3- Soil Nutrients						
1	Ca	-0.271	ns	-0.058	ns	0.102	ns
2	Mg	-0.128	ns	-0.067	ns	-0.189	ns
3	K	-0.116	ns	0.241	ns	0.085	ns
4	Co	-0.102	ns	-0.177	ns	-0.305	ns
5	Mn	-0.284	ns	-0.194	ns	-0.259	ns
6	Zn	0.093	ns	-0.174	ns	0.004	ns
7	Fe	-0.444	ns	-0.149	ns	0.375	P < 0.05

Key to abbreviations: r = Correlation coefficient, ns = Non significant, Prob. Level = Probability level.

Discussions

The advanced multivariate technique of ward's cluster analysis (Goodall 1973) and DCA method of 40 forested stands were used to analyze. Five tree group and five ground flora vegetation groups were classified. Greig-Smith (1983) has a described the advantage of both approaches concurrently on the grounds that yield corresponding results and as such useful for better explanation of ecological results. Okono (1996) described cluster analysis is a quantitative method which is used for objective categorization. Lovtt *et al.,* (2001) and Gajoti *et al.,* (2010) described that the environmental variables contribute very important role in recognizing the vegetation distribution pattern. They also suggested that the elevation is most important factor to investigate the vegetation distribution pattern. In the present study the elevation and slopes were taken to determine the vegetation pattern. By ward's cluster analysis a total of five groups were recognized as tree vegetation data domination with different tree species.

Group-I (a) is composed of 9 stands dominated by *Pinus wallichiana* with second co-dominant *Juniperus excels* and 3rd associated species *Betula utilis* this community prefer to grow high elevation at 3421 m and low slope 27° angle. In this group *Pinus gerardiana* found as second leading species in stand-35. Ahmed *et al.,* (1991) described that *Pinus gerardiana* and *Juniperus* species are restricted to drier sites of dry temperate area. In this study both species occupied timber line area (elevation about 3700 m) where moisture is limiting factor in contrast to *Betula utilis* and *Pinus wallichiana* which prefer moisture on fire line. Group-I (b) was comprises of ten stands which was also the largest group. This was pure *Pinus wallichiana* group which was recoded on low average elevation 3169 m and low average slope 28° angle. Ahmed *et al.,* (2010) reported *Pinus wallichiana* from different climatic zones of Pakistan at the elevation of 1950 to 2700 m and 23° to 45° slope.

Group-II was also differentiated by the predominance of with *Pinus wallichiana* but second leading species was *Betula utilis*. This group composed of 8 stands, stand-4 and stand-5 dominated by *Betula utilis* and *Juniperus excelsa* respectively while stand- 29 dominated by *Picea smithina*. This group was recoded on medium average elevation at 3373m and medium slope 33° angle. Ahmed *et al.,* (2006) studied different climatic zones of Himalayan forest of Pakistan and identified 4 monospecific and 24 different communities. They observed *Pinus wallichiana* as monospecific condition on south exposure at 2770 m elevation from Naltar Gilgit and higher elevation 3100 m from Tukht-e-Suleiman.

Group-III was composed of 7 stands characterized by the predominance of *Picea smithiana* on low average elevating 3178 m and high slope 39° angle. Ahmed *et al.,* (2006) also studied more or less pure *Picea smithiana* forest from Naltar Gilgit on 3100 to 3250 m.

Group-IV is monospecific *Betula utilis* group which is found on medium average elevation on 3214 and low slope 22° angles. *Betula utilis* community also identified Ahmed *et al.,* (2006) on the elevation of 3350 to 3500 with co-dominance species of *Picea smithiana.* The smallest group among all the groups is group-V composed of two stands stand-24 is pure *Juniperus macropoda* and stand-28 is pure *Abies pindrow* forest. This group is located on high average elevation 3600 m and high slope 45° angle. Ahmed *et al.* (2006) also described *Abies pindrow* community on 3450 elevation from Astore near Rama Lake.

On the basis of stands of ground flora five main groups were recognized by Ward's Cluster Analysis. These five groups were separate out due to the presences of different vegetation species. Group I is largest groups among the entire cluster which is composed of 10 stands dominated by *Potentilla anserine* located on high average elevation 3515 with low slop 26° angle. The second largest group consist of 9 stands is Group II which is recognized by abundance of *Urtica dioica* species with low mean elevation 3026 m and low slope 29° angle. *Viola rupestris*, and *Fragaria nubicola* are found as dominant species in Group III which was situated on low medium elevation 3122 m and high slope 36 ° angle. Group IV was differentiated due to the dominance of *Cicer songaricum* on high elevation3480 m and medium 32° slope angle whereas *Bergenia stracheyi* is dominated species in Group V located on medium elevation 3307 with medium slope 32° angle.

The tree vegetations stands showed distinguished groups only on the axis 2 and 3 while on axis 1and 2 and 1 and 3 stands are overlapping therefore no any distinguishable groups were found. The groups which were separate out clearly on the ordination axis 2 and 3 were dominated by different tree species likewise the ground flora shows five groups only on the axis of 1and 2. The resulted group showed similar distribution pattern to the cluster groups of tree and understory vegetation stands.

Classification and ordination showed similar distribution pattern of tree species as well as understory vegetation. Relationships between the ordination axes with topographic variables i.e. elevation and slope and edaphic variables i.e. PH, TDS, Salinity, conductivity and water holding capacity also employed. Among the environmental variables elevation and pH was found significant difference ($P < 0.05$) and ($P < 0.001$) in groups mean with the ground flora data respectively whereas tree vegetation data set showed significant difference only with the ph of soil ($P < 0.05$) value. Similar results also recorded Siddiquii *et al.,* (2010) and Khan (2012).

Relationship between environmental variables and DCA ordination axes also evaluated. The environmental variables were not found significant correlation with axis 1, 2 and 3 except salinity which is significant ($P < 0.05$) value to the axis 1 of tree data set while in case of understory vegetation data set Elevation ($P< 0.05$) with axis 1 and pH ($P< 0.05$), ($P< 0.001$) with axis 2 and 3 showed significantly correlation respectively.

Conclusions:

One the basis of the study, it was concluded that that group resulted from tree vegetation data set and ground flora data set grouped that were associated with the topographical i.e. elevation and slope and Edaphic i.e. water holding capacity, TDS, pH, salinity and conductivity. The classification and ordination and environmental variables formulated the real depiction of the distribution and relationship of vegetation communities. In the present investigation the floristic association can easily describe with the different environmental characteristics. In most of the group the frequency of plant species not reached at the level of abundant and very abundant. This indicates these forest are under the pressure due to human induce and other natural disturbances there should be pay special consideration to the forest understory vegetation in this area.

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