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A QUANTITATIVE DESCRIPTION OF MOIST TEMPERATE CONIFER FORESTS OF HIMALAYAN REGION OF PAKISTAN AND AZAD KASHMIR

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ABSTRACT

The present study is based on the examination of quantitative vegetation description of moist temperate conifer forests of Himalayan region of Pakistan. Forty one stands at five different locations from Himalayan Region of Pakistan were chosen for the study. The underlying group in the vegetation was exposed using Ward's cluster analysis. The three groups derived from cluster analysis were superimposed on principal component analysis (PCA) ordination axes. Three main groups were clearly separated out on ordination plane (axis 1 and 2) Group I was dominated by *Pinus wallichiana* stands, group II was dominated by *Abies pindrow* while group III was composed of *Cedrus deodara* dominating stands. The relationships between environmental factors and vegetation were examined. Environmental variables generally showed no significant relation with ordination axes, among the environmental variables only elevation showed significant correlation with the ordination axes suggesting that the altitudinal gradient has an overriding role in the composition of vegetation. Moist temperate forests are highly disturbed due to anthropogenic causes. Some recommendations are proposed for the improvement and future research in these forests.

Key Words: Moist temperate Himalayan region of Pakistan, PCA ordination, quantitative forest vegetation description.

INTRODUCTION

Some workers have investigated the phytosociology of moist temperate locations in different parts of Pakistan (Champion *et al.*, 1965), but no comprehensive study of the entire area of moist temperate region has been undertaken. This study attempts to cover a greater part of the moist temperate areas of Himalayan region of Pakistan to carry out quantitative phytosociological investigation to describe various community types on the basis of floristic composition and importance value of species. Pakistan has insufficient forest resources. The country due to its sharp climatic variations and arid conditions lacks reasonable tree cover. There is hardly 4.28 million hectares or 4.9 percent of total area under forest / tree cover. Out of it the productive forests are less than 2% (Amjad *et al*. 1996). According to Champion *et al.* (1965) this formation extends along the whole length of the outer ranges of the Himalaya between the subtropical pine forests and the sub-alpine formation with a rainfall from about 25" (64cm) or 30" (76cm) to about 60" (152cm), climatological data being too inadequate to relate to the vegetation. The course of the isohyets results in the change to the dry temperate forests in the inner ranges, to which the south west monsoon hardly penetrates. The altitudinal range is from about 1372 m up to 3047 m, the limits varying markedly with aspect and configuration. The elevations of present study area were between 1600 to 3100 m. Evergreen forests of conifers, locally with some admixture of oak and deciduous broad-leaved trees fall in this category. Their undergrowth is rarely dense, and consists of both evergreen and deciduous species. These forests occur between 1500 m and 3000 m elevation in the Western Himalayas except where the rainfall is below about 1000 mm in the inner ranges, especially in the extreme north-west. These forests are divided into a lower and an upper zone, in each of which definite species of conifers and/or oaks codominate. In the lower zone, *Cedrus deodara*, *Pinus wallichiana*, *Picea smithiana* and *Abies pindrow* are the main conifer species in order of increasing altitude, with *Quercus incana* at lower altitudes and *Q. ilex* above 2130 m. In the upper zone *Abies pindrow* is the dominant tree species. There may be pockets of deciduous broad-leaved trees, mainly edaphically conditioned, in both the zones. Degradation forms take the shape of scrub growth and in the higher reaches, parklands and pastures are subjected to heavy grazing. Shafique (2003) described the some aspect of Bio-Ecology of Ayubia National park, Khyber Pakhtoon khwah. The park is internationally known as a hot spot in the moist temperate West Himalayan mountainous range in the sense that many endangered or threatened species are inhabited in the park. The park is purely build to protect this beautiful landscape predominantly enriched with coniferous forest (*Abies pindrow, Cedrus deodara, Pinus wallichiana, Picea smithiana* and *Taxus wallichiana*) mixed with broad-leaved evergreen (*Quercus floribunda, Q. glauca* and *Q. incana*) and deciduous broad-leaved trees (*Acer caesium, Aesculus indica, Cornus microphylla, Juglans regia, Populus ciliate, Prunus cornuta, Salix tetrasperma* and *Ulmus wallichiana*).Ahmed & Naqvi (2005) described the quantitative vegetation description of *Picea smithiana* from

Himalayan range of Pakistan. Phytosociological attributes and absolute values are calculated. Five stands of moist temperate and dry temperate area were also included in sampling stands. They also estimated the size frequency distribution of trees of studied forests. Ahmed *et al*. (2006) presented phytosociological and structural description of Himalayan forest (including moist temperate forests) from different climatic zones of Pakistan. They reported 24 different communities and 4 monospecific forests types on the basis of floristic composition and importance values of species. Some communities exhibited similar floristic composition but different quantitative values, description of understorey species also recorded. Malik *et al.* (2007) described phytosociological attributes of different plant communities of Pir Chinasi hills (moist temperate area) of Azad Jammu and Kashmir. The hills are protected from biotic interference such as grazing and cutting, therefore they represent natural vegetation. Thirteen plant communities were recognized based on species dominance. Some of the communities were dominated by tree species such as *Ficus palmata*, *Pinus wallichiana* and codominants *Picea smithiana* and *Pinus roxburghii*. They not only described the vegetation description but also structure of the forest and environmental factors (climate, soil condition, temperature, humidity, rain fall, wind and biotic factors.), affecting the vegetation.

MATERIALS AND METHODS

Phytosociology of the vegetation of moist temperate area of Himalayan region of Pakistan and Azad Kashmir is presented in the present study. Sampling was carried out at five main different locations viz. Malakand division, Azad Kashmir, Murree hills, Hazara division and Kaghan valley (Fig. 1). Conifer dominating forests were selected for the study but understorey species present in the forest were also analyzed. However, the results of understorey vegetation are not included in this study. The present study deals with species composition, distribution pattern and dominance concentration of the forests.

Sampling was carried out in conifer forests, throughout their natural limits in moist temperate area in Himalayan region of Pakistan**.** Though some forests are disturbed but mature and least disturbed forests were selected for quantitative sampling. The criteria for the selection of a stand were:

1-That it should be dominated by conifer trees
2-There should be no recent sign of disturbance
3-Stand should cover at least five hectare area

Forty one stands were sampled by Point Centered Quarter Method (Cottam and Curtis, 1956). At each stands twenty points were taken at every twenty meter intervals**.** Point centered quarter method is widely and successfully used not only in developed countries (e.g., New Zealand ,Australia, UK and USA) but also in developing countries like Pakistan. Ahmed *et al*. (1976, 1986, 1988, 1990, 1991 and 2006) Khan *et al.* (2008), Siddiqui *et al.* (2009) etc. used this technique frequently for the quantitative study of various forest types. The p.c.q. method has been recommended by Kent & Coker (1992) and Mueller-Dombois and Ellenberg (1974) for systematic and random sampling, particularly for tree vegetation. This method gives reliable overall density and relative density estimates (Greig-Smith, 1983). It is fast, reliable and requires little labour with relative ease of calculation and is readily applied in thick dense forest with uneven topography. Phytosociological attributes (relative density, relative frequency & relative basal area) were calculated, according to the method described Mueller-Dombois and Ellenberg (1974). PCA ordination (Orloci 1975) was used to summarize the compositional variation and to seek any trends in the data. Cluster analysis was performed using Ward's method (Orloci 1975). The resulting groups were described in the framework of ordination. Soil compaction of each stand was measured by soil compact meter. Aspect, altitude, slope angle, longitude and latitude of each stand were recorded using GPS. Importance Value Index (Brown and Curtis, 1952) was used to rank species. Plants specimens were identified with the help of flora of Pakistan (Nasir & Ali, 1972).

RESULTS AND DISCUSSION

The phytosociological attributes of the vegetation are presented in Table 2 a and 2b and results of principal component analysis (PCA) are given in Table 3 and 4 and Fig. 2. The first principal component accounts for 51.571% of the total variance. While the second component accounts for 42.784% of the total variance. The third component represented only 4.995% of the total variability. The first three components together account for 99.36% of the total variability (Table 2). The first component is primarily controlled by *Cedrus deodara*, *Abies pindrow* and *Pinus wallichiana*. The second component is largely a function of *Pinus wallichiana*, *Abies pindrow* and *Cedrus deodara* in that order. Whereas, the third component is governed by *Picea smithiana*, *Abies pindrow* and *Pinus*

wallichiana. The PCA stand ordinations on axes 1 and 2, is shown in Fig. 2 An examination of the distribution pattern of stands in two dimensions shows a V shaped distribution pattern of stands though the configuration depicts a dense area of the location of stands in the lower left. The environmental factors were correlated with the ordination axes (Table 3). Only elevation was found to be significantly correlated with axis 1, 2 and 3 ($P < 0.01$, $P < 0.05$ and $P < 0.1$ respectively). When the three main groups (I, II and III) derived from the cluster analysis by Ward's method were superimposed on PCA ordination (axes 1 and 2) and (axes 1 and 3) no overlapping of groups was seen in all three groups. The three groups separated out clearly in PCA ordination of axes 1 and 2. Three main groups are separated on the basis of the dominance of species. All 12 stands in group I are dominated by *Pinus wallichiana*. Group II is designated as *Abies pindrow* dominating group with few exceptions. Group II is the largest group, consisting of seventeen stands in which thirteen stands are dominated by *Abies pindrow*. Group III is dominated by *Cedrus deodara*, all twelve stands are dominated by *Cedrus deodara*. Stand 7 Chikkar and Stand 13 Patriata 2 of group I are the monospecific stands of *Pinus wallichiana*. Stand 1 Kumrat, Stand 2 Panahkot and Stand 28 Thandyani are occupied by *Cedrus deodara* as co-dominant species. *Abies pindrow* occupied second position in Stand 4 Malam Jabba 2, Stand 10 Suddhan gali 3 and Stand 18 Ghora Dhaka 3. *Albizzia chinensis* in Stand 14 Patriata 3 and *Pyrus pashia* (angiospermic species) in Stand 11 Ghora gali occurred with second position. *Picea smithiana* is second dominant species in Stand 30 Paya and Stand 39 Naran river belt. Thirteen stands of Group II are dominated by *Abies pindrow* whereas in four Stands it is second dominant species. *Pinus wallichiana* was found as a dominant species in three stands (stand 23 Changla gali, stand 26 Nathia gali and stand 32 Shogran), where as in stand 31 Sri *Picea smithiana* is the first dominant species. *Taxus wallichiana* specifically associated with the *Abies pindrow* on second or third position in Group II (Stand No. 16, 17, 19, 22 and 23. *Taxus wallichiana* was found in only stand 11 of Group I whereas it is absent in Group III with *Cedrus deodara*. In Group III seven stands (stand 6, 12, 29, 33, 36 and 37) were occupied by *Pinus wallichiana* as a second dominant species whereas in stand 24 *Abies Pindrow*, in stand 34 *Picea smithiana* and in stand 35 *Juglans regia* occupied second position. Stand 38 and 40 are the monospecific deodar forest. *Picea smithiana* is distributed in all three Groups regardless of first and second dominant species. *Picea smithiana* found as a dominant species in only in stand 31 which is far from the other species of the group. *Juglans regia* was mainly found in Group II with *Abies pindrow* in stands No. 22, 15 and 20 but it also found in stand 33 of Group III and totally absent in Group I. Mean elevation of Group I is 2368 meter that is suitable for the growth of Pinus *wallichiana*, mean elevation of Group II is 2618 meter suitable for *Abies pindrow* and Group III *Cedrus deodara* grows on the elevation of 2208 meter. Mean elevation of three groups show that the *Abies pindrow* prefers to grow on high altitude. *Pinus wallichiana* dominated stands found on the elevation of 1930 m to 3100 m, *Abies pindrow* dominated stands found on the elevation of 2400 m to 3000 m while *Cedrus deodara* dominating stands found on 1600 m to 2730 m elevation. Mean slope angle of Group I is 29º, Group II is 36º and Group III is 30º which indicates the slope requirement of trees. *Pinus wallichiana* groups were prefers to grow on south or south-west facing exposure. Not a single stand of *Pinus wallichiana* was found on east facing exposure and very rare stands found on north or north-west facing aspect. Out of seventeen stands of *Abies pindrow* only one stand found on east facing exposure and other stands distributed on all exposures, indicates that it is also not to prefer grow on east facing exposure. Group III dominated by *Cedrus deodara* grow on all exposures almost equally, it shows exposure do not take part on the growth of *Cedrus deodara*. Out of twelve stands of *Pinus wallichiana* eight stands found in moderate canopy, one in open and three in closed canopy. Eleven stands of *Abies pindrow* show close canopy, four moderate and two open canopies. *Cedrus deodara* groups show maximum closed canopies (seven stands), four stands show moderate and one shows open canopy.

Disturbance in the native forests may provide the opportunity for invasion of aggressive exotic species that may prevent or slow down native species from reestablishment. These species should be recognized and their possible allelopathic effects on conifer germination and seedling growth should be investigated. Forest floor is one of the most important factor, which regulates the forest ecosystem. In mature forest (undisturbed) the bulk of annual net primary production is returned to the forest floor as litter fall. Here, action mainly by micro-organism and supplemented by leaching results in the release of nutrients in the form available for uptake by plants. A detailed soil and tissue analysis will provide information to understand nutrient cycling and the nutrient requirement of conifer forests in Pakistan. To enhance growth of native associated species, grazing and fire should be allowed in a controlled manner. This will not only reduce the rate of soil erosion, increase the fertility but also provide better chances for seedling survival and growth of conifer in natural forests. Seedling regeneration status of various conifer forests should be assessed. It is seen that many conifer stands are deteriorating due to absence of any re-generation. It should also be investigated that, how much and what type of ground flora should be promoted for better survival of conifers seedlings, saplings and to check soil erosion in these forests. Socio-economic conditions of the local population should be enhanced by providing alternative energy sources, construction material, jobs and education to reduce the pressure on conifer utilization from the natives.

Table 1. Distribution of Conifer species in moist temperate areas of Pakistan and Azad Kashmir. Site characterstics of the study area.

St. No.	Location and sites	Latitude (N)	Longitude (E)	Altitude (m)	Slope (º)	Aspect	Soil Comp. (TIP)
	1- Malakand Division						
	Dir Upper,						
1	Kumrat	35º 54'	72º 14'	2400	R. Top	R. Top	165
2	Pana Kot	35º 16'	71º 50'	2200	40	W	150
	Swat						
3	Malam Jabba 1	35º 12'	72º 81'	2600	34	W	175
4	Malam Jabba 2	35º 20'	72º 40'	2350	30	N W	200
5	Miandam	35º 09'	72º 30'	2600	49	N	150
	2- Azad Kashmir						
6	Keran,Neelam Valley	34º 56'	73º 12'	1960	30	N E	250
7	Chikar,Jhelum Valley	34º 54'	73º 10'	1930	28	N W	150
8	Sudhan Gali, Dist.Baagh 1	34º 20'	73º 22'	2450	22	E	200
9	Sudhan Gali, Dist.Baagh 2	34º 22'	73º 28'	2500	32	N	130
10	Sudhan Gali, Dist.Baagh 3	34º 19'	73º 25'	2420	38	West	110
	3- Muree, Rawalpindi Division						
11	Ghora Gali	33º 52'	73º 20'	2100	29	N	150
12	Patreata Top 1	33º 50'	69º 56'	2300	40	S E	210
13	Patreata Top 2	33º 50'	69º 56'	2300	25	S W	110
14	Nia, Near Patriata	33º 52'	69º 57'	2000	39	S	150
15	Kashmir Point	34º 54'	73º 24'	2500	39	S	150
	4- Abbot Abad, Hazara Division						
16	Ghora dhaka 1	34º 02'	73º 26'	2500	36	N E	130
17	Ghora dhaka 2	34º 04'	73º 24'	2500	32	S E	170
18	Ghora dhaka 3	34º 07'	73º 25'	2800	40	S W	180
19	Ghora dhaka 4	34º 09'	73º 27'	2800	40	W	220
20	Ghora dhaka 5	34º 11'	73º 28'	2600	37	S W	170
21	Khaira Gali	33º 57'	73º 23'	2730	42	S E	120
22	Changla Gali 1	33º 59'	73º 23'	2650	47	W	180
23	Changla Gali 2	33º 59'	73º 23'	2670	35	S	150
24	Kuzah Gali 1	34º 02'	73º 24'	2560	R. Top	R. Top	210
25	Kuzah Gali 2	34º 02'	73º 24'	2560	28	S E	210
26	Nathiagali, Lalazar 1	34º 54'	73º 46'	2640	35	S	160
27	Nathiagali, Lalazar 2	34º 54'	73º 46'	2630	33	N W	190
28	Thandyani 1	34º 14'	73º 22'	2320	31	S	140
29	Thandyani 2	34º 14'	73º 22'	2300	38	S	140
	5- Kaghan Valley, District Mansehra						
30	Paya	34º 47'	73º 30'	3100	38	S	250
31	Sri	34º 47'	73º 30'	2900	39	N	90
32	Shogran 1	34º 37'	73º 28'	2400	27	S W	170
33	Shogran 2	34º 37'	73º 28'	2400	23	S	190
34	Shogran 3	34º 37'	73º 28'	2500	33	S	150
35	Paras,Malkandi Pine Park	34º 41'	73º 35'	1600	20	N E	160
36	Khanian	34º 47'	73º 32'	2000	35	E	195

37	Shinu, Near Jurait Park 1	34º 38'	73º 26'	1900	39	N W	180
38	Shinu, Near Jurait Park 2	34º 38'	73º 26'	1650	43	W	120
39	Naran,River Belt 1	34º 53'	73º 39'	2500	R. Top	N W	190
40	Naran, River Belt 2	34º 53'	73º 39'	2500	R. Top	N W	170
41	Naran,Lalazar	34º 53'	73º 39'	3000	45	N W	150
	Note: Soil comp.= Soil compaction, R. Top = Ridge top, St. No. = Stand number.						

Table.2. Phytosociological Attributes, importance value index and absolute values of tree species in various moist temperate areas of Pakistan.

Stand No.	Main Location and Sites	Species Name	Phytosociological Attributes			
			Relative Freq.	Relative B. Area	Relative Density	IV
	A-Malakand division					
	Dir upper					
1	Kumrat	*Pinus wallichiana*	71	43	61	58
		Cedrus deodara	16	40	28	28
		Populus caspica	12	10	10	11
		Abies pindrow	1	7	1	3
2	Panahkot	*Pinus wallichiana*	57	61	60	59
		Cedrus deodara	43	39	40	41
	Swat					
3	Malam jabba 1	*Abies pindrow*	83	91	95	90
		Picea smithiana	17	9	5	10
4	Malam jabba 2	*Pinus wallichiana*	91	99	97	96
		Abies pindrow	9	1	3	4
5	Miandam	*Abies pindrow*	56	84	55	65
		Pinus wallichiana	44	16	45	35
	B-Azad Kashmir					
	i-District Neelam					
6	Keran, Nellam valley	*Cedrus deodara*	60	61	60	60
		Pinus wallichiana	40	39	40	40
	ii-District Muzzafar abad					
7	Chikkar	*Pinus wallichiana*	100	100	100	100
	iii-District Bagh					
8	Suddhan gali 1	*Abies pindrow*	41	49	42	44
		Pinus wallichinana	38	37	45	40
		Cedrus deodara	21	14	13	16
9	Suddhan gali 2	*Abies pindrow*	63	93	83	79
		Pinus wallichiana	31	4	15	17
		Cedrus deodara	6	3	3	4
10	Suddhan gali 3	*Pinus wallichiana*	83	70	95	83
		Abies pindrow	17	30	5	17
	C-Rawalpindi Divsion					
	Murree Hills					

11	Ghora gali	*Pinus wallichiana*	85	94	87	89
		Pyrus pashia	5	2	7	5
		Taxus wallichiana	5	2	3	3
		Quercus incana	5	2	3	3
12	Patriata top 1	*Cedrus deodara*	83	91	83	78
		Pinus wallichiana	17	9	17	22
13	Patriata top 2	*Pinus wallichiana*	100	100	100	100
14	Patriata top 3	*Pinus wallichiana*	88	97	87	91
		Albizzia lebbeck	12	3	13	9
15	Kashmir point	*Abies pindrow*	60	49	60	56
		Pinus wallichiana	27	25	27	26
		Juglans regia	8	21	8	13
		Cedrus deodara	5	5	5	5
	D-District Hazara Abbot Abad					
16	Ghora Dhaka 1	*Abies pindrow*	89	89	89	89
		Taxus walllichiana	5	9	5	7
		Pinus wallichiana	3	1	3	2
		Cedrus deodara	3	1	3	2
17	Ghora Dhaka 2	*Abies pindrow*	60	51	60	57
		Pinus wallichiana	35	47	35	39
		Taxus wallichiana	5	2	5	4
18	Ghora Dhaka 3	*Pinus wallichiana*	87	86	87	87
		Abies pindrow	13	14	13	13
19	Ghora Dhaka 4	*Abies pindrow*	60	60	60	60
		Pinus wallichiana	35	35	35	35
		Texus wallichiana	5	5	5	5
20	Ghora Dhaka 5	*Abies pindrow*	62	42	62	55
		Pinus wallichiana	17	16	17	17
		Cedrus deodara	13	18	13	15
		Juglans regia	8	24	8	13
21	Khaira gali	*Cedrus deodara*	42	67	63	57
		Pinus wallichiana	33	31	26	30
		Abies pindrow	25	2	11	13
22	Changla gali 1	*Abies pindrow*	57	78	57	64
		Pinus wallichiana	25	10	25	20
		Taxus wallichiana	15	11	15	14
		Juglans regia	3	1	3	2
23	Changla gali 2	*Pinus wallichiana*	50	72	50	57
		Abies pindrow	46	27	46	40
		Taxus wallichiana	4	1	4	3
24	Kuzah gali 1	*Cedrus deodara*	70	87	70	76
		Abies pindrow	25	12	25	21
		Pinus wallichiana	5	1	5	3
25	Kuzah gali 2	*Abies pindrow*	60	51	60	57
		Pinus wallichiana	25	28	25	26
		Cedrus deodara	15	21	15	17
26	Nathia gali 1	*Pinus wallichiana*	64	47	64	55
		Abies pindrow	36	53	36	45
27	Nathia gali 2	*Abies pindrow*	95	96	95	91

		Pinus wallichiana	5	4	5	9
28	Thandyani 1	*Pinus wallichiana*	80	83	80	81
		Cedrus deodara	20	17	20	19
29	Thandyani 2	*Cedrus deodara*	50	74	70	65
		Pinus wallichiana	50	26	30	35
	E-District Mansehra					
	Kaghan valley					
30	Paya, Shogran	*Pinus wallichiana*	57	60	57	58
		Picea smithiana	28	30	28	29
		Abies pindrow	15	10	15	13
31	Sri, Shogran	*Picea smithinana*	67	70	67	68
		Abies pindrow	33	30	33	32
32	Shogran 1	*Pinus wallichiana*	62	72	62	65
		Abies pindrow	38	28	38	35
33	Shogran 2	*Cedrus deodara*	70	92	86	82
		Pinus wallichiana	20	2	7	10
		Abies pindrow	10	6	7	8
34	Shogran 3	*Cedrus deodara*	84	95	94	91
		Picea smithiana	8	4	3	5
		Abies pindrow	8	1	3	4
35	Paras	*Cedrus deodara*	55	96	80	76
		Juglans rejia	18	1	8	9
		Pinus wallichiana	9	1	4	5
		Quercus ilex	9	1	4	5
		Quercus incana	9	1	4	5
36	Khanian	*Cedrus deodara*	75	91	83	83
		Pinus wallichiana	25	9	17	17
37	Shinu 1	*Cedrus deodara*	53	75	72	67
		Pinus wallichiana	47	25	28	33
38	Shinu 2	*Cedrus deodara*	100	100	100	100
39	Naran riverbelt 1	*Pinus wallichiana*	65	77	65	69
		Picea smithiana	13	16	13	14
		Cedrus deodara	13	3	13	10
		Populus alba	6	3	6	5
		Abies pindrow	3	1	3	2
40	Naran riverbelt 2	*Cedrus deodara*	100	100	100	100
41	Lalazar, Naran	*Abies pindrow*	100	100	100	100
	Note:					
	IV = Importance value .					

Table. 3. Results of principal component analysis showing eigenvalues percentage variance, cumulative percentage variance, first four ranked eigenvector coefficients and the associated species.

Component	Eigenvalue	% Variance	Cumulative % of variance	First four eigenvector coefficient	Associated variables
1	72099.391	51.571	51.571	-0.8242	CD
				0.4644	AP
				0.3228	PW
				0.0225	PS
2	59814.586	42.784	94.355	-0.7576	PW
				0.648	AP
				0.0695	CD
				0.0278	PS
3	6983.593	4.995	99.35	-0.8677	PS
				0.3231	AP
				0.2692	PW
				0.2642	CD

Table. 4. Correlation coefficients of environmental variables with the first three axes of PCA ordination.

Environmental variables	Vegetation components (axes)		
	axis 1	**axis 2**	**axis 3**
Elevation	0.484 **	0.303 *	0.2625 †
Slope	0.1513	0.0077	0.1726
Soil compaction	0.1732	0.1221	0.0678

Note: ** = P < 0.01, * = P < 0.02 and † = P < 0.1.
CD = *Cedrus deodara*, PW = *Pinus wallichiana*, AP = *Abies pindrow* and PS = *Picea smithiana.*

Table. 5. Summary of Phytosociological sampling of 41 stands of moist temperate area of Pakistan. Mean importance value, presence of species in number of stands and dominant position of conifer and angiospermic tree species are presented. Species are ranked on the basis of importance value.

S.No	Name of Species	Presence in # of Stands	Mean importance value	Dominant 1st	2nd	3rd
1	*Pinus wallichiana* A.B.Jackson	35	46±5.2	15	18	3
2	*Abies pindrow* Royle	27	42.9±5.9	13	7	4
3	*Cedrus deodara* (Roxb. Ex Lamb.) G. Donf.	22	49.6±7.3	12	3	5
4	*Taxus wallichiana* Zucc.	6	6±1.7	-	1	5
5	*Picea smithiana* (Wall.) Boiss.	5	25±11	1	4	-

6	*Juglans regia* L.	4	8±3.2	-	1	1
7	*Quercus incana* Roxb	2	4±1	-	-	-
8	*Quercus ilex* Griffith	1	5	-	-	-
9	*Populus caspica* Bornm	1	11	-	-	1
10	*Albizzia chinensis* (L.)	1	9	-	1	-
11	*Populus alba.* L	1	5	-	-	-
12	*Pyrus pashia* Ham ex D.Don	1	5	-	1	-
				41	36	19

Note: Species 1-5 are Conifer while 6-12 belong to Angiosperm.

Fig.1. Map showing different locations of study area in moist temperate Himalayan region of Pakistan.
* shows the main locations of sampling sites.

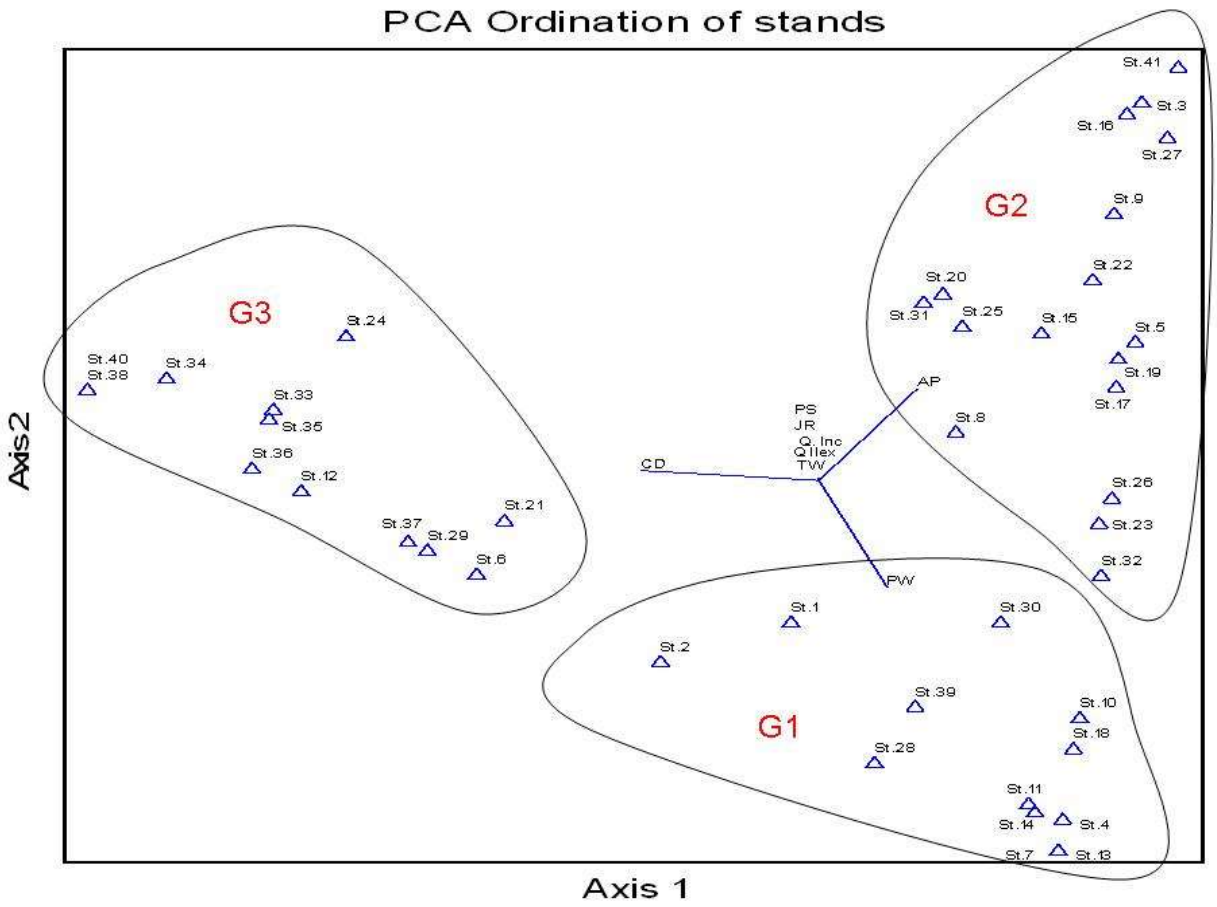

Fig. 2 Two-dimensional PCA ordination of stands, using tree species data of 41 stands of moist temperate areas of Pakistan.

Note: CD = *Cedrus deodara*, PW = *Pinus wallichiana*, AP = *Abies pindrow*, PS = *Picea smithiana*, TW = *Taxus wallichiana*, JR = *Juglans regia*, Q. Inc. = *Quercus incana*. Q. Ilex = *Quercus ilex*.

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