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PHYTOSOCIOLOGY AND STRUCTURE OF HIMALAYAN FORESTS FROM DIFFERENT CLIMATIC ZONES OF PAKISTAN

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Abstract

A quantitative phytosociological survey was conducted in 184 sampling stands in various climatic zones of Himalayan forests of Pakistan. Based on floristic composition and importance value, 24 different communities and 4 monospecific forest vegetations were recognized. Quantitative description and their population structure are presented. Many communities show similar floristic composition, however, differ in quantitative values. Vegetation of forests ground flora is also presented.

Introduction

Champion *et al*., (1965) and Beg (1975) carried out an observational survey and recognized various types of forests and different vegetational zones on the basis of temperature and altitude. Rafi (1965) presented similar studies from Balochistan Province. Hussain & Illahi (1991) presented ecology and vegetation types for Lesser Himalayan of Pakistan. Hussain (1984) described vegetation of Pakistan and vegetation of Karachi. Ahmed (1974, 1976) conducted extensive phytosociological sampling in hills of Himalayan region during a scientific expedition in northern areas of Pakistan. A quantitative sampling around Karachi University was conducted by Qadir *et al*., (1964).

Various workers have also presented quantitative phytosociological work from different areas of Pakistan. Chaudhri & Qadir (1958), Chaudhri (1960, 1961), Qadir *et al*., (1966), Hussain (1969a,b), Hussain & Qadir (1970), Shaukat & Hussain (1970), Shaukat & Qadir (1970,1972), Ahmed (1974, 1976), Hussain *et al*., (1980,1981), Amin & Ashfaque (1982), Beg & Khan (1984), Qadri (1986), Rashid *et al*., (1987), Malik & Hussain (1987), Ahmed (1988a). Hussain & Illahi (1991), Hussain & Shah (1991), Durrani & Hussain (2005), Khan & Shaukat (2005).

Population structure of planted tree species of Quetta was presented by Ahmed (1988 b), while population structure of *Juniperus excelsa* M.B. and *Pinus gerardiana* Wall.ex Lamb., from Balochistan was shown by Ahmed *et al*., (1990) and Ahmed *et al*., (1991) respectively. Beside these individual and localized works from a few areas of Pakistan, no comprehensive quantitative investigations were carried out to describe various types of forest communities and population structure in different climatic areas of Pakistan. Bearing these points in mind present paper is presented to describe population structure and quantitative description of different Himalayan forests from various climatic zones of Pakistan.

Methods

In various climatic zones of Pakistan mature and least disturbed vegetation was selected for quantitative sampling. The criteria of vegetation sampling were (1) that it should contain trees at least 60 cm dbh (diameter breast high). In case of Angiospermic vegetation, that criterion was relaxed. 2- There should be no sign of recent disturbance. 3- It covered at least two ha^{-1} in area. Point Centered Quarter Method (Cottam & Curtis, (1956) with the modification of Ogden & Powell (1979) was used to sample 184 stands. In each stand, 20 points were taken at 20-meter intervals along 400 meters transects: however, in some area due to steep slopes, landslides and small area of the vegetation, shorter transects were applied.

Phytosociological attributes (density, frequency & basal area); aspects and elevation of each stand were recorded. Importance value (Brown & Curtis 1951), was used to rank each species and the plant species with the highest importance value in the stand was considered the dominant species. The plant community was named on the basis of dominant species. Diameter breast high (dbh) of individual in a stand were divided into (> 10cm dbh) various size classes and size structure of tree species in each vegetation types were presented. A species list with a frequency table for under story (ground flora) plants (<10 cm dbh) was made, using a circular plot (2 m diameter) at each sampling point. Lower plants were ignored and plants distributed in at least 40% of the circular plots are presented.

Results and Discussion

A. Sub-tropical zone

Vegetation of this zone was sampled at foothills of Murree, (Islamabad–Murree Road), Ghora Gali, Malakand and Marghazar. Meteorological records for each location were not available. However, the meteorological data of Haripur shows that the area receive an annual rainfall of about 761 mm with a maximum 161 mm in August and a minimum 10 mm in November with hottest month (32°C) in June while the coldest month is January (10°C). This type of climate supported the broad-leaved forests in the area, vegetation sampling were carried out in the following three sub types as described by Champion (1965).

a. Broad leaved forests: Rafi (1973) and Beg (1975) described these forests as Sub-Tropical Evergreen type. Hussain (1984) described the vegetation of the area under Potowar Plateau and dry hills of frontier province. Naqvi (1976) classified this type of vegetation under Sub-Montane Zone while Hussain & Illahi (1991) described this area as dry sub-tropical broad-leaved forests.

On the foothills of Murree two communities were recorded 1- *Acacia modesta 2- Olea ferruginea* communities. Southern aspects of the hills were dominated by *Acacia modesta* Wall., while the northern aspects were dominated by *Olea ferruginea* Royle. The density of *Acacia modesta* Wall., and *Olea ferruginea* Royle was 534 and 620 ha^{-1} while Basal area was 16 and 26 m^2 ha^{-1} respectively. Except this difference in quantitative characteristic, both communities show same vegetation composition. Both dominated species indicate higher density in low size class (10–20cm dbh). As far as the

ground flora is concerned only six species were recorded in which *Punica granatum* L., *Rosa macrophylla* Lindl., and *Dodonaea viscosa* were recorded from 50% to 60% points.

b. Lower pine forests: One community of *Pinus roxburgii* Roxb., was sampled in this area. At elevation from 830 to 1870 meters from Malakand and on the way to Marghzar rainfall and temperature changes with the increasing altitude. At Malakand 30% *Pinus roxburgii* Roxb., were recorded in 30 to 40 dbh classes, while less individual in 10 to 20 cm dbh class may associate with anthropogenic disturbances. *Olea ferrugirea* occupied around 38%of relative density and basal area. Overall, size class structure represents poor regeneration in this stand. Champion *et al*., (1965) described these forests as Himalayan Pine Forests, while Naqvi (1976) kept this community under Montane Zone on the basis of climate, physiognomy and altitude. Beg (1975) described it as Himalayan Dry Chir Pine Forest, and Hussain (1969a) placed it in Dry Temperate Forest. The climate of these areas is hotter and soils drier than Upper Pine Forests.

Due to overgrazing ground flora was scattered, representing five species. Among these species *Otostegia limbata* (BTL.) Boiss., *Dodonaea viscosa* and *Dicliptera roxburghiana* Nees were recorded in 30% to 40% of the circular quadrates. In which *Dodonaea viscosa* L., is the characteristic species of hotter and drier sites.

c. Upper pine forests: Champion *et al*., (1965) described these forests under upper or as Himalayan Chir Pine forests. Beg (1975) considered it as Himalayan moist Chir Pine Forest. Hussain (1984) placed it in Moist Temperate Forest. Hussain & Illahi (1991) described this type under Sub-Tropical Chir Pine–Oak Ecotonal Forests. At higher elevation from 1300 to 1870 meter (Kuldunna, Ghoragali and Marghazar) *Pinus roxburghii* Roxb. dominated among pine tree species, which occupied highest density (715 ha^{-1}). In this community *Quercus incana* Roxb., shows low density (3%), while a large number of dominant species fall in 10 to 30 dbh size classes, showing a good regeneration of this species, in contrast to the Lower Pine Forest.

During the sampling, 16 species were recorded under the tree species, *Myrsine africana* L., *Berberis lycium* Royle, *Viburnum cotinifolium* D. Don., *Indigofera heterantha* Wall. ex Brand, *Hedera nepalensis* K.Koch., and *Chrysanthemum leucanthemum* L., were found in 40% to 60% plots at Kuldunna and Ghoragali. In the sampling Marghazar similar tree species supporting *Cotoneaster nummularia* Fisch. & Mey., *Apluda mutica* L.var.*aristata* (L.) Hack. *et* Baker., *Dicliptera roxburghii* Roxb., *Microstegium nudum* (Trin.) A. Camus., in 30% to 60% circular quadrates.

B. Sub-tropical and moist temperate ecotonal zone

Two forests types are recognized (A) Broad Leaved Forests (B) Mixed Pine Forests were sampled in this area. Champion *et al*., (1965) and Beg (1975) recognized these forests as Himalayan Moist Pine Forests. However, the area where change (transitional) from one zone to another zone is recognized here as Ecotonal Zone. These zones were described on the basis of characteristic species distributed in both zones. *Pinus wallichiana* A.B.Jackson and *Quercus incana* Roxb., are found in Moist Temperate Areas while *Pinus roxburghii* Roxb., and *Olea ferruginea* Royle are the Sub-Tropical species distributed in near by areas.

Table 1. Characteristics of sampling sites in different climatic zones of Pakistan.

Location of sampling sites	Latitude N	Longitude E	Altitude m	Aspect	SD ha^{-1}	SB $m^2 ha^{-1}$
A. Sub tropical zone						
a. Broad leaved forests						
Aa1-Murree Road	33°34	73°74	300-650	S	669	28
Aa2-Murree Road	33°34	73°74	750	N	751	32
b. Lower pine forests						
Ab1-Malakand-Marghazar	34°33	71°56	910-930	W/N	250	30
c. Upper pine forests						
Ac1-Murree-Ghoragali-Marghazar	33°34	73°74	1300-1870	N/E	732	31
B. Subtropical and moist temperate ecotonal zone						
a. Mixed pine forests						
Ba1-Ghoragali (Mixed)	33°34	73°34	1570	N	555	49
b. Broad leaved forests						
Bb1-Marghazar	34°35	72°73	1110	S	1681	48
C. Moist temperate zone						
a. Moist temperate broad leaved forests						
Ca1-Mankial Town	35°36	72°73	2000-2100	W	634	28
b- Moist temperate mixed forests						
Cb1-Lower Topa-Jhikagali-Murree	33°34	73°74	1970-2250	S-W	382	31
Cb2-Charyan (Murree)	33°34	73°74	1930	N	484	81
Cb3-Ayubia, Dungagali, Miandum	33°34	73°74	2245-2350	N-S-E-W	401	77
c. Moist temperate conifer forests						
Cc1-Dunga Gali (Ayubia-Murree)	33°34	73°74	1890-2250	W-E	395	56
Cc2-Murree-Nathiagali-	33°34	73°74	2100-2400	N-W	370	76
Miandam (Swat)	35°36	72°73				
Cc3-Mankial-Town	35°36	72°73				
Matiltan-Ushu	35°36	72°73	2100-2250	W	177	92

Table 1. (Cont'd.)

Location of sampling sites	Latitude N	Longitude E	Altitude m	Aspect	SD ha^{-1}	SB $m^2 ha^{-1}$
D. Sub-alpine zone						
a. Sub-alpine Birch conifer forests						
Da1-Kalam (Swat)	35°36	72°73	2350-2400	W-N	411	116
Da2-Near Matiltan (Swat)	35°36	72°73	2300	W	479	121
Da3-Astore	35°22	74°51	3450	NW	406	46
b. Sub-alpine Betula forests						
Db1-Nalter (Gilgit)	36°20	74°13	3350-3500	N	698	34
E. Alpine and dry temperate ecotonal zone						
E1-Near Astore	35°22	74°51	3250	S	339	64
F. Dry temperate zone						
a. Dry temperate mixed coniferous forests						
Fa1-Near Astore	35°22	74°51	3070-3290	Flat	309	57
Fa2-Nashterbool (Zhob, Balochistan)	31°32	70°	3100	E,S,W	556	49
Fa3-Around Astore	35°22	74°51	3100	S	229	93
Fa4-Around Astore	35°22	74°51	3200	E	365	39
Fa5-Nashterbool (Zhob, Balochistan)	31°22	70°	2800-2976	S	538	38
b. Dry temperate broad leaved forests						
Fb1 Zhob (Balochistan)	31°32	70°	1950-2130	Flat	213	33
c. Dry temperate monospecific coniferous forests						
Fc1-Nalter (Gilgit)	36°20	74°13	2770-3100	S-N	387	43
Nashterbool (Zhob, Balochistan)	31°32	70°	2800-2976	S		
Fc2-Tukht-e-Sulaiman (Balochistan)	31°20	69°40	1981-2700	S-W-E-N	269	26
Fc3-Nalter Gilgit	36°20	74°13	3250-3100	N	333	167
Fc4- Juniper Track (Balochistan)	30°50	70°	2100-2800	S-W-E-N	174	42

Note:- Capital letters (A B C D E F) = Climatic zones, Small Letters (a b c) = Types of forest or sub-zones.
Numbers 1 2 3 4 5 represent the sampling location. **SD**= Overall stand density, **SB** = Overall stand basal area.

a. Broad leaved forests: Broad Leaved Community of *Quercus incana* Roxb., was sampled at 1110 meters elevation near Marghazar where Subtropical species *Olea ferruginea* Royle occupies 23% of the total density of the stand. Most of the individual (955) of the dominant species were in the 10-30 cm. This species attained highest density (1303 ha) among all species. Hussain & Illahi (1991) call this type as Oak-Olive Ecotonal Forest. Ground flora was extremely poor due to overgrazing and human disturbance. Among the total three species *Dodonoes viscosa* L. Jacq., was found only in 10-30% of the sampling plots.

b. Mixed pine forests: Hussain & Illahi (1991) considered it as Sub-Tropical Chir Pine-Blue Pine Ecotonal Forests. These types of forests are sampled at Ghoragali at 1570 m elevation. In which 25% of the density was occupied by co-dominant *Pinus wallichiana* A.B.Jackson. Basal area of *Pinus roxburghii* and co-dominant species were 37 and 10 m^2 ha^{-1} respectively. Other associate was *Aesculus indica* L., with small basal area (Table 2). In these stand, *Pinus wallichiana* A.B. Jackson represented by small sized (10-40cm) individuals while a higher number of *Pinus roxburghii* in small size classes show a good regeneration pattern of this species. Highest basal area (37 m^2 ha^{-1}) of this species are also recorded from this type of community. Ground flora was occupies by 16 species, however only 3 species were considered viz., *Chrysanthemum leucanthemum L*., (60%). *Myrsine africana* L., (80%) and *Berberis lycium* Royle (100%).

C. Moist temperate zone

Moist temperate zone extended from Murree Hills, Ayubia, Nathiagali to Miandam from 1890 to 2500 meter along the whole length of the outer ranges of the Himalayan between the Sub-Tropical Pine Forests and the Sub-alpine formation. Since no meteorological station is located at the central Moist Temperate Forest, climatic summary is presented here for Murree. The area receives a maximum rainfall (351 mm) in the month of August and a minimum of (17.8 mm) in the month of November. The mean daily temperature peaks in June (12.5°C) and drops to the minimum of (3°C) in January. Murree Hills receive about 1.8 m snowfall at the elevation of 1935 m while at 2440 m Nathiagali receive 6.7 m of snowfall. Gradual melting of snow in the early summer prolong the season during which adequate moisture is produced for the vegetational growth.

Human disturbances (overgrazing, cutting for timber, lopping), natural fires and snow slides have been frequently reported by various workers in these forests. Three types of forests (Champion *et al*., 1965 and Hussain & Illahi 1975) were sampled in this zone.

a. Moist temperate broad leaved forests: *Quercus incana* Roxb., community stands at Mankial Town a few miles from Bahrain (Swat)) at about 2000 to 2100 meter elevation. Dominant species are listed, 602 individual ha^{-1} with basal area of $19m^2$ ha^{-1} occupied about 95% of the total stand density. *Quercus dilatata* Lindl.ex Royle is the co-dominant species with low density. Nine species were recorded during the circular plot study in which *Euphorbia cornigera* Boiss., *Galium aparine* L., *Thalictrum alpinum* L. var. *microphyllum* and *Rumex nepalensis* Spreng., were found in 50% to 90% of the sampling plots. Beg (1975) described it as Ban Oak forest under lower west Himalayan Temperate Forest.

Table 2. Quantitative summary of certain Himalayan plant communities of Pakistan.

	RF1	RD2	RB3	IM4	DH5	BA6
A. Sub tropical zone						
a. Broad leaved forests						
1. *Acacia modesta* community						
Acacia modesta Wall.	59	80	86	75	534	16
Olea ferruginea Royle	41	20	14	25	133	12
2. *Olea ferruginea* community						
Olea ferruginea Royle	63	83	81	75	620	26
Acacia modesta Wall.	37	17	19	25	131	6
b. Lower pine forests						
1. *Pinus roxburghii* community						
Pinus roxburghii Roxb	60	62	62	61	158	20
Olea ferruginea Royle	40	37	38	38	92	10
c. Upper pine forests						
1. *Pinus roxburghii* community						
Pinus roxburghii Roxb.	91	97	99	96	715	29
Quercus incana Roxb.	9	3	1	4	17	2
B. Sub tropical and moist temperate ecotonal zone						
a. Mixed pine forests						
a1. *Pinus roxburghii* community						
Pinus roxburghii Roxb.	50	67	71	63	384	37
Pinus wallichiana A.B. Jackson	35	25	21	27	143	10
Aesculus indica L.	10	5	5	7	28	2
b. Broad leaved forests						
b1. *Quercus incana* community						
Quercus incana Roxb.	62	77	85	74	1303	32
Olea ferruginea Royle	38	23	15	26	378	16

Table 2. (Cont'd.)

	RF1	RD2	RB3	IM4	DH5	BA6
C. Moist temperate zone						
a. Moist temperate broad leaved forests						
a1. *Quercus incana* community						
Quercus incana Roxb.	91	95	91	92	602	19
Quercus dilitata Lindl. ex Royle.	9	5	9	8	34	9
b. Moist temperate mixed forests						
b1. *Pinus wallichiana* community						
Pinus wallichiana A.B. Jackson	66	63	88	72	258	27
Quercus incana Roxb.	18	20	10	16	125	4
b2. *Cedrus deodara* community						
Cedrus deodara (Roxb. ex Lamb.) G. Don.	69	85	93	82	433	78
Quercus incana Roxb.	15	10	1	9	51	3
b3. *Abies pindrow* community						
Abies pindrow Royle	56	71	65	64	300	54
Pinus wallichiana A.B. Jackson	24	19	27	23	78	19
Prunus cornuta (Wall. ex Royle) Steud.	5	2	4	4	14	3
Aesculus indica L.	5	2	1	2	9	1
c. Moist temperate conifer forests						
c1. *Pinus Wallichiana* community						
Pinus Wallichiana A.B. Jackson	72	77	89	79	319	51
Abies pindrow Royle	20	17	9	15	77	4
c2. *Abies pindrow* community						
Abies pindrow Royle	72	75	80	76	274	62
Pinus wallichiana A.B. Jackson	21	32	19	21	96	14
c3. *Cedrus deodara* community						
Cedrus deodara (Roxb. ex Lamb.) G. Don.	84	85	84	84	148	83
Abies pindrow Royle	7	6	8	7	17	6
Pinus wallichiana A.B. Jackson	6	4	5	5	12	3

Table 2. (Cont'd.)

	RF1	RD2	RB3	IM4	DH5	BA6
D. Sub-alpine zone						
a. Sub-alpine conifer forests						
a1. *Cedrus deodara* community						
Cedrus deodara (Roxb.ex Lamb.) G. Don.	56	70	73	66	336	82
Betula utilus D.Don.	31	21	24	25	75	24
a2. *Abies pindrow* community						
Abies pindrow Royle	31	29	72	44	102	29
Betula utilus D. Don.	50	53	16	40	233	9
Pinus wallichiana A.B. Jackson	19	18	12	16	71	8
b. Sub-alpine Betula forests						
b1. *Betula utilis* community						
Betula utilis D. Don.	91	93	85	90	666	30
Picea smithiana (Wall.) Boiss.	8	6	15	10	32	4
E. Sub-alpine and dry temperate ecotonal zone						
a. *Pinus wallichiana* community						
a1. *Pinus wallichiana* A.B. Jackson	53	75	82	70	254	52
Juniperus communis L.	26	12	12	17	42	8
Abies Pindrow Royle	16	10	3	10	24	2
Betula utilis D. Don.	5	3	3	3	9	2
F. Dry temperate zone						
a. Dry temperate mixed coniferous forests						
a1. *Pinus wallichiana* community						
Pinus wallichiana A.B. Jackson	48	53	70	57	175	41
Abies pindrow Royle	41	40	26	36	134	16

Table 2. (Cont'd.)

	RF1	RD2	RB3	IM4	DH5	BA6
a2. *Pinus wallichiana* community						
Pinus wallichiana A.B. Jackson	67	71	62	67	337	28
Pinus gerardiana Wall. ex Lamb.	33	29	38	33	219	21
a3. *Picea smithiana* community						
Picea smithiana (Wall.) Boiss.	53	67	78	66	155	72
Pinus wallichiana A.B. Jackson	47	33	22	34	74	21
a4. *Abies pindrow* community						
Abies pindrow Royle	83	90	88	87	329	34
Pinus wallichiana A.B. Jackson	17	10	12	13	36	5
a5. *Pinus gerardiana* community						
Pinus gerardiana Wall. ex Lamb.	35	48	56	46	301	23
Pinus wallichiana A.B. Jackson	38	34	47	40	238	15
b. Dry temperate broad leaved forests						
b1. *Olea ferruginea* community						
Olea ferruginea Royle	56	82	87	75	200	28
Pistacia khinjuk Stocks.	16	8	11	12	13	5
c. Dry temperate monospecific coniferous forests						
Dry Temperate *Pinus wallichiana* A.B. Jackson	100	100	100	100	387	42
Dry Temperate *Pinus gerardiana* Wall. ex.Lamb.	91	95	94	93	266	25
Dry Temperate *Picea smithiana* (Wall.) Boiss.	100	100	100	100	333	167
Dry Temperate *Juniperus excelsa* M. Bieb.	90	100	97	98	174	42

Abbreviations are same as Table 1. 1-2-3-4-5 = Represent community number.

Relative phytosociological attributes importance values, density and basal area of dominant species of various plant communities in Himalayan forests of Pakistan. Plant communities are divided on the basis of major climatic zones by Champion et al (1965).

Note:- 1- Average relative frequency 2- Average relative density 3- Average relative basal area 4- Average Importance values 5- Average species density ha^{-1} 6- Average species basal area m^2 ha^{-1}

b. Moist temperate mixed forests: Champion *et al*., (1965) and Beg (1975) named these forests as Western Mixed Conifer Forests while Naqvi (1976) describe as *Pinus–Quercus* mixed forest. These forests are dominated by *Coniferous* species with broad leaves associates as co-dominant. Based on floristic composition and higher importance value three different communities were recognized.

Pinus wallichiana A B Jackson community was located on lower Topa and Jhikagali and Murree at elevation of 1970 to 2250 meter. Chaudhri (1960) stated that *Pinus wallichiana* A.B. Jackson is a pioneer species distributed on all aspects with wide altitudinal limit. According to Naqvi (1975), a connecting species link up other coniferous species in the area. *Pinus wallichiana* A.B.Jackson attained 63% of density with 88% of the total basal area. Its 140 individual distributed in the 10 to 30 cm dbh class with a few individual in higher size classes, showing a good regeneration. Two tree species *Populus ciliata* Wall.ex Royle and *Aesculus indica* L., listed by Hussain & Illahi (1991) are almost eliminated by locals, therefore, *Quercus incana* Roxb., was the co-dominant species with low density and basal area (Table 2). Forest floor was supported by 17 species, in which *Hedera nepalensis* K. Koch., *Lolium perenne* L., *Chrysanthemum leuconthemum* L., *Berberis lyceum* Royle, *Myrsine africana* L., *Viburnum contifolium* L., were recorded in 60% to 90% of the sampling plots.

Cedrus deodara Community, This community occupied the highest number of trees ($433ha^{-1}$) and higher basal area ($78\ m^2\ ha^{-1}$) of this species. This community was sampled near Charyan Rest house (Murree) at 1930-meter elevation. According to Beg (1975) *Cedrus deodara* (Roxb.ex Lamb) G. Don., like Mediterranean climate and avoids area, which received high summer rainfall therefore, he placed under the Dry temperate forests. Champion *et al*., (1965) stated that *Cedrus deodara* (Roxb.ex Lamb) G. Don., extend gradually into the dry inner valley of the Himalayan and ultimately shift to an entirely different Dry *Cedrus deodara* forest. He described it under the moist temperate forest. Dominant species *Cedrus deodara* (Roxb.ex Lamb) G. Don., occupied 85% of the density and 93% of the total basal area of stand. A large number of individual ($317\ ha^{-1}$) of this species occupied 30 cm to 60cm dbh size classes, while in 10 to 30 cm size classes density was fairly low, showing a low regeneration. *Quercus incana* Roxb., a co-dominant species show low density and basal area (Table 2).

Ground flora was occupied by 10 species in which *Hedera nepalensis* K.Koch, *Myrsine africana* L., *Saccharum bengalense* Retz., and *Pteris cretica* L., were recorded from 60% to 90% of the sampling plots.

Abies pindrow Community, This community prefers cool and moist sites even in dry zones (Hussain & Illahi 1991). Sampling stands were located near Dungagali, Murree hills, Ayubia and Miandam from 2245 to 2350-meter elevation. Dominant species occupied 71% of total density while 65% of the total basal area of the stand. Its 184 individual ha distributed in 10 to 40 cm dbh size classes indicating a good regeneration pattern. *Pinus wallichiana* as a co-dominant species hold the 23% of the stand importance value (Table 2). Two broad-leaved species *Prunus cornuta* (Wall.ex Royle) Steud., and *Aesculus indica* L., *are* the associates of this community with low values.

Ground flora was thick and rich comprised of 15 species, in which *Hedera nepalensis* K. Koch., *Rumex nepalensis* Spreng., *Adiantum capillus-veneris* L., *Poa alpina* L., *Veronica biloba* L., *Thalictrum alpinum* L. var. *microphyllum, Euphorbia cornigera* Boiss., and *Ranunculus diffusus* DC., were the widely distributed species with 70% to 90% of relative frequency.

c. Moist temperate coniferous forests: In these forests, no broad-leaved tree species were recorded. This zone is distributed from 1890 to 2420 m in elevation. Hussain & Illahi (1991) recognized *Pinus wallichiana* community as mixed temperate forest. Based on higher importance value of dominant species following 3 different coniferous communities were recognized.

1. *Pinus wallichiana* community
2. *Abies pindrow* community
3. *Cedrus deodara* community

Floristic composition of canopy species in all 3 communities are same. The difference is only in their quantitative phytosociological attributes (Table 2). The ground flora of each community show different floristic composition. In these communities, dominant species show 75%to 85% stand density and 80%to 82% of stand basal area. Co-dominant species (Table 2) show 6%to 32% of the relative density and 8%to 19% of the total basal area. Dominant species of *Pinus wallichiana* A.B.Jackson *Abies pindrow* Royle *and Cedrus deodara* (Roxb.ex Lamb) G. Don., show 151, 105 and only 46 individual ha^{-1} respectively in 10 to 40 cm dbh size classes (Table 3). Size class structure of *Pinus wallichiana* A.B.Jackson and *Abies pindrow* Royle in general show adequate regeneration except under *Cedrus deodara* community, where it may on the way be of extinction: *Cedrus deodara* (Roxb.ex Lamb) G. Don., structure also represents frequent reproduction.

In general basal area m^2 ha^{-1} was considerably higher than previously described moist temperate mixed forests. Highest basal area ($83m^2$ ha^{-1}) from *Cedrus deodara* (Roxb.ex Lamb) G. Don., and *Abies pindrow* Royle ($63m^2$ ha^{-1}) was recorded in this area. Ground flora of *Pinus wallichiana* community, which was located near Charyan Rest house Murree, Ayubia and Dungagali was thick and consist of 11 species. However, *Polygonatum multiflorum* (L.) All., *Myrsine africana* L., and *Berberis lyceum* L., were most abundant and found in 90% of the sampling plots. In the areas near Resthouse Murree, Nathiagali and near Miandum where *Abies pindrow* was the dominant, 14 species were recorded from forest ground. *Galium aparine* L., *Galium borcale* Wall., *Adiantum incisum* Forssk., *Geum urbanum* L., *Bellis perennis* L., *Galium elegans, Hedera nepalensis* K. Koch., and *Chrysanthemum leucanthemum* L., were occupied 50%to 60% plots while *Adiantum capillus-veneris* L., and *Rannunculus muricatus* L., were recorded in 90%to 100% circular plots.

Sampling areas where *Cedrus deodara* (Roxb.ex Lamb) G. Don., was dominant 10 broad leaved species were recorded in sampling plots in which *Artemisia brevifolia* Wall.ex DC., and *Viola biflora* L., occupied 50% while *Veronica biloba* L., *Cotoneaster nummularia* Fisch. & Mey., *Fragaria nubicola* Lindle. ex Lacaita., and *Rosa macrophylla* Lindl., were distributed in 60%to 70% of the sampling plots.

D. Sub-alpine zone

a. Sub-alpine birch-coniferous forests: These forests were sampled from 2350 to 3500 m elevation, near the tree line. According to Hussain (1984) they are developed between timber line and snowline zones of Kaghan, Swat, Baltistan, Gilgit, Chitral, Dir and Koh Safed region. The upper and lower limits for the extension of these forests vary with local

factors and aspects. The conifers are smaller in size than those growing in the temperate zone. *Betula utilis* D.Don., is the characteristic species of the sub alpine zone. Meteorological data of this zone is not available. However, according to Champion *et al*., (1965) maximum temperature do not exceed (15.5°C), snowfall is even more important. A depth of 1.8 m to 5.5 m is reported. On the basis of quantitative values and floristic composition, 3 different communities were recognized.

***Cedrus deodara* community:** This community was recorded near Matiltan glacier and Kalam on west and north facing slopes. Dominant species occupied 336 individuals ha^{-1} with a similar basal area ($82m^2$ ha^{-1}) of moist temperate conifer forest. Its 153 individual distributed from 10 to 30 cm dbh classes with a gradual decrease in larger size classes. Co-dominant *Betula utilis* D. Don., has 75 individual with 24 m^2 ha^{-1} basal area. This community was distributed on their lowest side (2350 m altitude) of sub-alpine zone. During the plot sampling 9 species were recorded in which *Ailiaria petiolat* (M.B.) Cav., *Rosa macrophylla* Lindl., and *Fragaria nubicola* Lindle. ex Lacaita., were observed in 50%-60% of the circular plots.

***Pinus wallichiana* community:** The adaptability and colonization of this species is phenomenal (Hussain & Illahi 1991). This community was recorded near Matiltan on west facing slope at 2300-meter elevation. *Pinus wallichiana* occupied the highest basal area (82 m^2 ha^{-1}) of this species in this location. Due to the presence of *Betula utilis* D. Don., this community was placed in Sub-Alpine zone. Champion *et al*., (1965), Hussain & Illahi (1975), consider it under Sub-Alpine Blue pine forest. Size class distribution of this community show higher number of individuals in small size classes with gradual decrease in large classes (Table 3), indicating proper regeneration pattern. Among the 6 species recorded on forest floor only *Rosa macrophylla* Lindl., was distributed in 60% of the sampling plots. Due to overgrazing and human disturbance, most of the species listed by Champion *et al*., 1965 and Hussain & Illahi (1991) are not recorded.

***Abies pindrow* community:** This community was sampled near Rama Lake (Astore) on North West facing slopes at an elevation of 3450 meters. Champion *et al*., (1965) described these forests as West Himalayan sub-alpine birch forests. Density of *Betula utilis* D. Don., was 50% higher than *Abies pindrow* Royle but due to quantitative attributes the community was named as *Abies pindrow* community, other associate *Pinus wallichiana* A.B.Jackson showing same basal area as *Abies pindrow* Royle (Table 2). Seven species were recorded in the sampling area on forest floor in which *Pseudomertensia moltkioides* (Royle) Kazmi and *Thymus serpyllum* L., occupied 50% while *Aquilegia moorcroftiana* Wall.ex Royle and *Gentiana marginata* (G.Don). Griseb., were recorded in 70% of the circular plots.

b. Sub-alpine betula forests

***Betula utilis* community:** This sampling site was located on Nalter near Gilgit at the elevation of 3350 to 3500 meter on north facing slopes. Highest density and basal area of *Betula* were recorded in these stands (Table 2). Co-dominant species *Picea smithiana* was distributed in a scattered form. At higher elevation *Betula utilis* D.Don., form a pure stand. In these stands, *Betula utilis* D. Don., has a dbh up to 70 cm while small sized

individuals of *Picea smithiana* were common. *Betula utilis* D. Don., produced 666 individual ha^{-1} with a basal area of $30m^2$ ha^{-1}. Champion *et al*., (1965) considered these forests as a sub-alpine birch forest. Ground flora was associated with 14 species in which *Geranium* sp., *Mentha longifolia* (L.) Huds., *Viola sylvestris* Lam., found in 70% while *Leopodium* sp., *Gagea elegans* Wall.ex Royle, *Artemisia brevifolia* Wall. ex DC., and *Juniperus squamata* Buch. Ham. ex Lambert were recorded in 40%to 50% of the circular plots.

E. Sub-alpine & dry temperate ecotonal zone

***Pinus wallichiana* community:** This zone was also named on the basis of characteristic species.Sampling area was located at Rama Rest House (Astore) at 3250 m on south facing slopes. Due to presence of a characteristic species *Betula utilis* D. Don., of sub alpine zone and *Juniperus communis* L., from dry temperate zone, this community was placed in the intermediate zone. Both species comprised 20% of the importance value of the stands, while *Pinus wallichiana* A.B.Jackson (dominant species) occupied 70% of the importance value. In addition, its 170 individual's ha^{-1} distributed from 10 to 40 cm dbh size classes with a considerable decrease in larger size classes. The structure represents frequent reproduction according to Knight (1975). *Abies pindrow* Royle was also associated in this community with low density and basal area (Table 2). Area was subjected to grazing. Therefore, 10 species were recorded on forest floor. *Rannunculus lactus* Wall. ex H. & T., *Aquilegia moorcroftiana* Wall.ex Royle, *Pseudomertensia malkioides* Royle were associated in 40% of the plot while *Fagonia bruguieri* DC., and *Asparagus filicinus* Ham., were found in 80% of the sampling area.

F. Dry temperate zone

Sampling stands in this zone are located at Astore, Nalter (Northern area) Nashterbool Ziarat and Takht-e-Sulaiman, Balochistan from 1950 m to 3290 m elevations. These areas exhibit Mediterranean type of climate. Meteorological data from sampling sites are not available; however, the annual precipitation is always less than 76 m winter spring bring ample amount of snow and rainfall. The mean average temperature varies between 5.5°C to 15.5°C while mean minimum temperature goes below zero (Hussain & Illahi, 1975).

Three types of dry temperate forests were investigated under dry temperate zone i.e., a) Dry temperate mixed conifer forests. b) Dry temperate broad-leaved forests. c) Dry temperate monospecific coniferous forests.

a. Dry temperate mixed coniferous forests: Beg (1975) Hussain, (1984) and Hussain & Illahi (1991) described these forests and stated more or less similar floristic composition to the mixed Conifer forest of the moist temperate zone. In these forests 86%to 100% importance values were occupied by two coniferous species. Broad-leaved tree species are rare or completely eliminated by the human disturbance. In this category, five communities were recognized. *Pinus wallichiana* A.B.Jackson (two communities) *Picea smithiana* (Wall.)Boiss., *Abies pindrow* Royle and *Pinus gerardiana*. Most common species was *Pinus wallichiana* A.B. Jackson representing as a dominant or co-dominant species. This species is also widely distributed in moist temperate area, showing wide ecological amplitude.

Table 3. Size class structure of various communities. Diameter size class distribution of dominant tree species of a community in different climatic zones of Pakistan. Diameters more than 10 cm dbh are included. Each class shows 10 cm intervals. Abbreviations are same as given in Table 1 and 2.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A. Sub tropical zone																	
a. Broad leaved forests																	
Aa1 *A. modesta*	400	135															
O. ferruginea	133																
Aa2 *O. ferruginea*	392	145	83														
A. modesta	66	52	13														
b. Lower pine forests																	
Ab1 *P. roxburgii*	7	14	57	5	33	19	-	5	9	9							
O. ferruginea	25	46	14	5	2												
c. Upper pine forests																	
Ac1 *P. roxburgii*	354	189	74	69	17	6											
Q. incana	13	-	4								6						
B. Subtropical & moist temperate ecotonal zone																	
a. Mixed pine forests																	
Ba1 *P. roxburgii*	142	71	99	15	14	28											
P. wallichiana	79	16	48														
A. indica	7	14	7														
Bb1 *Q. incana*	955	304	44														
O. ferruginea	302	76	-														
C. Moist temperate zone																	
a. Moist temperate broad leaved forests																	
Ca1 *Q. incana*	205	295	79	23													
Q. dilitata	28	5	1														
b. Moist temperate mixed forests																	
Cb1 *P. wallichiana*	86	54	36	41	18	9	-	9	-	5							
Q. incana	109	8	-	-	-	8											
Cb2 *C. deodara*	13	26	140	89	88	39	25	13									
Q. incana	38	-	13														
Cc3 *A. pindrow*	57	62	65	34	38	10	5	3	5	13	-	5	3				
P. wallichiana	15	-	13	10	2	15	2	15	6								
P. cornuta	-	5	5	-	4												
A. indica	5	-	4														

Table 3. (Cont'd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
c. Moist temperate coniferous forests																	
Cc1 *P. wallichiana*	46	35	71	56	66	25	10	10									
A. pindrow	39	20	6	6	6												
Cc2 *A. pindrow*	64	15	26	35	50	28	18	14	7	12	3	2					
P. wallichiana	30	12	9	6	16	9	8	4	-	-	-	2					
Cc3 *C. deodara*	21	14	11	6	7	9	11	8	9	11	8	7	10			4	
A. pindrow	-	-	2	-	5	-	7	3									
P. wallichiana	-	-	-	5	4	2	-	1						10	6		
D. Sub-alpine zone																	
a. Sub-alpine mixed coniferous forests																	
Da1 *C. deodara*	51	57	45	40	34	23	34	11	11	11	10	-	-				
B. utilis	19	38	18														
Da2 *P. wallichiana*	55	40	14	42	42	-	-	14	41	14	12			-	6	-	3
C. deodara	55	41	14	14	14	28	14	25									
Da3 *A. pindrow*	51	10	-	-	11	10	10	-	10								
B. utilis	165	29	29	-	10												
P. wallichiana	30	-	20	11	-	-	10										
b. Sub-alpine Betula forests																	
Db1 *B. utilis*	418	209	154	88	-	11											
P. smithiana	26	13	12	7	-	7											
E. Sub-alpine and dry temperate ecotonal zone																	
Ea1 *P. wallichiana*	76	26	68	25	9	8	17	-	8	-	8						
J. communis	-	17	-	8	17												
A. pindrow	10	15	7	2													
B. utilis	-	-	5	4													

Table 3. (Cont'd.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
F. Dry temperate zone																	
a. Dry temperate mixed coniferous forests																	
Fa1 *P. wallichiana*	22	5	36	49	40	34	27	16	4								
A. pindrow	71	45	33	13	30	2	10	6									
Fa2 *P. wallichiana*	95	81	75	65	16	-	11										
P. gerardiana	46	60	-	49	66												
Fa3 *P. smithiana*	24	-	23	23	23	18	12	12	6	12							
P. wallichiana	-	10	-	10	10	16	17	11									
Fa4 *A. pindrow*	85	84	67	34	17	34	8										
P. wallichiana	-	-	20	16													
Fa5 *P. gerardiana*	148	112	97	60	-	30											
P. wallichiana	215	107	30	15													
b. Dry temperate broad leaved forests																	
Fb1 *O. ferruginea*	80	64	32	16	8												
P. khinjuk	-	-	4	6	3												
c. Dry temperate monospecific coniferous forests																	
Fc1 *P. wallichiana*	103	48	90	97	21	7	-	-	14	7							
Fc2 *P. gerardiana*	132	50	41	32	30	15	14	10	4	-	4	4					
Fc3 *P. smithiana*	18	21	33	42	54	35	33	27	25	9	4	8	12	8	-	4	1
Fc4 *J. excelsa*	60	50	25	10	19	-	6	-	2	2							

Note: B= *Betula*, C= *Cedrus*, J= *Juniper*, O= *Olea*, P= *Pinus*, Q= *Qucrcus*

A. modesta = Acacia modesta, A. indica = Aesculus indica, P. cornuta = Prunus cornuta, P. smithiana = Picea smithiana, P. khinjuk = Pistacia khinjuk

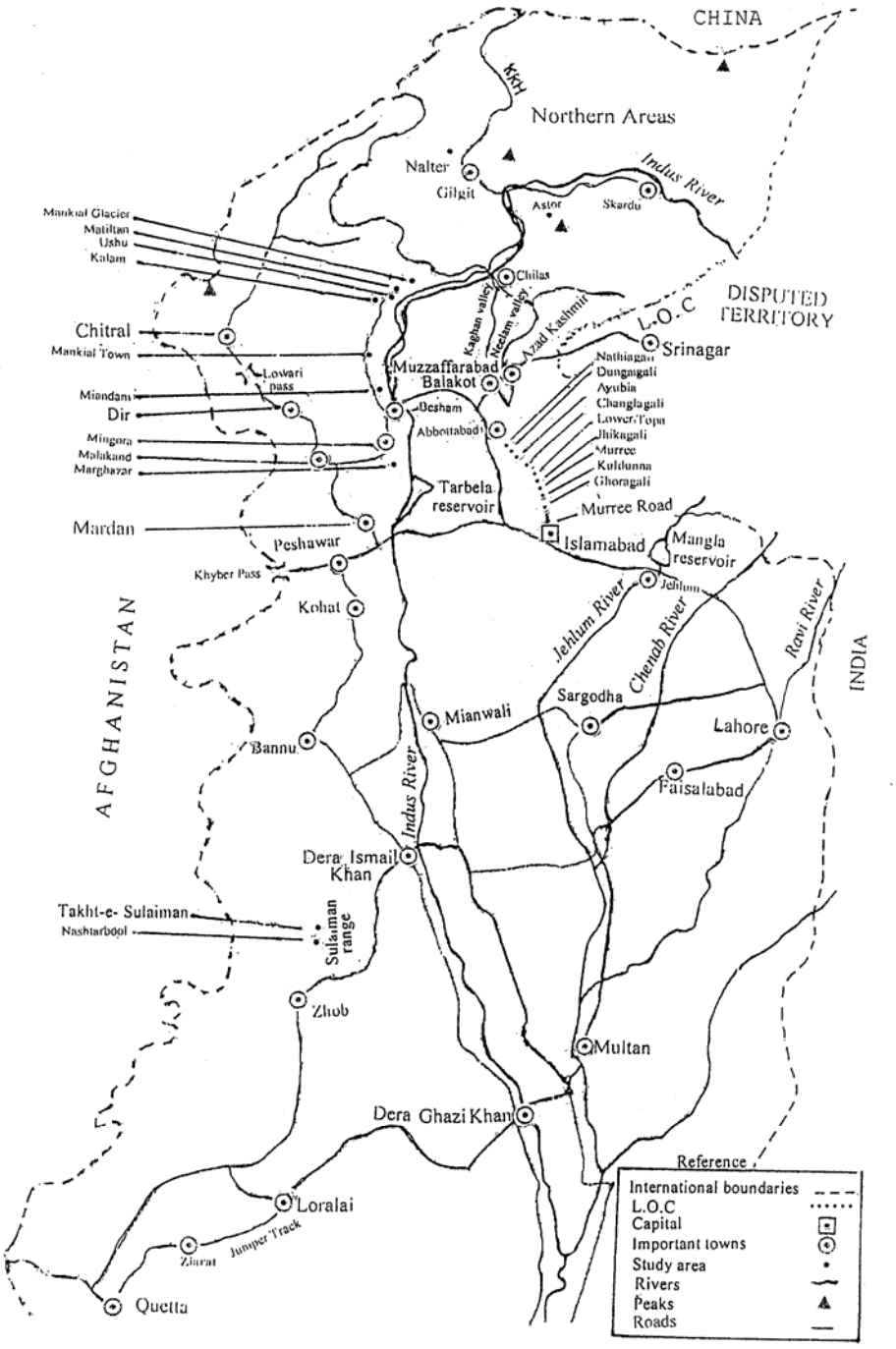

Fig. 1. Study area map. Out of 180 stands only nearest localities are indicated in the map. Details are given in Table 1.

In Dry Temperate Mixed Forests, *Pinus wallichiana* A.B.Jackson is dominating around Rama (northern areas) and Nashterbool (Takht-e-sulaiman, Balochistan). Its importance value at Balochistan is higher (67%) than Rama (57%), while basal area m^2 ha^{-1} was considerably less. Its 337 individual's ha^{-1} occupied 28 m^2 ha^{-1} basal area at Balochistan, if compared with Rama 232 individual with basal areas 41m^2 ha^{-1}. At Astore area co-dominant species was *Abies pindrow* Royle with 36% of average importance value while *Pinus gerardiana* L., was associated as a co-dominant species in Balochistan occupying 33% of the importance value. Size class distribution of dominant species at Astore indicates more individual in middle diameter classes. Such a structure represents inadequate reproduction and if such a trend continues, the population is on the way to extinction. However, in the same location and community, *Abies pindrow* Royle occupies larger number of individuals in lower classes, indicating frequent regeneration. In Balochistan *Pinus wallichiana* A.B.Jackson stands shows good trend of reproduction.

Ground flora of Astore was richer than Balochistan. At Astore 12 species were recorded in which *Rannunculus lactus* L., *Aquilegia moorcroftiana* L., *Fagonia bruguieri* D.C., and *Thymus serpyllum* L., were recorded in 50% of plots while *Asparagus filicinus* Ham., *Carduus edelbergii* Rech. f., *Viola rufectris* L., were found in 80% of the sample plot.

In Balochistan 12, species were also recorded, but due to disturbance only two species *Cotoneaster racemifolia* K. Koch., and *Thymus serpyllum* L., attained 30% of the sampling plots.

Picea smithiana community was recorded on 1300 m elevation on south facing slopes near Astore, where this species has 66% of the importance value. Its 153 individual's ha^{-1} occupied 72 m ha^{-1} basal area. In general, size class structure of dominant species shows normal reproduction, however gap in early class and similar number of trees in 10 cm to 60 cm classes indicate possible selective logging of the trees in this area. Co-dominant species *Pinus wallichiana* A.B. Jackson showed poor regeneration and gaps in this size class structure (Table 3). Beg (1975) classified these forests under Dry Zone Spruce Forests, except for the presence of ground flora this community can hardly be differentiated from those growing in moist mixed conifer forests. Grazing and human disturbance are high in this area. *Viola rufectris* L., *Fagonia bruguier* D.C., and *Rannunculus* sp., found 70%to 80% of the sampling plots.

Abies pindrow community was also recorded from Astore but Eastern slopes at 3200-meter elevation. Dominant species occupied 87% of the total importance value and about 90% of the stand density (328 ha^{-1}), this is the highest stand density in different sampling areas. A large number of *Abies pindrow* Royle (72%) are distributed in 10 to 40cm dbh size classes with a gradual decrease in large size classes. This trend in structure indicates an excellent reproduction, while co-dominant species *Pinus wallichiana* A.B.Jackson. showed uneven distribution with gaps in size classes (Table 3).

Ground flora supported ten species in which *Asparagus filicinus* Ham., and *Carduus edelbergii* Rech. f., was recorded in 80% while *Silez* sp and *Gentiana marginata* (G.Don.) Griseb., found in 50% of the sampling plots.

***Pinus gerardiana* community:** This community was recorded on higher elevation (2000-2976 meter) of cooler sites at Sulaiman range. Dominant species occupied 46% of the importance value with a density of 301 ha^{-1} while co-dominant species *Pinus wallichiana* A.B.Jackson distributed with 40% of the importance value and a density of 238 ha^{-1}.

Larger number of *Pinus gerardiana* Wall. ex Lamb., were recorded in 10 to 30 cm dbh size classes. Co-dominant species also showed similar trend (Table 3). This type of structure represents a good regeneration of both species. Other broad-leaved associated trees were *Fraxinus xanthoxyloides* (Wall. ex G. Don) DC., and *Pistacia khinjuk* Stocks with low importance value.

Ground flora was occupied by 12 species in which *Astragalus polybotrys* and *Stipa himalacia* Rosher., were recorded in 40 to 50 % plots while *Thylictrum vaginatus*, *Cotoneaster racemiflora* K. Koch., and *Ziziphus clinopodioides* Lam., were distributed in 60% of the sampling plots.

b. Dry temperate broad leaved forests

***Olea ferruginea* community:** This community was sampled on flat and gentle slopes of Tukht-e-Sulaiman range from 1950 to 2130-meter elevation. This community was also recorded in sub-tropical zone at low elevations, (750–910 meter), however, unlike that zone, *Pistacia khinjuk* Stocks appeared as a co-dominant species in this community. Highest dbh (28 m^2 ha^{-1}) of *Olea ferruginea* was recorded in this area with considerable low density (200 ha^{-1}). Dominant species occupied 88% of the total importance value while scattered but large sized individual of co-dominant species attained 27% of the total average importance value. Diameter size class structure of dominant species shows a good regeneration pattern. The area also occupies a big sized (up to 60m dbh), trees if compared to other zones of the study areas. During the circular plot study, only six species were recorded in which *Sophora grifthii* (Royle) Baker. *Ephedra intermediata* Stapf., and *Dicanthium annulatum* (Forssk.) Stapf., were found in 40%to 50% of plots.

c. Dry temperate monospecific coniferous forests: Champion *et al*., (1965) and Hussain & Illahi (1991) described these forests. Low precipitation is largely compensated by heavy snowfall in these areas. In these forests only one conifer species dominated the area, occupying 93% to 100% of the total importance value of the stands. Community was not recognized in these area and the stands were named based on the only dominant species.

Dry temperate *Pinus wallichiana*: Beg (1975) recognized it as dry zone Blue-Pine forests. This species required more moisture than other species of dry temperate zone (Champion *et al*., 1965). Pure stands of this species were located on south facing slope of Nalter (Gilgit at 2770 m elevation) and higher elevation (3100 m) of Tukht-e-Sulaiman range. The stand shows the highest density of *Pinus wallichiana* A.B.Jackson in the sampling areas. An average 387 individual ha^{-1} had basal area of 43m^2 ha^{-1}. Higher number of trees (241 ha^{-1}) distributed in 10 to 40 cm dbh classes showed a normal recruitment. This forest is similar to the *Pinus wallichiana* A.B.Jackson forests distributed in moist zone expect in ground flora.

Dry temperate *Picea smithiana*: Champion *et al*., (1965) dry zone spruce forests these stands were sampled on Northern aspects of Nalter (Gilgit) from 3100 meter to 3250 meter elevation. More or less pure form of *Picea smithiana* (Wall.) Boiss., is also distributed in moist temperate area. However, except for the ground flora, species growing on different zone can hardly be distinguished. The species shows higher density

(333 ha^{-1}) and occupies the highest basal area (167 m^2 ha^{-1}) in the study area. Large size trees up to 190 cm dbh were recorded in this area, while 80cm to 110cm dbh trees were common (Table 3). Size class distribution of this species occupies more trees in medium size classes and decreasing individual both towards the higher and lower size classes. According to Knight (1975), such structure represents poor regeneration.

Due to overgrazing ground flora was poor, 10 species were recorded in which *Rosa webbiana* Wall. ex Royle., *Sedum* sp., and *Aquilegia moovaofolia* Wall. ex Royle were distributed in 25%to 30% of the sampling plots. On the lower margin of the sampled stand a few *Pinus wallichiana* A.B.Jackson while on the upper margin a few scattered *Betula utilis* D. Don., were distributed.

Dry temperate *Pinus gerardiana*: Champion *et al*., (1965) described it as Chilghoza Pine forests. The sampling sites lie in Takht-e-Sulaiman range from 2000 m to 2700 m. Meteorological records from the mountain is not available but they receive more rainfall than lower elevation. Closed to the Fort Sandman and in many stands *Pinus gerardiana* formed a closed canopy. However, some stands dead medium sized trees were also observed. If compared to the dry temperate mix conifer area, these stands show less density (266 m^2 ha^{-1}) with higher basal area (25 m^2 ha^{-1}). Predominant broad leaves species and shrubs reported by Rafi (1951) are extremely rare. Overall, size class structure of trees had higher density (63%) in small size classes with a gradual decrease in large size classes, indicating adequate recruitment. The area is subjected to extensive disturbance and most of the trees were deformed and unhealthy. *Pinus gerardiana* attained 93% of the stand importance value. Ground flora was extremely poor and scattered. *Caragana ambigua* Stocks, *Berberis lyceum* L., and *Daphne oleoides* Schreb., found in only 30% of the sampling plots.

Dry temperate juniper: These forests are similar to the *Pinus gerardiana* forests but, absolutely absent in that area. Both forests show almost same type of broad-leaved trees and other shrubs and herbs. However, these sites are considered hotter and drier than *Pinus gerardiana* sites. *Juniperus excelsa* M. Bieb., forests were sampled from Kuch to Chautair, in Balochistan province from 1200 to 3000 m elevation. The average annual rainfall is 269 mm with a maximum of 74 mm in July. The coldest month is January (7.9°C) while the hottest month is July (27.4°C) (Champion *et al*., 1965). The average density of *Juniper excelsa* was 175 stems ha^{-1} with an average basal area of 42m^2 ha^{-1}. It attains 98% of the total importance value. Diameter distribution within stands were mostly skewed and unimodel with gaps appearing in large size classes (Table 3). This implies adequate recruitment, despite occurrence of gaps (Ahmed 1990). *Fraxinus xanthoxyloides* (Wall.ex G.Don) DC. , *Pistacia khinjuk* Stocks and *Prunus amygdalis* L., were extremely rare due to anthropogenic disturbance. *Rosa laccrans* Boiss. & Bushse, *Cotoneaster racemiflora* K.Koch., *Artemisia maritima*, *Peganum hermala* L., and *Lepidium draba* ssp., Chaleprnse var. *repensthell* were recorded in 55% to 70% of the sampling plots.

References

Ahmed, M. 1976. Multivariate analysis of the vegetation around Skardu. *Agri. Pak*., 26: 177-187.

Ahmed, M. 1986. Vegetation of some foothills of Himalayan range in Pakistan. *Pak. J. Bot*., 18(2): 261-269.

Ahmed, M. 1988a. Plant communities of some northern temperate forests of Pakistan. *Pak. J. For*., 38: 33-40.

Ahmed, M. 1988b. Population studies of some planted tree species of Quetta. *J. Pure. Appl. Sci*., 7: 25-29.

Ahmed, M., A. Mohammad, A. Mohammad and S. Mohammad. 1991. Vegetation structure and dynamics of *Pinus gerardiana* forest in Baluchistan. *Pakistan. J. Veg. Sci*., 2: 119-124.

Ahmed, M., S.S. Shaukat and A.H. Buzdar. 1990. Population structure and dynamics of *Juniperus excelsa* in Baluchistan, Pakistan. *J. Veg. Sci*., 1: 271-276.

Ahmed, M. and S.A. Qadir. 1976. Phytosociological studies along the way of Gilgit to Gopis, Yasin and Shunder. *Pak. J. For*., 26: 93-104.

Amin, A. and R.M. Ashfaque. 1982. Phytosociological studies of Ayub National Park, Rawalpindi. *Pak. J. For*., 32: 130-135.

Beg, A.R. 1975. *Wildlife habitats of Pakistan.* Bull, no. 5. Pak. Forst. Inst. Peshawer.

Beg, A.R. and M.H. Khan. 1984. Some more plant communities and the future of dry oak forest zone in Swat valley. *Pak. J. For*., 34: 25-35.

Benton, A.H. and W.E. Werner Jr. 1976. *Field Biology and Ecology*. McGraw-Hill, New York. 564 pp.

Champion, G. Harry and S.K. Seth. 1965. *Forest types of Pakistan*. Pakistan Forest Institute, Peshawar. 233 pp.

Chaudhri, I.I. and S.A. Qadir. 1958. Sand dunes vegetation of coastal region, Karachi. *Pak. J. For*., 8(4): 332-341.

Chaudhri, I.I. 1960. The vegetation of Kaghan valley. *Pak. J. For*., 10: 285-294.

Chaudhri, I.I. 1961. The Vegetation of greater Karachi. *Vegetatio*, 3(4): 229-246.

Cottam, G. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology*, 37(3): 451-460.

Durrani, M. Jan and F. Hussain. 2005. Ethno ecological profile of plants of Harboi rangeland, Kalat, Pakistan. *Int. J. Bio. Biotech*., 2(1): 15-22.

Hussain, F., I. Hag and H.H. Naqvi. 1981. Phytosociological study on some saline areas of Peshawar valley. *J. Sci. Tech*., 5: 65-68.

Hussain, F. and A. Shah. 1991. Phytosociology of vanishing sub-tropical vegetation of Swat with special reference to Docut Hills. II. Spring Aspect. *Sarhad J. Agri*.,

Hussain, F. and I. Illahi. 1991. *Ecology and Vegetation of Lesser Himalayan Pakistan*. Bot. Dept. Uni. of. Peshawar, pp. 187.

Hussain, S.S. 1969a. Vegetational survey of Ayub National Park, Rawalpindi. *Pak. J. Forst*., 19: 339-348.

Hussain, S.S. 1969b. Phytosociological survey of Wah Garden. (Campbelpur District). *Agri. Pak*., 20: 309-325.

Hussain, S.S. and S.A. Qadir. 1970. An Autecological study of *Euphorbia caducifolia* Haines. *Vegetatio*, 25(6): 329-380.

Hussain, S.S. 1984. *Pakistan Manual of Plant Ecology*. National Book Foundation. Islamabad. pp vi + 255.

Khan, D. and S.S. Shaukat. 2005. Above ground standing phytomass of some grass-dominated communities of Karachi: Winter aspect. *Int. J. Bio.Biotech*., 2(1): 85-92.

Knight, D.H. 1975. A phytosociological analysis of species-rich tropical forest on Barro Colorado Island, Panama. *Ecol. Monogr*., 45: 259-284.

Malik, Z.H and F. Hussain. 1987. Phytosociological study of vegetation around Muzaffarabad. (Eds.): Illahi and Hussain. Modern Trend of Plant Science Research in Pakistan. Botany Dept. Peshawar University13-17.

Naqvi, H.H. 1976. Vegetational zonation of Murree Hazara Hills.University grant commission project, Islamabad, Pakistan.

Ogden, J. and J.A. Powell. 1979. A quantitative description of the forest vegetation on altitudinal gradient in Mount Field National Park, Tasmania and a discussion of it history and dynamics. *Australian J. of Ecology*, 4: 293-325.

Qadri, M.Z.H. 1986. Phytosociological study on the vegetation of Kotli Hill, Azad Kashmir, M.Phil Thesis, Bot. Dep. Peshawar, University, 211 pp.

Qadir, S.A., S.Z. Qureshi and M.A. Ahmed. 1966. A phytosociological survey of Karachi University Campus. *Vegetatio*, 13(8): 339-362.

Rafi, M. 1965. *Vegetation types of Baluchistan Province*. Pak.Govt.Printing Press. Punjab. Lahore, Pakistan.

Rashid, A., F. Hussain and I. Illahi. 1987. Phytosociology of Attock-Nizampur Hills. 1: Summer aspect. In: Modern Trends of Plant Science.Res.in Pakistan. (Eds.): Illahi and Hussain. Bot. Dep. Peshawar University, pp. 47-52.

Shaukat, S.S and S.S. Hussain. 1970. Phytosociological studies on Khadeji Fall area. *Agri. Pak.*, 23(1): 75-85.

Shaukat, S.S and S.A. Qadir. 1970. Observation on the vegetation of Calcareous hills around Karachi. *Agri. Pak*., 21(3): 285-299.

Shaukat, S.S and S.A. Qadir. 1972. Life form and leaf size of the flora of Calcareous hills around Karachi. *Journal of Science*, 1.2: 126-132.

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