Pak. J. Bot., 44(5): 1617-1625, 2012.

THE ECOLOGY AND DYNAMICS OF *JUNIPERUS EXCELSA* FOREST IN BALOCHISTAN-PAKISTAN

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Abstract

The ecology and dynamics of Ziarat *Juniper forests,* was analyzed, fifteen stands were sampled during summer 2010. The main results of this research indicate the floristic composition, density ha^{-1} and basal area m^2 ha^{-1}, physical condition, sex distribution; age and growth rates, and soil analysis. On the basis of mean relative frequency values, herbs were accounted (55.02%), followed by (29.45%) while grasses accounted only (15.52%) across all the stands. Density of juniper trees (>6 cm dbh) ranged from 29 to 268 stems ha^{-1} with a mean 176±77 individuals ha^{-1}. Highest stand density 268 stem/ha was recorded from Ziarat Prospectus point at elevation 2785 meters from west facing slopes while the lowest stand density 29 stem/ha was from Sasnamana Khawas Neikh on an elevation 2858 meters from north east facing slopes. The over all mean density recorded for juniper trees were 176 ha^{-1} with an average basal area 91±41 m^{2}ha^{-1}.. Juniper density and basal area were not significantly correlated (r= 0.59). Density of seedlings (< 6 m) also varied considerably and ranged from 3676 to 9222 inds/ha with a mean 6450±382 inds/ha. In the present condition *Juniperus. excelsa* exhibits an adequate recruitment and does not confront any immediate danger, however, if grazing stops in the future. A large number of individuals were recorded alive (62%) as compared with standing dead trees (11%) and recently logged stumps (3%). Trees in the best condition were generally healthy (32%) with living foliage, followed by over mature (14%), while unhealthy juniper (12%) and cut stumps were accounted (12%) respectively. Sex ratio showed predominance of male with a mean value of 100±43 ha^{-1} (57%), followed by female 66±29 ha^{-1} (38%) while bisexual were very rare (4%) in the population. The combine data show a balanced size class structure. Cross section of ten trees was used to determine age and growth rate. Number of rings in trees with 26 to 69 cm dbh ranged from 113 to 788 years (Mean 301±45). Diameter and age was not related. Highest overall radial growth rate was estimated as 15±18 years/cm. Soil variables were basic in reaction, free from salinity, calcareous in nature. No significant correlation was recorded between juniper tree density/ seedlings density and some of the soil variables. It is observed that the present degraded stage of the juniper forests in the study area might be due to anthropogenic disturbances, drought, poor soil conditions, mistletoe and fungal infections and effects of climatic change. It is also suggested that the present study will provide information to understand the current status, dynamics and the future trends of these forests.

Introduction

Juniper forests and the associated diversity of plants and animals constitute a unique ecosystem in the arid and harsh climatic conditions in Baluchistan Province, Pakistan. Ecologically speaking, Juniper forest is not only a rare genetic resource but it also one of our national and biological heritage of Baluchistan and Pakistan. These forests also considered as one of the world's largest, oldest, extremely slow growing and drought resistant tree species, therefore, often termed as "Living Forest Fossil" (Sheikh, 1985). According to Kew Herbarium classification (Anon., 1994) there are 54 species of junipers occurring in the North America, Europe, North Africa, West Asia and Central Asia and South Asia. Six of these including *Juniperus excelsa* are found in mixture in northern Pakistan). Balochistan has one of the largest remaining tracks of pure *Juniperus excelsa* forests in the world that has global significance Most of the Juniper forests have open canopy. Juniper trees grow very slowly with poor natural regeneration. They cover approximately 141,000 hectares. The most extensive (100,000 hectares) and best known examples are found in the Ziarat and Zarghun range near Quetta (Khatak, 1963). The other big blocks of juniper forests are found in Herboi hills of Kalat district. Yet its distribution is confined to a small area. The whole forest area including the mountain slopes of the district is reported 35,325 hectares, which represent 54% of the total area of district Ziarat (Khatak, 1963).

The investigation of population dynamics (i.e., density, basal area, tree conditions, sex ratio, size class distribution, age and growth rates) of economically and environmentally important trees are of great interest to foresters, silvicultureists, ecologists and biologists. A lot of quantitative phytosociological investigations have been carried out by various workers in different parts of the country. Population structure of planted tree species of Quetta was presented by (Ahmed, 1988), While population structure and dynamics of *Juniperus excelsa* from Rod-Mullazai (Ahmed *et al.*, 1990). Juniper tract and *Pinusa gerardian* Wall. ex Lamb., from Zhob District were explored by Ahmed *et al.,* (1991). Atta (2000) investigated population dynamics and regeneration potential of Juniper forests in north eastern Baluchistan. Phytosociology work and structure of various Himalayan forests from various climatic zones were presented by Ahmed *et al.,* (2006). Recently, Wahab *et al.,* (2008), described phytosociology and dynamics of some pine forests of Afghanistan close to Pakistan border While, Ahmed *et al.,* (2009), conducted the same type of investigation in *Pinus roxberghii* and *Olea feruginea* forests respectively. Beside these individuals, no comprehensive quantitative investigations were carried out, describing the structure and dynamics of Juniper and other forests in Pakistan.

Since the time of British control in Baluchistan, local people have been allowed to use Juniper forests and collecting dry woods (Ahmed, *et al.,* 1990a). It has been reported that juniper forests in Ziarat, Balochistan are exhibiting widespread decline. During the past 60-70 years, these forests have suffered from a severe process of degradation. Many ecological, pathological, socio-economic impacts, increased human population, over-grazing, illegal cutting for timber and collection for fuel wood, periodic drought, and effect of climate change have been left adverse affects and brought drastic changes not only on regeneration patterns, species composition and productivity but also on the structure and dynamics of these forests. During the last few decade these activities have been extended to the upper elevations and many broad leaves tree species such as *Fraxinus xanthoxyloides* and *Pistacea khinjuk*) which were widely distributed in these forests are now disappeared or very rare along water streams. They are being altered, degraded and destroyed at a point in time, when hardly any scientific data on their structure and dynamics are available.

In this context, the aims of the present study were to obtain quantitative information on the current status, dynamics, regeneration patterns and future trends for future understanding of the management practices as well as the use and conservation of this species.

Study area: The study area is located in the northeastern region of Ziarat district Balochistan at altitude ranging from 2000-3000 m. which is bordered on the south by Sibi district, on the north by the district of Pishin, and on the east by Loralai distract. The whole sampling area occur at elevations between 1980-3,350 meters and geographically extend between Latitude 30° 18' N to 30° 30' N and longitude 67° 54' E to 67° 57' E (Fig. 1). The highest peak in the study area is Koh-Khalifa (3,475) m. The area is composed of irregular rugged ridges with steep terrain on comprising several narrow valleys, running from east to west.

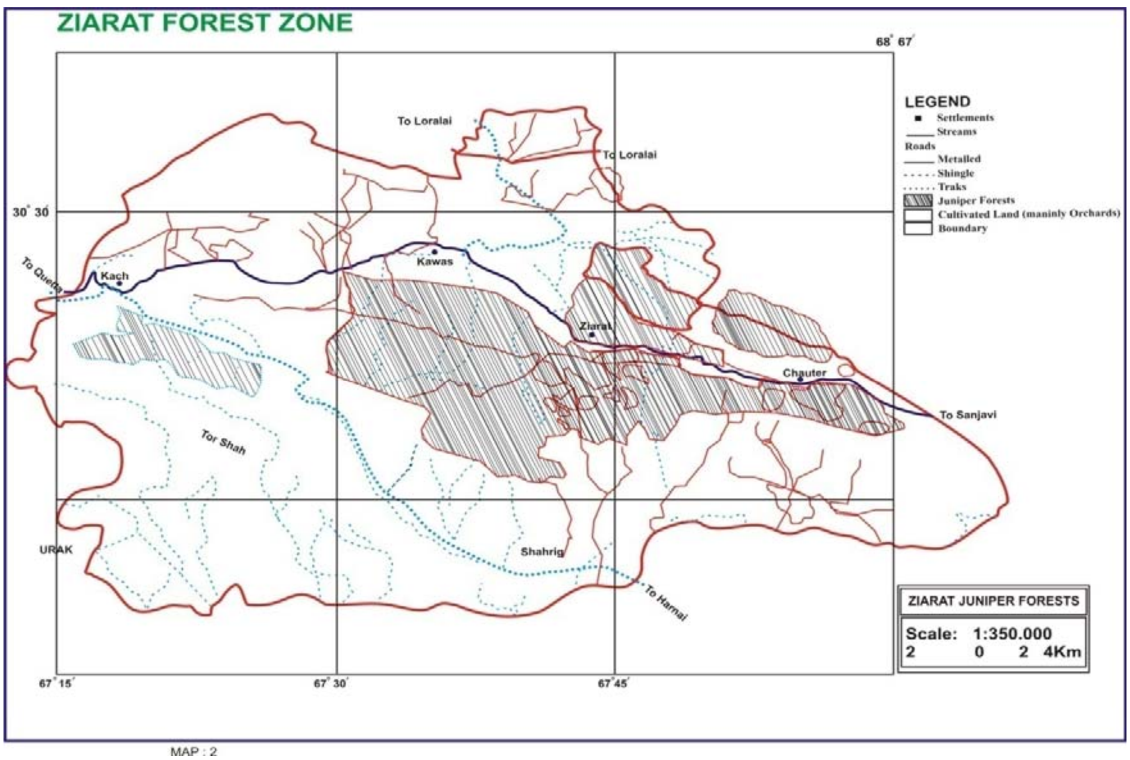

Fig. 1. Location Map of Ziarat *juniperus excelsa* forests zones in Balochistan.

The climate of the project area over the greater part is of dry temperate type (Champian, 1965). The area is also characterized by excessive cold during winter and refreshingly cool and pleasant in summer (Holdrege, 1947). Snow falls from December to March and frosts are frequent (Khattak, 1963). Mean annual precipitation of is about 282 millimeter/yr is mainly received during winter in the form of snow (Ali, 1966; Ahmed *et al.,* 1990). The highest snow fall of 82 centimeter is reported in February 1977. Some showers also occur in July and August.

Temperature extremes are Characteristics feature of the climate with mean maximum temperature of 28°C in July and August and mean minimum temperature of -9°C in January. The highest average relative humidity of 67% was recorded December, while the lowest of 23% in October. The average wind speed is 132 km/ hr. Geological subtract include sedimentary rocks, ranging from cretaceous to recent in age (Shah *et al*., 1964). Parent material in the area is shallow and lime stone and soil is sandy clay-loam in texture.

Material and Methods

During the summer 2009-2010 quantitative survey was conducted in the old growth juniper forests at different valleys of Ziarat District. Although many forest areas were fragmented, disturbed and with mature stands but during this study, healthy and least disturbed stands were selected for quantitative sampling.

Around the study area 10 stands were sampled using Point Central Quarter method of Cottam & Curtis (1956) for juniper tree population while Circular plot method (1.5 m radius) was used for sampling of the associated vegetation. At each stands 15 points were taken at 30 meter intervals along transect in a stratified random way over an area of at least 3 ha (Ogden & Powell 1979). GPS was use to reco rd elevation, position of stands, and aspect while degree of slope was recorded by the help of slope meter. Phytosociological attributes (stand density ha^{-1} and basal area m^{-2} ha^{-1}) for both juniper trees and seedlings were calculated using the method described by Mueller-Dombois & Ellenberg (1974). Wood samples were obtained from trees at the level diameter breast height (dbh).

Trees greater than 6 cm dbh (Diameter at the breast height) were included in this sampling. Juniper seedlings (less than 6 cm) density of and relative frequencies herbs, shrubs and grasses were obtained using circular plots (1.5 meter diameter) at each P.C.Q point. Diameter at breast height (dbh) of trees in stand was divided in to 10 cm dbh size classes and overall size class structure of juniper trees/seedlings were presented of each stand.

Juniper of each stand were also divided into various categories: (1) Healthy = dark green color with dense branches and leaves: (2) Unhealthy = dull color with open branches and leaves; (3) over mature = trees greater than 70 cm dbh with twisted, hollow, depressed or dead branches; (4) disturb = signs of broken or chopped branched; (5) logged = logged stumps remain; (6) = Dead = standing dry or dead tree. In each stand the sex of each juniper tree was observed in the field. Diameter and height of individual trees were measured using the measuring tap and Abney level (Korning *et al*., 1991).Relationships between density and basal area and soil characteristics was calculated. Diameter size class frequency distribution of *Juniperus excelsa* were obtained as follows: seedlings were divided into six classes in which the zero class was included in seedlings from 0.5-1 cm diameter, class 2-6 had 1 cm intervals. All individuals with a diameter (> 6 cm) were considered trees. In the tree size class diagram the class interval was 11 cm.

Stem discs in the form of cross-sections were taken from stumps of fallen trees and remains of recently cut trees while cores were obtained at the level of breast height from selective healthy and sound trees, free from severe competition and situated on dry ground in each stand. Dendrochronological method (Fritts, 1976) was followed for the determination of ages and growth rates. Sample collection and preparation were carried out according to the method outlined by Stockes & Smiley (1968) and Ahmad (1984). Every sampled tree wood section and cores were numbered. The cores were kept in drinking straws to prevent possible damage and were air dried. Later, the cores were grooved mount and allowed to dry. These cores were sanded with a sanding machine and progressively finer grades of sand papers until a suitable polished surface was achieved. An attempt was made to establish cross-dating visually under the variable power binocular microscope. The radial uniformity of the trees and the ring width pattern of the site, was checked by cross-matching the cores from the same tree and with different trees. During this process missing rings and falls rings were identified in their correct sequence and each ring was properly dated in the year of its formation.

From each stand a soil sample (0-25 cm) was taken at different points and mixed in to a composite sample, air dried and passed through a two mm sieve in order to separate the gravel. The portion of soil finer than 2 mm was used for physical and chemical analysis. Soil texture was determined by Bouyocous hydrometer method (1951). Maximum water holding capacity was determined according to the method of Keen (1931). Soil organic matter was estimated, following the method described by Pandeya *et al*., (1968). Soil $CaCO_3$ was determined by the method described by U.S.D.A, (1954). Soil pH was determined by H>M-10k digital pH meter (Doughty, 1956). Electrical conductivity of saturated soil extract was measured by CM-30 ET digital conductivity meter.

Results

Juniperus excelsa and the associated vegetations grow between 2000 to 3,000 m on ridge tops, and moderate (18º) to steep (30º) slopes and forms pure, open and dense vegetation without any stratification. Since *Juniperus excelsa* is a single dominant and mono-specific forest of the sampling area therefore, these forests are described on the basis of density and basal area per hectare both for juniper trees & seedlings. During the sampling, Density ha^{-1}, basal area m^2ha^{-1}, regeneration, physical condition, sex ratio, was recorded. The associated flora were also listed and classified on the basis of mean relative frequency level. Main locations, aspect, slope, canopy, elevations, latitude and longitude of each stand of the study area are given in the Table 1.

Table 1. Ecological Characteristics of Sampling Sites and Stands.

Stand No.	Main location	Site name	Field code	Slope (0)	Aspect	Canopy	Altitude (m)	Latitude (N)	Longitude (E)
1	Ziarat	Prospectus point	ZPP	20	North	Open	2685	30°.21′	69°.44′
2	Ziarat	Prospectus point	ZPP	15	North	Open	2785	30°.21′	69°.44′
3	Ziarat	Prospectus point	ZPP	30	North	Open	2785	30°.21′	69°.44′
4	Ziarat	Prospectus point	ZPP	12	North	Open	2785	30°.21′	69°.44′
5	Ziarat	Prospectus point	ZPP	18	West	Open	2785	30°.097′	67°.49′
6	Sasnamana	Sarro Narri	SSN	30	West	Open	2858	60°.24′	67°.49′
7	Sasnamana	Khawas Neikh	SKN	20	North East	Open	2858	60°.24′	67°.49′
8	Sasnamana	Khawas Neikh	SKN	30	North East	Open	2858	60°.24′	67°.49′
9	Chasnak	Chasnak Aghburg Aghbugi	CAA	12	South West	Open	2720	30°.27′	69°.48′
10	Chasnak	Chasnak Aghburg Bailzai	CAB	10	South West	Open	2750	30°.27′	69°.48′

Plant association: Circular plot samplings were used to assess the associated vegetation including juniper seedlings on the forest floor. A total about 20 species of shrubs, herbs and grasses were recorded across all the stands in the present study area. The number of species varied 1-4 in each of the family. Based on the mean relative frequency values, Composite (4 Spp) was found the dominant family while Labiatae and Gramineae (each with 3 Spp) were the second contributors. They were followed by, Berbaridiaceae, Iridiaceae, Liliaceae, Plumbaginceae, Paplionaceae and Ephedraceae with single species each. The widely distributed shrubs of the study were *Berchemia lineata*, *Caragna ambigua*, *Dephnae mucronata*, *Prunus microca. Epedra procera, Baerbaris balochistanica and Cotonaster numularia*. The herbs (non grasses) were frequent throughout the sampling area, mostly dominated by *Acantholimon longiflurum, Artemasia maritima, Asparagus racemosus, Erimorus persicus, Heteropapus canescens, Iris stockii, Nepeta juncea, Salvia hydrangea, Tanaceutum macropodium and Thymus serphyllum. Stipa bipennata, and Maleca persica* were the prominent grasses dominated by *Pennisetum orientali*s (Table 2). On the basis of overall mean relative frequency values, the herbs were accounted (55.02 %), followed by shrubs (29.45 %) while grasses contributed only (15.52%) across all the stands of the study area.

Table 2. Summary of plot sampling quadrate in 10stands of the study area Pol= number of stands in which species occur, RF_2 Mean relative frequency with standard deviation, FR_3=Range of relative values.

S. No.	Name of species/family	Local name	Pol.	RF_2	RF_3
1.	*Abellia trifolia*,R.Br .(Caprifoliaceae)	Ghurspari	15	6.23 ± 2.4	288 - 13.52
2.	*Acantholimon longiflorum*, Boiss. (Plumbaginaceae)	Sassi	35	9.47 ± 4.43	3.32 - 22.82
3.	*Artemesia martima* (Compositae)	Tarkha	27	11.65 ± 6.97	3.93 - 28.25
4.	*Asparagus racemosus*, Willd. (Liliaceae)	Faribagh	8	5.35 ± 2.26	2.8 - 12.45
5.	*Berbaris baluchistanica*, Royle (Berbaridaceae)	Zaralg	27	9.09 ± 6.80	35 - 15.05
6.	*Berchemia lineata*, DC. (Rhamnaceae)	Spera Spari	12	10.97 ± 5.90	2.12 - 15.55
7.	*Caragna ambigua*, Stocks, (Papilionaceae)	Makhi	28	8.07 ± 4.05	4.32 - 18.96
8.	*Cousinea minuta*, Bloiss. (Compositae)	Shashnar	16	9.27 ± 5.55	2.03 - 25.10
9.	*Dephne mucronata* Scherb (Thymelaceae)	Walaghuni	25	5.56 ± 2.83	295 - 14.29
10.	*Ephedra procera*, Fish. & Mey. (Ephedraceae)	Oman	14	8.13 ± 7.17	2.01 - 21.42
11.	*Eremurus persicus* (Jaub & Spach, Boiss) (Liliaceae)	Shazergi	37	6.75 ± 3.24	1.50 - 13.25
12.	*Heteropapus canescens* (Nees) Novopokr (Compositae)	Sheengulai	24	7.11 ± 4.08	3.41 - 16.31
13.	*Iris stocksii*, Hemsley (Iridaceae)	Ghurghashi	26	7.36 ± 4.96	3.93 - 28.75
14.	*Maleca persica*, Guss (Gramineae)	Lavani bootai	16	21.90 ± 4.33	13.72 - 30.30
15.	*Nepeta juncea Benth.* (Labiatae)	Chenjenbooti	13	8.70 ± 5.00	6.41 - 23.25
16.	*Pennisetum orientals*, Pers. (Graminae)	Speena weesha	15	13.32 ± 4.83	3.22 - 19.44
17.	*Salvia hydrangea*, Wall. ex Sweet (Labiatae)	Sarsandi	24	6.84 ± 5.11	3.84 - 14.22
18.	*Stipa bipenneta*, L.(Graminae)	Washtee	37	8.28 ± 3.67	1.50 - 18.25
19.	*Tanacetum macropodium*, Hemsley. *et al.,* Lace (Compositae)	Ghursani Tarkha	16	20.69 ± 4.47	2.77 - 21.27
20.	*Thymus serphyllum* (L.) Lace (Labiatae)	Moverii	23	5.17 ± 2.77	2.22 - 9.25

Density and basal area: Density ha-¹, basal area m²ha-¹ values of both Juniper trees (> 6 cm dbh) and seedlings (< 6 cm dbh) greatly varied from site to site, even within the same sites as summarized on (Table 3). As Juniper constitute approximately 96.6% of the stand density. Highest stand density 268 stem/ha was recorded from Ziarat Prospectus point (stand 5) at elevation 2785 meters from west facing slopes while the lowest stand density 29 stem/ha was from Sasnamana Khawas Neikh area (stand 8) on an elevation 2858 meters from north east facing slopes. However, stands at Sasnamana Sarro Narri (stand 6) also indicated higher density of 233 stem/ ha-¹. The overall mean density of Juniper trees recorded was 176 ha-¹ (Table 3). The basal area of *J. excelsa* trees were also highly variable both within and between the sites, with an average 90.93 m²ha-¹ and ranged from 10.91 to 285.07 m²ha-¹. The overall basal area recorded for juniper trees were 91±41 m²ha-¹ (Table 3). The basal area did not differ between north and west facing slopes but tree density was higher on west facing slopes (Table 3).Juniper density and basal area was not significantly correlated (r= 0.590. *J. excelsa* seedlings were recorded in nine stands out of ten stands. Stand density of seedlings varied greatly, not only between the localities but also in different stands of the same sites. Overall seedling densities varied considerably, from 3676 to 9222 inds/ha with a mean 6450±382 inds/ha (Table 3). Juniper seedlings indicated the highest density values from Sasnamana Khawas Neikh area (stand 8) with low basal area 21.99 cm² ha-¹ while the lowest stand density value 3673 inds/ha-¹ with higher basal area 110 cm² ha-¹ were recorded from Ziarat Prospectus point (stand 1). Seedlings occurred in the vicinity of groups of parent trees and also near dense shrubby patches. Significant correlations were found between seedling densities and both tree density and basal area (r= 0.63. p<0.001; r = 0.28. p<0.05) respectively.

Size class frequency distribution: The overall size class frequency distribution of *Juniperus excelsa* resembles- a reverse J- shaped distribution indicating better future progressive recruitment of trees (> 6 cm dbh) and mostly fell in small size classes; their number gradually increased in the larger size classes (Fig. 3a).Similarly seedlings (< 6 cm dbh) showed almost an uneven distribution pattern. Stands with a large density showed a highly skewed size frequency distribution with the mode in the smallest (10-20 cm dbh) class. Some stands showed more than one mode. Low density stands had flatter structure, often with several modes. Stands with moderate density normally formed intermediate size class frequency distribution. The combine data show a balanced size class structure (Fig. 2b). About 60% of the trees fell in the small size classes (classes 1-4). All the stands showed gaps in their size class structure. i.e., individuals in some classes are missing.

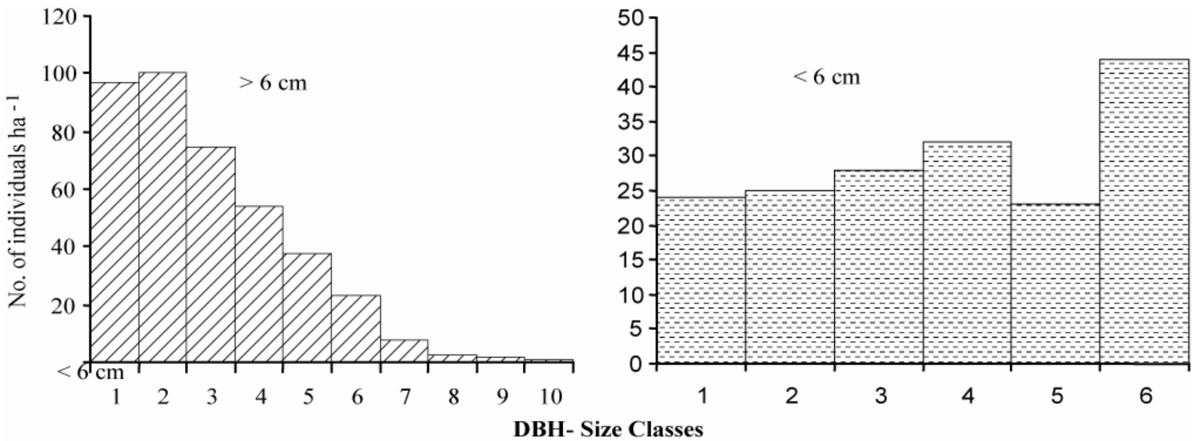

Fig. 2. Size class frequency distribution of 10 juniper stands. Seedling/sapling size structure (0.5 cm to 6cm dbh) is shown in 6 classes' intervals. Tree size structure were >6cm shown in 10 classes intervals.

Table 3. Summary of Juniper trees/seedlings Density ha^{-1} and Basal area m^2 ha^{-1} from ten stands of the study area.

S. No.	Main location	Sampling sites	Elevation (m)	Aspect	Trees (>6 cm dbh)		Seedlings (< cm dbh)	
					Density ha^{-1}	Basal area m^2 ha^{-1}	Density ha^{-1}	Basal area cm^2 ha^{-1}
1.	Ziarat	Prospectus Point	2685	North	211	99.95	4387	111.0
2.	Ziarat	Prospectus Point	2785	North	208	24.41	4416	94.98
3.	Ziarat	Prospectus Point	2785	North	233	12.52	8445	39.99
4.	Ziarat	Prospectus Point	2785	North	118	10.91	3673	71.32
5.	Ziarat	Prospectus Point	2785	West	268	65.38	7485	62.23
6.	Sasnamana	Sarro Narri	2858	West	233	126.87	8006	51.51
7.	Sasnamana	Khawas Neikh	2858	North East	132	77.09	4086	83.32
8.	Sasnamana	Khawas Neikh	2858	North East	29	285.07	9222	21.99
9.	Chasnak	Aghburg Arzani	2720	South West	156	103.07	4354	70.40
10.	Chasnak	Aghburg Bailzai	2750	South West	172	104.1	4429	78.87
Over all mean values					**176 ± 77**	**91 ± 41**	**6450 ± 382**	**68 ± 30**

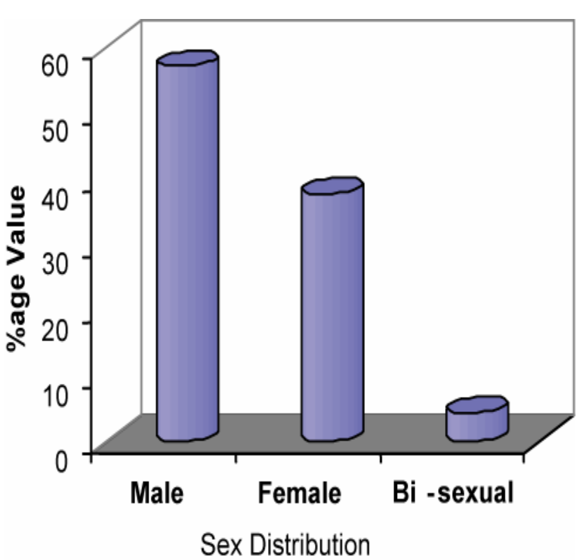

Fig. 3. Sex distribution ratio of juniper in 10 stands of the study area.

Sex distribution: The relative abundance of male, female and bisexual of Junipers varied greatly from site to site. In some stands male plants predominated while in others female plants has greater density. Bisexual individuals were rare, constituting about 4.41% of the total samples. Generally the sex ratio showed predominance of male with a value of 100±43 ha^{-1} 0r 57 % in the population. The mean density of female recorded was 66±29 ha^{-1} or 38% in the present study (Fig. 3). The male and female ratio did not differ significantly from 1(Chi square =0.39 N.S).

Physical condition: A large number of individuals were recorded alive (62%) as compared with standing dead trees (11%) and recently logged stumps (3%). Trees in the best condition were generally healthy (32%) with their branches bearing living foliage while over mature juniper trees with hollow and twisted stems of the population occupied only (14%), followed by unhealthy juniper (12%) and cut stumps (12%) respectively. Unhealthy (UH) with a mean of (21 ha^{-1} or12 %) while the density of over mature (OM) contributed (24 ha^{-1} (14 %) with a range of 4 to 55 individuals ha^{-1} (Fig. 4).

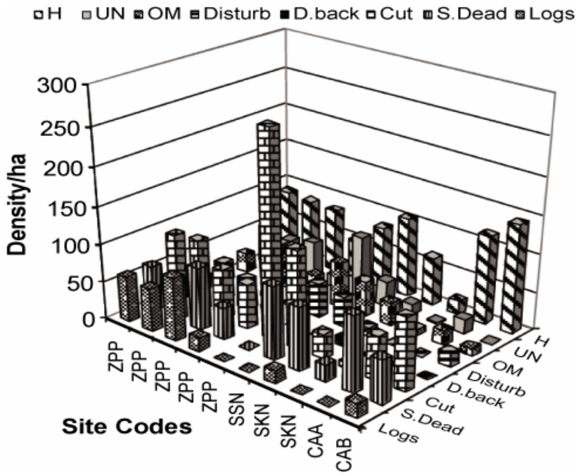

Fig. 4. A graphical representation of juniper physical conditions. All values are the mean values of 10 stands. H=Healthy plant ha^{-1}, UH=unhealthy plant ha^{-1}, OM=over mature plant ha^{-1}, DB=Dieback Plant ha^{-1}, AT=Alive Juniper tree ha^{-1}, BA= Basal area m^2 $ha^{-1}$of Juniper tree, LF=Logged Fallen tree ha^{-1}, DS= Dead Standing ha^{-1}, CS= Cut stump ha^{-1}
ZPP =Ziarat prospectus point, SNN = Susnamana Sarro Narri, SKN= Susnamana Khawas Neikh, CAA= Chasnak Aghburg Arzani, CAB= Chasnak Aghburg

Tree age and growth rates: Tree age and radial growth rates are presented in (Table 4). Since all the wood samples were in the form of cross section, they were considered 100% reliable. Age also varied greatly among individuals of the same size. Smaller trees may attain higher ages than larger individuals. However, In general, age increases with increase in diameter. The average age of 10 of different small and large trees were found 301 years. Diameter was not significantly correlated with age.

The growth rate, expressed as years/cm, varied greatly among the individuals of similar size (Table 4) with values ranging from 8.06 years/cm to 32.43 years/cm, but was slow on average; 15.52 years/cm, or just about 1mm increment per year. Diameter and growth rate was found to be not significantly correlated (r= 0.18, N.S) (Fig. 5).

Soil analysis: Soil of the present study area showed great variability not only between the sites but also among the stands of the same sites. Sandy-loam was the predominant soil type which represents the main part of the soil sampling analyzed. Sand fraction showed (64%) followed by silt (13%), clay (5%) while water holding capacity indicated (18%) of the total samples across the study area. Percentage of organic contents in the sampling area is generally low except in few stands (2, 4, 5 and 9) which range between 1.1 to 3.31%. Most of the stands were basic in reaction and free from salinity in the study area. PH values ranged from 6.9 to 8.0% while electrical conductivity were ranged between 0.92 to 2.76% ds/cm and showed stable condition in all the stands. All the soil samples were invariably calcareous in nature, their lime contents ranged between10.0 to15 % and comparatively stable in all the stands (Fig. 6).

No correlation appears to be present between soil variables and density, basal area and seedling densities of *Juniperus excelsa* trees.

Fig. 5. Cross section of *Juniperus excelsa* showing annual growth rings.

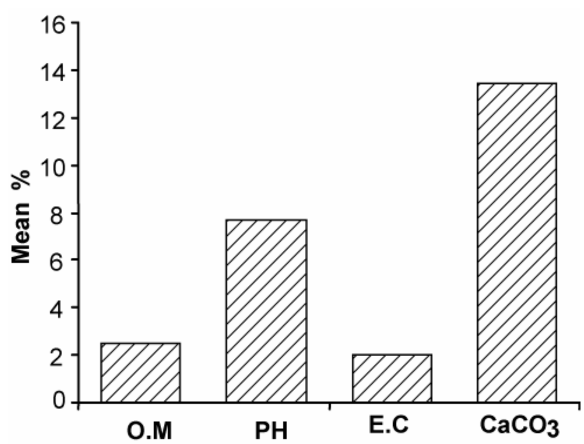

Fig. 6. Overall percentage value (mean of 10 stands) of soil chemical characteristics of study area. OM=Organic matter; pH= Hydrogen concentration; EC=Electrical conductivity; $CaCO_3$ =Calcium Carbonate.

Discussion

Juniperus excelsa is the dominant monospecific dry temperate tree species of forests land in upper elevations of Ziarat, Zerghune and Herboi mountains in Balochistan. These forests are considered at altitude ranging from 2000 to 3000 m and forms pure, open and uncertified stands in the area studied. .Human activities (illegal cutting and overgrazing) have completely changed not only the regeneration patterns but also the vegetation composition of the area. No broad leaf tree species now exist in these forests except *Fraxinus xanthoxyloides*, a widely disturbed species of dry temperate areas in Pakistan; is now completely eliminated from this forest Ahmed & Qadir (1976). However, they are available very rarely along the water streams at Ziarat juniper forests and Hazar Gangi National Park near Quetta (Rafiq & Rubina (1997). At present, only 20 species of herbs, shrubs and grasses were recorded as associated flora with juniper trees, while 24 species were reported by Shafeeq (1987) from Ziarat Juniper forest area.

Table 4. Diameter (dbh cm), age and growth rate estimation (yrs/cm) ± standard deviation for 10 trees in Ziarat *Juniper excelsa* forest of Balochistan.

S. No.	Main location	Diameter cm	Growth rate (yr/cm)	Total age (years)	Elevation (m)	Aspect
1.	Ziarat	22.3	8.06 ± 138	132	2685	North
2.	Ziarat	26.7	8.64 ± 1.78	131	2785	North
3.	Ziarat	27.5	14.22 ± 2.16	152	2785	North
4.	Ziarat	30.8	15.50 ± 2.10	170	2785	North
5.	Ziarat	31.3	8.91 ± 0.46	138	2785	West
6.	Sasnamana	33.4	9.13 ± 1.71	113	2858	West
7.	Sasnamana	43.2	32.43 ± 16.52	788	2858	North East
8.	Sasnamana	58.6	17.5 ± 5.33	345	2858	North East
9.	Chasnak	61.2	16.39 ± 3.13	408	2858	South West
10.	Chasnak	69.2	24.43 ± 8.96	639	2858	South West
	Total		**15.0 ± 18.0**	**301 ± 45**		

Density of juniper tract ranged from 56 to 332 ha-¹ Ahmed *et al.*, (1990b). *Pinus gerardiana* forest of the Zhobe District showed an average 226 ha-¹ with a range of 24 to 930 trees ha-¹ (Ahmed *et al.*, 1990a). In comparison to these near by forests, during the present study, the density of junipers ranged from 29 to 268 ha-¹ with an average 176±77 individuals ha-¹. The relatively increased human population in Ziarat and consequently the greater intensity of logging, cutting and overgrazing and mistletoe and fungal attack have presumably reduced the juniper stock density in the locality (Atta, 2000). A sharp decline in forest vegetation attributes occurred with increased levels of human and livestock interference.is reported in Bagh district, Kashmir (Shaheen *et al*., 2011). Relatively little is known about the insects, diseases and other factors that affect the health and productivity of *Juniper* forests in Ziarat district of Balochistan province, Pakistan (Atta *et al*., 2010). Some other published data of Ahmed *et al.,* (1990a, 1990b, 1991 and 2006) of Juniper and other forests in Pakistan is also available for comparison.

The overall mean basal area of present juniper tract was higher (91±41 m² ha-¹) than juniper tract (41 m² ha-¹) and *Pinus gerardiana* forest (25.5 m² ha-¹). The differences may be explained by assuming that the earlier estimates were based on the entire juniper tract, where our average 176 ha-¹ refers to 10 random mature juniper stands rather than selective stands in the areas. The large variation in the data from site to site might be that stem density depends on various historical and environmental factors (Ahmed, 1984). However, in these forests it may be due to anthropogenic disturbances. The variability of juniper trees and seedlings/saplings density and gaps in particular size classes as found in the study area might be predominantly due to associated anthropogenic and historical factors and to less extent with physiographic factors. This pattern of tree structure indicates an inadequate recruitment (Knight, 1975). Similar type of investigation is also reported by Wahab *et al.,* (2008) and Khan *et al.,* (2008).

According to Zakullah (1978) the incidence of decay was higher (33%) on the southern slopes particularly on over matures juniper trees than on the young trees. In the present study, the density and basal area was found great variability not only on elevations but also on various aspects might be due to human disturbances and climate change. Sheikh (1985) reported that the juniper forests of Balochistan are unable to regenerate may be due to lack of natural regeneration, hard seed coating, and seed borer. Beg (personal communication, 1973) reported that *J. excelsa* is a living forest fossil in the area and that deteriorating and thinning out very rapidly. The size/age structure of population provides an indication of their regeneration process and their conservation status. In the present study, however, large number of seedlings and young trees of various size classes recorded which suggests that regeneration in the study is quite good, despite high pressure for fuel wood collection, extensive grazing, and selective cutting of timber and collection of Juniper berries/seeds. Despite the continued disturbances in the area, the size class structure in the present juniper stands is normal and a sufficient number of individuals in small size classes are available This implies adequate number of recruitment. The combine data show a balanced size class structure. This enough quantity can be justified by the providing of natural gas to Ziarat district that have reduced the illegal cutting in these unique forests. During the present study, a similar large number of seedlings were found either under the tree canopies or near the close vicinity of the parent trees. Ahmed *et al.,* 1989a) also argued that juniper seedlings require shade in their early stages of development; therefore, it is likely that exposed soil surface, distance between juniper trees, low vegetation cover with over grazing and climate change were the main factors responsible for lack of natural regeneration in the study area. However, in few plots no seedlings were recorded from completely logged or eroded sites which suggest that seedlings require shade or better soil conditions (or both) in the early stages of growth. Such situation has also been reported for other tree population (Veblen & Stewart 1982; Norton 1983; Ahmed 1984). On the basis and present study it is suggested that these forests will not deteriorate and can be maintained stable, if urgent management and conservation measures are initiated. Ahmed *et al.,* (1990b) also calculated densities of healthy; over mature and disturbed juniper individuals on the juniper tract (from Kuch to Chautair).Higher densities of healthy (61 to 76%) and over mature individuals (18 to 32%) were reported by these workers. Present study area showed 32% healthy juniper trees with 12% unhealthy individuals. Over mature trees occupied only 14% of the total density probably due to the cutting of selective timber and logging of large trees. In many plots large number of standing dead trees (11%) and cut stumps (12%) were recorded while this situation did not exist in the juniper tract in the same province. A higher number of male individuals (57%) and (37%) of female individuals were recorded in the study area. Zaman *et al.,* (1968) also reported male predominance while according to Ahmed *et al.,* (1990b) male and female ratio was close 1:1 on the juniper tract. Bisexual plant was rare (4%) in the present study. Ward (1982) and Falinski (1980) found that in older populations of *juniperus communis* on dry nutrient-poor sites, male plants predominated, where as in young populations female plants predominated.

Cross section of ten trees was used to determine age and growth rate. Number of rings in trees with 26 to 69 cm dbh ranged from 113 to 788 (Mean 301±45). Diameter and age was not related. The average radial growth rate was estimated as 15±18 years/cm. Age and growth rate data from nearby dry temperate forests were available. Overall growth rate of *Pinus gerardiana* was 12 years/cm Ahmed *et al.,* (1990a), while Juniper trees from the juniper tract showed 10 years/cm radial growth (Ahmed *et al.,* 1990b). Slowest radial growth (32 years/cm was recorded in the present study. The reason of extremely slow radial growth might be due to poor soil conditions, steep slopes and prevailing climatic conditions. Due to great variability in age and growth rate (even among the same size individuals) the present study confirms that diameter is poor indicator of age and growth, as reported by Ahmed *et al.,* (1990a, b).

Soil texture has great effect on the water content, soil fertility, soil erosion, soil temperature and water holding capacity. The soil analyses of *J. excelsa* stands presented here showed that loamy sand was the predominant soil. Sand fraction represents the main part of the soil sampled analyses and ranges between 64% of the total 10 stands (Fig. 7). The findings were supported by the results of Hussain & Rizvi, (1974). The findings were supported by the indicators that these soils have very low amount of silt and clay which may be due to rocky nature of soil. All the soil samples indicated low to medium water holding capacity presumably due to coarse textured nature and low organic matter contents. The analysis revealed that the soils were well drained. Qadir and Ahmed (1989) and Majeed (1985) also reported similar results from the soils of the Hazar Gangi National Park near Quetta. Percentage of low organic content of the soil in the study area is generally low. This is in accordance with the conclusion of humus or it may be due to erosion of the upper horizons of the soil. Soil of the study areas are basic in reaction, free from salinity with less pH, which might be due to the presence of resins. Conductivity was comparatively stable in all the stands mainly due to accumulation of salts in the surface layer, which in turn may be because of the evaporation of the water. Accumulation of calcium carbonate is a characteristic feature of the arid zone soils. In the present study soil samples appear moderate to low calcareous in nature. Shafeq, (1987) carried out soil survey in the juniper tract. In the most cases the present values were similar to their work. A poor correlation was recorded only between soil texture values; Sand (r= 40; p<0.01) and Clay (r= 63; p< 0.01) indicating that density of Juniper trees/seedlings are greatly dependent upon the soil containing sand, clay and calcium carbonate probably due to some animal grazing, human disturbances, climate change particularly prevailing drought conditions in the past few years. Therefore, it may be suggested that these Juniper forests have degraded extensively that can be saved if urgent steps are taken for management and conservation.

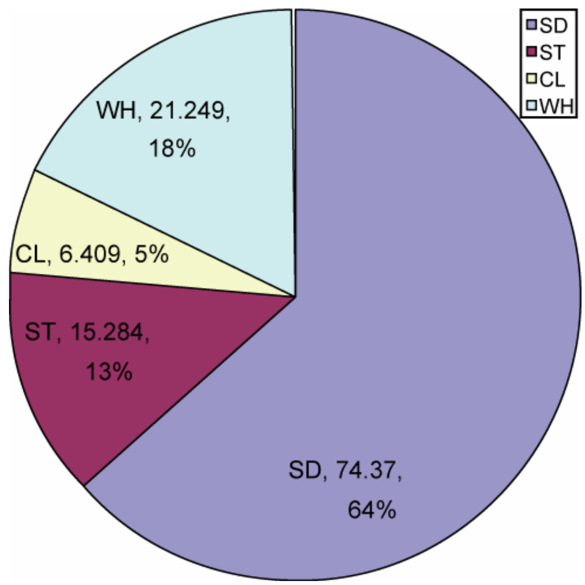

Fig. 7. Overall percentage values (mean of 10 stands) of soil physical characteristics in the study area. CL=Clay; ST= Silt; WH= Water holding capacity; SD= Sand.

Acknowledgements

Special thanks to Higher Education Commission (HEC) for providing funds for this project. We also extend many thanks to S.A. Qadir, Project Manager, Ziarat Juniper Ecosystem, Conservation, for providing support and field facilities in Ziarat. Thanks are also due to all those who helped us in the field work and preparation of this manuscript.

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(Received for publication 29 May 2011)