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PHYTOSOCIOLOGY OF SUMMER VEGETATION OF SUDAN GALLI HILLS, DISTRICT BAGH, AZAD KASHMIR, PAKISTAN

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Abstract

Four associations: *Pinus wallichiana, Abies pindrow, Abies-Pinus* and Temperate grassland containing thirteen communities were recognized on the basis of importance values. *Pinus wallichiana* association consisted of five communities: *Pinus-Berberis-Carex sempervernse, Pinus-Sarcococa-Hedra, Pinus-Sarcococa-Carex schalgintiweitiana, Pinus-Vibernum-Poa* and *Pinus-Sarcococa-Carex sempervernse* on the south facing slopes. *Abies pindrow* association comprised of six communities viz: *Abies-Sarcococa-Fragaria, Abies-Sarcococa-Anogromma, Abies-Sarcococa-Urochloa, Abies-Vibernum-Fragaria, Abies-Vibernum-Galium* and *Abies-Vibernum-Viola* on the north facing slopes. *Abies-Pinus* association on the south facing slope and the temperate grassland on top of the hills had one community each. The plant species, communities and associations differed on south and north facing slopes. Grasses dominated the top. The South facing slopes had relatively xeric conditions. In contrast the north facing slopes were mesic and therefore supported different plant communities. Biomass of the forbs increased with altitude up to 2350 m but thereafter it gradually decreased towards the top, on the south-facing slope. Quite opposite behavior has been observed regarding biomass for the grasses on the same slope. Grasses in the foothills and at the peaks of the south-facing slopes had more biomass. The biomass of the forbs was greater than of the grasses on the north-facing slopes.

Introduction

Sudan Galli, District Bagh, Azad Kashmir is bound on the east by Hajipir, on the west by Islamabad, in the north by Muzaffarabad and on the south by Singhgola and Rawalakot. It touches India at various places such as Mehmood galli and Ganga choti (3045m). The spring and autumn are pleasant but winters are severe. June is the hottest month, while December and January are the coldest months. The average maximum temperature varies in between 5°C (December) to 32°C (June) while the lowest recorded temperature in December is -2°C. The peaks of the mountains are usually covered with snow. The rainfall varies from 370mm (February to April) to slightly more than 390mm during July and August. The area is also in the range of monsoon, which makes it humid and cool. The soil varies from clay loam to loam. Natural vegetation of the area consists of temperate coniferous forests. Overgrazing, deforestation and other malpractices have disturbed the original vegetation of the area.

The vegetation of Sudan Galli is diverse due to altitudinal variation. Some phytosociological studies have been conducted in some parts of Azad Kashmir (Malik *et al*., 1990; 1994; Malik & Hussain, 1987, 1988, 1990). According to their observation, the subtropical *Olea-Pinus* and *Olea-Acaia* forests reflect highly deteriorated condition due to intensive human pressure, deforestation and overgrazing. Phytosociological studies on various parts of District Swat have also been carried out (Shah *et al.*, 1991; Hussain *et al*., 1992, 1995, 1997, 2000). Deforestation and overgrazing have decreased the plant diversity of these fragile ecosystems. Many plant species have either become threatened or endangered. *Pinus roxburghii, Quercus incana* and *Pinus wallichiana* forests have converted to scrubs and grasslands. stated that deforestation, overgrazing, uprooting of plants and terrace cultivation have not only accelerated soil erosion but decreased plant diversity in the area (Hussain & Ilahi, 1991; Ahmad & Quratulann, 2011). Chaghtai & Ghawas (1976) observed that the north and south facing slopes of Malakand Pass have different species composition. Champion *et al*., (1965) and Hussain & Ilahi (1991) stated that temperate forests in between 1600 to 1900m consist of *Pinus wallichiana,* and *Quercus incana* while *Cederus deodara*, *Abies pindrow* and *Pinus wallichiana* occur from 2600 to 3800m. It is evident from the review of literature that no work has been carried out on the vegetation of Sudan Galli hills. The present study reports the existing vegetation diversity of the area, which might be helpful for future workers involved in the development of this area.

Materials and Methods

The study was conducted during summer (May-June) of 1994. The area was divided into13 stands on the basis of physiognomy, exposure and altitude. The data was recorded using 20 quadrats of 1 x14 m, 1x 4m, and 1x 1m for trees, shrubs and herbs, respectively. The herbage cover was determined by the Daubenmire's cover scale (Daubenmire, 1959). Trees with diameter at breast height (1.5m) were measured to obtain basal area (Hussain, 1989). The density, frequency and coverage/basal areas were converted to relative values and summed to obtain importance values (IV). Fresh biomass for herbaceous plants was determined by harvesting all herbaceous plants in five 1x1m quadrats. Soils were sampled and analyzed by standard methods (Hussain, 1989). Species maturity was determined after Pichi- Sermolli, (1948), species diversity after Simposon (1949) & Menhinik (1994) and species richness after Margalef, (1957). Plants were identified through Flora of Pakistan (Nasir & Ali, 1971-1995; Ali & Qaiser, 1995-2007) and then confirmed at National Herbarium, NARC, Islamabad.

Results and Discussion

Associations and communities: The following four associations comprising 13 communities were recognized.

A. *Pinus wallichiana* association: This association was recognized on the south-facing slope and composed of the following five communities.

1. *Pinus- Berberis-Carex* community (PBC): This community recognized at an altitude of 2200 meters, was dominated by *Pinus wallichiana, Berberis lycium* and *Carex sempervernse* with importance values of 91.74, 14.31 and 19.62 respectively (Table 1). These were followed by *Fragaria nubicola, Plantago ovata, Oxalis corniculata, Sarcococa saligna, Carex schlagintiweitiana* and *Vibernum nervosum* as the co-dominants. *Galium asperuloides, Viola kashmiriana* and *Rosa ellipticus* appeared as associated species. The remaining 16 species possessed low importance values. The soil was loamy, rich in phosphorus and organic matter with pH 6.1 (Table 2). Intensive grazing, trampling and browsing were primary ecological problems in this community.

2. *Pinus-Sarcococa-Hedra* community (PSH): The plant community was dominated by *Pinus wallichiana, Sarcococa saligna* and *Hedra nepalensis* having the importance values of 97.3, 38.07 and 29.72 (Table 1) respectively at 2250 meters. *Carex sempervernse* (IV=21) and *Vibernum nervosum* (IV=22.01) were the co-dominants. *Galium asperuloides, Fragaria nubicola* and *Rosa ellipticus* (IV= 8.81, 8.69 and 8.46 respectively) were associated species. Four species, including *Quercus incana, Berberis lycium* and *Sarcococa saligna* were considered to be the next important species. The remaining species had low importance values. The soil of this community was clay loam and rich in P, N and organic matter (Table 2).This community was found to be highly disturbed by grazing and browsing.

3. *Pinus- Sarcococa-Carex schalgintiweitiana* community (PSC): This community located on south facing slope, showed the dominance of *Pinus wallichiana, Sarcococa saligna* and *Carex schalgintiweitiana* having the importance value 81.54, 19.27 and 19.53 respectively at a height of 2300 meters (Table 1). Co-dominant species of this stand were *Carex sempervernse, Galium asperuloides* and *Pinus wallichiana* exhibiting the importance values 18.1, 15.07 and 14.39 respectively. *Berberis lycium, Vibernum nervosum* and *Plantago ovata* (IV= 9.46, 8.45 and 8.2 respectively) were the associated species. The remaining 16 species had low importance values. The soil was silty clay loam and rich in N and organic matter (Table 2). Grazing pressure was comparatively light.

4. *Pinus-Vibernum-Poa* community (PVP): *Pinus wallichiana, Vibernum nervosum* and *Poa bactriana* dominated at 2400m having importance values 92.56, 20.61 and 15.13, respectively. They were followed by *Galium asperuloides* (IV=15.08), *Fragaria nubicola* (IV=13.62), *Sarcococa saligna* (IV=11.44) and *Plantago lanceolata* (IV=11.42). Fourteen other species including *Berberis lycium, Oxalis corniculata, Viola serpense, Trifolium repense, Sibbaldia cuneata* and *Duchesnia indica* were other important species. The remaining species with low importance values were rare (Table 1). The silty clay loam was rich in N (0.12%) and had the highest organic matter (2.4%) of all sites studied (Table 2).

5. *Pinus-Sarcococa-Carex sempervernse* community (PSC): The plant community, dominated by *Pinus wallichiana* (102.15), *Sarcococa saligna* (IV=22.94) and *Carex sempervernse* (27.6) was found at 2450 meters (Table 1). *Fragaria nubicola* (25.83), *Galium asperuloides* (IV=12.89) and *Berberis lycium* (IV=11.52) were sub-dominants. They were followed by eight other species including *Trifolium repense, Sibbaldia cuneata, Adiantum incisum* and *Vibernum nervosum*. Low importance values were observed in the remaining 16 species (Table 1). The loamy soil of this stand contained N (0.09%), P (20%) and 1.6% organic matter (Table 2).

B. *Abies pindrow* associations: This association was recognized on the north facing slope with following six communities.

1. *Abies-Sarcococa-Fragaria* community (ASF): *Abies pindrow* (91.65), *Sarcococa saligna* (28.22) and *Fragaria nubicola* (19.92) were dominant at 2200m (Table 1). *Viola kashmiriana* (IV=15.54), *Trifolium repense* (IV=14.34) and *Poa bactriana* (IV = 11.92) were sub-dominants; followed by eleven other species including *Polypodium khasyanum, Dryopteris stewartii, Anogromma microphylla* and *Rubus fruiticosus*. The remaining species had low importance values (Table 1). The clay loam soil had pH by 7.0 and P with highest contents (Table 2). The community was found to be highly disturbed by intensive grazing and browsing.

2. *Abies-Sarcococa-Anogromma-* community (ASA): This community, located at 2250 m, was dominated by *Abies pindrow* (IV =76.33), *Sarcococa saligna* (IV = 17.38) and *Anogromma microphylla* (IV =23.51) (Table 1). They were followed by *Viola kashmiriana* (IV =20.09), *Trifolium repense* (IV = 17.72) and *Fragaria nubicola* (IV = 17). The remaining 20 species had low importance values (Table 2). The silty loam had high P contents. Grazing is the major ecological problem in this stand.

3. *Abies-Sarcococa-Urochloa* community (ASU): This community is dominated by *Abies pindrow, Sarcococa saligna* and *Urochloa pancoides* having the importance values of 91.45, 16.53 and 23.22 respectively at 2300 m (Table 1). *Fragaria nubicola* (IV =17.23), *Rubus niveus* (IV =18.8) and *Rananculus aquatilis* (IV = 16.82) were associated species. Eight other species including *Vibernum nervosum, Onychium contiguum, Urtica dioica, Trifolium repense* and *Oxalis corniculata* were also important. The remaining 12 species had low importance values. The soil was silty loam exhibiting low N% and organic matter (Table 2).

4. *Abies-Vibernum-Fragaria* community (AVF): The plant community, dominated by *Abies pindrow, Vibernum nervosum* and *Fragaria nubicola* was found at 2350 m. The importance values of these were 94.1, 26.51 and 25.59 respectively (Table 1). *Carex sempervernse* (IV = 15.68), *Viola kashmiriana* (IV = 13.74) and *Oxalis corniculata* (IV = 13.55) were the co-dominants. Eleven species had importance values of less than 5. The soil was loam rich in P (Table 2). Various pteridophytes represented a reasonable number in this community.

Table 1. Importance value and habitat character of communities of Sudan Galli District Bagh (Azad Kashmir) during June 1994.

Associations	*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	TG
Altitude (m)	2200	2250	2300	2400	2450	2200	2250	2300	2350	2400	2450	2350	2500
Exposure	South	South	South	South	South	North	North	North	North	North	North	South	Top
Communities	PBC	PSH	PSC	PVP	PSC	ASF	ASA	ASU	AVF	AVG	AVV	APC	CPE
No of individuals	557	370	680	761	831	831	568	738	705	373	532	663	552
No of species	28	23	31	28	29	34	26	26	27	19	22	34	12
I. Tree layer													
Abies pindrow Royle	----	----	7.06	----	----	91.65*	76.33*	91.45*	94.1*	91.87*	103.7*	65.04*	----
Pinus wallichiana A.B.Jackson	91.74*	97.3*	81.54*	92.56*	102.2*		----	----	2.16	----	----	3.79	----
Quercus baloot Griffith	----	----	----	----	----	2.2	----	----	----	----	----	----	----
Q. dilatata Lindley ex Royle	-----	----	1.96	----	----	----	----	----	----	----	----	----	----
Q. incana Roxb.	4.38	6.63	----	----	----	----	----	----	----	----	----	----	----
II. Shrub layer													
Abies pindrow Royle	1.99	----	5.54	6.85	----	2.21	----	----	----	----	----	1.42	----
Berberis lycium Royle	14.31*	6.09	9.46	8.35	11.52	3.81	----	----	----	----	----	6.29	----
Cedrus deodara (Roxb.ex Lambert) G.Don	----	----	----	5.35	----	----	----	----	----	----	----	----	----
Machilius odoratissima Nees	----	----	1.54	2.23	----	----	----	----	----	----	----	----	----
Pyrus pashia Ham ex.D.Don.	----	----	----	----	----	----	----	----	----	----	----	2.2	----
Pinus wallichiana A.B.Jackson	5.74	1.49	14.39	6.44	6.48	3.17	----	----	----	----	----	27.02*	----
Quercus dilatata Lindley ex Royle	5.79	----	3.99	----	----	----	----	----	----	----	----	2.2	----
Q. incana Roxb.	----	1.79	----	----	----	----	----	----	----	----	----	3.79	----
Rhayza stricta Decne	4.03	1.49	2.62	6.29	----	7.13	6.25	----	----	----	----	----	----
Rosa ellipticus Smith	7.3	8.46	6.03	8.00	6.86	4.12	----	----	----	----	----	4.95	----
Rubus fruiticoses Hk.f.	----	----	7.13	----	----	6.66	----	----	----	----	----	0.97	----
Sarcococa saligna (D.Don.) Muell.Arg.	13.11	38.07*	19.27*	11.44	22.94*	28.22*	17.38*	16.53*	11.68	15.89	12.02	23.08	----
Vibernum nervosum D.Don.	11.83	22.01	----	20.61*	11.21	7	16.68	10.43	26.51*	24.3*	27.56*	16.06	----
Zanthoxylum alatum D.C.	----	----	0.9	----	----	----	----	----	----	----	----	----	----

Table 1. (Cont'd.).

Associations	*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	TG
III. Herb layer													
Achilea millfolium L.	2.14	----	----	3.61	----	----	----	----	----	----	----	----	----
Adiantum incisum Frosk.	1.48	2.42	5.13	----	5.08	----	11.22	4.59	7.55	8.35	8.72	1.32	----
Ajuga bracteosa Wall.	4.91	----	----	----	4.21	1.9	----	----	----	----	----	8.05	----
Anogramma microphylla (Hk) Diels.	----	----	----	----	----	6.86	23.51*	----	4.94	----	----	----	----
Arenaria surphyllifolia L.	----	----	----	----	----	----	----	----	----	----	----	1.58	6.49
Arisaema jacquemontii Blume	----	----	----	----	----	----	----	----	0.71	1.09	----	----	----
Asplenium fontanum (L.) Beruk.	----	----	----	----	----	----	3.38	----	----	----	----	----	----
Prunella vulgaris L.	----	----	----	----	----	8.52	----	3.15	1.1	----	3.74	----	----
Carex schlagintiweitiana Bocck.	12.46	6.84	19.53*	----	----	----	----	----	----	----	----	6.24	----
C. semperverense Vill.	19.62*	21	18.1	7.87	27.6*	----	----	----	15.68	5.94	----	24.72*	----
Cenchrus setigerus Vahl	----	----	----	----	----	3.65	----	----	----	----	----	----	54.31*
Clinopodium umbrosum (M.Bieb.) C.Koch.	----	----	----	----	1.82	----	----	----	----	----	----	----	44.96
Conyza canadensis Cronquist	----	----	4.77	----	----	----	----	----	----	----	----	0.46	----
Cucubalus baccifer L.	----	----	----	----	----	----	0.85	----	----	----	----	----	----
Duchesnia indica (Andr)Focke	----	----	----	5.57	----	----	----	8.13	----	----	5.68	----	----
Dryopteris stewartii More.	----	----	----	----	----	11.72	11.89	----	8.31	----	----	----	----
Elaeagnus umbellata Thunb.	----	----	----	----	----	----	----	1.4	6.05	----	----	----	----
Eragrostis poaeoides Beauv.	----	----	----	----	----	----	----	----	----	----	----	----	45.23*
Fragaria nubicola Lindle ex Lacaita.	16.69	8.69	6.8	13.62	25.83	19.92*	17.0	17.23	25.59*	20.47	26.86	13.74	----
Galium asperuloides Edgew.	9.4	8.81	15.07	15.08	12.89	4.71	4.03	3.79	4.31	31.8*	19.93	12.17	----
Gentiana argentea Royle.	----	----	----	----	----	4.64	----	----	----	----	----	3.44	----
Geranium nepalense Sweet.	4.27	----	----	----	----	----	----	----	----	----	----	5.48	----
Geum urbanum L.	----	2.66	----	7.73	2.38	----	----	----	5.29	3.58	----	----	----

Table 1. (Cont'd.).

Associations	*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	TG
Gnaphalium pulvinatum Del.	----	----	----	----	2.29	----	----	----	----	----	----	----	----
Hedra nepalensis Koch.	4.31	29.72*	7.45	5.79	3.71	9.06	4.76	2.25	0.71	----	2.37	1.32	----
Impatiens balsamina L.	----	----	----	----	----	----	----	----	----	----	2.04	----	----
Leonurus cardiaca L.	5.42	----	----	----	----	----	----	----	----	----	----	----	----
Lespedeza juncea (L.F.) Persoon.	3.96	----	----	----	----	----	----	----	----	----	----	----	----
Lunathyrium allontodioides (Bedd) Ching.	----	0.96	----	1.55	----	5.46	0.85	7.25	----	5.29	7.85	1.58	----
Micromeria biflora Benth.	----	----	----	----	----	----	----	1.4	----	----	----	1.86	----
Nepeta cataria L.	----	----	4.9	----	----	----	2.08	4.11	----	----	----	----	24.92
Oenothera rosea L.Her ex Ait.	----	----	----	2.57	----	----	----	----	----	----	----	0.69	6.32
Onychium contiguum Wall ex Hope.	1.32	1.2	2.63	2.7	0.74	----	5.2	9.94	5.88	3.01	1.26	1.43	----
Oxilas corniculata L.	17.1	----	7.95	8.28	2.49	6.47	9.69	9.61	11.5	25.08	13.38	9.32	----
Pinus wallichiana A.B.Jackson	----	----	5.63	2.78	1.3	----	----	----	----	----	----	----	----
Plantago lanceolata L.	----	----	----	11.42	----	----	----	----	----	----	----	----	----
Plantago ovata Frossk.	15.87	----	8.2	----	6.13	5.46	----	1.54	----	----	1.59	8.81	----
Poa annua L.	----	----	----	----	4.81	----	----	----	----	----	19.71	----	52.0*1
Poa bactriana Roshev.	----	----	----	15.13*	1.82	11.92	4.2	----	13.55	----	----	9.12	14.23
Podophyllum emodi Wall.	----	----	----	----	----	1.01	----	----	----	----	----	----	----
Bistorta amplexicaul (D.Don)	----	----	----	----	1.58	----	----	1.54	0.71	----	----	----	----
Polypodium khasyanum Hk.	----	----	----	----	----	6.09	1.03	----	----	----	0.91	----	----
Pteris cristica L.	----	----	----	----	2.49	0.62	9.14	2.48	3.55	2.88	1.26	----	----
Rananculus aquatilis L.	----	----	----	----	1.36	2.01	----	16.82	----	----	----	----	----
R. arvensis L.	----	----	----	----	----	----	8.87	----	9.55	16.7	2.5	----	3.87
R. leatus	----	----	7.4	----	1.68	----	----	4.09	----	----	9.7	----	----
R.muricatus L.	----	----	----	----	----	----	1.93	----	----	----	----	----	----

Table 1. (Cont'd.).

Associations	*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	TG
Rosa ellipticus Smith	----	10.00	----	----	----	----	----	----	----	----	----	----	----
Rubus fruticosus Hk.f.	----	----	5.96	----	----	----	----	----	----	----	----	----	----
Rubus niveus Wall.	----	----	----	----	----	----	7.72	18.8	----	----	----	----	----
Rumex dentatus L.	----	----	----	----	----	0.62	----	3.69	0.85	2.48	1.08	1.32	----
R. nepalense Sperng.	2.65	----	----	----	----	----	----	----	----	----	----	----	----
Sallginella chrysorhizos (Hk. & Grev)	----	----	----	----	----	----	----	----	0.85	----	----	----	----
Sarcococa saligna (D.Don.) Muell.Arg.	3.5	7.03	6.28	4.55	----	0.62	----	----	----	1.74	----	----	----
Siballdia cuneata Hornum.	----	----	----	6.55	----	----	----	----	----	----	----	2.67	3.16
Sonchus arvensis L.	----	----	3.63	----	----	----	----	----	----	----	----	----	----
Sonchus asper L.	----	----	----	----	1.47	----	----	----	----	----	----	----	----
Stellaria media (L.) Cyr.	----	----	----	----	----	----	----	----	----	8.21	----	----	----
Tarraxcum officinale Weber.	----	----	----	----	----	0.73	----	----	----	----	1.08	2.31	34.15
Torilis nodosa (L.) Gaertn.	----	----	----	----	----	0.73	----	----	----	----	----	----	----
Trifolium repense L.	6.69	4.56	----	6.14	7.48	14.34	17.72	15.89	9.11	----	----	13.35	----
Trigonella kashmiriana Camb.	----	----	----	----	----	----	----	----	----	----	----	----	10.2
Urochoala pancoides P.Beauv	----	----	2.75	----	----	----	9.34	23.22*	----	----	----	----	----
Urtica dioica L.	----	----	----	----	----	0.73	8.37	5.43	1.46	----	----	----	----
Valeriana jatamansi Jones	----	-----	----	----	2.07	----	----	----	----	----	----	----	----
Viola kashmiriana W.Bkr.	7.56	7.47	8.45	----	10.46	15.54	20.09	14.8	13.74	29.91	27.82*	15.26	----
Viola serpens Wall.	----	4.99	----	10.23	----	----	----	----	10.66	1.29	----	----	----

Key to communities

PBC= *Pinus-Berberis-Carex* community, PSH= *Pinus-Sarcococa-Hedra* community, PSC= *Pinus-Sarcococa-Carex schalgintiweitiana* community, PVP= *Pinus-Vibernum-Poa* community, PCF= *Pinus-Sarcococa-Carex sempervernse* community, ASF= *Abies-Sarcococa-Fragaria* community, ASA= *Abies-Sarcococa-Anogromma*-community, ASU= *Abies-Sarcococa-Urochloa* community, AVF= *Abies-Vibernum-Fragaria* community, AFV= *Abies-Vibernum-Galium* community, AVV= *Abies-Vibernum-Viola* community, APC= *Abies-Pinus-Carex* community, CPE= *Cenchrus-Poa-Eragrostis* community, TG= Temperate grassland

Table 2. Habitat characteristics of communities of Sudan Galli Hills.

Associations	*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	TG
Communities	PBC	PSH	PSC	PVP	PSC	ASF	ASA	ASU	AVF	AVG	AVV	APC	CPE
Habitat factor													
Altitude (m)	2200	2250	2300	2400	2450	2200	2250	2300	2350	2400	2450	2350	2500
Exposure	South	South	South	South	South	North	North	North	North	North	North	South	Top
Soil type	Loam	Clay loam	Silty clay loam	Silty clay loam	Loam	Clay loam	Silty loam	Silty loam	Loam	Clay loam	Silty clay loam	Loam	Silty clay loam
Saturation (%)	36	56	52	48	36	54	40	42	32	60	46	36	48
Ph	6.1	5.0	5.4	5.2	5.3	7.0	4.9	5.2	5.6	5.5	5.3	5.2	4.8
Organic matter	1.8	2.0	2.3	2.4	1.9	1.1	1.1	0.9	1.0	2.2	2.3	0.8	0.6
P_2O_5 (ppm)	30	30	28	28	20	32	30	22	30	30	26	32	22
Nitrogen (%)	0.09	0.10	0.11	0.12	0.09	0.05	0.05	0.04	0.05	0.11	0.11	0.04	0.03
Protection	Up	Up	Up	P	P	Up	Up	Up	Up	P	P	Up	P

TG= Temperate grassland, UP= Unprotected, P= Protected

5. *Abies-Vibernum-Galium* community (AVG): This community, at 2400 m, was found to be dominated by *Abies pindrow*, *Vibernum nervosum* and *Galium asperuloides* having the importance values 91.87, 24.3 and 31.8, respectively (Table 1). They were followed by *Oxalis corniculata* (IV = 25.08), *Fragaria nubicola* (IV =20.47), *Viola kashmiriana* (IV = 29.91), *Rananculus arvensis* (IV = 16.7) and *Sarcococa saligna* (IV = 15.89) as sub-dominants. The remaining species had low importance values. The clay loam was rich in N, P, and organic matter (Table 2). Two trees of *Abies pindrow* were severely affected by lightning and thunder.

6. *Abies-Vibernum-Viola* community (AVV): The dominants were *Abies pindrow, Vibernum nervosum* and *Viola kashmiriana* with importance values of 103.69, 27.56 and 27.82 respectively at 2450 m. *Fragaria nubicola* (IV = 26.86), *Galium asperuloides* (IV = 19.93), and *Poa annua* (IV = 19.71) were the co-dominants (Table 1). Six species including *Adiantum incisum, Oxalis corniculata* and *Sarcococa saligna* were the other important species. Ten species including *Pteris cristica* and *Onychium contiguum* showed poor representation. The silty clay loam was rich in organic matter and N (Table 2).

C. *Abies pindrow-Pinus wallichiana* Association: This association was recognized on the south-facing slope at 2350m with only one community, namely

***Abies-Pinus-Carex* community (APC):** *Abies pindrow, Pinus wallichiana* and *Carex sempervernse* were the dominants with importance values 65.04, 27.02 and 24.72 respectively. *Vibernum nervosum, Viola kashmiriana* and *Trifolium repense* with importance values 16.06, 15.26 and 13.35 were the co-dominants (Table 1). They were followed by *Oxalis corniculata, Poa bactriana* and *Ajuga bracteosa. Carex schalgintiweitiana* and *Berberis lycium* were also important. The remaining 21 species had an importance value of less than 5. The soil was loam with .04% N and 0.8% P, but rich in organic matter and with pH 5.2 (Table 2).

D. Temperate grassland association: This association was recognized at the hill top (2500m) with only one of the following community.

***Cenchrus-Poa-Eragrostis* community (CPE):** It is devoid of trees and shrubs. The dominants are *Cenchrus setigerus, Poa annua* and *Eragrostis poaeoides* with importance values of 54.31, 52.01 and 45.23 respectively (Table 1). *Clinopodium umbrosum* (IV = 44.96), and *Taraxicum officinale* (IV = 34.15) were the sub-dominants. Seven species including *Poa bactriana, Trigonella kashmiriana* and *Arenaria serphyllifolia* had low importance values. The soil was silty clay loam with 4.8 pH, N (0.03%) and organic matter (Table 2). The local people use such meadows for grazing their animals in summer.

Table 3. Fresh Biomass (g/m^2) of herbaceous plants of each community of Sudan Galli Hills in June 1994.

Associations		*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	**TG**
Communities		**PBC**	**PSH**	**PSC**	**PVP**	**PSC**	**ASF**	**ASA**	**ASU**	**AVF**	**AVG**	**AVV**	**APC**	**CPE**
Altitude (m)		2200	2250	2300	2400	2450	2200	2250	2300	2350	2400	2450	2350	2500
Exposure		South	South	South	South	South	North	North	North	North	North	North	South	Top
Biomass	Grasses	150	99	50	51	60	40	30	45	59	49	49	199	150
	Forbs	95	100	99	125	99	90	130	150	95	80	110	200	50
Total biomass		245	199	149	176	159	130	160	195	154	129	159	399	200

TG= Temperate grassland

Table 4. Diversity and its components.

Associations	*Pinus wallichiana*					*Abies pindrow*						*Abies pinus*	**TG**
Communities	**PBC**	**PSH**	**PSC**	**PVP**	**PSC**	**ASF**	**ASA**	**ASU**	**AVF**	**AVG**	**AVV**	**APC**	**CPE**
Altitude (m)	2200	2250	2300	2400	2450	2200	2250	2300	2350	2400	2450	2350	2500
Exposure	South	South	South	South	South	North	North	North	North	North	North	South	Top
Simpson diversity	0.07	0.11	0.07	0.06	0.11	0.07	0.07	0.07	0.07	0.11	0.10	0.08	0.15
Shanon index	2.88	2.52	2.95	3.00	2.68	2.90	2.85	2.81	2.75	2.38	2.48	2.83	2.04
N_2 (1/)	14.28	9.09	14.28	16.66	9.09	14.28	14.28	14.28	14.28	9.09	10.00	12.5	6.66
N_1 (l^x) expected value	17.81	12.42	19.10	20.08	14.58	18.17	17.28	16.60	15.64	11.02	12.18	16.94	7.69
Margalif species richness	3.95	3.04	3.68	3.61	4.01	4.61	3.78	3.78	4.12	2.87	3.34	4.77	1.74
Menhinik species richness	1.10	0.98	0.95	0.90	0.97	1.11	1.04	0.95	1.05	0.93	0.95	1.24	0.42
Hill's Equilibility	0.79	0.70	0.73	0.82	0.59	0.77	0.81	0.85	0.91	0.81	0.80	0.72	0.84
Species maturity	54.48	47.89	59.33	53.46	44.16	41.14	41.86	47.17	40.83	46.10	40.45	42.08	56.66

TG= Temperate grassland

Biomass: Biomass of herbaceous plants for each plant community is given in the Table 3. Biomass of the forbs increased with altitude, up to 2350m; but from there it gradually decreased towards the top (Table 3) on the south-facing slope. Quite the opposite behavior regarding biomass has been observed for the grasses on the same slope. Grasses had more biomass in the foothills and peaks of the south-facing slope. The biomass of the forbs was greater than the grasses on the north-facing slope.

Species diversity and richness: Table 4 shows that the overall species diversity based on the Simpson index, was slightly high at higher altitude in all the associations. While the Shanon index showed that there were not many differences in the diversity of various altitudes. Species richness as determined by the Margalif index was high at lower altitudes than at higher altitude in all associations. It was least at the top of the hill (1.74). The Menhinik species index values also agreed with the Margalif index as it was also high at low altitude and decreased towards the top. No specific trend was seen for Hill's equitability values in all the sites and communities. The value for species maturity was in the range of 40.45 to 59.33 showing no trend with respect to altitudinal variation, aspect or other features of the community. The overall species maturity, richness and diversity were low. These conditions are owed to human interference that has caused the decline of the vegetation by severe deforestation, collection of medicinal and other useful plants for fodder, firewood and timber.

Topographical situation in respect of altitude, slope and aspect strongly affect the distribution of plants by modifying light, temperature, and soil moisture conditions (Hussain & Ilahi, 1991; Shah *et al.,* 1991; Champion *et al.,* 1965). Remarkable differences in the vegetation of north and south facing slopes in Pakistan have been reported by Hussain & Shah (1989) and Hussain *et al*., (1992). The south facing slopes receive more solar radiation and therefore are warmer than the north facing slopes, resulting in distinct differences between the two sides. The south facing slopes bear relatively xeric conditions. In contrast the north facing slopes are mesic or moist and therefore support the growth and reproduction of pteridophytes. It appears that the investigated area is primarily blue pine forest in the lower part and *Abies* and temperate grassland in the upper reaches. The associated species are typical for temperate forest in Pakistan (Hussain *et al.,* 1995; 2000). All these hills are surrounded by settlements whereby deforestation and overgrazing is common practice. The locals utilize the forest resources for various needs. The investigated area is rich in medicinal plants and therefore in need of care and preservation for the sake of future resource. Species of *Polygonum, Viola, Berberis, Adiantum, Sarcococa, Ajuga, Taraxicum, Vibernum* and many others are valuable medicinal plants. Many medicinal plants are also used as fuel wood and fodder species, which has definitely hampered their regeneration. It is suggested that ecological management should be undertaken to conserve the genetic resources and diversity of plants. These forests are not only sources of income but also a habitat for valuable wildlife and medicinal wealth of the area.

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