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PRESENT STATE AND FUTURE TRENDS OF PINE FORESTS OF MALAM JABBA, SWAT DISTRICT, PAKISTAN

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Abstract

Present state and future trend of pine forests of Malam Jabba, Swat district, Pakistan explored. We focused on vegetation composition, structure, diversity and forests dynamics. Thirteen stands were sampled by Point Centered Quarter method. Among all stands four monospecific forests of *Pinus wallichiana* attained highest density ha^{-1} except in one stand where *Picea smithiana* attained 401 trees ha^{-1}. Unlike density, the basal area m^2 ha^{-1} of these stands varies stand to stand. Based on floristic composition and importance value index, five different communities viz *Pinus wallichiana-Picea smithiana; Picea smithiana-Pinus wallichiana; Abies pindrow-Pinus wallichiana; Pinus wallichiana-Abies pindrow; Abies pindrow-Picea smithiana* and 4 monospecific forests of *Pinus wallichiana* were recognized. Size class structure of forests showed marked influence of anthropogenic disturbance because not a single stand showed ideal regeneration pattern (inverse J shape distribution). Future of these forests is worst due to absence trees in small size classes. Gaps are also evident in most of the forest stands. Stand diversity, richness, equitability and Simpson's dominance values formulated on single stand basis. Diversity of *Abies pindrow* and *Pinus wallichiana* stand was highest because these stand occupied dominant species, while lowest diversity observed in some *Pinus wallichiana* and *Picea smithiana* stand as these stands have mark difference between the dominance of two species. In the monospecific forests, the diversity level was zero, suggesting the monopolization of resources by one species or elimination of other tree species in these stands.

Key words: Vegetation composition, Structure, Diversity and forests dynamics.

Introduction

Distribution and abundance of plant species and communities has been related to a range of physical environmental variables especially anthropogenic disturbance (Enright & Miller, 2007). Civil war badly disturbed the vegetation of the forests under study. The area was recently hit by a worst type of so called religious extremism, in which alongside other sectors of society the forest resources were badly affected (Sharar, 2009). According to Ilyas *et al.* (2012) the remnant temperate forests in the form of logging, deforestation, over-grazing and clearance of forest for terrace cultivation in district Swat, Khyber Pakhtunkhwa is under severe anthropogenic pressure. The natural forest cover is decreasing at a rate of 0.75% annually (Anon., 2009).

Champion *et al.* (1965) stated the major characteristic of the humid forests is the development of coniferous forests that begin in the northern area in the form of subtropical pine forests. The prevalence of species is largely a function of altitude and the aspect. Hussain & Ilahi (1991) reported that Montane temperate forests in Pakistan are predominantly coniferous in nature with some broad leaved species. The structure, composition and function of forest ecosystem change in response to climatic, topographic, edaphic and anthropogenic influences (Timilisina *et al.,* 2007; Ahmed *et al*., 2010; Shaheen *et al*., 2011; Namgail *et al.,* 2012). Like other forest types, temperate forests are experiencing severe anthropogenic pressure (Ahmad *et al.,* 2006; Shaheen *et al*., 2011). Similar conclusions were also made by other worker like Hussain *et al*. (1997); Sher *et al*. (2010); Ahmad *et al.* (2010). The coniferous forests in the northern mountain regions particularly are under the heavy social and economic pressure of tree felling (Siddiqui *et al.,* 1999). Some factors like intensive deforestation and unlimited expansion of urban area have considerably reduced the extent of plant communities' worldwide (Boza, 1993). Shafique (2003) described some aspects of Bio-Ecology of Ayubia National park, Khyber Pakhtoonkhwah Province. Ahmad *et al.* (2009) and Ahmad (2010) evaluated ecological aspects of roadside vegetation around Havalian city using multivariate techniques and vegetation along motorway (M-2), Pakistan using detrended correspondence analysis. Ahmed *et al*. (2006) presented phytosociological and structural description of Himalayan forest from different climatic zones of Pakistan. They reported that some communities exhibited similar floristic composition but different quantitative values, description of understorey species also recorded. Siddiqui *et al.* (2013) had undertaken a detailed study of many forests belonging to moist temperate areas of Pakistan while phytoecological evaluation with detail floristic appraisal of the vegetation around Malam Jabba, forests was studied by Rashid *et al.* (2011). Wahab (2011) evaluated population dynamics of pine tree species from District Dir while Khan (2011) studied the Vegetation ecology and Dendrochronology of Chitral Gol National Park.

The present study focuses on the vegetation composition, distribution, diversity, species richness, equitability, dominance, future trends and relationship of vegetation with the two topographic factors. Since no such type of information is available from this areas after civil war, considering the increased pressure and threat to ecology and biodiversity of Malam Jabba forests, the present study would provide baseline information on the community structure, species diversity and governing factors, for the proper conservation measures of the existing vegetation in the area.

Materials and Methods

Phytosociology: Thirteen stands were sampled by Point Centered Quarter Method (Cottam & Curtis, 1956) with the modification of Ogden & Powell (1979). Phytosociological attributes and absolute values of forest were calculated according to Mueller-Dombois & Ellenberg (1974) and Ahmed & Shaukat (2012). The conifer forests in Pakistan are generally exposed to anthropogenic disturbances, therefore least disturbed stands were selected for vegetation analysis. In each stand, twenty points has randomly taken with a distance interval of fifty meters from base to uphill direction. Only living trees were included in sampling and the dbh of main trunk measured. Six communities and four monospecific forests of *Pinus wallichiana* were recognized using importance value index following Brown & Curtis (1952); Ahmed & Shaukat (2012) which is the sum of relative frequency, density and basal area. Tree species that have highest importance value index was considered dominant. Communities were named based on first two dominant species.

Environmental variables: At all sampling stands some important site characteristics (elevation, slope, exposure, longitude and latitude) were noted with the help of Global Positioning system (Garmin eTrex Legend HCx Handheld). Degree of slope angle estimated with the help of clinometers (Slope Meter PM-5/1520 PC) while site exposure was determined through geographical compass.

Diversity analysis: Shannon & Weaver (1963) diversity index (H); Krebs (1999); Booth *et al.* (2003) and Magurran (2004) used to determine diversity of trees. The components of diversity i.e., equitability (J) and species richness (d) were calculated after (Pielou, 1977) and (Menhinick, 1964) respectively while dominance was calculated following Simpson (1949). Statistical analyses performed following the method described by Zar (2009).

Size class structure: The diameter values (dbh) of conifer species were classified into following 10 classes:

where Class 1 = 10 - 20 cm diameter at breast height (dbh), (class 2) = 20.1 – 30 cm, (class 3) = 30.1 – 40 cm, (class 4) = 40.1 – 50 cm, (class 5) = 50.1 – 60 cm, (class 6) = 60.1 – 70 cm, (class 7) = 70.1 – 80 cm, (class 8) = 80.1 – 90 cm, (class 9) = 90.1 – 100 cm and (class 10) = 100.1 – 110 cm. using these classes, dbh/density ha^{-1} bar diagrams were prepared for each stand. However, under result section the adjacent classes were combined into following four classes:

1. Small size class (10 to 30 cm dbh)
2. Medium size class (30.1 to 60 cm dbh)
3. Large size class (60.1 to 90 cm dbh)
4. Extra large six class (90.1 to 110 cm dbh)

Results and Discussion

Locations of the sampling stands presented in Fig. 1 while the site characteristics (latitude, longitude, elevation of forest, slope angle, aspect and forest canopies) presented in Table 1.

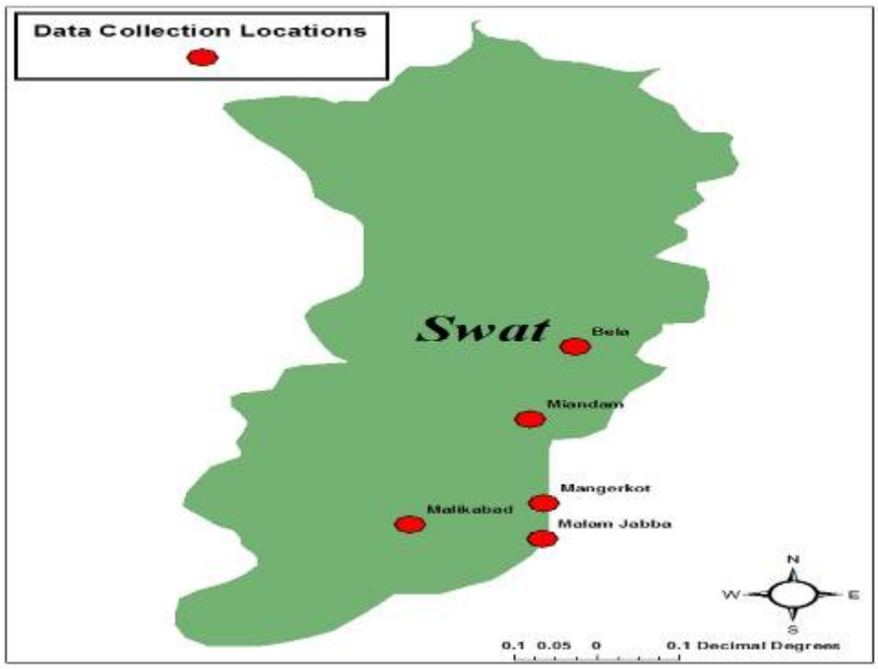


Fig. 1. Study area map, main locations are shown by red marks while all stands are described in Table 1.

Phytosociology: Phytosociological attributes and absolute values of tree species from all stands are presented in Table 2 while the summary of these attributes are presented in Table 3. Summary of phytosociological analysis showed that relative density of dominant species (*Pinus wallichiana*) ranged from 31 to 100%, except stand No. 4 and 5, where it occupied as a co-dominant species. It seems that in most of the stands the co-dominant species were under extreme anthropogenic pressure. *Pinus wallichiana* was the most dominant species in 8 stands with highest mean density ha^{-1} (244) and mean basal area (115.3) m^2 ha^{-1} (Table 3). *Abies pindrow* occupied in 6 stands as first and second leading dominant species of the area with the mean 160 density / hectare and 82.4 m^2 ha^{-1} basal area while *Picea smithiana* hold 3rd position on overall basis. It occupied first, second and third dominancy in two stands each with the mean density 125.3 per hectare and 30.4 m^2 ha^{-1} mean basal area.

Forest communities and range of topographic attributes presented in Table 4. Based on higher IVI and floristic composition, following four pure stands of *Pinus wallichiana* and five other communities were recognized.

1. *Pinus wallichiana-Picea smithiana* community
2. *Picea smithiana-Pinus wallichiana* community
3. *Abies pindrow-Pinus wallichiana* community
4. *Pinus wallichiana-Abies pindrow* community
5. *Abies pindrow–Picea smithiana* community

Authority of species: *Pinus wallichiana* A.B.Jackson, *Abies pindrow* Royle, *Picea smithiana* (Wall.) Boiss.,

Table 1. Site characteristics of Malam Jabba, Swat Valley, district Swat Pakistan.

Stand No.	Location and sites	Latitude (N)	Longitude (E)	Elevation (m)	Slope (º)	Aspect	Canopy
1.	Sur Glu	34º 79' 79''	72º 57' 16''	2120	25º	E	Moderate
2.	Mangerkot,	34º 79' 699''	72º 57' 72''	2120	30º	N	Open
3.	Bela	34º 79' 698''	72º 57' 72''	2240	41º	N	Moderate
4.	Kuo	34º 79' 697''	72º 57' 72''	2330	30º	N	Open
5.	Dur Sher	34º 79' 699''	72º 57' 72''	2410	35º	W	Open
6.	Pendy	34º 79' 698''	72º 57' 72''	2300	25º	S	Close
7.	Pechao	34º 79' 699''	72º 57' 72''	2400	50º	E	Close
8.	Falak Gel	34º 79' 696''	72º 57' 72''	2110	25º	W	Moderate
9.	Malikabad	34º 79' 699''	72º 57' 72''	2120	50º	S	Open
10.	Malikabad	34º 79' 76''	72º 57' 72''	2100	30º	W	Open
11.	Malam Jabba 1	33º 37' 12''	73º 71' 41''	2600	34º	E	Close
12.	Malam Jabba 2	33º 37' 12''	73º 71' 41''	2350	30º	W	Close
13.	Miandam,	33º 37' 12''	73º 71' 41''	2700	49º	W	Moderate

Table 2. Phytosociological attributes and absolute values of all stands of Malam Jabba, district Swat, Khyber Pakhtoonkhua, Pakistan.

Stand No.	Species name	Phytosociological Attributes				Absolute values	
		Relative frequency	Relative basal area	Relative density	IVI	D ha^{-1}	BA m^2 ha^{-1}
1	*Abies pindrow*	69	68	69	207	176	133
	Pinus wallichiana	31	32	31	93	78	16.5
2	*Pinus wallichiana*	100	100	100	300	293	291
3	*Pinus wallichiana*	87	86.4	87	261	272	80
	Abies pindrow	8	5.2	8	20	23	4.8
	Picea smithiana	5	8.4	5	19	16	7.8
4	*Picea smithiana*	80	83.4	80	243	401	88.9
	Pinus wallichiana	20	16.5	20	57	100	17.6
	Picea smithiana	77	77.4	77	232	288	66.8
5	*Pinus wallichiana*	23	22.5	23	68	84	19.1
	Pinus wallichiana	92	99	92	284	232	288
6	*Picea smithiana*	8	1	8	16	19	10.4
	Pinus wallichiana	52	63	52	168	271	249
7	*Abies pindrow*	45	35	45	125	232	184
	Picea smithiana	3	2	3	7	13	2.84
	Pinus wallichiana	100	100	100	300	421	140
8	*Pinus wallichiana*	100	100	100	300	432	120
9	*Pinus wallichiana*	100	100	100	300	461	121
10	*Abies pindrow*	83	91	95	269	288	64
11	*Picea smithiana*	17	9	5	31	15	6
	Pinus wallichiana	92	99	97	288	93	22
12	*Abies pindrow*	8	1	3	12	2	1
	Abies pindrow	56	84	55	195	239	108
13.	*Pinus wallichiana*	44	16	45	105	196	20

Key to abbreviations: IVI = Importance value index, **D ha^{-1}** = Density per hectare of a species and BA **m^2 ha^{-1}** = Basal area m^2 ha^{-1}

Table 3. Summary of Phytosociological attributes of 13 stands. Mean importance value, absolute density ha^{-1}, basal area m^{2}ha^{-1} and dominant position. Species are ranked on the basis of importance value.

Sr. No	Name of species	Presence in # of stands	Mean importance value	Mean density ha^{-1}	Mean basal area m^2 ha^{-1}	Dominant		
						1st	2nd	3rd
1.	*Pinus wallichiana*	12	221.5 ± 27.9	244.4 ± 40.5	115.3 ± 31	8	4	-
2.	*Abies pindrow*	6	89.2 ± 36.8	160 ± 48.9	82.4 ± 29.7	3	3	-
3.	*Picea smithiana*	6	87.8 ± 47.3	125.3 ± 70.8	30.4 ± 15.2	2	2	2

Table 4. Stand numbers and topographic attributes of communities are listed below.

S. No.	Community	Stand No.	Elevation (m) range	Slope (o)	Aspect
1.	*Pinus wallichiana* (Pure)	2,8,9,10	2100-2120	25-50	N,W,S,W
2.	*P. wallichiana / Picea smithiana*	6	2300	25	S
	Picea smithiana / P. wallichiana	4,5	2330-2410	30-35	NW
3.	*Abies pindrow / P. wallichiana*	1,13	2120-2700	25-49	E,W
	P. wallichiana / Abies pindrow	3,7,12	2350-2400	30-50	N,E,W
4.	*Abies pindrow / Picea smithiana*	11	2600	34	E

Note: For main location and sites of stands refer to Table 1

Monospecific *Pinus wallichiana* forest: These pure forests were recorded from four different locations i.e., Mangerkot (stand 2), Falak gel (stand 8), and Malikabad (stand 9 and 10) of study area. It occupied between the altitudes 2100 to 2120m with 25º to 50º moderate to steep slopes. Its density ranged from 293 to 461 individuals ha^{-1} while the basal area was 120 to 291 m² ha^{-1}. Siddiqui *et al.* (2013) stated that this species distributed in moist, dry and timberline areas of temperate region of Pakistan. 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). Chaudhri (1960) stated that *Pinus wallichiana* is a pioneer species distributed on all aspects with wide altitudinal limit. According to Naqvi (1976), a connecting species link up other coniferous species in the area. Ahmed *et al.* (2006) reported this species from different climatic zones (moist and dry temperate areas) of Pakistan. They recorded its pure stands from Takht-e-Sulaiman range, Balochistan at 3100m elevation and from Nalter valley, Gilgit at 2770m elevation on south facing slope. They reported this species from Matiltan, lower Topa, Jhika Gali and Murree at elevation of 1970 to 2250 meter. *Pinus wallichiana* attained 63% of density with 88% of the total basal area. An average 387 individual ha^{-1} had basal area of 43m^2 ha^{-1}. Nasrullah (2011) and Wahab (2011) recorded the pure stands of this species from Chitral and Dir respectively while Akber (2013) and Hussain (2013) recorded the pure stands of this species from Gilgit and Baltistan respectively. Siddiqui *et al.* (2013) recorded the monospecific forests of this species from Chikkar (Azad Kashmir) and Patriata (Murree hill) at the elevation of 1930m and 2230m elevation. They quantify almost similar situation of this species in Malam Jabba that showed high ecological amplitude. Bokhari *et al.* (2013) recorded *Pinus wallichiana-Pinus roxburghii* community from Azak Kashmir. *Pinus roxburghii* is typically sub-tropical species and prefers to grow at low elevation but recorded with *Pinus wallichiana* showed the wide ecological amplitude of *P. wallichiana*.

***Pinus wallichiana-Picea smithiana* community:** This community recorded at Pendy (stand 6) on 2300m elevation on South facing gentle slope (25º). *Pinus wallichiana* attained 284 importance value index with 232 density ha^{-1} and 288 m^2 ha^{-1} basal area while co-dominant species *Picea smithiana* occupied 16 importance value index**,** 19 trees ha^{-1} density with 10.4 m² ha^{-1} 1 basal area. Ahmed *et al.* (2006; 2010) reported this community from Nulter which is dry temperate area and Siddiqui *et al.* (2013) recorded this community from Shogran and Naran valleys (moist temperate areas) at the elevation of 2500m and 3100m respectively, showed its distributional limit. The biotemperature associated with these forests was 16 to 17.5°C and the annual precipitation estimated as 170 to 184 cm.

***Picea smithiana-Pinus wallichiana* community:** This community was located between 2330m to 2410m elevation, moderate slopes angle (30º to 35º) on north and west exposure with open canopy. In this community, dominant species *Picea smithiana* had 232 and 243 importance value index with 288 to 401 density ha^{-1} while the basal area was 88.9 to 66.8 m² ha^{-1}. *Pinus wallichiana* had 84 to 100 trees ha^{-1} with 18 to 19 m² ha^{-1} basal area while its importance values index was 57 to 68. Ahmed *et al.* (2011) studied many forests dominated by *Cedrus deodara*, in this study they observed *Picea smithiana* and *Abies pindrow* as associated species with *Pinus wallichiana* indicating an ecotonal zone between dry and moist temperate areas.

***Abies pindrow-Pinus wallichiana* community:** This community recorded at two different locations (stand 1 & 13) between 2120m and 2700m elevation respectively. The slope angles were gentle (25º) to steep (45º) and exposures were east and west. At many places, the canopy was moderate in both stands**.** In these stands, the importance value index of *Abies pindrow* was higher than that of *Pinus wallichiana* that ranged from 207 to 270 with 176 to 239 density ha^{-1} while basal area was 133 to 108 m² ha^{-1}. The IVI of *Pinus wallichiana* was low i.e. 93 and 105 with 78 and 196 density ha^{-1} with 16.5 and 20 m² ha^{-1} basal area. Dominant species occupied 71% of total density while 65% of the total basal area of the stand. Its 184 individual ha^{-1} 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. According to Hussain & Illahi (1991), this

community prefers cool and moist sites even in dry zones. Ahmed *et al.* (2006) recorded this community from Dunga Gali, Murree hills, Ayubia and Miandam from 2245 to 2350-meter elevation and Rama Lake (Astore) at an elevation of 3450m, showing its altitudinal range. Siddiqui *et al.* (2013) recorded this community from 9 different locations of moist temperate areas i.e. Malam Jabba, Miadam, Suddhan Gali (Azad Kashmir), Kashmir point (Murree hill), Ghora Dhaka, Changla Gali, Kuzah Gali, Nathia Gali and Shogran valley at the altitude of 2350m to 2800m on moderate (22°) to very steep (49°) slopes. They recorded the biotemperature ranges from 14.5 to 17.5°C while the annual precipitation varies from 165 to 180 cm. Along with *P. wallichiana* and *Abies pindrow*, they recorded some other conifer species (*Cedrus deodara* and *Taxus fuana*) and broad leaf species (*Juglans regia*) but in the current study the other species were absent, could be due high anthropogenic pressure and civil war.

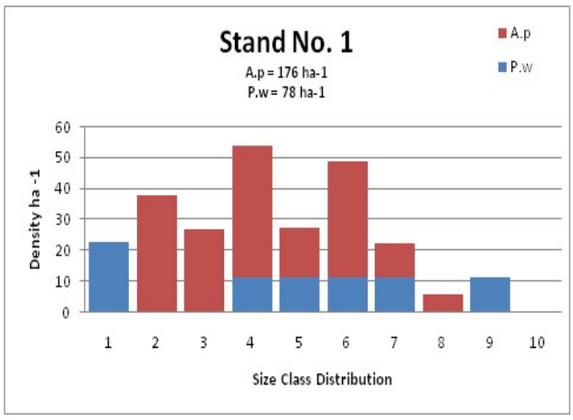
***Pinus wallichiana-Abies pindrow* community:** This community recorded at three different locations (stand 3, 7 and 12) between 2350m to 2400m elevation. The slope angle was moderate (30º) to very steep (50º) and the exposure were north, east and west respectively. In stand 7 and 12 the canopy was closed while moderate in stand 3. The first leading dominant *Pinus wallichiana* attained the importance value index of 261, 168 and 270 respectively while the IVI of *Abies pindrow* were 20, 125 and 30 respectively. *Picea smithiana* was also associated with this community, having quite low IVI (19 and 7), density (16 & 13 trees ha^{-1}) and basal area (7.8 & 2.84 m^2 ha^{-1}). The densities of *Pinus wallichiana* were 293, 271 & 93 trees ha^{-1} and basal area 80, 249 and 22 m^2 ha^{-1}. *Abies pindrow* attained the densities of 23, 232 and 2 trees ha^{-1} while the basal areas were 4.8, 184 and 1 m^2 ha^{-1} respectively. Siddiqui *et al.* (2013) recorded this community from 6 different locations of moist temperate areas i.e. Malam Jabba, Suddhan Gali (Azad Kashmir), Ghora Dhaka, Changla Gali, Nathia Gali and Shogran valley at the altitude of 2350m to 2800m. Siddiqui *et al.* (2010a) reported this community in-group II from different locations of moist temperate areas of Pakistan. They classified the vegetation by using Ward's cluster analysis.

***Abies pindrow–Picea smithiana* community:** This community was found only at Malam Jabba (stand 11) on East facing exposure, steep slope (34º) and on 2600m elevation. The Importance value index of *Abies pindrow* was 269 while the density was 288 trees ha^{-1} and low basal area i.e. 64 m^2 ha^{-1}. *Picea smithiana* showed quite low IVI, density and basal area i.e. 30, 15 trees ha^{-1} and 6 m^2 ha^{-1} respectively. Ahmed *et al.* (2006) recorded *Picea smithiana* as co-dominant species with *Betula utilis* D. Don., from Nulter valley, Gilgit at 3500m elevation. They recorded *Abies pindrow* and *Picea smithiana* from dry temperate area Astore, showed its compositional compatibility. Siddiqui *et al.* (2010b) used principal component analysis (PCA) to ordinate the vegetation of moist temperate area. They observed the minimum principal component for group III which represented only 4.995% of the total variability, that governed by *Picea smithiana*, *Abies pindrow* and *Pinus wallichiana,* the results of that study showed minimum existence of *Picea smithiana* in moist temperate forests. Due to overgrazing and human disturbance, most of the species listed by Champion *et al*., 1965 and Hussain & Illahi (1991) were not recorded in current study. Siddiqui *et al.* (2011) suggested that foresters, silviculturalist, nongovernmental organizations should take interest to conserve and manage these forests.

Future trend of forest stands: Density size class structure and distribution of conifer tree species in different size classes presented in Fig. 2 that showed their future trend. The pure stands (2, 8, 9 and 10) of first dominant species *Pinus wallichiana* exhibited poor regeneration pattern because of absence of small trees in 10 to 20cm diameter size class. Trees mostly occupied in middle and larger size classes that could be vanish in future due to anthropogenic disturbance. The bar diagram of stands 1, 11 and 13 showing some stability due to presence of small trees in small size class, however the future of first dominant species *Pinus wallichiana* (stand 1) and *Picea smithiana* (stand 11) is uncertain due to low number of individual in small size classes. The second dominant species *Abies pindrow* showed better current picture and good regeneration pattern in stand 11 and 13. In stand 3 and 12 *Abies pindrow* and *Picea smithiana* showed poor representation pattern, therefore it may be suggested that these species may be eliminated in near future. In stands 2, 4, 6, 7, 8, 9 and 10 no trees were recorded in 10 to 20cm dbh and larger size classes. It seems that these trees were removed either illegally or due to overgrazing and human disturbances. No trees of small size can survived. Not all the three conifer species (*Pinus wallichiana, Abies pindrow* and *Picea smithiana*) showed satisfactory regeneration pattern (inverse J shape distribution) in any forested stand. All the stands exhibited mark influence of anthropogenic disturbance as also noticed by many workers i.e., Siddiqui *et al.* (2013); Ahmed *et al.* (2006; 2010) in different mountainous areas of Pakistan.

Correlation between overall density/basal area and with topographic factors: Correlation between densities (ha^{-1}) and basal area (m^2 ha^{-1}) of all 13 stands did not show significant correlation (Table 5). Stands density (ha^{-1}) and basal area m^2 ha^{-1} also did not show any significant correlation with topographic factors except Slope /Density ha^{-1} that exhibited positive significant correlation ($p<0.5$).

Correlation between density/basal area of *Pinus wallichiana* and with topographic factors: Density ha^{-1}/ basal area m^2 ha^{-1} of *Pinus wallichiana* showed positive significant correlation ($p<0.05$) while density ha^{-1} showed negative significant correlation ($p<0.05$) with elevation (Table 5). Density ha^{-1}/ basal area m^2 ha^{-1} of this species did not show significant relationship with topographic attributes. *Abies pindrow and Picea smithiana* excluded from this calculation because of small sample size. Siddiqui *et al.* (2013); Khan (2011); Wahab (2011); Akber (2013) and Hussain (2013) conducted such type of correlations and found better results as compare to current study, it could be due to large sample size.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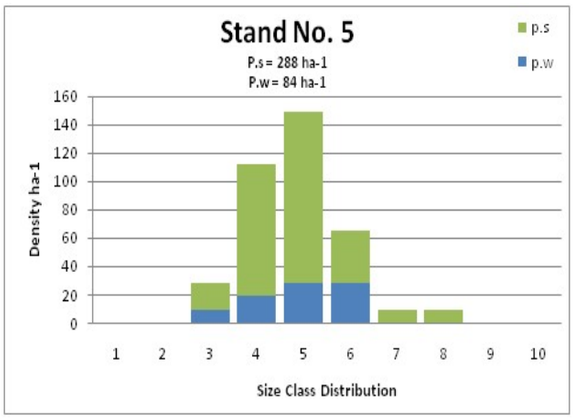
P.w = 78 ha-1
A.p
P.w
Density ha -1
Size Class Distribution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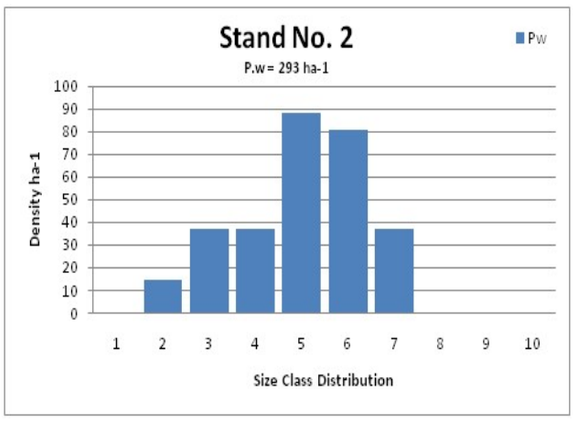
P.w = 84 ha-1
p.s
p.w
Density ha-1
Size Class Distribution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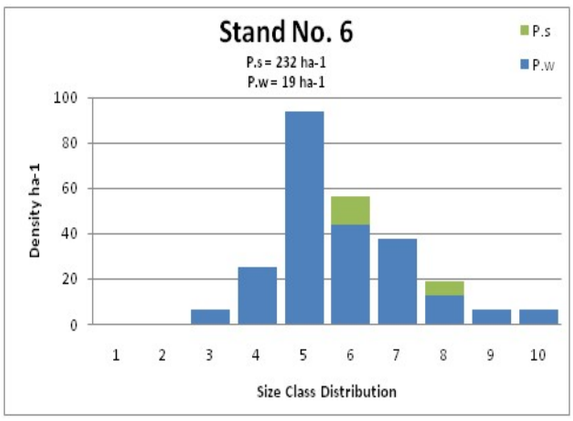
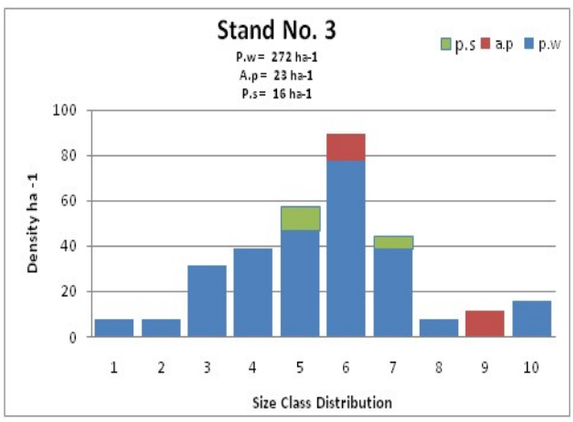
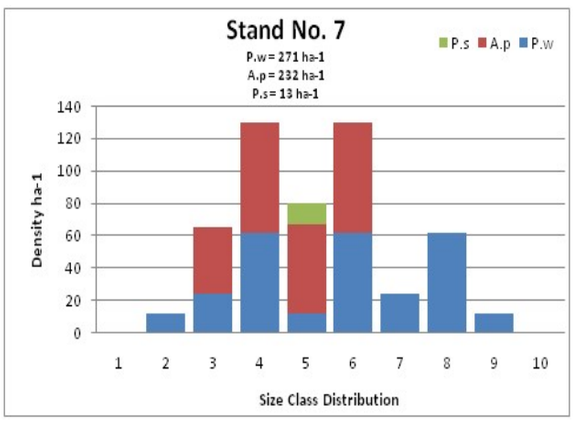
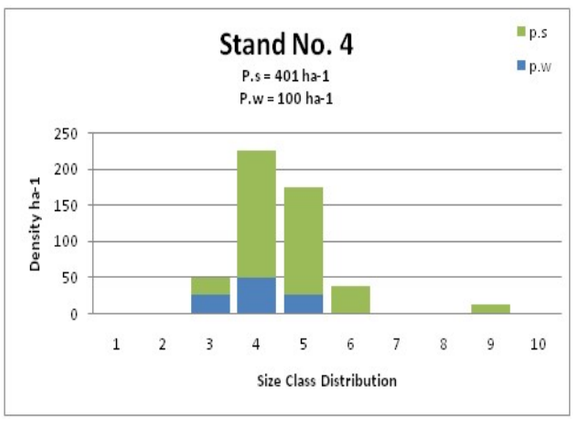
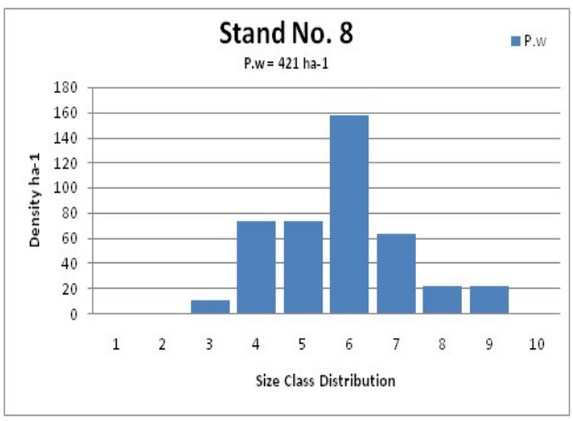
P.w = 293 ha-1
Pw
Density ha-1
Size Class Distribution


Stand No. 6
P.s = 232 ha-1
P.w = 19 ha-1
P.s
P.w
Density ha-1
Size Class Distribution


Stand No. 3
P.w = 272 ha-1
A.p = 23 ha-1
P.s = 16 ha-1
p.s
a.p
p.w
Density ha -1
Size Class Distribution


Stand No. 7
P.w = 271 ha-1
A.p = 232 ha-1
P.s = 13 ha-1
P.s
A.p
P.w
Density ha-1
Size Class Distribution


Stand No. 4
P.s = 401 ha-1
P.w = 100 ha-1
p.s
p.w
Density ha-1
Size Class Distribution


Stand No. 8
P.w = 421 ha-1
P.w
Density ha-1
Size Class Distribution

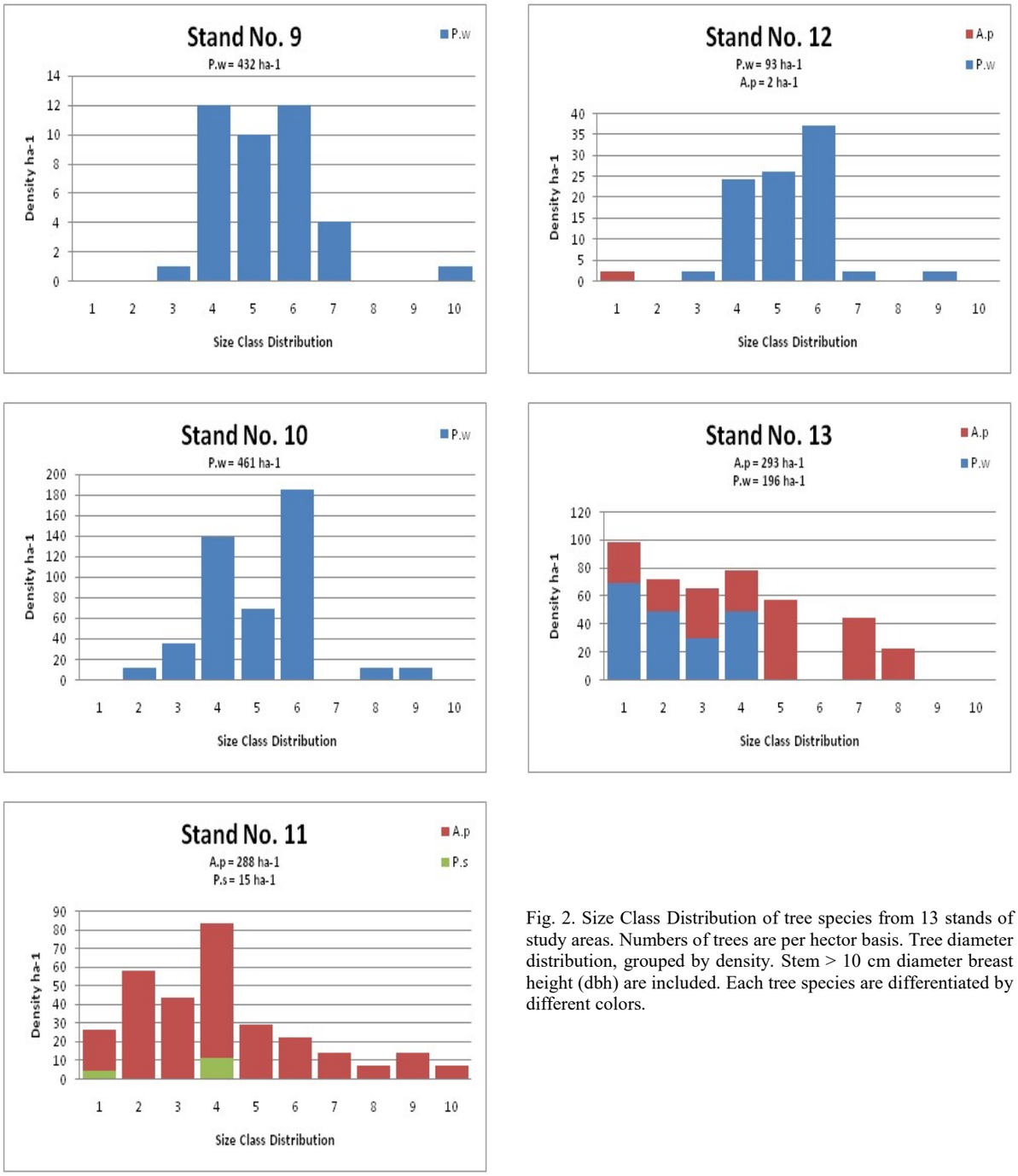


Fig. 2. Size Class Distribution of tree species from 13 stands of study areas. Numbers of trees are per hector basis. Tree diameter distribution, grouped by density. Stem > 10 cm diameter breast height (dbh) are included. Each tree species are differentiated by different colors.

Table 5. Correlation between structural attributes among each other and with topographic variables on overall stands basis and individual *Pinus wallichiana* species.

S.No.	r value		Significance level	r value	Significance level
	Overall stands			*Pinus wallichiana*	
1.	Density ha^{-1}/ Basal area m^2 ha^{-1}	0.281	ns	0.541	$p<0.05$
2.	Elevation /Density ha^{-1}	0.036	ns	-0.532	$p<0.05$
3.	Slope /Density ha^{-1}	0.515	$p<0.05$	0.188	ns
4.	Elevation / basal area m^2 ha^{-1}	-0.103	ns	-0.289	ns
5.	Slope / basal area m^2 ha^{-1}	0.168	ns	-0.035	ns

Table 6. Shannon diversity index (H), species richness (d1), Equitability (J) and Simpson's dominance (D) values formulated on single stand basis.

Stand no.	Diversity (H)	Species richness	Equitability (J')	Dominance "D"
1.	0.2441	0.3162	0.811	0.4923
2.	0	0.1581	0	0
3.	0.2001	0.4743	0.5906	0.7679
4.	0.2173	0.3162	0.7219	0.6718
5.	0.2315	0.3162	0.769	0.64231
6.	0.1156	0.3162	0.3841	0.8577
7.	0.2818	0.4743	0.4208	0.7923
8.	0	0.1581	0	0
9.	0	0.1581	0	0
10.	0	0.1581	0	0
11.	0.2988	0.3162	0.9926	0.7038
12.	0.1411	0.3162	0.4688	0.8154
13.	0.2014	0.3162	0.6689	0.6152

Note: The zero value of diversity, equitability and dominance indicated pure stands

Diversity analysis: General species diversity (H) and equitability (J) were lowest in stand 6 i.e., (0.1156) and (0.3162) respectively (Table 6) which represent the disturbance in forest vegetation. According to Johnson *et al.* (1993) plant communities losing their species richness due to clear cutting. The highest, diversity (0.2988) and equitability (0.9926) were recorded from stand 11 that indicate the stability of the forest. The dominance of species in current study in increasing gradually from stands 1 < 13 < 5 < 4 < 11 < 3 < 7 < 12 < 6 respectively. In general, dominance (D) was high when diversity (H) was low and vice *versa*. In present study dominance and diversity were inversely related as suggested by the Shaukat *et al.* (1981) and Sapkota *et al.* (2010). The pure stands of *Pinus wallichiana* (stand 2, 8, 9 and 10) showed the zero value of diversity, equitability and dominance while the species richness of corresponding stands was 0.1581 which is lesser than the species richness of all other stands. The species richness of the stands having two species (stand 1, 4, 5, 6, 11, 12 and 13) is 0.316 while 0.4743 of those stands having three species (stands 3 & 7).

In a nutshell the overall situation of the studied forests are not good and the future of the forests is also worst, this could be due to high degree of anthropogenic disturbance and the operation clean up against the militants by Pakistan Army. Local population pressure has resulted in an increased demand for fuel wood so trees are becoming increasingly remote and sites heavily depleted. Assuming there is no change to current pressures and practices, it is anticipated that if these practice are remain continue and no conservative and management measures are taken immediately then these existing trees would be vanished soon.

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