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Analyzing the Diameter Distribution of *Juniperus excelsa* M. Bieb Stands of Northeast Iran, Using Probability Distribution Functions

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ABSTRACT

Aim The present study aimed to analyze the diameter distribution of *Juniperus excelsa* m.bieb stands of northeast Iran, using probability distribution functions consider to cardinal directions.
Materials & Methods The data have been collected from 168 sample plots of 0.1ha areas in natural juniper stands of Iran. In this study, the diameter distribution of the juniper stands has been evaluated in four main geographical aspects, using various statistical distributions. Weibull (two- and three-parameter), Gamma (two- and three-parameter), Beta, Johnson, and lognormal probability distributions have been used for modeling diameter distribution.
Findings According to the Kolmogorov-Smirnov test, the most appropriate distribution functions in the northern, eastern, and southern slopes were the two-parameter Weibull and Johnson probability distributions western slopes, the most appropriate distribution functions were Beta and Johnson. Besides, considering Anderson-Darling's fitting test, only lognormal distribution in the northern, eastern, and southern aspects, and lognormal and three-parameter Weibull in western aspect did not show a significant difference compared with the frequency of trees in diameter classes.
Conclusion Generally, the results show Weibull (2p) and longermal are the most appropriate statistical distribution functions for describing the distribution of trees in the diameter classes of *Juniperus excelsa* in different aspects.

Keywords Anderson-Darling; Aspect; Fitting; Juniper; Slope; Stand Structure

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[1] dentification and characterization of amento flavone from six species of juniperus against H2O2 induced oxidative damage in ... [2] Junipers of the world: The genus ... [3] Flora of Iran: Pinaceae, taxacae, cupressaceae ... [4] Comprehensive Studies of Juniperus ... [5] Iranian long-lived ... [6] Forest inventory measurement of tree ... [7] Biomass and carbon allocation of 10-years-old poplar (Populous alba L.) ... [8] Individual tree growth derived from diameter ... [9] Evaluation of different statistical distribution for estimation of diameter distribution within forest ... [10] A study of tree distribution in diameter classes in natural forests ... [11] Juvenile diameter distribution of loblolly pine characterized by the ... [12] Fitness of distribution of diameter at breast height by using some ... [13] Deriving tree diameter distribution using bayesian ... [14] Spatial and statistical analysis of quantitative characteristics of Juniperus stands in chahar-bagh of Gorgan ... [15] Quantitative and qualitative characteristics of Arasbaran forest protected area ... [16] Forest vegetation patterns along an altitudinal gradient in sub-alpine ... [17] The growth ecology of Juniperus excelsa bieb trees in the central part of the Nestos valley (NE Greece) in the ... [18] The study of effective factors on Almond (Amygdalus scoparia Spach) distribution ... [19] Investigation on quantitative characteristic and soil properties of Juniperus excels M.Bieb ... [20] Population structure and natural regeneration potential of (Juniperus excelsa M) in ... [21] Predicting parameters of a weibull function for ... [22] Structure and regeneration patterns of Juniperus polycarpos C.Koch ... [23] Diameter distribution of trees in natural stands managed ... [24] Fitting probability distribution functions for modeling diameter distribution of oak species ... [25] Effect of the decline on changes in the ... [26] Effect of land uses on aboveground biomass and carbon ... [27] Fine root biomass in acer monspessulanum trees and ... [28] Tree diameter distribution modeling: Introducing ... [29] Structure and development of expanding western ...

Introduction

The genus of Juniper, of the family of Cupressaceae, consists of 60 species and a large number of subspecies that extend to Europe, Southeast Asia (including Iran), and North America [1, 2]. In general, the Iranian junipers are divided into two groups of phenotypes of standing and creeping. Creeping junipers of Iran include *Juniperus sabina* L. and *J. communis* L., and standing junipers of Iran include *J. excelsa* M. Bieb. and *J. foetidissima* Willd. Asadi [3] have been introduced another type of Juniper that named *J. oblonga* M. Bieb. (*Juniperus communis* var. *saxatilis* Pall.) which have two phenotypes of creeping and standing. The presence of *J. excelsa* species in Iran is so vast that it could be found in all the main vegetation regions of Iran, including Hyrcanian, Arasbaran, Zagros, Iran and Turanian, and the Persian Gulf and Oman sea coasts and often grown in mountainous regions [4]. Although this species is often seen in the size of a shrub, some trees with 25m height and a circuit equal to nine meters are also observed in some spots of Iran [5].

The efficient and proper management of juniper forests requires knowledge about the structure of these forests. However, despite the ecological importance of the juniper species in the high and mountainous forests of the country, studies that have been conducted on the conditions and structure of these forests were insufficient. The tree diameter of a forest stand and its distribution in the diameter classes is one of the most important structural features of the forest [6]. Therefore, modeling the characteristics of the tree, such as diameter and height, could prepare the necessary information to manage the forests [7].

Diameter distribution models use probability functions to investigate the structure of forest stands. The first attempt to model the distribution of tree variables in 1898 was made by Dolikourt [8]. The application of diameter distribution models is often used in modeling forest growth and yield [9]. Besides, diameter distribution could provide information about the structure, age, livestock, and stability of the stands. To provide the fairest distribution, the choice of a superior model and the estimation of its parameters and the best distribution is the most critical issues in the use of statistical distributions in the forest [10].

In Iran, since the past, studies have been done on modeling the frequency distribution of tree diameter, but most of these studies have used curve fitting for this purpose, and only in a few studies the density assessment was used in statistical distributions [5]. It is worthy of note that there are many differences between the curve fitting method and density estimation. However, at times there is a similarity between some of their models. For example, the exponential distribution and exponential function are different from each other, and the Meyer formula is an exponential function, not exponential distribution [5, 11, 12]. It has now been proven that not only the probability distribution of diameter varies in different species of trees in different habitats, but also within a habitat, the type of distribution varies in different stages of the sequence. In this regard, various studies have been carried out on the appropriate statistical distribution for showing diameter distribution, such as beta, gamma, normal, Weibull, etc. [13].

Some studies have evaluated the effect of topographic factors such as elevation and geographic aspect on the diameter distribution of forest stands. By examining the habitats of Juniper, Maghsoudlou Nezhad *et al.* [14] argued that this species is significantly affected by geographical orientation, to the extent that they are more likely to appear on the eastern, northern, and western slopes, and not in the southern slopes. However, more than ecological factors, the reason is more related to human factors because the northern, eastern, and western slopes of juniper highlands are usually low in temperature, and the establishment of villagers, livestock, and natives regions is not typical. Nonetheless, in southern areas, the presence of these factors is more and more common. The effects of human activity and their livestock animals has caused the destruction of juniper stands in this region. Recent studies about this field include Moradidirmandrik *et al.* [15], Sanjay *et al.* [16], Smyris Pavlos *et al.* [17], Goodarzi *et al.* [18], and Daghestani *et al.* [19]. The study of these researches shows that various factors such as human interactions, topographical and edaphic factors, and climatic factors significantly affect the spread of different species of Juniper [20]. This study investigates the diameter distribution of natural Juniper (*Juniperus excelsa* M. Bieb.) stands of Iran in four main aspects. These kinds of researches are significant mathematical researches about the forest structure, and for the first time, we tried it for natural junper stands of Iran. About the sensitive forests like Spiro that have noticeable effects on keeping the surface water and soil and coping with erosion, the forest managers could decide that witch aspect of these forests need some reinforcement.

Materials and Methods

Study area

This study performed in Spiro natural juniper habitats, located in the longitude of 55°04′01″E to 55°09′23″E and latitude of 36°44′25″N to 36°46′52″ N in north-eastern Iran and Semnan Province (Figure 1). The area is 2000ha, and the altitude of the habitat is 1550 to 2700m.a.s.l. In terms of geology, the region belongs to the Mesozoic and Paleozoic periods. The soil texture of the area is clay, clay loam, loam, and sandy loam. The average annual rainfall in the region is 350mm, and the average annual temperature is 6.9°C, the average maximum in July (from 18.6 to 21.6°C), and its average minimum in February (-3 up to 3°C). Because of the effect of human activities, Site quality is not good (low).

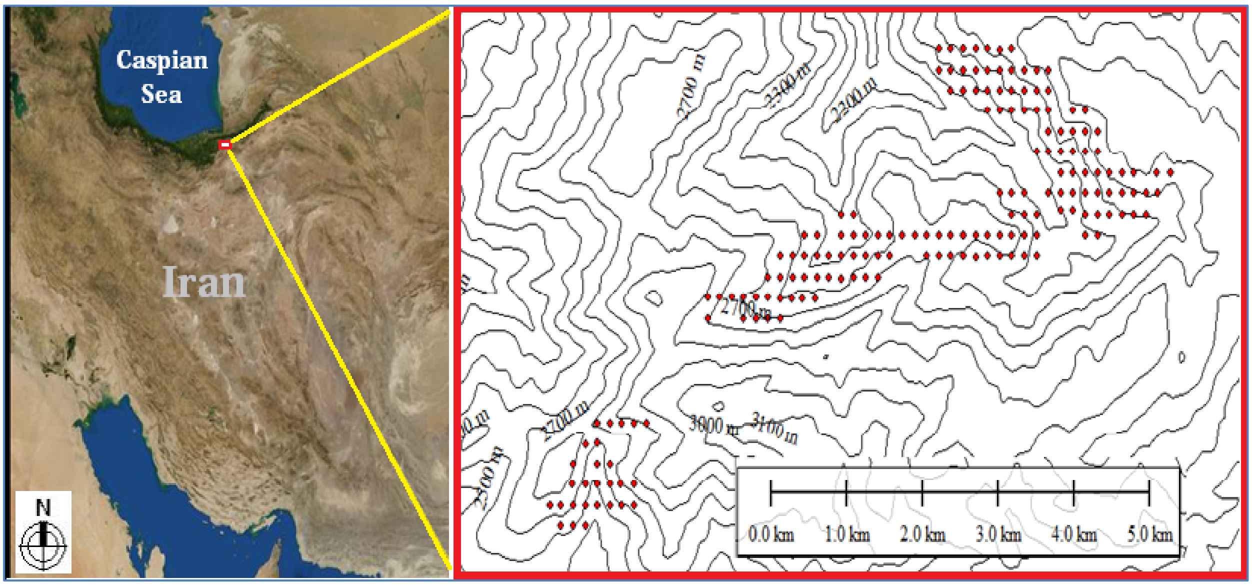

Figure 1) The study area and location of the sample plots on the map

Data collection

Necessary data for this study were collected in summer 2018. For this purpose, the number of 168 sample plots with a 0.1ha area designed in a randomized, systematic sampling method in four main geographical aspects of the study area includes north, south, east, and west (42 sample plots in each aspect). The net dimensions were 300×400m. Then, in each one of the sample plots, the diameter at breast height (DBH) of all trees taken and recorded in the prepared inventory forms. According to the result, the forest stand is uneven-aged, then the Statistical characteristics of the number per hectare and basal area of the forest area are calculated for the stand and summarized in Table 1.

Data modeling

In this study, some frequent statistical distributions in biological researches include Weibull (2P and 3P), beta, Johnson, gamma (2P and 3P), and lognormal have been used [13, 21]. Then the data are processed, and the frequency of diameter data is in each diameter class obtained. Hereafter, the trees' diameter distribution modeled using density functions (Table 2). Then obtained results for all distributions compared and ranked, and the best models for the definition of *Juniperus excelsa* diameter distributions were extracted. They were modeling the diameter distribution done for all the trees that were recorded in each geographical aspect. Then, seven models for each aspect were obtained.

Function fitting and assessment

In this study, Kolmogorov Smirnov (KS) and Anderson Darling (AD) tests were used to investigating the models' goodness of fit and ranking them. Modeling the functions and drawing the graphs were done in Easy Fit 5.5 professional software.

Descriptive statistics of tree diameter in four different aspects are summarized in Table 3. As data show in the table, the most massive range of diameter distribution of *Juniperus excelsa* trees is related to the eastern aspect, and the least amount is related to the southern aspect.

The distribution of trees in different aspects is shown in Diagram 1. In each of the four geographical aspects, the diameter distribution of the trees is first digressive, and from the 25 to 30 diameter class, it is additive, and then it is digressive again. Sixty-seven trees in the north, 122 trees in the east, 117 trees in the south, and 88 number of trees in the west aspect were investigated.

Table 1) Number per hectare and basal area characteristics of juniper trees in the study area

Statistic feature	Number per hectare	Basal area (m^2)
Number of plots	168	168
Mean	104	10.36
Minimum	10	0/96
Maximum	480	19/04
Standard Error	6.81	0.39

Table 2) Probability distribution functions applied in the study area

Distribution	Density functions	Parameters
Weibull	$f(x) = \frac{\alpha}{\beta}\left(\frac{x}{\beta}\right)^{\alpha-1} \exp\left[-\left(\frac{x}{\beta}\right)^{\alpha}\right]$	x: tree diameter α: continuous shape parameter ($\alpha > 0$) β: continuous scale parameter ($\beta > 0$)
Weibull (3P)	$f(x) = \frac{\alpha}{\beta}\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1} \exp\left[-\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right]$	x: tree diameter α: continuous shape parameter ($\alpha > 0$) β: continuous scale parameter ($\beta > 0$) γ: continuous location parameter
Beta	$f(x) = \frac{(x-a)^{\alpha_1-1}(b-x)^{\alpha_2-1}}{\beta(\alpha_1,\alpha_2)(b-a)^{\alpha_1+\alpha_2-1}}$	x: tree diameter (a_1, a_2): continuous shape parameters (a_1, $a_2 > 0$) α and b: continuous boundary parameters ($a < b$)
Johnson SB	$f(x) = \frac{\delta\lambda}{\sqrt{2\pi(x-\xi)(\xi+\lambda-x)}}\exp\{-\frac{1}{2}\left[\gamma + ln\left(\frac{x-\xi}{\xi+\lambda-x}\right)\right]\}$	x: tree diameter ξ: continuous location parameter γ: continuous shape parameter δ: continuous shape parameter ($\delta > 0$) λ: continuous scale parameter ($\lambda>0$)
Gamma	$f(x) = \frac{x^{\alpha-1}}{\beta^{\alpha}(\alpha)}\exp\left(-\frac{x}{\beta}\right)$	x: tree diameter α: continuous shape parameter ($\alpha > 0$) β: continuous scale parameter ($\beta > 0$) $\Gamma(\alpha)$: gamma function*
Gamma (3P)	$f(x) = \frac{(x-\gamma)^{\alpha-1}}{\beta^{\alpha}\Gamma(\alpha)}\exp\left(-\frac{x-\gamma}{\beta}\right)$	x: tree diameter α: continuous shape parameter ($\alpha > 0$) β: continuous scale parameter ($\beta > 0$) γ: location parameter
Lognormal	$f(x) = \frac{exp\left[-\frac{1}{2}\left(\frac{ln(x-\gamma)-\mu}{\sigma}\right)^2\right]}{(x-\gamma)\sigma\sqrt{2\pi}}$	x: tree diameter γ: location parameter σ and μ: continuous parameters ($\sigma > 0$)

Note: * – gamma function $\Gamma(\alpha)$ is used to extend the factorial function to complex numbers.

Table 3) Descriptive statistics of tree diameter in different geographical aspects

Aspect	Min (cm)	Max (cm)	Mean (cm)	Standard deviation	Skewness	Kurtosis
North	7.5	102	35.34	20.9	0.79	0.09
East	7.5	106	27.37	18.15	0.095	1.04
South	8	91	30.26	15.17	0.65	0.455
West	7.5	101	32.68	18.82	0.64	-0.13

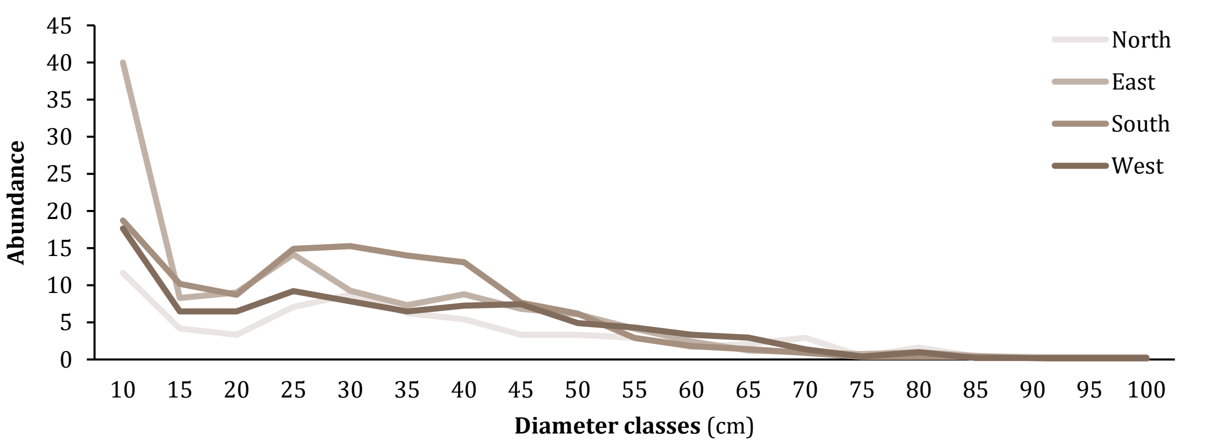

Diagram 1) Distribution of trees in diameter classes in different geographical aspects

Findings

Distribution models

According to the results, the distribution of trees in different diameter classes in the northern aspect is irregular and does not follow a particular trend. Except for the lower diameter classes, most distributions have the same decreasing trend but in higher classes do not show much difference. The diameter structure of the trees in the eastern aspect is close to the converted form of J, which is unique to uneven-aged forests. Also, in the southern aspect, the distribution of trees in the diameter classes is more similar to the structure of the even-aged forests (normal-shaped), but still, the most frequent trees in the 10cm diameter class are observable. In the western aspect and the lower diameter classes (10-25cm), gamma (3P), beta, and gamma (3P) distributions are more capable of describing the frequency of trees in this aspect. However, with increasing diameter, the beta distribution is more suitable for the studied species in this aspect (Diagram 2).

Generally, the diameter distribution of this stand confirms the good regeneration (first class of diameter) in all studied aspects. However, a cross-sectional decrease is observed in the next two diameter classes. Most trees have middle diameters (25-55cm), and the most massive trees have the smallest frequency.

Goodness of fit

According to the Kolmogorov-Smirnov test, the Weibull (2P) and Johnson distributions are more suitable for describing the diameter distribution of juniper trees in the northern aspect. According to the Anderson-Darling fitting test, the most appropriate distribution for this species in the northern aspect is lognormal. The Kolmogorov-Smirnov test showed that statistical distributions of Johnson and Weibull (2P) were more suitable for modeling the frequency of trees compared to other distributions in the eastern aspect, and Anderson-Darling's test identified the lognormal distribution to be the most appropriate in this aspect. Based on results obtained from the Kolmogorov-Smirnov test, the Weibull (2P) and Johnson distributions have a more remarkable ability to describe the frequency of the studied species in the southern aspect. Furthermore, according to the Anderson-Darling fitting test, the most appropriate distribution for this species in the southern aspect is the lognormal model. Finally, the Kolmogorov-Smirnov test showed that the distributions of the Beta and Johnson, compared to other distributions, are better functions for modeling the frequency of trees diameter in the western aspect, and the Anderson-Darling test found that the Weibull (3P) is more appropriate in this case (Table 4).

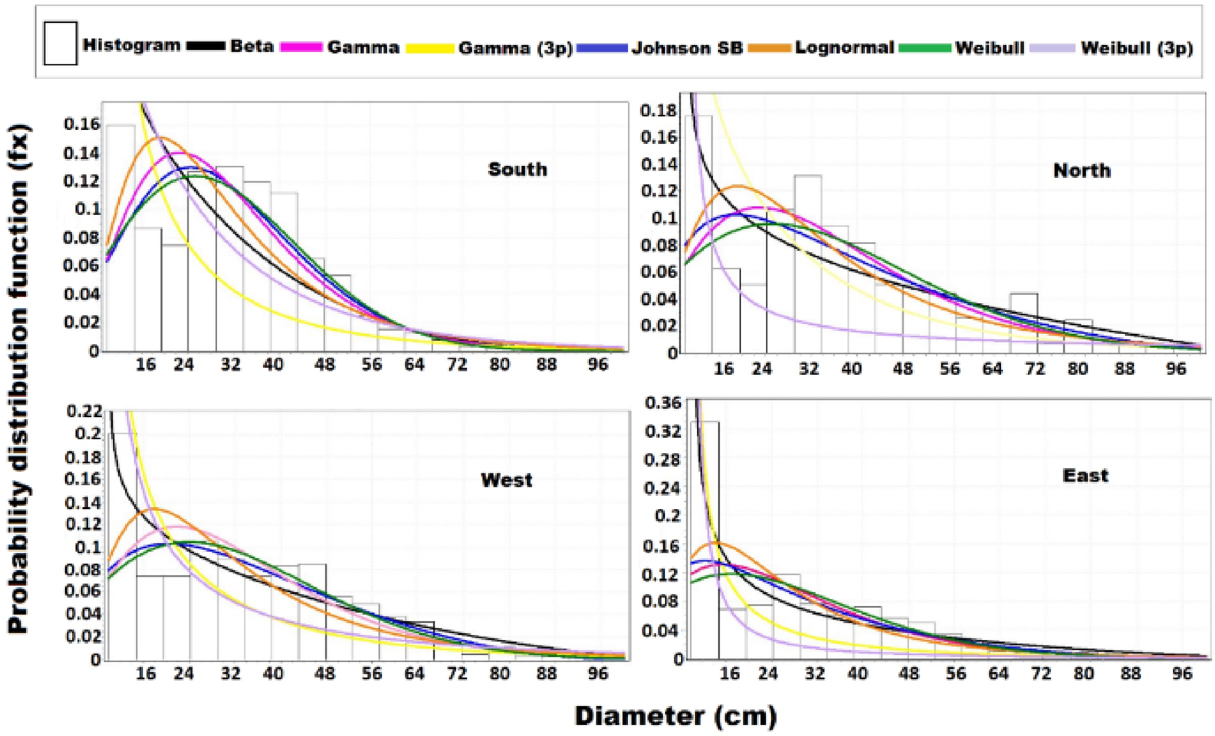

Diagram 2) The diameter distribution of studied trees in four main aspects

Table 4) The goodness of fit of used diameter distribution functions in four main aspects

Aspect	Distribution	Kolmogorov-Smirnov statistic	*p*-value	Rank	Anderson-Darling statistic	Critical value	Rank
North	Weibull (2P)	0.094ns	0.989	1	7.038*	2.5018	5
	Weibull (3P)	0.301*	0.018	7	14.089*	2.5018	7
	Beta	0.106ns	0.966	3	9.37*	2.5018	6
	Johnson	0.104ns	0.972	2	6.763*	2.5018	2
	Gamma (2P)	0.114ns	0.937	4	6.97*	2.5018	4
	Gamma (3P)	0.283ns	0.076	6	16.78*	2.5018	3
	Lognormal	0.119ns	0.888	5	1.25ns	2.5018	1
East	Weibull (2P)	0.179ns	0.513	2	15.60*	2.5018	5
	Weibull (3P)	0.445**	4.0256E-4	7	33.20*	2.5018	7
	Beta	0.329*	0.024	5	11.89*	2.5018	2
	Johnson	0.177ns	0.532	1	14.69*	2.5018	4
	Gamma (2P)	0.187ns	0.463	3	14.52*	2.5018	3
	Gamma (3P)	0.336*	0.008	6	18.98*	2.5018	6
	Lognormal	0.212ns	0.310	4	1.72ns	2.5018	1
South	Weibull (2P)	0.089ns	0.944	1	18.53*	2.5018	5
	Weibull (3P)	0.239ns	0.244	6	12.40*	2.5018	2
	Beta	0.214ns	0.300	5	23.35*	2.5018	7
	Johnson	0.094ns	0.990	2	17.30*	2.5018	4
	Gamma (2P)	0.114ns	0.941	3	15.66*	2.5018	3
	Gamma (3P)	0.435**	8.6223E-48	7	22.46*	2.5018	6
	Lognormal	0.145ns	0.800	4	2.09ns	2.5018	1
West	Weibull (2P)	0.113ns	0.944	3	10.26*	2.5018	4
	Weibull (3P)	0.226ns	0.244	6	1.87ns	2.5018	1
	Beta	0.098ns	0.983	1	11.26*	2.5018	6
	Johnson	0.107ns	0.963	2	10.83*	2.5018	5
	Gamma (2P)	0.135ns	0.237	4	9.77*	2.5018	3
	Gamma (3P)	0.317*	0.033	7	19.86*	2.5018	7
	Lognormal	0.140ns	0.800	5	1.15ns	2.5018	2

Note: ** – significant in 0.01 level; * – significant in 0.05 level; ns – not significant.

Table 5) The function's parameters of the statistical distribution in four main aspects

Aspect	Distribution	Parameters
North	Beta	α_1=0/78021; α_2=2/1541; a=10/0; b=111/25
	Gamma	α=2/8734; β=12/262
	Gamma (3P)	α=0/81964; β=22/946; γ=10/0
	Johnson SB	γ=1/1329; δ=1/0354; λ=120/32; ξ=0/95993
	Lognormal	σ=0/64806; μ=3/3706
	Lognormal (3P)	σ=0/56022; μ=3/5146; γ=-3/7457
	Weibull	α=1/7894; β=39/769
	Weibull (3P)	α=0/27958; β=67/802; γ=10/0
East	Beta	α_1=0/55167; α_2=2/3154; α=10/0; b=115/15
	Gamma	α=2/2939; β=11/912
	Gamma (3P)	α=0/25188; β=34/573; γ=10/0
	Johnson SB	γ=1/4709; δ=1/0285; λ=116/14; ξ=0/58194
	Lognormal	σ=0/66315; μ=3/0922
	Lognormal (3P)	σ=5/6869; μ=-0/5765; γ=10/0
	Weibull	α=1/6198; β=30/729
	Weibull (3P)	α=0/31092; β=1/2538; γ=10/0
South	Beta	α_1=0/91595; α_2=4/2887; a=10/0 b=111/07
	Gamma	α=3/9838; β=7/5878
	Gamma (3P)	α=0/45737; β=24/428; γ=10/0
	Johnson SB	γ=2/7649; δ=2/2128; λ=192/36; ξ=-14/412
	Lognormal	σ=0/55706; μ=3/2679
	Lognormal (3P)	σ=0/33876; μ=3/7527; γ=-14/881
	Weibull	α=2/1229; β=34/222
	Weibull (3P)	α=0/93061; β=18/482; γ=10/0
West	Beta	α_1=0/83415; α_2=2/4847; a=10/0; b=109/89
	Gamma	α=3/0149; β=10/838
	Gamma (3P)	α=0/53899; β=29/089; γ=10/0
	Johnson SB	γ=1/0365; δ=1/1518; λ=113/09; ξ=-2/9406
	Lognormal	σ=0/6429; μ=3/2986
	Lognormal (3P)	σ=0/61088; μ=3/3496; γ=-1/1592
	Weibull	α=1/8309; β=36/913
	Weibull (3P)	α=0/64452; β=19/123; γ=10/0

Note: Description of all the parameter symbols is explained in Table 2.

The results of the current study confirm that, according to the KS test, the Weibull (3P) could not be an appropriate probability function to fit with the diameter distribution trend of *Juniper excels*a in the study area. In comparison, Weibull (2P) has a good correlation with the diameter distribution of this species. Also, Bea and Johnson have a middle ability in modeling the diameter distribution of studied species. However, according to the AD fitting test, the Lognormal function has the best accordance with the diameter distribution of this species.

Distribution parameters

The parameters related to the statistical distribution used in this study, with the division of its aspects, are summarized in Table (5).

Discussions

In this study, the diameter distribution of juniper trees was evaluated in different geographical aspects. This research showed that the distribution pattern of trees in diameter classes varies in different aspects, and the appropriate statistical distribution is also different for each one of the aspects. According to the Kolmogorov-Smirnov test, in the northern, eastern, and southern aspects, the Weibull (2P) and Johnson were the better functions, and in the western slopes, beta and Johnson were the most appropriate distribution functions. Furthermore, considering Anderson-Darling's goodness of fitting test, only the lognormal distribution in northern, eastern, and southern aspects, and lognormal and Weibull (2P) distributions of western aspect did not show a significant difference with the frequency curve of trees in the diameter classes.

The distribution curves of trees in the diameter classes for this stand indicates an irregular uneven-aged forest. Moreover, in similar studies, such as Taheri Abkenar *et al.* [22], the structure of juniper forests is often uneven-aged and irregular. Therefore, statistical distributions with a digressive curve such as gamma (2P) should be more consistent with the frequency of trees, but contrary to expectations, Gaussian and curved distributions showed the most suitable fit. This is due to the concentration of the most frequent low-diameter classes in the 10cm diameter class. By omitting this diameter, we find out that in other diameter classes, the distribution curve of trees is usually bell-shaped or normal that causes the curved distributions such as Johnson and Weibull (2P) to be the fittest with the stand curve.

Many studies have proved the suitability of the Johnson, Weibull (2P), and beta distribution functions in modeling the distribution of trees in different classes. Among them are Zheng & Zhou [23], who used Weibull for describing the DBH distribution in the north-western forests of China. Sohrabi & Taheri-Sarteshnizi [24] also used beta distribution for describing the DBH in the Northwest of Iran, and Modaberi *et al.* [25] has used Johnson's distribution to describe the DBH distributions in the forests of southwest of Iran, which also confirms the results of this study.

A remarkable point in this research is the confirmation of the lognormal distribution in the Anderson-Darling test, which is more sensitive than the Kolmogorov-Smirnov test and has high accuracy in estimating the goodness of the fit of distribution functions. The reason for this is the relevance and appropriateness of the lognormal distribution in fitting with the distribution curve in the diameter classes of forests located in the early stages of the sequence (with lots of low-diameter trees and with a skewness to the right) [9, 26, 27]. In this study, due to the abundance of low-diameter trees, the Anderson-Darling test recognized lognormal distribution as the most appropriate statistical distribution for this species.

The differences in the obtained results are empirically common. For example, the results of studies by Amanzadeh *et al.* [9] and Wang & Rennolls [28] showed that there is no reason for statistical distribution to be best in every earth's conditions and geographic aspects, which can also be applicable in the region under study. This is due to the different conditions of the stand and the factors affecting it in different geographical aspects [9]. Johnson & Miller [29] studied the conditions and distribution of juniper trees in the habitats of this species in Idaho, United States. They found that at an identical altitude and constant steepness, moving from the northward aspect to the southern slope, the number of trees decreases 4.9 ha^{-1}. The distribution of trees in the diameter classes is also different in two areas. Moreover, the differences in density and canopy of this have been significant, which also justifies the results of this study.

Conclusions

According to the results of this study, the most appropriate statistical distribution functions for describing the distribution of trees in the Greek Juniper (*Juniperus excelsa*) in different aspects are the Weibull (2P), Johnson, and lognormal tests. By having the diameter distribution of the juniper stands in different aspects, the forest managers will be able to have proper planning for these stands, and they will not need other extra information. For example, if they have a stand with the lognormal distribution form, they need to keep larger trees, and maybe they need to thin the low diameters trees, but by attention to that in natural juniper open forests, we cannot have any direct interference on the stand we should use the diameter distribution curves for the conservation of these forests. Then, about the sensitive forests like Spiro that have main effects on keeping the surface water and soil and coping with erosion, the forest managers could decide that witch aspect of these forests need some reinforcement. For example, in the east aspect, the middle classes of trees' diameter are weak and need more support to growth, but small diameters have a height density. In the northern aspect, everything is different, and we can see good density for middle diameters. According to the results of the current study, best fitting to the diameter distribution in the northern aspect is related to Weibull (2P), Johnson, and lognormal tests. Then these functions could be our reference to classify and manage the juniper stands of Iran or other similar stands in other places.

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References

1- Bais S, Prashar Y. Identification and characterization of amento flavone from six species of juniperus against H_2O_2 induced oxidative damage in human erythrocytes and leucocytes. Res J Phytochem. 2015;9(2):41-55.
2- Adams RP. Junipers of the world: The genus Juniperus. Bloomington: Trafford Publishing; 2004.
3- Asadi M. Flora of Iran: Pinaceae, taxacae, cupressaceae and ephedraceae. Flora of Iran. Tehran: Research Institute of Forests and Rangelands; 1998.
4- Ali Ahmad Korori S, Khoshneviss M, Metinizadeh M. Comprehensive Studies of Juniperus species in Iran. Tehran: Pune Publications; 2010.
5- Khoshnevis M, Matinizaded M, Shirvani A, Teimouri M. Iranian long-lived Junipers. Iran Nat. 2017;2(5):20-35. [Persian]
6- Zobeiri M. Forest inventory measurement of tree and forest. Tehran: Tehran University Press; 2000.
7- Heidari Safari Kouchi A, Moradian Fard F, Rostami Shahraji T, Iranmanesh Y. Biomass and carbon allocation of 10-years-old poplar (Populous alba L.) plantations in the south west Iran. For Res. 2017;6(2):1-13.
8- Baily RL. Individual tree growth derived from diameter distribution model. For Scie. 1980;26(4):626-32.
9- Amanzadeh B, Sagheb Talebi KH, Fadaei Khoshkebijari F, Khanjani Shiraz B, Hemmati A. Evaluation of different statistical distribution for estimation of diameter distribution within forest development stages in Shafaroud beech stands. Iran J For Poplar Res. 2011;19(2):254-67. [Persian]
10- Sheykholeslami A, Kia Pasha KK, Lashaki AK. A study of tree distribution in diameter classes in natural forests of Iran. Ann Biol Res. 2011;2(5):283-90.
11- Bullock BP, Burkhart HE. Juvenile diameter distribution of loblolly pine characterized by the two-parameter weibull function. New For. 2005;29:233-44.
12- Mohammadalizadeh KH, Zobeiri M, Namiranian M, Hourfar A, Maravi Mohajer M. Fitness of distribution of diameter at breast height by using some statistic distribution models. Iran J For Poplar Res. 2010;17(1):116-24. [Persian]
13- Bullock BP, Boone EL. Deriving tree diameter distribution using bayesian model averaging. For Ecol Manag. 2007;242(2-3):127-32.
14- Maghsoudlou Nezhad M, Shataee SH, Habashi H, Babanezhad M. Spatial and statistical analysis of quantitative characteristics of Juniperus stands in chahar-bagh of Gorgan regarding to topographic and soil features. Iran J For. 2013;5(2):195-206. [Persian]
15- Moradidirmandrik SH, Ramezanikakroudi E, Alijanpour A, Banjshafiei A. Quantitative and qualitative characteristics of Arasbaran forest protected area in slope gradient classes. For Res Dev. 2015;1(1):1-15. [Persian]
16- Sanjay G, Rawal RS, Todaria NP. Forest vegetation patterns along an altitudinal gradient in sub-alpine zone of west Himalaya, India. Afr J Plant Sci. 2008;2(6):42-8.
17- Smyris Pavlos ME, Ilias P, Petrou P. The growth ecology of Juniperus excelsa bieb trees in the central part of the Nestos valley (NE Greece) in the context of anthropogenic disturbances. J Biol Res. 2009;11:83-94.
18- Goodarzi GR, Sagheb Talebi K, Ahmadloo F. The study of effective factors on Almond (Amygdalus scoparia Spach) distribation in Markazi province. Iran J For. 2012;4(3):209-20. [Persian]
19- Daghestani M, Zanganeh M, Taheri M. Investigation on quantitative characteristic and soil properties of Juniperus excels M.Bieb stands in Tarom Zanjan. For Res Dev. 2017;3(2):175-19. [Persian]
20- Atta Mohammad S. Population structure and natural regeneration potential of (Juniperus excelsa M) in northern Balochistan Pakistan [dissertation]. Quetta: University of Balochistan; 2000.
21- Cao QV. Predicting parameters of a weibull function for modeling diameter distribution. For Sci. 2004;50(5):682-5.
22- Taheri Abkenar K, Fadaie Khosh-e-Bijari F, Jahdi R,

Sotoudeh-Foumani B. Structure and regeneration patterns of Juniperus polycarpos C.Koch in Alborz mountains, Iran. J Basic Appl Sci Res. 2012;2(6):5993-6.
23- Zheng LF, Zhou XN. Diameter distribution of trees in natural stands managed on polycyclic cutting system. For Stud China. 2010;12:21-5.
24- Sohrabi H, Taheri-Sarteshnizi MJ. Fitting probability distribution functions for modeling diameter distribution of oak species in pollarded northern Zagros forests (case study: Armardeh-Baneh). Iran J For. 2012;4(4):333-43. [Persian]
25- Modaberi A, Soosani J, Khosravi S. Effect of the decline on changes in the statistical distribution of hight breast diameter in the central Zagros forests (case study: Lorestan-Ilam). J Zag For Res. 2015;2(1):105-17. [Persian]
26- Motaharfard E, Mahdavi A, Iranmanesh Y, Jafarzadeh AA. Effect of land uses on aboveground biomass and carbon pools in Zagros forests, Iran. Ecopesia. 2019;7(2):105-14. [Persian]
27- Sepahvand F, Abrari Vajari K, Soosani J. Fine root biomass in acer monspessulanum trees and its relation to ecological factors in Zagros mountain forests. Ecopesia. 2019;7(2):79-85. [Persian]
28- Wang M, Rennolls K. Tree diameter distribution modeling: Introducing the logit-logistic distribution. Can J For Res. 2005;35(6):1305-13.
29- Johnson DD, Miller RF. Structure and development of expanding western Juniper woodlands as influenced by tow topographic variables. For Ecol Manag. 2006;229(1-3):7-15.