

The Effect of Physiographic and Edaphic Factors on the Quantitative and Qualitative Characteristics of Juniper Trees (Case Study: Chalghofain Semirom County, Isfahan Province)

Soheil Soheili Esfahani^{1*} and Davood Azadfar²

¹PhD Student in Forestry and Forest Ecology, Faculty of Forest Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Iran

Email: soheilisoheil@yahoo.com

²Associate Professor, Department of Forestry and Forest Ecology, Faculty of Forest Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Iran

Abstract

To investigate the effect of environmental characteristics of slope, and slope and soil aspect on the quantitative status of Juniper forest stand in Chalghofa forest reserve, maps of this characteristic were prepared and after combining them, homogeneous units were identified. 100% inventory or full caliper sampling method was used for sampling. Measurement parameters included diameter at breast height (DBH), total height, canopy length, canopy surface and gender of rootstocks. Samples of topsoil were collected in the whole area and the physical and chemical properties of the soil were analyzed. The results showed that in low slopes these vegetative characteristics are less than more sloping areas. The lowest and highest vegetation parameters are related to the eastern and western aspects, respectively. The ratio of male to female rootstocks in the slope class of 15-30% is significantly different from the slope class of 30-60% and the ratio of male to female rootstocks in the northern aspect is statistically different from the other three aspects. In combining the slope map of 15-30% with the aspects, it was found that the number of juniper rootstocks is more in the western aspect and also the vegetative parameters in the western aspect are significantly different from the southern aspect. In combining the slope map of 30-60% with the aspects, despite the greater number of juniper rootstocks in the western slope aspect, the vegetative parameters in the northern aspect are significantly different from the other three aspects. Soil parameters in the aspect of the western slope are better than the other three aspects.

Keywords: Juniper Forest Stands, Slope, Aspect, Soil Sample, Chalghofa

Introduction

The genus *Juniperus* includes 4 species and a large number of subspecies; in this regard, it has the third place in the category of conifers after genera *Podocarpus* and *Pinus*. Juniper in many parts of the world has the harshest climatic conditions (even up to -40°C) and the poorest soil conditions compared to the other conifers (Javanshir, 1981). Junipers usually appear from a height of 1800 to 2500 meters on the southern slopes of Alborz, from 2000 to 3000 meters in the central areas of Zagros and from 3400 meters up in the southern areas as scattered rootstocks that these habitats called juniper forests cover an area of about 1.3 million hectares (Ghahraman, 1994; Marvie Mohajer, 2005). genus *Juniperus* has two subspecies called *Juniperus polycarpus* subsp. *excelsa* (*J. polycarpus*) and *Juniperus excelsa* subsp. *excelsa* (*J. excelsa*), (Farjon, 1992). The results of ISO protein and isoenzyme studies showed that these two subspecies are closely related together and in fact they are the same. Most of the

rootstocks of these trees are in the poorest living conditions such as completely rocky beds and eroded pebbles and soils, although they have remained with morphological changes in any case (Ali ahmad- Koroori&Khoshnevis, 2000).Unfortunately, these forests, despite the importance of many different aspects of the environment and genetics, have a declining trend, and this situation is especially acute and critical, especially in areas that are not under control and management, so that the size of these forests is decreasing day by day due to excessive cutting and grazing of livestock and unprincipled exploitation. In recent decades, a lot of studies have been conducted on the ecological characteristics of habitats of this species in Iran and other parts of the world to know the type of movement of juniper natural habitats towards modification or destruction (Ramezani, 1995).A few researches have been done on the habitat of different junipers inside and outside the country and little information has been published in this regard, among which the following can be mentioned:

In the study by Mellati (1995) on geobotanical evaluation in Tandoureh National Park, it was found that altitude was the limiting factor of juniper dispersion and slope and aspect factors did not play a limiting role. Juniper exists in Tandoureh area in all geographical directions and steep slopes. Ghelich Nia (1999) investigated the correlation between Juniper communities and topographic factors in Nardin area of Semnan province. He found that there was a significant correlation between altitude, slope and aspect with density and vegetation diversity. The results of the study by Momeni-Moghadam (2003) on the ecological characteristics of juniper (*J. polycarpus*) on the slopes of Kopet Dag of Shirvan county showed that the aspect slope affects the number per hectare, slenderness coefficient and freshness of trees. Altitude also affected the number per hectare, land cover, slenderness coefficient and regeneration. Rastin (2008) studied and compared the ecological factors of genus *Juniperus* in the natural habitats of Central Alborz in Chashm area of Semnan province. The results of this study showed the undeniable effect of slope and aspect factors on the establishment and growth of genus *Juniperus*. It has identified the most suitable conditions for the establishment and growth of genus *Juniperus* in the altitude class of 2200-2600 meters, slope class of 20-40%, northern and earthy fronts with light texture and alkaline acidity. Poormajidian and Moradi (2009) investigated the habitat and forestry characteristics of the genus *Juniperus excelsa* in natural forests of Ilan in Qazvin province according to topographic and soil factors. The results showed that except for the characteristic of height and asymmetric canopy of juniper trees in different slopes, other vegetative characteristics between work units have significant differences at the level of 1 and 5%. There was also a significant relationship between the number of juniper regeneration and soil properties at the level of 5%. The highest correlation was observed between lime percentage and number of regenerations ($r = 0.54$). The number of shrubs, number of trees per hectare, land cover and canopy percentage showed a significant correlation with the rate of regeneration. The highest correlation was observed between canopy percentage and juniper regeneration ($r = -0.64$). Therefore, vegetative characteristics of juniper are closely related to topographic and soil factors. Ramin (2009) investigated the spatial distribution of juniper stands and its relationship with environmental parameters in juniper stands of Aminabad, Firuzkuh. The results showed that the study habitat in terms of tree distribution in diameter classes has an irregular peer structure with left skew. Investigation of the relative effect of physiographic factors on the

quantitative characteristics of the canopy showed that the effect of altitude class is 2200-2200, slope class 0-30% and northern aspect is more than other classes. The results obtained from the regression model showed the altitude variable and the percentage of slope has an inverse effect on the surface characteristic of canopy. Qualitatively, the percentage of seedling trees in the whole stands was more than the coppice trees and among male, female and soft rootstocks, female rootstock was observed more than other rootstocks. Momeni-Moghadam et al. (2012) investigated the effect of environmental factors of slope, aspect and altitude on the quantitative and qualitative status of regeneration of juniper forest stands on the slopes of Hezar Masjed located in northern Khorasan Razavi. The results showed that altitude had an effect on the characteristics of the number of seedlings in the sample plot, collar diameter, height and percentage of succulent seedlings. The slope factor affects the characteristics of the number of seedlings in the sample plot. The aspect only affects the percentage of seedlings with moderate vigor and the overall shape of the land has no significant relationship with any of the study characteristics. According to the results of PCA test, it can be said that lime, salinity, clay and phosphorus have the greatest effect on juniper regeneration. In the study by Ahmed et al. (1989) on the natural reproduction of juniper (*J. excelsa*) in Balochistan province, Pakistan showed that there was a significant relationship between density and cross section of seedlings and juniper trees. The highest density of seedlings was observed in the western aspect. Since any planning for the development and expansion of juniper forests and the preservation of the status quo requires comprehensive information on the characteristics of its habitats, in this study, the effect of various edaphic and physiographic factors on the quantitative and qualitative status as well as the regeneration of natural juniper forests were investigated on a case-by-case basis in the juniper forest reserve of Chalgofain Semirrom county of Isfahan province.

Materials and Methods

- Introducing the Area

400-hectare juniper forest reserve in Chalgofa (in 30 km west of Semirrom county in Isfahan Province) was selected to do this research. This area is in the range of longitude 533000 to 539000 and latitude 3471000 to 3478000 according to UTM and the whole area has been managed since 2009 in the form of forest reserve management plan. The average rainfall in Semirrom county during the year is 400 mm, of which 27% is in autumn, 58% in winter, 13% in spring and 2% in summer. The average annual temperature is 10.1 °C, the average maximum temperature is 17.3 °C, the average minimum temperature is 3.5 °C, the absolute maximum temperature is 40 °C, the minimum is -30 °C, i.e., 70 °C difference between the absolute maximum and the absolute minimum, and the number of frost days averages 143 days. The type of climate is semi-arid based on the De Marton method. The maximum and minimum altitude of this area is 3200 and 2400 meters. The predominant genus of forests in this area is juniper and in addition to juniper, there are the other genera such as Arjan, Daphne, Ranas, Cotoneaster, Nastaran, Barberry and Lonicera as wood elements and accompanying genera. There are various species of the genera Artemis, Echinops, Achilea,

Asteragalus, Poa, Agropyron and Phlomiscancellata, Acantholimon, Eremurus in the area as understory plant species.

Method

First, in Arc Gis 10 software, digital elevation model of the area, slope class maps (15 to 30%, 30 to 60%), altitude classes (2400 to 2500, 2500 to 2600, 2600 to 2700, 2700 to 2800, 2800 to 2900, 2900 to 3000, 3000 to 3100 and 3100 to 3200 meters altitude) and aspects (south, north, east and west) were prepared using a 1: 25000 topographic map and digital elevation model of the area (DEM). Due to the importance of the subject, 100% inventory method was selected and the measured parameters of juniper trees included total height, diameter, canopy length, canopy surface, gender (male, female) in the classes, aspects and combination of classes and aspects. In the whole study area, 20 soil samples were evaluated at a depth of 0-30 cm. In the laboratory, soil texture characteristics, EC, pH, percentage of saturated moisture, lime, organic matter and nitrogen were measured. Duncan's multiple range test in SPSS 16 software was used to compare the mean of vegetative variables.

Findings

- Number of Rootstocks

The total number of measured rootstocks was 845 ones.

- Slope Classes

In the slope class of 15-30% with an area of 83 hectares, there are 131 rootstocks and in the slope class of 30-60% with an area of 317 hectares, there are 714 rootstocks. That is, according to 3.82 times ratio of the slope class of 30-60% to 15-30 slope class, the number of juniper rootstocks is 5.45 times and in terms of density (number of rootstocks per hectare) the slope class of 30-60% with number of 2.25 rootstocks per hectare has the highest density and the slope class of 15-30% with the number of 1.58 rootstocks per hectare has the lowest density (Table 1).

Table 1. Characteristics of the slope classes of the central core of Chalhofa forest reserve

row	Slope class (percentage)	Area (hectares)	Total number of rootstocks	Number of rootstocks per hectare
1	15-30	83	131	1/58
2	30-60	317	714	2/25

Also, quantitative parameters in the slope class of 30-60% such as average diameter (20.8 cm), average total height (4.02 m), average canopy length (3.83 m) and average canopy cover (6.65 m²) According to Duncan test shows a significant difference compared to the slope class of 15-30% (Table 2).

Table 2.Characteristics of quantitative parameters in slope classes

row	Slope Class (percentage)	Average diameter (centimeter)	Average total height (Meter)	Average canopy length (Meter)	Average canopy cover (Square meters)
1	15-30	^b 17/5	^b 3/94	^b 3/78	^b 5/87
2	30-60	^a 20/8	^a 4/02	^a 3/83	^a 6/65

The ratio of male to female rootstock in the slope class of 15-30% is equal to 5.19 and in the slope class of 30-30% is equal to 2.98 (Table 3).

Table 3.Characteristics of the number and type of rootstocks in slope classes

row	Slope Class (percentage)	Number of male rootstocks	Number of male rootstocks	The ratio of male rootstock to female rootstock
1	15-30	109	21	5/19
2	30-60	535	179	2/98

-Aspects

There are 139 rootstocks in the north slope with an area of 77 hectares, 142 rootstocks in the south slope with an area of 50 hectares, 102 rootstocks in the east slope with an area of 48 hectares and 462 rootstocks in the west slope with an area of 225 hectares. In terms of density (number of rootstocks per hectare), the southern slope with 2.84 rootstocks per hectare has the highest density and the northern slope with 1.80 rootstocks per hectare has the lowest density (Table 4).

Table 4. Characteristics of the aspects of the central core of Chalhofa forest reserve

row	aspect	Area (hectares)	Total number of rootstocks	Number of rootstocks per hectare
1	northern	77	139	1/80
2	southern	50	142	2/84
3	eastern	48	102	2/12
4	western	225	462	2/05

Also, quantitative parameters in the western aspect such as average diameter (23.46 cm), average total height (4.49 m), average canopy length (4.31 m) and average canopy cover (7.46 m²) according to Duncan's test shows a significant difference compared to other three aspects (Table 5).

Table 5. Characteristics of quantitative parameters in aspects

row	aspect	Average diameter (centimeter)	Average total height (Meter)	Average canopy length (Meter)	Average canopy cover (Square meters)
1	northern	^b 18/12	^b 3/64	^b 3/43	^b 4/95
2	southern	^c 17/15	^c 3/56	^c 3/29	^c 4/08
3	eastern	^d 8/83	^d 2/58	^d 2/5	^d 2/92
4	western	^a 23/46	^a 4/49	^a 4/31	^a 7/46

The ratio of male to female rootstock in the northern aspect is 3.96, in the southern aspect is 2.23, in the eastern aspect is 3.44 and in the western aspect is 3.32 (Table 6).

Table 6. Characteristics of number and type of rootstocks in aspects

row	aspect	Number of male rootstocks	Number of female rootstocks	The ratio of male rootstock to female rootstock
1	northern	111	28	3/96
2	southern	98	44	2/23
3	eastern	79	23	3/44
4	western	355	107	3/32

- Combining Classes and Aspects

Number of Rootstocks

In the combination of classes and aspects, it was determined that there are 9 juniper rootstocks in the class of 15-30% and in the northern aspect with an area of 1.6 hectares, 9 juniper rootstocks in the slope class of 15-30% and in the southern aspect with an area of 2 hectares, 102 juniper rootstocks in the slope class of 15-30% and east aspect with an area of 0.3677 hectares, and 122 juniper rootstocks in the slope class of 15-30% and west aspect with an area of 79 hectares. Also, there are 139 juniper rootstocks in the class of 30-60% and in the northern aspect with an area of 4.75 hectares, 133 juniper rootstocks in the slope class of 30-60% and in the southern aspect with an area of 48 hectares, 102 juniper rootstocks in the slope class of 30-60% and east aspect with an area of 47.6323 hectares, and 340 juniper rootstocks in the slope class of 30-60% and west aspect with an area of 146 hectares (Table 7).

Table 7. Characteristics of the number of rootstocks in the combination of classes and aspects

row	slope class (percentage)	aspect	Area (hectares)	Total number of rootstocks
1	15-30	northern	1/6	0
2	15-30	southern	2	9

3	15-30	eastern	0/3677	0
4	15-30	western	79	122
5	30-60	northern	75/4	139
6	30-60	southern	48	133
7	30-60	eastern	47/6323	102
8	30-60	western	146	340

- Quantitative Characteristics of Rootstocks

In the combination of classes and aspects, it was determined that the slope class of 15-30% and in the western aspect of the rootstocks in terms of quantitative characteristics such as average diameter of 10.98 cm, average total height of 2.38 m, average canopy length of 35.35 m and the average canopy cover of 4.02 m² have better condition than the rootstocks in the combination of slope class of 15-30% and the southern aspect with quantitative characteristics of the average diameter of 7.45 cm, the average total height of 6.1 m, the average canopy length of 1.5 m and the average canopy cover of 2.15 m². Also, the slope class of 30-60% and in the northern aspect of the rootstocks in terms of quantitative characteristics such as average diameter of 18.12 cm, average total height of 3.64 m, average canopy length of 3.43 m and the average canopy cover of 4.95 m² have better condition than the rootstocks in the combination of slope class of 15-30% and the southern aspect with quantitative characteristics of the average diameter of 8.83 cm, the average total height of 2.06 m, the average canopy length of 1.86 m and the average canopy cover of 2.46 m² (Table 8).

Table 8. Quantitative characteristics of rootstocks in combining classes and aspects

row	Slope class (percentage)	aspect	Average diameter (centimeter)	Average total height (Meter)	Average canopy length (Meter)	Average canopy cover (Square meters)
1	15-30	northern	0	0	0	0
2	15-30	southern	7/45	1/6	1/5	2/15
3	15-30	eastern	0	0	0	0
4	15-30	western	10/98	2/38	2/35	4/02
5	30-60	northern	18/12	3/64	3/43	4/95
6	30-60	southern	8/83	2/06	1/86	2/46
7	30-60	eastern	10/04	2/58	2/5	2/92
8	30-60	western	13/77	2/55	2/38	4/08

- Soil Condition of The Study Area

According to the results of experiments performed on soil samples in the area, it can be said that soil acidity varies between 7.35 to 7.50 and this is consistent with the percentage of soil lime, which varies between 1.4 to 2.30 percent. The soil salinity varies between 0.44 to 0.48 ds/m. The area has soils with loam, clayloam, and sandy loam textures. In terms of fertility,

the percentage of organic matter varies between 1.41% to 1.83% and the amount of nitrogen varies between 0.7% to 0.23%.

Table 9. Results of soil profile analysis in the western aspect

Descript & Dep (cm)	EC ds/r	PH	T.N. %	OC %	N %	Physical Tests			
						%San	%Sil	%Cl	Text
0-30	0/44	7/35	1/4	1/83	0/23	41/82	32/91	25/27	Clay loam- Loam

Table 10. Results of soil profile analysis in the northern aspect

Descript & Dep (cm)	EC ds/r	PH	T.N. %	OC %	N %	Physical Tests			
						%San	%Si	%Cl	Text
0-30	0/48	7/475	2/02	1/65	0/225	49/5	32	18/5	Sandy loam- Loam

Table 11. Results of soil profile analysis in the southern aspect

Descript & Dep (cm)	EC ds/r	PH	T.N. %	OC %	N %	Physical Tests			
						%San	%Sil	%Cl	Text
0-30	0/45	7/5	2/30	1/41	0/07	55/67	24/33	20	Sandy loam- Clay loam

Table 12. Results of soil profile analysis in the eastern aspect

Descript & Dep (cm)	EC ds/r	PH	T.N. %	OC %	N %	Physical Tests			
						%San	%Si	%Cl	Text
0-30	0/455	7/5	2/05	1/8	0/165	49	27/5	23/5	Sandy loam- Clay loam

Table 13. Summary of soil profile analysis results

Descript & Dep (cm)	EC ds/r	PH	T.N. %	OC %	N %	Physical Tests			
						%San	%Sil	%Cl	Text

Discussion

Slope is one of the effective and limiting factors for the growth of forest trees. With increasing slope in mountainous areas, soil depth decreases and this factor causes the slope to be one of the determining and influential factors in the distribution of plant species. The study results of the number of juniper trees in different slope classes showed that with increasing the slope, the number of juniper rootstocks increases. This difference is statistically significant and is consistent with the results of the study by El mahi (2003). The effect of slope on different vegetation characteristics of juniper such as average diameter, average total height, average canopy length and average canopy surface is significant so that in low slopes these vegetative characteristics are less than more sloping areas. The steep lands, despite the unfavorable habitat conditions, rocky bed and shallow soil, but due to the difficulty of access, these areas have been less attacked and cut down in recent years; as a result, the trees obtained more opportunity to grow and increase in DBH, the height, length of the canopy and the surface of the canopy. The results of this study are consistent with the results of the studies by Ghelichnia (1999), Momeni-Moghadam (2003), Rastin (2008), Momeni-Moghadam et al. (2012). Also, with increasing slope, the percentage of weak trees increases and the percentage of succulent rootstocks decreases. With increasing slope, moisture, soil depth and litterbag thickness decrease and the soil becomes debris and shallow, and this factor causes physiological weakness of the rootstock and increases the percentage of weak rootstock.

Aspect

Aspect is one of the important factors in the establishment of plant species. In the northern hemisphere, the slopes overlooking the north and east have better conditions than the southern and western slopes. Regarding to the mountainous nature of the area on the one hand and the ecological nature of juniper species which is a drought tolerant species on the other hand, there is a significant relationship between the distribution of this species with the aspect, despite having more juniper rootstocks in the western aspect and high density in the southern slopes. The results of this study are consistent with the results of the studies by Poormajidian and Moradi (2009), Momeni-Moghadam (2003), Ahmed et al. (1989). The DBH, total height, canopy length and canopy area on the western aspects have statistically significant difference with the northern, southern and eastern aspects. It is worth mentioning that the lowest vegetation parameters are related to the eastern aspects and the highest vegetation parameters are related to the western aspects. The findings of this study contradict the results of the study by Bordbar et al. (2010) who determined the highest level of canopy in the northern aspects and the lowest in the western aspects. However, it is consistent with the results of the studies by Poormajidian and Moradi (2009) who mentioned the highest number and DBH of juniper in the forests of Ailan in Qazvin province related to the western aspects.

- The Ratio of Male to Female Rootstocks

The ratio of male to female rootstocks in the slope class of 15-30% has a significant difference compared to the slope class of 30-60% and also the ratio of male to female rootstocks in the northern aspect has statistically significant difference with three other aspects.

- Combining Slope and Aspect

Combining a slope map of 15-30% with aspects, it was found that the number of juniper rootstocks was higher in the western aspect and also vegetative parameters such as average DBH, total height, canopy length and canopy surface in the western aspect were significantly different from the southern aspect. It is consistent with the results of the study by Poormajidian and Moradi (2009). Another reason is the location of the western aspect in rocky areas, and due to the difficulty of access, these areas have been less attacked and cut down in recent years, and as a result, trees have had the opportunity to grow more and increase vegetation parameters. Combining a slope map of 30-60% with aspects, it was found that despite having more juniper rootstocks in the western aspect, the vegetative parameters such as average DBH, total height, canopy length and canopy surface in the northern aspect were significantly different from three other aspects. The findings of this study are consistent with the findings of the study by Bordbar et al. (2010) who determined the highest level of canopy in the northern aspects.

- Investigation of Soil and Vegetative Parameters

Clay and Silt has the most effect and the percentage of saturated moisture has the least effect among the study soils. The results of experiments on topsoil samples taken from the area show that the soil of the area is somewhat alkaline and the acidity of the soil in all samples fluctuates between 7.35 to 7.50 and the percentage of lime fluctuates between 1.4 and 2.30. regarding to the ecological nature of the genus *Juniperus* and the calcareous of this genus, these factors are not among the factors limiting the growth of the genus *Juniperus*. Soil salinity is low (Zarrinkafsh, 2001). Given the mountainous nature of the study area, such a result is not far off. Accordingly, it can be said that the soil texture in most samples is moderate and its saturated moisture is somewhat suitable. In terms of factors expressing soil fertility, it should be said that the amount of soil nitrogen is less than desirable (Zarrinkafsh, 1998). However, the amount of soil organic matter is relatively desirable according to the conditions of the area. Soil measurement parameters in the soil sample for the western slope are more appropriate than the other three aspects and one of the reasons for the better quantitative parameters and vegetative characteristics in the western slope is the soil.

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