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A STUDY OF NATURAL REGENERATION OF *JUNIPERUS EXCELSA* M. BIEB. IN BALUCHISTAN, PAKISTAN

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Abstract

Regenerating seedlings from 60 mature stands on Juniper track in Baluchistan ranged from zero to 219 ha^{-1} with a mean of 52 ha^{-1}. Seedling density and basal area ($P < .001$) and tree basal area and seedling density ($P < .05$) were significantly correlated indicating that seedlings are shade loving. Highest average seedling density and basal area were recorded from West facing slope. Size frequency distribution of seedling showed a wave of recruitment in addition to past and future trends of the seedling populations suggesting that Juniper forests are not deteriorating.

Introduction

Juniper forests of Baluchistan have been reported to be dying or declining and due to a variety of reasons, there is hardly any natural regeneration in Juniper species which would disappear if the current state of affair continues (Sheikh, 1985). However no quantitative evidence has yet been produced supporting the 'dying forest' concept. Work on Juniper have been confined to seed germination, seedling establishment trials in nursery and field, and ecophysiology of Juniper (Quraishi *et al.*, 1978; Sheikh & Rafiq, 1982) but no studies have been carried out to obtain quantitative data from regenerating seedlings in mature Juniper forests. The present paper describes the natural regeneration of Juniper seedlings from mature Juniper forests of Baluchistan.

Materials and Methods

Site selection concentrated, as far as possible, on mature Juniper forest in which no recent logging was known to have occurred (Table 1). Sixty stands were sampled from May to November, 1986 using circular plot of 2.5 m radius in Sibi (Kuch to Ziarat), Ziarat (Yarget to Babakhurwari) and Loralai districts (Chautair). In each stand thirty plots were made and number of Juniper seedlings (upto 6 cm dbh) were recorded. Density and basal area ha^{-1} were calculated according to Mueller-Dombois & Ellenburg (1974). Aspect and elevation of each stand were also recorded.

Size frequency distribution of seedlings is shown by histograms. Duncan's Multiple Range test was carried out. To obtain possible relation among various aspects, regression analysis were also performed between Juniper seedlings ha^{-1} and a few edaphic and com-

Table 1. Summary of sites and Juniper seedlings for sixty stands.

Stand No. (1)	Altitude m (2)	Juniper seedling Aspect (3)	Density ha^{-1} (4)	Basal area cm^2 ha^{-1} (5)	Stand No. (1)	Altitude m (2)	Juniper seedling Aspect (3)	Density ha^{-1} (4)	Basal area cm^2 ha^{-1} (5)
Kuch to Ziarat Area					Yarget to Babakhurwari Area				
1.	2301	NE	16	135.31	31.	2551	N	5	62.85
2.	2301	N	21	234.94	32.	2731	N	29	384.50
3.	2281	EW	16	232.60	33.	2691	NE	16	237.60
4.	2331	EW	6	50.68	34.	2551	SW	24	506.50
5.	2661	NE	20	243.00	35.	2551	SN	8	158.19
6.	2391	W	68	838.29	36.	2581	N	14	280.42
7.	2381	NE	190	1619.17	37.	2551	SE	4	81.72
8.	2401	SW	103	1293.86	38.	2711	SE	133	1069.44
9.	2381	NE	219	1047.44	39.	2681	SN	51	654.23
10.	2401	W	117	891.60	40.	2681	SW	27	189.32
11.	2631	W	5	74.37	41.	2731	S	35	320.50
12.	2531	W	35	364.39	42.	2671	NW	6	45.56
13.	2301	NE	6	64.8	43.	2831	W	72	813.22
14.	2531	EW	42	153.3	44.	2791	SN	138	1186.61
15.	2571	S	22	251.24	45.	2481	E	172	1304.92
Ziarat Area					Chautair Area				
16.	2631	NE	12	136.8	46.	2301	NE	4	51.04
17.	2631	E	16	382.72	47.	2309	NW	27	265.68
18.	2881	NE	64	417.28	48.	2381	NW	32	267.20
19.	2631	8	23	355.12	49.	2411	E	24	261.36
20.	2881	EW	10	63.4	50.	2431	N	56	629.85
21.	2441	W	103	950.69	51.	2431	S	69	828.69
22.	2631	S	74	853.96	52.	2501	EW	57	741.57
23.	2691	E	13	132.73	53.	2501	EW	29	483.43
24.	2786	W	97	1105.80	54.	2551	N	54	482.76
25.	2701	S	83	759.45	55.	2511	SW	Zero	Zero
26.	2731	N	71	643.97	56.	2861	W	37	236.06
27.	2721	W	168	356.16	57.	2881	N	67	603.67
28.	2781	EW	38	280.06	58.	2371	E	11	134.53
29.	2901	NE	11	66.33	59.	2871	N	65	386.10
30.	2831	EW	77	920.92	60.	2731	W	50	539.00

munity variables. Data of stand density ha^{-1} basal area m^2 ha^{-1} (6 cm dbh), stand organic matter and stand water holding capacity were taken from Ahmed (in preparation).

For seedlings the following 6 dbh size classes were made:

up to 1 cm dbh = class 1
1.1 to 2 cm dbh = class 2
2.1 to 3 cm dbh = class 3

3.1 to 4 cm dbh = class 4
4.1 to 5 cm dbh = class 5
5.1 to 6 cm dbh = class 6

Six seedlings for each size class were obtained and mean ages were determined by a simple ring count.

Results

Seedlings density and basal area: Seedling densities in Kuch area ranged from 5 to 219 stems ha^{-1} with a mean of 59 ± 66 ha^{-1} (Table 1). A similar mean value (58 ± 43) was also recorded from Ziarat area, ranging from 11 to 168 individuals ha^{-1}. Relatively lower mean value (49 ± 53) was calculated from Yarget/Babakhurwari sites with a range of 4 to 172 ha^{-1}. Chautair density data, ranges from 0 to 67 with a mean of 42 ± 22. The highest density value was recorded from stand No. 9 while no seedling was observed from stand No. 55. Seedlings densities in sixty stands averaged 52 ± 49 ha^{-1} ranging from Zero to 219 ha^{-1} (Table 1).

Basal area cm^2 ha^{-1} values in Kuch, Ziarat and Yarget/Babakhurwari ranged from 45.56 to 1619.17 cm^2 ha^{-1} with a similar mean value (Table 2), while in Chautair it ranged from zero to 828.69 cm^2 ha^{-1} with a low mean of 394.1 ± 239.6. The highest basal area was recorded from stand No. 7 while lowest value was calculated from stand No. 42 (Table 1). The average basal area for all stands was 473.9 ± 381.87 cm^2 ha^{-1} ranging from zero to 1619.2 cm^2 ha^{-1}. Some stands with similar basal area values had quite different densities while in some cases reverse was the case. However overall correlation between seedlings density ha^{-1} and basal area cm^2 ha^{-1} was highly significant (Fig. 1).

Effect of aspect on seedlings density and basal area: Juniper seedlings show highest mean density and basal area on West facing slope while the lowest mean values for both

Table 2. Juniper seedling densities ha^{-1} and basal area cm^2 ha^{-1} values from different sites.

S.No.	Sites	Density ha^{-1} Min.	Max.	Mean	Basal area cm^2 ha^{-1} Min.	Max.	Mean
1.	Kuch	5	219	59 ± 66*	50.7	1619.2	499.6 ± 487.3*
2.	Ziarat	10	168	58 ± 43	63.4	1105.8	495.0 ± 388.3
3.	Yarget/Babakhurwari	4	172	49 ± 53	62.8	1304.9	486.4 ± 409.2
4.	Chautair	Zero	67	42 ± 22	Zero	828.7	394.1 ± 239.6
	Over all mean			52 ± 49			473.9 ± 381.8

*Standard deviation; Min. Minimum; Max. Maximum

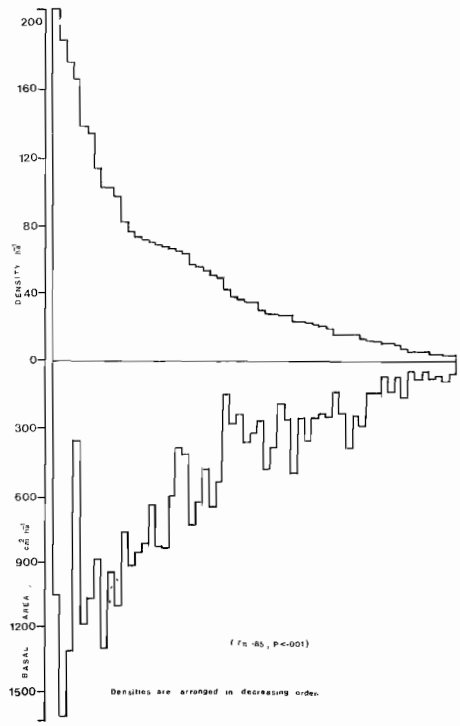

Fig. 1. Summary diagram showing seedlings density ha^{-1} and basal area cm^2 ha^{-1} in 60 stands.

Table 3. Juniper seedling density ha^{-1} and basal area cm^2 ha^{-1} on various aspects.

S. No.	No. of stands	Aspect	Density ha^{-1} Min.	Max.	Mean	Basal area cm^2 ha^{-1} Min.	Max.	Mean
1.	6	E	5	172	40 ± 65	374.4	1304.9	381.8 ± 425.1
2.	9	W	35	168	83 ± 43	236.1	1105.8	677.2 ± 291.3
3.	9	N	5	71	42 ± 25	62.8	643.9	412.1 ± 187.1
4.	6	S	22	74	51 ± 27	251.2	853.9	561.5 ± 255.9
5.	10	NE	4	219	56 ± 80	64.8	1619.2	401.9 ± 494.1
6.	3	NW*	6	32	22 ± 14	45.6	267.2	192.8 ± 104.1
7.	2	SE*	4	133	—	81.7	1069.4	—
8.	4	SW*	0	103	38 ± 45	189.3	1292.9	494.1 ± 570.1
9.	3	SN*	8	138	66 ± 66	158.2	1186.6	666.3 ± 419.9
10.	8	EW	6	77	34 ± 24	63.4	920.9	365.7 ± 300.9

*Not included in Analysis of variance.

Table 4. Result of Analysis of Variance.

Source of Variance	Sum of square	D.F.	F.
Treatment	12861.79	8	
Error	126282.43	49	.624
Total	139144.22	57	

Seedling density ha^{-1} from 58 stands were used in Duncan's multiple range test. Nine different aspects were included as shown in Table 3. Due to small sample size Southeast facing slops were excluded from the analysis. F-Value was not significant.

attributes were calculated from North West facing slopes (Table 3). The higher values of standard deviations indicate the great variability in density ha^{-1} and basal area cm^2 ha^{-1} from stand to stand within each aspect. Table 4 indicates the possible differences among various aspects in relation to the seedlings density ha^{-1}. Due to a small sample size SE is not included in analysis of variance. The analysis of variance yielded low F-value (.624) which is non-significant. Because of high variability within each slope category the differences in density between various slopes were found insignificant in Duncan's Multiple Range test.

Regression analysis: Seedlings density ha^{-1} was regressed with stand density ha^{-1}, basal area m^2ha^{-1} (trees), altitude, stand organic matter and stand water holding capacity using a package programme 'SAS' on IBM computer. (Table 5). Juniper seedlings ha^{-1} shows a significant correlation ($r=.2554$, $P<.05$, $n=60$) with stand basal area m^2 ha^{-1} Fig. 2.

Age estimate: Age varies from seedling to seedling even in a same size class (Table 6). Since seedlings were collected from various stands, therefore these ages give a rough idea of a diameter/age relationship of the Juniper seedlings in the study area.

Seedling size frequency distribution: Size structure diagrams for Juniper seedlings prepared for each stand (Fig. 3) indicates that 13 stands are composed of mosaic of mixed

Table 5. Summary of Regression Analysis on Juniper seedling ha^{-1}.

		Slope	r	P	N
1.	Standing density ha^{-1}*	Y = 42.41 + .05x	.1454	NS	60
2.	Stand basal area m^2 ha^{-1}*	Y = 32.68 + .48x	.2554	P < .05	60
3.	Altitude m	Y = 31.44 + .008x	.03	NS	60
4.	Organic matters	Y = 1.45 + 3.09x	.17	NS	45
5.	Water holding capacity %	Y = 37.78 + 6.10	.03	NS	60

r = correlation; n = number of observations; * = values based on large trees, greated them 6cm dbh.

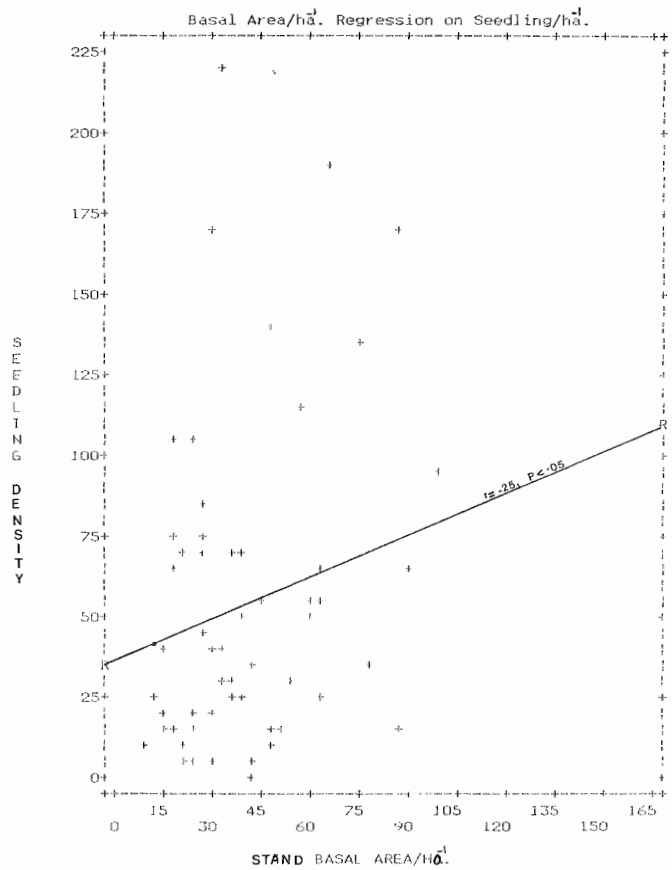

Fig. 2. Regression analysis between these variable is highly significant (r = .85, P < .001, N = 60).

size classes and in these stands, individuals are found in small size classes with a gradual decrease in number in bigger size classes. Some stands have similar number of seedlings ha^{-1} but show different size structure. Most of the stands show one or more gaps due to the absence of seedlings of the particular size classes. These gaps have been frequently observed in the population structure but the reason of these gaps has not been reported. Absence of seedling in a particular size class indicates either lack of regeneration or mortality during the particular period or year. For example absence of seedling in class 6 of the size frequency diagrams may indicate, that mature population could not add any individual, approximately 59 years before (Table 6). Furthermore after a few years similar gap will appear in a very early size class of the mature size class structure and known as regeneration gaps.

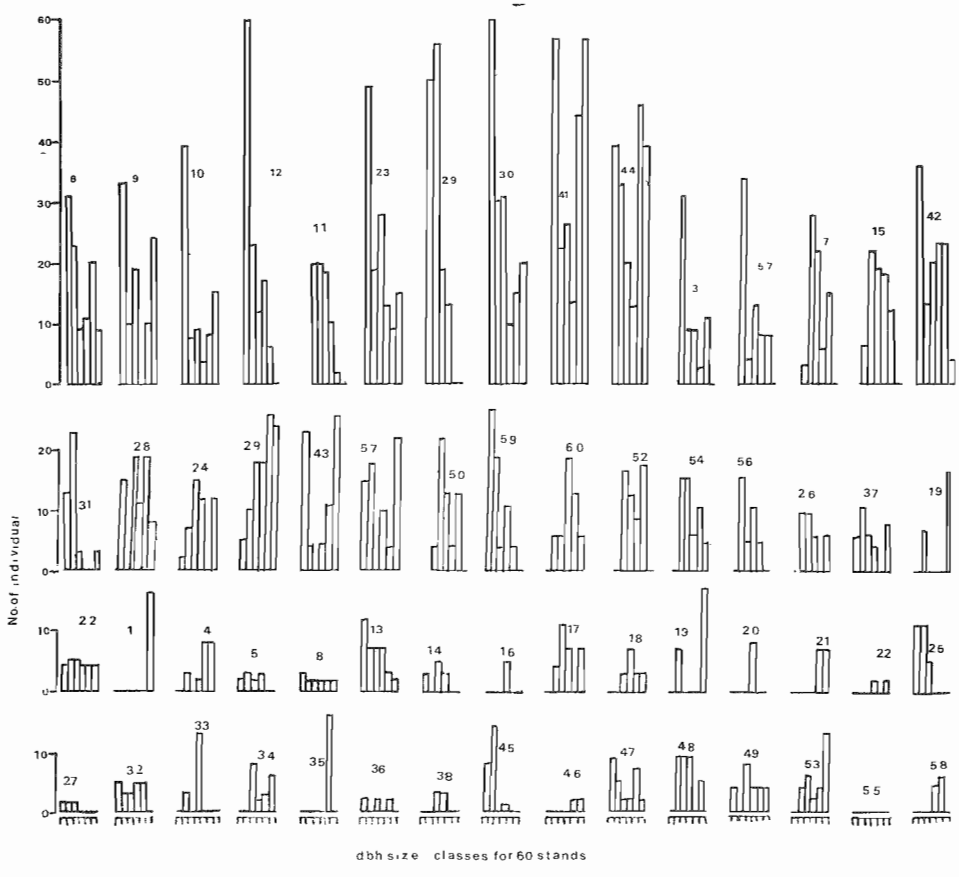

Fig. 3. Size frequency distribution of Juniper seedlings ha^{-1} in each stand. Numbers on the diagrams are the stand number as showin in Table 1.

Table 6. Age estimate in various sizes of Juniper seedlings.

dbh size class	Age in years Minimum age	Maximum age	Mean age
1	8	12	10 ± 1.5
2	14	24	19 ± 4.1
3	25	37	28 ± 7.4
4	24	49	37 ± 9.0
5	32	59	47 ± 10.5
6	40	66	59 ± 11.2

Age of each dbh size is based on six seedlings.

Discussion

In contrast to the earlier reports, the present study would strongly suggest the regeneration occurs in mature juniper stands. Whether the seedling values are good enough to maintain a balance between death of old and birth of new individuals in the forest is a question. According to Wardle (1969) low number of seedling do not necessarily mean that stand is deteriorating. These stands have seedling population ranging from zero to 219 ha^{-1} with an average of 52 seedlings ha^{-1}. No such data is available from any other forest of Pakistan to compare the present seedling values. Seedling density and basal area are higher where conditions are favourable, but the conditions are so often unfavourable that less natural regeneration is generally seen in most of the stands. Changing climate and soil erosion have been suggested for declining population (Grose, 1957; Hope-Simpson, 1957). In Juniper forests human disturbance and soil erosion may be accounted for low seedling densities in most of the mature stands. The seedling and smaller juvenile Juniper plants with their sharp acicular leaves would probably not be grazed, but they could be damaged or killed by animals ponderous tread or trampling. Ogden *et al.*, (1987) concluded that disturbance may have caused the relatively sparse and patchy regeneration which increased the rate of mortality due to competition. In the present study patchy regeneration was observed in some stands.

Juniper seedlings are recorded frequently with a canopy cover of dense shrubs or with small trees, probably due to shade and improved soil conditions. These seedling can persist for quite a long period under a dense parent canopy making a considerable size. Their age was found to be over 50 years with more than one m height. These seedlings failed to survive when canopy cover was removed as done by Baluchistan Forest Department a few years ago. Similar observations have been made on *Nothofagus solandri* (Wardle, 1970) and *Agathis australis* (Ahmad, 1984) in New Zealand. Sheikh (1985) reported higher survivorship in planted Juniper seedling under shade conditions. A high significant correlation ($P < .05$) between stand basal area $m^2\ ha^{-1}$ and seedlings density ha^{-1} would suggest that Juniper seedlings are shade loving in early stage of seedling establishment.

Duncan's Multiple Range Test gave no significant difference among various aspects in relation to seedling density ha^{-1}. The regression analyses indicated that stand density, altitude, organic matter and water holding capacity of the soil had no correlation with seedling density which may be associated with disturbance. For knowing the future and past of these stands their demography needs to be known which has not been done in any forest of Pakistan. According to Ahmed & Ogden (1987) and Ogden *et al* (1987), age and growth rate varies from site to site in a same size class. Therefore the present ages of seedlings do not represent the age of all the 60 stands but, these values could be used as approximate ages. If these ages are combined with size class structure, future and past

trends of the population could be predicted. The present study shows that for 50% stands the most destructive period, was probably 1975 to 1979 when no regeneration occurred, most likely due to an increase in human population associated with cutting and overgrazing. However, this may be overcome by minimising the cutting and overgrazing which would also control soil erosion.

Larger number of seedlings in small size classes with a gradual decrease in large size classes (in many stand) implies a wave of recruitment which will take place gradually in time. If these seedlings are absent in one stand, they are abundant on other site, so that despite local variation (except disturbance) a balanced population structure can be achieved by combining all data. This phenomenon is also reported by Ogden (1971), Clayton-Greene (1978), Veblen & Stewart (1982), Norton (1983) and Ahmed (1984) in other forests. It would therefore suggest that despite some declining stands due to human disturbances, the Juniper forests in general, are not deteriorating in Baluchistan.

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