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Structure of natural *Juniperus excelsa* stands in Northwest of Iran

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Abstract. *Tavankar F. 2015.Structure of natural* Juniperus excelsa *stands in Northwest of Iran. Biodiversitas 16: 161-167. Juniperus excelsa* M. Bieb. stands are important forest ecosystems in mountain areas of Iran. In this research the structure of *J. excelsa* stands was studied at altitudes of 1,400 to 1,900 m in northwest of Iran. The results showed that the mean densities of trees and seedling (trees with height up to 1.3 m) were 99.8 ± 32.0 and 70.5 ± 18.3 stem ha^{-1}, respectively. The juniper trees comprise 52.8% of the total tree density, while the juniper seedlings comprise 19.3% of total seedling density. The mean of basal area in this stand was 3.12 ± 0.3 $m^2 ha^{-1}$ and the mean of canopy cover was 42.7 ± 17.9 percent. The mean of trees height was obtained 2.75 ± 1.1 m. The total of 28 woody species belonging to 14 families was recorded from the study area. The juniper trees had the maximum value of species importance value (SIV=87.3). *Amygdalus lyciodes* and *Pistacia atlantica* were two tree species that have high SIV values, 34.1 and 27.0, respectively.The distribution of trees density in different tree diameters resemble to a reverse J-shaped indicating uneven-aged structure. The results indicated juniper seedlings were increased by increasing stand crown cover ($P< 0.01$). Moreover extreme environmental conditions, grazing and timber harvesting for firewood are two important socioeconomic problems in these forests. These valuable stands needs to urgently conservation strategies.

Keywords: *Juniperus excelsa*, stand structure, species importance value, natural regeneration

INTRODUCTION

Junipers (*Juniperus* spp.), containing 60 species and spreading among many different temperature environments from the northern hemisphere to Southern Africa, are evergreen trees and shrubs (Assadi 1997; Deligoz 2012). Although most juniper trees are unisexual (dioecious), but there are also monoecious individuals. The seed production is very low in these trees (Javanshir 1981; Ahani et al. 2013). Juniper stands cover an area of 1.3 million ha in Iran (Marvie-Mohadjer 2006), and the genus *Juniperus* is represented by six species: *J. sabina* L., *J. communis* L., *J. oxycedrus* L., *J. foetidissima*, *J. oblonga* M. Bieb and *J. excelsa* M. Bieb (Javanshir 1981; Korouri et al. 2011). The *J. polycarpos* and *J. excelsa* are the most common species among the six juniper species in the Iran (Korouri and Khosnevis 2000; Ahani et al. 2013). The *J. excelsa* (Cupressaceae) grow naturally over most of the mountainous areas of Iran (south slopes in high mountains of Elburz, Arassbaran, and Northern parts of Khorassan), and have a great ecological importance (Korouri and Khosnevis 2000; Marvie-Mohadjer 2006; Taheri Abkenai et al. 2012). *J. excelsa* exhibits growth plasticity and can adapt and grow in diverse regimes (shade - light), while, in favorable conditions, it is able to increase its growth rates even at old ages (Milios et al. 2009). Their vital needs are limited (Deligoz 2012; Ramin et al. 2012). The juniper trees can grow from lowland at sea level up to an altitude of 3,600 m depending on latitude, so elevation has an in-reverse relation with latitude (Javanshir 1981; Fisher and Gardner 1995; Zangiabadi et al. 2012). *J. excelsa* usually appears in mountainous areas (Ahmed et al. 1990; Fisher and Gardner 1995; Sabeti 2006; Milios et al. 2009). *J. excelsa* is a cold resistant species but their seedling requires a high degree of humidity (Aussenac 2002; Ozkan et al. 2010) and shady conditions (Ahani et al. 2013). *J. excelsa* can grow not only in harsh abiotic environments such as shallow and stony soils, cold, hot and dry climates, but also have ability to grow in extreme biotic conditions like grazed sites (Ahmed et al. 1989; Fisher and Gardner 1995; Korouri and Khosnevis 2000; Carus 2004; Stampoulidis et al. 2013). They are important food sources for wildlife, several bird species feed on juniper cones (Decker et al. 1991). This species is capable of protecting the soil; it has high resistance against cold weather and can grows in areas where the minimum of temperature reaches to -35° C (Ghahreman 1994; Korouri and Khosnevis 2000; Aussenac 2002; Taheri Abkenai et al. 2012).

In a study by Ahmed et al. (1989) natural regeneration of *J. excelsa* was investigated in Balouchistan, Pakistan and reported regenerating seedlings ranged from zero to 219 stem ha^{-1} with a mean of 52 stem ha^{-1} that the highest seedling density and basal area were recorded on west facing slopes. The researchers also indicated that the seedling density was significantly correlated with tree basal area of the parent trees. An investigation on the distribution and ecology of juniper genus was conducted as a national plan in the Iran (Korouri and Khosnevis 2000). According to previous studies the natural regeneration of juniper trees is very low and difficult due to grazing and tree felling for firewood by villagers in Iranian juniper forests (Ravanbakhsh et al. 2010; Shirzad and Tabari 2011; Ramin et al. 2012; Taheri Abkenai et al. 2012). Shahi et al. (2007) studied age structure and seed characteristics of juniper stands in the northwest of Iran and reported that due to high rate of seed production there is no extinction risk for species. The researchers also reported about 13% of individuals were damaged by wild and domestic herbivores. They concluded maintenance of natural juniper regeneration needs to production of good quality seeds.

Juniper is a suitable tree species for afforestation in semi-arid and arid areas (Javanshir 1981; Esmaeelnia et al. 2006; Ozkan et al. 2010; Deligoz 2012). The best age for transferring saplings to natural areas is three years; a 86.9% success rate was achieved in Iran by Koruri et al. (2011). Ramin et al. (2012) studied properties of *J. excelsa* stands in northern Iran and reported that average of canopy cover was 7.5%, and the average tree height was 4.9 m. There is some indication from previous studies that Physiographic factors effects on attributes of juniper stands (Pourmajidian and Moradi 2009; Khosrojerdi et al. 2010; Ravanbakhsh et al. 2010; Maghsoudlou Nezhad et al. 2013). Momeni Moghaddam et al. (2012) studied the impact of some physiographic and edaphic factors on quantitative and qualitative characteristics of *J. excelsa* stands in northeast of Iran. They reported that the elevation has significant effect on density of trees and regeneration, stand basal area, slenderness ratio and crown diameter of trees. It was also indicated that slope gradient has significant effect on trees height and diameter, and pH and texture of soil are important factors in distribution of juniper trees.

Pourmajidian and Moradi (2009) studied site characteristics and silvicultural properties of *J. excelsa* stands in southern slopes of Alborz Mountain in Iran. They reported site characteristics were different from altitude, slope direction and soil properties. The researchers also indicated that the silvicultural properties of *J. excelsa* stands such as tree and seedling density, basal area and canopy cover depended to site characteristics. Their results indicated that the seedling density of *J. excelsa* was increased by increasing stand basal area and canopy cover. Maghsoudlou Nezhad et al. (2013) studied quantitative characteristics of *J. excelsa* stands in Gorgan province in northern Iran. The researchers reported that landform units were different significantly in terms of tree density, canopy cover, tree diameter and stand basal area. They also reported that the slope aspect and soil wetness indices are the best predictors for the density of trees. *J. excelsa* stands are widespread in Iran, under different environmental conditions. Cataloging silvicultural properties of juniper stands is essential as a basis for monitoring and management of these valuable forests (Gardner and Fisher 1996; Pourmajidian and Moradi 2009).

Preparation and planning for biodiversity conservation and sustainable management of forest ecosystems is needed to identify the exact structure of the forest (Zenner and Hibbs 2000; Haidari et al. 2012; Tavankar 2013). The main objective of the present study was to investigate structure of *J. excelsa* stands, such as tree density, species compositions, trees height and diameter, stand basal area, canopy cover, regeneration, and stand structure in Northwest of Iran and compare these data with silvicultural properties from other sites.

MATERIAL AND METHODS

Study area

The study area is located in the Ardebil Province in the northwest of Iran (latitude 37° 27' 14" to 37° 27' 50" N, longitude 48° 22' 25" to 48° 23' 10" E) (Figure 1). The elevation of the study area ranges from 1,400 to 1,900 m above sea level. The mean annual temperature is 12.5°C and the mean annual precipitation is 380 mm for the years 1990 to 2008. The slope aspect is southwestern and the slope gradient ranges from 24 to 63% with an average 37%. The soil type is lithic lithosol and texture varies between clay loam to loam. The original vegetation of this area is natural uneven-aged mixed stands of *Juniperus excelsa* with the companion species.

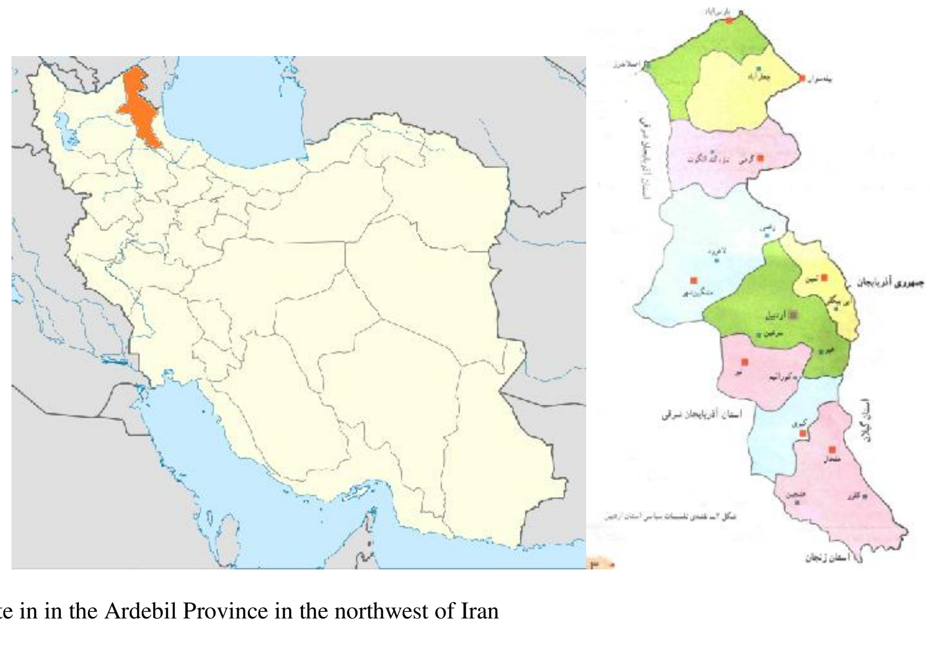

Figure 1. Study site in in the Ardebil Province in the northwest of Iran

Data collection and analysis

Data were collected in summer 2014, by systematic sample plots with an area of 400 m^2 (20 m × 20 m). The number of sample plots was 55. The sample plots were located on the study area (59 ha) through systematic grid (100 m × 100 m) with a random start point. Diameter at breast height (DBH) and heights of all trees (height ≥ 1.3 m) were measured. Individuals of trees with height < 1.3 m were counted by species as seedling (Stampoulidis et al. 2013). Species importance values determine the dominant species in an area and at the same time provide an overall estimate of the influence of these species in the community (Amoroso et al. 2011). Species importance value (SIV) for each tree specious was calculated by: SIV= Relative density (RD) + relative frequency (RF) + relative dominance (RD). Basal area was considered for dominancy and relative dominance (RD) calculated by: RD = (basal area of a species × 100) / total basal area of all species (Amoroso et al. 2011; Pourbabaei et al. 2013; Tavankar and Bonyad, 2015). Confidence intervals on the means calculated as accuracy by: CI% = ($S_{\bar{x}} \times t_{95\%}$) × 10(, where CI is confidence interval, is standard error, $t_{95\%}$ is t value in 95% confidence level from t table and is mean (Zobeiri 2007). After checking for normality of data distributions (Kolmogorov-Smirnov test) and homogeneity of variances (Levene's test), regression analysis was applied to test of the relations between DBH and trees density and trees height. The means of juniper seedlings in crown cover classes were compared using Analysis of Variance (ANOVA) test and multiple comparisons were made by Tukey's test (significant at $\alpha < 0.05$). SPSS 19.0 software was used for statistical analysis; also the results of the analysis were presented using descriptive statistics.

RESULTS AND DISCUSSION

Results

The structural properties of the studied juniperstand are shown in Table 1. The mean densities of trees and seedling (trees with height up to 1.3 m) were 99.8 ± 32.0 (SD) and 70.5 ± 18.3 stem ha^1, respectively. Juniper trees comprise 52.8% of total trees density, while juniper regeneration comprises 19.3% of total seedling density in the study area. The means of trees diameter (DBH) and trees height were obtained 10.1 ± 6.5 cm and 2.75 ± 1.1 m, respectively. The means of juniper trees diameter (8.4 cm) and trees height (2.53 m) were lower than the mean diameter (13.7 cm) and height (3.12 m) of other tree species. The mean of basal area in this stand was obtained 3.12 ± 0.3 m^2 ha^{-1} and the mean of canopy cover was obtained 42.7 ± 17.9 percent (Table 1).

A total of 28 woody species belonging to 14 families were recorded from the study area (Table 2).The family of Rosaceae with 9 species had the highest number of woody species in the study area that includes *Amygdalus lyciodes, Crataegus songarica, Prunus divaricata, Sorbus torminalis, Malus orientalis, Amygdalus scoparia, Cerasus microcarpa, Cotoneaster nummularia* and *Rosa canina*. The families of Caprifoliaceae, Rhamnaceae and Aceraceae had 4, 3 and 2 woody species, respectively; and each of other families had only one species.

The density of different tree species is shown in Table 2. The total density of trees was 99.8 stem ha^{-1}. The density of juniper trees (*J. excelsa*) was 52.7 stem ha^{-1}, which comprise 52.8% of the total tree density. After juniper trees, the species of *Amygdalus lyciodes*, *Pistacia atlantica* and *Acer monspessulanum* have the highest density, (9.1, 7.4 and 5.5 stem ha^{-1}, respectively) in the study area. These species (*A. lyciodes*, *P. atlantica* and *A. monspessulanum*) comprise 22% of the total tree density. Other tree species (24 species) comprise 25.2% of the total tree density.

The total basal area in the study area was 3.12 m^2ha^{-1}, that the *J. excelsa* had the highest value of basal area (0.67 m^2ha^{-1}, 21.5%). The basal areas of *A. lyciodes*, *P. atlantica* and *A. monspessulanum* were 0.32, 0.19 and 0.17 m^2ha^{-1}, respectively. These species comprise 21.8% of the total basal area. Other tree species (24 species) comprise 56.7% of the total basal area (Table 2).

The total seedling (regeneration) density was 70.5 stem ha^{-1}, that the *Amygdalus lyciodes* with 14.2 stem ha^{-1} (20.1%), had the highest frequency of seedlings in the study area. The *Pistacia atlantica* had 13.8 stem ha^{-1} (19.6%) and the *J. excelsa* had 13.6 stem ha^{-1} (19.3%) of seedling density. The seedling density of *Acer monspessulanum* was 6.3 stem ha^{-1} (8.9%). Other tree species (24 species) comprise 32.1% of the total tree density (Table 2).

Species Importance Value (SIV) of different tree species in the natural junipers stands is shown in Table 2. Eight species (*J. excelsa*, *A. lyciodes*, *P. atlantica*, *A. monspessulanum*, *L. nummulariafolia*, *R. spathulaefolia*, *P. spina Christi*, *A. campestre*) have SIV more than 10 and formed over 73% of total SIV. The SIV of *J. excelsa* was the highest (87.3) in the study area. The SIV of *A. lyciodes*, *P. atlantica* and *A. monspessulanum* were 34.1, 27.0 and 19.6, respectively.

Relation between diameter (DBH) and height of trees are shown in Figure 2. According to this figure, the height of juniper and other tree species were increased by increasing of their DBH. The heights of juniper trees were lower than the heights of other tree species in DBH more than 4 cm. The regression analysis showed that the correlation coefficient (R) between trees height and trees DBH are statistically significant (P < 0.01).

The distribution of trees density in different DBH resemble to a reverse J-shaped indicating uneven-aged structure (Figure 3), so trees density were decreased with increasing DBH. The density of juniper trees was more than the density of other tree species up to DBH of 21 cm. The regression analysis showed that the correlation coefficient (R) between trees density and trees DBH are statistically significant (P < 0.01).

The abundance of sampling plots in crown-cover classes are shown in Figure 4. According to Fig. 3, the crown-cover class 20 to 30 percent has the highest abundance (29.1%) of sampling plots (n=16). The abundance of sampling plots was decreased by increasing crown cover class more or less than 20-30 percent.

The results of this study showed that the juniper seedlings were increased by increasing crown-cover percentages (Figure 5). The ANOVA test showed the crown-cover classes had significantly affect on the mean of juniper seedlings (F=3.67, P < 0.01).

Discussion

The results of this study showed that the density of trees (height ≥1.3 m) was estimated to be about 100 stem ha^{-1}. The density of trees in other studies was reported as: 65 to 102 stem ha^{-1} in different land units of *J. excelsa* stands by Zangiabadi et al. (2012) and 60 to 200 stem ha^{-1} by Momeni Moghaddam et al. (2012) in southeast Iran; 32 stem ha^{-1} by Ramin et al. (2012), 188 stem ha^{-1} by Pourmajidian and Moradi (2009) and 66 stem ha^{-1} by Maghsoudlou Nezhad et al. (2013) in Northern Iran; 592 stem ha^{-1} in protected juniper stands by Rostami kia and Zobeiri (2013) in Northwest Iran. Atta et al. (2012) density of juniper trees (> 6 cm DBH) reported from 29 to 268 stems ha^{-1} with a mean 176 ± 77 individuals ha^{-1} in *J. excelsa* forests in Balouchestan Pakistan. The density of seedlings (trees with height up to 1.3 m) in this study was estimated 70 stem ha^{-1}.

Pourmajidian and Moradi (2009) reported the mean density of seedlings 71 stem ha^{-1} in the *J. excelsa* stands in the Northern Iran. They reported the highest seedlings density on Northwestern facing slopes (102 stem ha^{-1})

Table 1. Structural properties of a *Juniperus excelsa* stand in the northwest of Iran

Stand properties	Max.	Min.	Mean	SD	CI%
Tree density (stem ha^{-1})					
Juniper	68.3	12.6	52.7	12.8	6.5
Other	59.0	14.2	47.1	11.5	6.6
All	119.7	23.5	99.8	32.0	8.6
Seedling density (stem ha^{-1})					
Juniper	19.4	2.5	13.6	4.8	9.5
Other	78.4	23.6	56.9	11.3	5.4
All	103.7	26.6	70.5	18.3	7.0
Tree diameter (cm)					
Juniper	22.5	1.0	8.4	4.4	14.2
Other	28.4	1.0	13.7	9.4	18.4
All	28.4	1.0	10.1	6.5	17.3
Tree height (m)					
Juniper	3.07	0.55	2.53	0.7	7.5
Other	5.33	0.72	3.12	1.1	9.5
All	5.33	0.55	2.75	1.1	10.8
Basal area (m^2 ha^{-1})					
Juniper	0.47	0.08	0.67	0.2	14.6
Other	0.86	0.15	2.45	0.3	10.8
All	1.30	0.32	3.12	0.3	7.2
Canopy cover (%)					
Juniper	35.6	8.0	25.5	13.1	13.8
Other	29.3	7.7	17.2	10.5	16.5
All	55.2	10.3	42.7	17.9	11.3

Note: SD: Standard deviation, CI: Confidence interval

Table 2. Density of trees and seedling, basal area and species importance values (SIV)

Tree species	Family	Tree (stem ha^{-1})	Basal area (m^2 ha^{-1})	Seedling (stem ha^{-1})	SIV
Juniperus excelsa M. Bieb.	Cupressaceae	52.7	0.67	13.6	87.3
Amygdalus lyciodes L.	Rosaceae	9.1	0.32	14.2	34.1
Pistacia atlantica F&M.	Anacardiaceae	7.4	0.19	13.8	27.0
Acer monspessulanum L.	Aceraceae	5.5	0.17	6.3	19.6
Lonicera nummulariafolia J.	Caprifoliaceae	4.0	0.16	2.4	15.7
Rhamnus spathulaefolia F&M.	Rhamnaceae	3.3	0.14	2.0	14.0
Paliurus spina christi Mill.	Rhamnaceae	3.1	0.13	1.3	12.8
Acer campestre L.	Aceraceae	2.4	0.12	1.0	10.3
Berberis integerrima L.	Berberidaceae	2.0	0.12	1.0	7.5
Quercus macranthera Fish & Meyer	Fagaceae	1.3	0.14	1.0	9.4
Carpinus orientalis Mill.	Corylaceae	1.0	0.12	1.0	7.5
Crataegus songarica C. Koch	Rosaceae	0.8	0.10	1.0	6.2
Prunus divaricata Ledeb.	Rosaceae	0.7	0.12	1.0	4.6
Sorbus torminalis(L.) Crantz	Rosaceae	0.6	0.11	1.0	4.2
Viburnum opulus L.	Caprifoliaceae	0.6	0.08	1.0	4.2
Viburnum lantana L.	Caprifoliaceae	0.6	0.10	1.0	4.1
Malus orientalis Ugl.	Rosaceae	0.6	0.10	1.0	3.0
Eunymus latifolia(L.) Mill.	Celastraceae	0.5	0.07	1.0	3.1
Amygdalus scoparia Spach.	Rosaceae	0.5	0.05	0.8	4.0
Colutea persica Boiss.	Papilionaceae	0.5	0.01	0.8	3.1
Cerasus microcarpa(C.A.Mey)	Rosaceae	0.5	0.01	0.8	2.7
Cotoneaster nummularia Pojark.	Rosaceae	0.4	0.01	0.5	2.5
Cornus sanguinea L .	Cornaceae	0.4	0.01	0.5	2.5
Lonicera iberica M.B.	Caprifoliaceae	0.3	0.01	0.5	2.2
Rhamnus pallasii F. M.	Rhamnaceae	0.3	0.01	0.5	2.2
Rosa canina L.	Rosaceae	0.3	0.01	0.5	2.2
Celtis caucasica Willd.	Ulmaceae	0.2	0.03	0.5	2.0
Jasminum fruticans L.	Oleaceae	0.2	0.01	0.5	2.0
All species	-	99.8	3.12	70.5	300

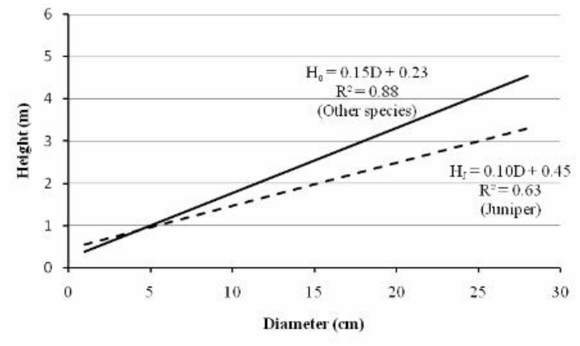

Figure 2. Relation between diameter and height of trees

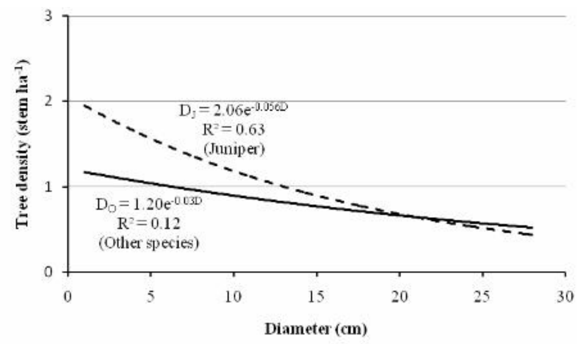

Figure 3. Relation between diameter and density of trees

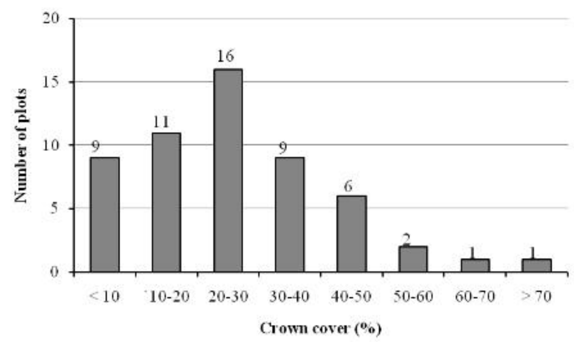

Figure 4. Abundance of sampling plots in crown-cover classes

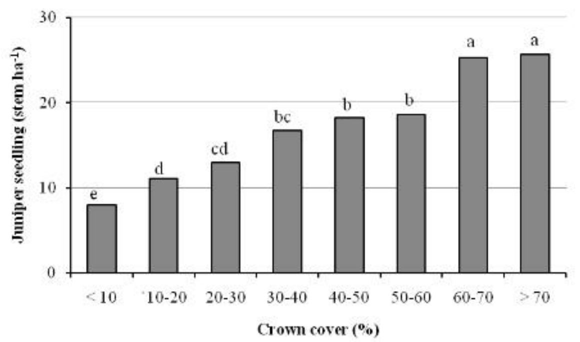

Figure 5 . Density of juniper seedlings in crown-cover classes

and the lowest on Southeastern facing slopes (48 stem ha^{-1}). The results of this study indicated juniper seedlings were increased by increasing stand crown cover. Ahmed et al. (1989) also concluded that juniper tree seedlings need shady conditions in the early stages of their growth and development. Reforestation by local tree species in empty areas is necessary. Many studies have been noted that the nurse trees have a major role in the success of juniper regeneration (Ahmed et al. 1989, 1990; Fisher and Gardner 1995; Milios et al. 2007; Stampoulidis et al. 2013). In a study by Khosrojerdi et al. (2010) reported that establishment, growth and survival of juniper seedlings that planted under *Cotoneaster* sp. and *Rosa* sp. as nurse trees were more than the juniper seedling that planted in open areas.

The mean basal area in the study area was obtained 3.12 m^2 ha^{-1}. The other researchers reported of basal area 4.67 m^2ha^{-1} by Rostami Kia and Zobeiri (2013) in the Northwest Iran, 1.09 m^2ha^{-1} by Momeni Moghaddam et al. (2012) in the Northeast Iran and 10.55 m^2ha^{-1} by Maghsoudlou Nezhad et al. (2013) in the northern Iran.

The mean height of trees was 2.53 m in the study area. The mean tree height in the other *J. excelsa* sites were reported 4.51 m by Momeni Moghaddam et al. (2012) in the Northeast Iran, 4.9 m by Ramin et al. (2012) in the Northern Iran, 2.9 m by Rostami kia and Zobeiri (2013) in the Northwest Iran, 4.7 m by Pourmajidian and Moradi (2009) in Northern Iran.

The results of this research showed that the juniper stands are rich for tree species, so 28 tree species from 14 families were present in the study area in the northwest Iran. After the *J. excelsa*, the three species of *Amygdalus lyciodes*, *Pistacia atlantica* and *Acer monspessulanum* are the important trees that have the highest tree and seedling density and species importance values (SIV) in the study area. Stampoulidis and Milios (2010) reported that in the natural *J. excelsa* stands in the Greece there are also species such as *Quercus macedonica*, *Juniperus oxycedrus*, *Quercus pubescens*, *Pyrus amygdaliformis*, *Carpinus orientalis*, *Acer monspessulanum* and *Juniperus foetidissima*. Shirzad and Tabari (2011) reported 16 woody species from 9 families in the *J. excelsa* stands in the Northeast Iran. Rostami kia and Zobeiri (2013) reported 8 woody species from 7 families in *J. excelsa* stands in the Northwest Iran. It is widely accepted in forest ecology that different management practices affect species diversity, and high diversity of plant and animal species is needed to ensure more complex forest structure (Bacaro et al. 2014). Many ecological, pathological, socioeconomic 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 on regeneration and structure of these forests. These factors also reported as the main impacts on species composition, productivity, structure and dynamics of juniper forests by Atta et al. (2012) in Pakistan.

Considering to the results of this study and comparing with previous studies it can be concluded that the *J. excelsa* stands are very important forests in Iran. Conservation strategies for these stands are urgently needed. The richness of woody species in these forests is high and this issue is very important for conservation biodiversity. These stands are open forests with low regeneration densities. Forest protection should aim at ensuring that forests continue to perform all their productive, socio-economic and environmental functions in the future. It is widely accepted, that a structurally diverse stand provides living space for a larger number of organisms (Tavankar and Bonyad 2015). Iran is a country with low forest cover (UNFF 2005), so that only 7.3% of it is covered by forest areas (FAO 2005). Therefore, the main objective of forest policy is to protect forests in natural ecosystem. Moreover extreme environmental conditions, grazing and timber harvesting for firewood are two important socioeconomic problems in these forests.

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