



## Efficiency of distance sampling methods in quantitative assessment of *Haloxylon* forests of Kashan, Iran

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### Abstract

Considering importance and role of forests in ecological protection and soil conservation in these regions, collection of appropriate qualitative and quantitative data is necessary for proper management and planning. In this study, in order to reach the best inventory method in *Haloxylon* stands of Kashan county in Isfahan province (in terms of accuracy and precision of results), full inventory of entire study area compared with some distance sampling methods. The assessment of the precision of sampling methods showed that the highest precision in estimating numbers and canopy cover per ha was belonged to T-Square and Joint-Point method, respectively. According to results, the second nearest neighbor and ordered distance for second nearest individual sampling methods have maximum and minimum accuracy in estimating canopy cover per hectare, respectively. Assessment of results with regard to  $(E\%)^2 \times T$  factor showed that the best method in estimating canopy cover and number per ha were Joint-Point method and ordered distance for third individual methods, respectively.

**Keywords:** Number per Hectare, Canopy, Distance Sampling Methods, *Haloxylon*, Kashan, Iran



## Council for Innovative Research

Peer Review Research Publishing System

Journal: JOURNAL OF ADVANCES IN BIOLOGY

Vol 4, No.2

editor@cirjab.com

[www.cirjab.com](http://www.cirjab.com), [www.cirworld.com](http://www.cirworld.com)

## 1- INTRODUCTION

From a botanical and ecological perspective, Iran's forest vegetation is not uniform. Majority part of Iran country extent located in sensitive ecosystems of arid and semi-arid zones (Jafari et al, 2008). In arid and desert regions of Iran, vegetation is mainly characterized by small trees, shrubs and bushes. *Haloxylon* is one of these shrubs. As a resistant species, this species forms more or less dense and sparse stands which it has been used systematically to combat desertification in 1961 (Amani&Parvizi, 1996). Considering importance and role of forests in ecological protection and soil conservation in these regions, collection of appropriate qualitative and quantitative data is necessary for proper management and planning. Quantitative data are essential to adequately characterize the woody component of forest communities (Curtis & McIntosh, 1950; Shanks, 1954). Some form of sampling is required because total counts of individuals in naturally occurring plant populations are generally impractical without an exhaustive expenditure of energy and resources (Beasom&Haucke, 1975). In ecological research, the basic objective of sampling is to obtain a descriptive estimate of some attribute of plant population. This estimate should be a relatively accurate representation of allow detection of real differences among plant populations (Askari &Tahmasebikohani, 2013).Distance methods measure different distances between plants. The results of this technique can provide important information about inter-species and intra-species relationships in plant communities (Kiani *et al*,2013). Accuracy time and cost of inventory are criteria for selecting the most appropriate sampling method to qualitative and quantitative evaluating of forest in many studies (Mohagheghiet *al*, 2014). This research have been tried a step to be taken in advancing presentation optimum distance sampling method in planting forest inventory of Iran desert regions that actually examine the inventory methods and compared them. In order to reach the best inventory method in *Haloxylon* stands of Kashan county in Isfahan province (in terms of accuracy and precision of results), full inventory of entire study area compared with some distance sampling methods.

## 2- MATERIAL & METHODS

### 2.1 Study Area

Study area with 30 hectares located in the north of Isfahan province and 36 kilometers toward north east of Kashan city with coordinates "30 '21 '51 to "10 '28 '51 E and "15 '6 '34 to "15 '10 '34 N (figure 1). Minimum and maximum altitude above sea level are 852 to 888 m, respectively. Current use of this region is forest so artificial saxaul trees and some other plant species have covered all over the region. Implant experience of the forest refers to year 1974. Used species have been *Haloxylonpersicum* and in some region *Haloxylonaphyllum* and *Colligonum Sp*. Geologically, the study area is a part of Aran and Bidgol structure and the most ancient deposits in the study area belongs to quaternary era and these deposits and formations are very young and also vulnerable to water and wind erosion.

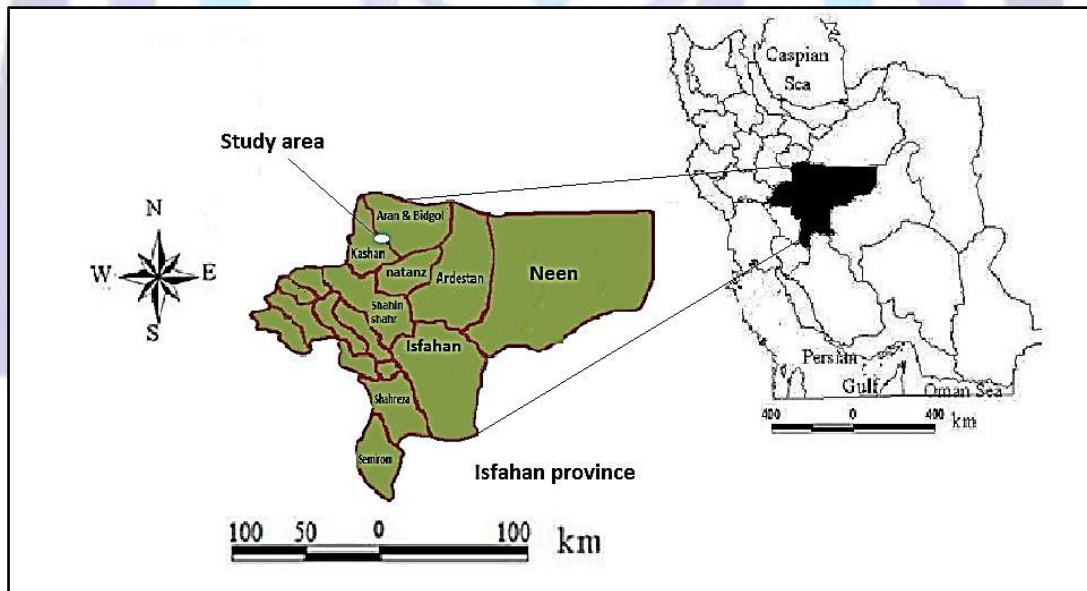


Figure1: Location of *Haloxylon* stands in Kashan County in Isfahan province

### 2.2 Full Inventory

This type of inventory is performed to achieve different goals. One of these goals is to assess different inventory methods. To do such assessments, first statistical population is inventoried with full inventory method to assess various inventory methods by comparing results obtained from sampling inventory methods to the real results (full inventory). In this investigation, full inventory was used as a basis for comparing different inventory methods.

To do this, all the small and large diameters and other required information were recorded. Time of measurements of crown diameters for each plant was recorded in inventory forms where this information was required latter. Given the

measurement of all plants, the real density and canopy cover per hectare were calculated from following relations so that they are used as a measure to prove the accuracy of the methods.

$$\lambda = N / A$$

Where  $\lambda$  is the real density, N is the number of all individuals, A is area (30ha), C is the real canopy cover per ha and  $\sum c_i$  is the sum of canopy cover of all plants.

### 2.3 Distance Sampling Methods

#### 2.3.1-Nearest Individual (Byth and Ripley):

This method was simplest distance methods and name of shrub species and distance of random point to nearest shrub (Regardless of aspect).

$$\lambda_2 = n / \pi \sum r_i^2 \quad \text{Byth and Ripley (1980)}$$

$$C = \sum c_i / n \times \lambda_i$$

Where  $\lambda$  is estimated density, n=number of sample,  $r_i$  is distance sample point to nearest shrub, C is canopy cover per ha  $c_i$  and is canopy area for each tree.

#### 2.3.2-Nearest Neighbor (Byth and Ripley)

In this method after the detection of sample point two distances was recorded include 1: distance of sample point to first tree 2: distance of first tree to nearest shrub from first tree (askari et al, 2013).

$$\lambda_3 = 1 / \left[ 2.778 \left( \sum z_i / n \right)^2 \right] \quad \text{NN Cottam and Curtis (1956)}$$

#### 2.3.3-Second Nearest Neighbor (Cottam and Curtis):

In this method after the detection of sample point three distances was recorded include 1: distance of sample point to first tree 2: distance of first tree to nearest shrub from first tree, 3: distance of second tree to nearest shrub from second tree.

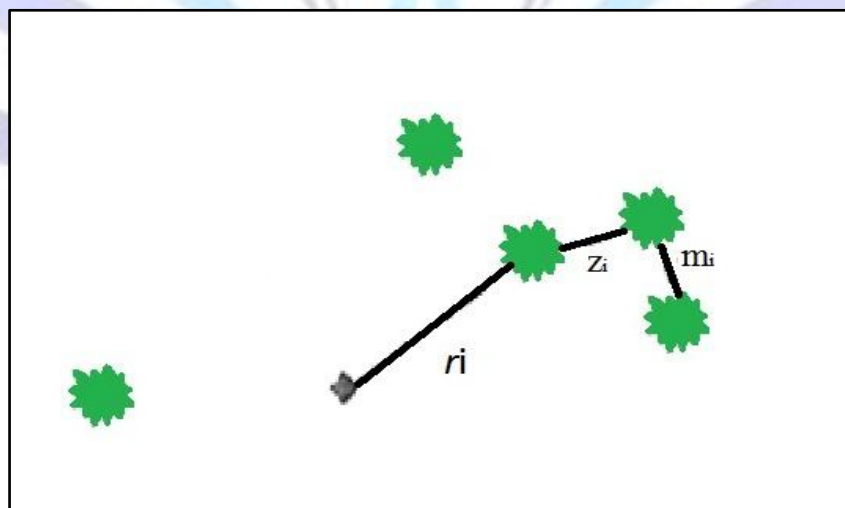


Figure 2: Perform of second nearest neighbor

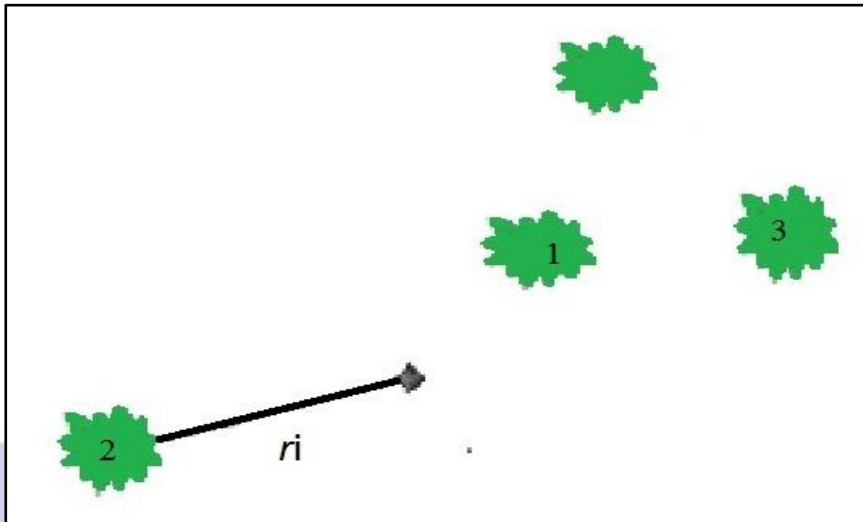
$$\lambda_4 = 1 / \left[ 2.778 \left( \sum m_i / n \right)^2 \right] \quad \text{2NN Cottam and Curtis (1956)}$$

where:  $\lambda$  is estimated density,  $z_i$  is distance between closest individual and its nearest neighbor,  $z_i^2$  is squared  $z_i$ ,  $m_i$  is distance between nearest neighbor and second nearest neighbor and  $n$  is sample size.

**2.3.4-Ordered Distance Methods (OD1, OD2, OD3)**

The method involves measuring the distance from the random sampling point to the  $g$ th closest individual (Kiani et al, 2013). Pollard (1971) demonstrated that, for the random spatial pattern, as  $g$  increases, the variance of the density estimate decreases. However, he also indicated that using

$g > 3$  may be impractical in the field. We therefore considering = 1, 2 and 3



**Figure3: Perform of distance for second nearest individual**

$$\lambda_5 = (n - 1) / \pi \sum r_i^2 \quad \text{OD1 (Morisita 1957)}$$

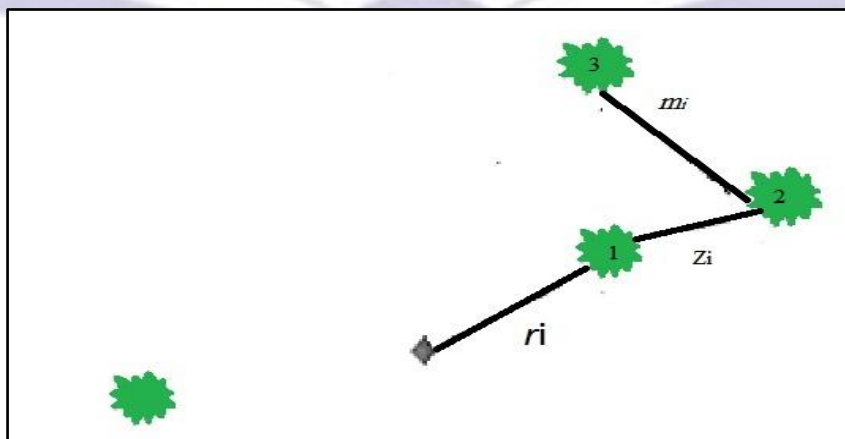
$$\lambda_6 = (2n - 1) / \pi \sum r_{i2}^2 \quad \text{OD2 (Morisita 1957)}$$

$$\lambda_7 = (3n - 1) / \pi \sum r_{i3}^2 \quad \text{OD3 (Morisita 1957)}$$

**Where:**  $r_i$  is distance between random point and closest individual,  $r_{i2}$  is distance from random point to second closest individual,  $r_{i3}$  is distance from random point to third closest individual and  $n$  is sample size.

**2.3.5-Joint-Point Method (JP)**

An estimate of density is made by using the measurements on the distance to the closest individual, the distance to the nearest neighbor and the second nearest neighbor (figure 4). Application of the correction factors involves a series of calculations (kiani et al, 2013).



**Figure 4: Perform of Joint-Point method**

$$\begin{aligned}
 JP \text{ Batcheler}(1975) \quad & F = P / N \\
 & \text{Log}E(CV) = -1.0319 + 0.4892f^2 - 0.7182f^4 + 0.6095f^6 \\
 & A_1 = 1/E(CV) \left[ \sqrt{ \left[ ((P \sum r_i^2 - (\sum r_i)^2)n2N) / (\sum r_i \sum z_i P_3) \right] } \right] \\
 & A_2 = 1/E(CV) \left[ \sqrt{ \left[ ((P \sum r_i^2 - (\sum r_i)^2)n2N) / (\sum r_i \sum m_i P_3) \right] } \right] \\
 & a = 1 + 2.473f \\
 & b = 1 + 2.717f \\
 & \lambda_s = (d / 2a) [b^{A_1} + b^{A_2}]
 \end{aligned}$$

where: *p* is number of sample points included a measured tree, *M*is total sample points, *f* is a ratio, *r<sub>i</sub>* is distance between random point to closest individual, *z<sub>i</sub>* is distance between closest individual and its nearest neighbor, *m<sub>i</sub>* is distance between nearest neighbor and second nearest neighbor, *n* is sample size and *λ* is estimated density.

### 2.3.6-T-Square (Digel)

In this methods distance of nearest shrub from the sample point measured (figure 5). In the second stage the imaginary line draws Perpendicular on the line that connected two sample points and nearest shrub, and distance of shrub to nearest shrub measured.

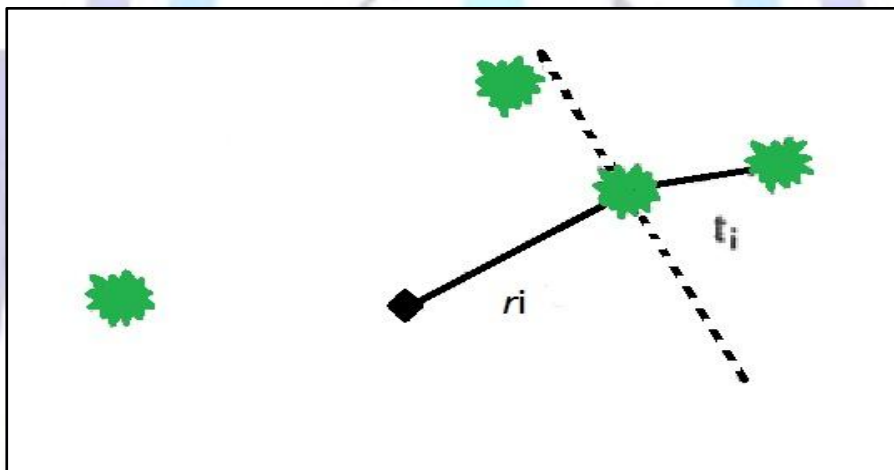


Figure 5: Perform of Joint-Point method

$$\lambda_9 = n^2 / \left[ 2 \sum r_i (\sqrt{2} \sum t_i) \right] \text{TSQ Byth (1982)}$$

$$\lambda_{10} = 2n / \left[ \pi \sum r_i^2 + 0.5 (\sum t_i^2) \right] \text{TSQ Diggle (1975) Basic}$$

$$\lambda_{11} = n / \left[ \pi \sum r_i^2 + 0.5 (\sum t_i^2)^{1/2} \right] \text{TSQ Diggle (1976) clumped}$$

Where *N* = density (N/ha), *n*=number of sample, *p* = distance of sample point to first shrub and *r<sub>i</sub>* is Distance of first tree to second shrub.

## 2.4 Evaluation Criteria

Accuracy, precision, time and cost of inventory are criteria for selecting the most appropriate sampling method to qualitative and quantitative evaluating of forest in many studies (Mohagheghi *et al*, 2014). Accuracy of results is calculated of distance from the actual average and precision results is estimation error (E %). Because costs of inventory correlates directly to time consumed for inventory, in this assessment time consumed for inventory (T) was used instead of inventory cost. (E%)<sup>2</sup>×T is one of comparison criteria of sampling methods that second degree for sampling error in the formula is Emphasizing importance of accuracy. Utilizing time in the formula is due to involving costs indirectly.

## 3- RESULTS

Information obtained from full inventory and distance sampling methods including number of tree per ha and canopy cover are shown in table 1.



**Table 1: results obtained from different sampling methods (number and canopy cover per ha)**

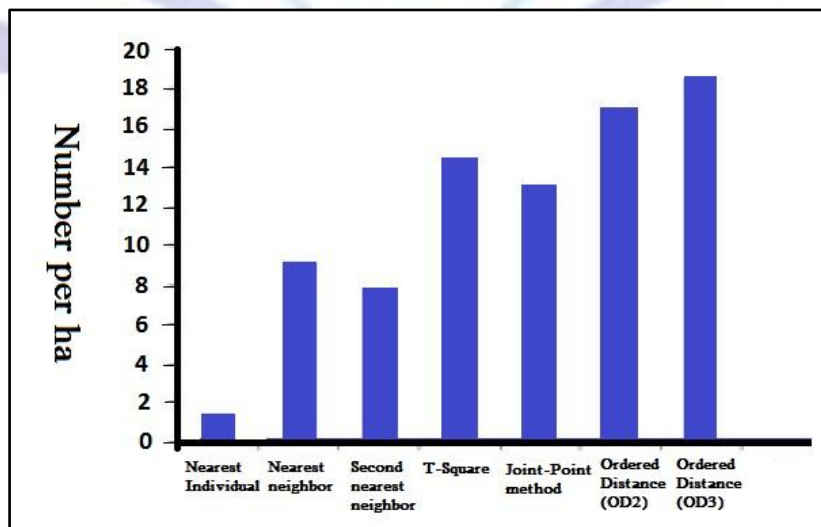
Method	Canopy cover (m <sup>2</sup> per ha)	Number per ha
Full inventory	903.76	490.07
Nearest individual	752.83	483.03
Nearest neighbor	1030.6	535.35
second nearest neighbor	952.25	452.72
T-Square	1026.67	560.89
Joint-Point method	1026.36	554.49
Ordered Distance for second individual	728.16	407.92
Ordered Distance for third individual	1087.22	400.02

The assessment of the precision of sampling methods showed that the highest precision in estimating numbers and canopy cover per ha was belonged to T-Square and Joint-Point method, respectively (table 2).

**Table 2: Sampling error in estimating the amount per ha (%)**

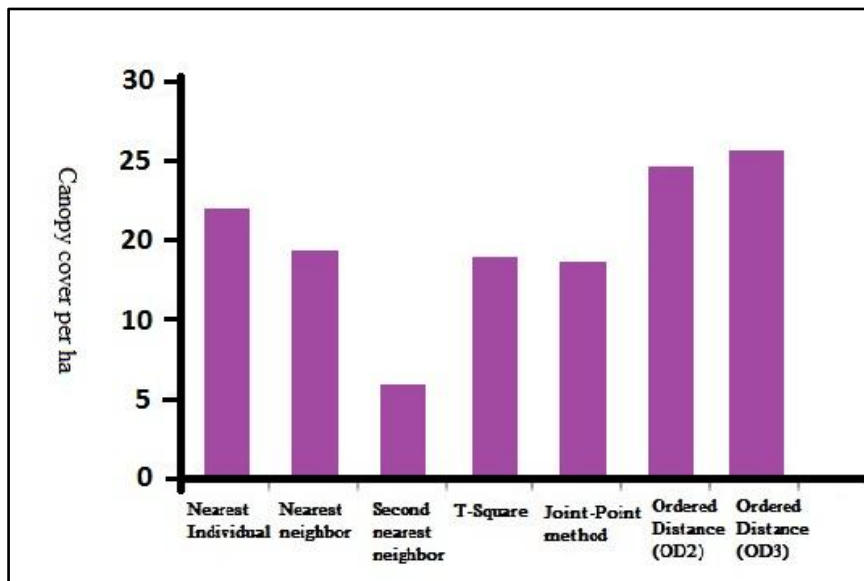
Method	Sampling error in estimating crown coverage per ha (%)	Sampling error in estimating number per ha (%)
Nearest individual	26.4	31.9
Nearest neighbor	23.6	39.22
second nearest neighbor	22.3	23.48
T-Square	25.15	16.83
<i>Joint-Point method</i>	15.3	23.13
<i>Ordered Distance</i> for second nearest individual	23.3	22.85
<i>Ordered Distance</i> for third nearest individual	34.55	19.1

The results showed that in term of accuracy of results (distance from the actual average) in reviewed methods, the nearest individual and ordered distance for third nearest individual sampling methods, have maximum and minimum accuracy in estimating number per hectare, respectively (figure 6).



**Figure 6: Distance from the actual average in estimating number per hectare**

According to these results, the second nearest neighbor and ordered distance for second nearest individual sampling methods have maximum and minimum accuracy in estimating canopy cover per hectare, respectively (figure 7).



**Figure 7: Distance from the actual average in estimating canopy cover per hectare**

Assessment of results with regard to  $(E\%)^2 \times T$  factor showed that the best method in estimating canopy cover and number per ha were Joint-Point method and ordered distance for third individual methods, respectively (table 3).

**Table 3: Results of  $(E\%)^2 \times T$  multiplied by sampling duration (time) for different methods**

Method	$(E\%)^2 \times T$ crown coverage	$(E\%)^2 \times T$ Number per ha	Time (minute)
Nearest individual	255037.9	642428.8	365.93
Nearest neighbor	239804.7	642291	430.56
second nearest neighbor	264125	935675.1	494.93
T-Square	291524.9	331773	460.99
Joint-Point method	115859.2	920675.7	494.93
Ordered Distance for second individual	213362	205200.1	393.01
Ordered Distance for third individual	499313.3	152596.2	418.29

#### 4- CONCLUSION

In the recent years, timber production, as the main goal of forest management has changed to the other important forest functions (Maleknia et al, 2013). Forest based recreation, soil and water sources protection, habitats and species conservation are some of these new important functions (Pukkala, 2004). Correct and scientific planning and management of natural resources especially in desert regions has important role in ecologic protection and achievement to sustainable development in community of these regions (Jafari et al, 2008). Thus, In this study, considering importance and role of forests in protection and soil conservation in desert areas, accuracy of common distance sampling method in inventory of Haloxylon stands located in the Kashan county with 30 hectares area was assessed. The results showed that the average of trees in the area is 490 trees per hectare and the average canopy cover per hectare is 903.76 square meters. The mean canopy per hectare estimated by different methods except ordered distance for second nearest individual method and the estimated average number per ha by different methods other than ordered distance for third nearest individual comprises actual mean in 95% probability level. Accuracy and precision are important factors in determining an appropriate sampling method in each region and high extent in each of these two factors is not indicating that another is high, and best sampling method, in addition having sufficient accuracy and precision, must have spending less costs.



## REFERENCES

- [1] Amani, M., Parvizi, S. 1996. Silviculture and treatment of *Haloxylon* sp. Institute of forests and rangelands research press. 118 p.
- [2] Askari, Y., Tahmasebi Kohyani, P. 2013. Evaluation accuracy of nearest neighbor sampling method in Zagross forests. *International journal of Advanced Biological and Biomedical Research*. 1( 9) : 999-1008
- [3] Askari, Y., Kafash Saei, E., Rezaei, Dorna. 2013. Evaluation of different sampling methods to study of shrub density in Zagros forest. *European Journal of Experimental Biology*, 3(2):121-128
- [4] Batcheler, C.L., and Bell, D.J., 1970. Experiments in estimating density from joint-point and nearest neighbor distances, *Proceedings of the New Zealand Ecological Society*, 17: 111-117.
- [5] Beasom SL, Haucke HH. 1975. A comparison of four distance sampling techniques in South Texas live oak notes. *Journal of Range Management*, 28:142-144.
- [6] Cottam, G., Curtis, J.T. and wild Hale, B., 1953. Some sampling characteristics of a population of randomly dispersed individuals, *Ecology*, 34(4):741-757.
- [7] Cottam, G., and Curtis, J.T., 1956. Some sampling characteristics of a series of aggregated population. *Ecology*, 38(4): 610-622.
- [8] Curtis JT, McIntosh RP. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, 31:434-455.
- [9] Diggle, P.J., 1975. Robust density estimation using distance methods. *Biometrika* 62: 39-48.
- [10] Jafari, M., Nasri, M., Shameli, M.H., Jafari, M., Jafari M., 2008. Management of Saxaul-Plot (*Haloxylon* sp) Lands in Desert Areas using GIS Technique and Field Assessments (Case Study: Aran and Bidgol region, Iran). *World Academy of Science, Engineering and Technology*, 43:631-639.
- [11] Kiani, B., Fallah, A., Tabari, M., Hosseini, S. M., Parizi, M. H. 2013. A Comparison of distance sampling methods in saxaul (*Haloxylon Ammodendron* C.A. Meybunge) shrub-lands, *Polish journal of Ecology (Pol. J. Ecol.)*, 62(2): 207-219.
- [12] Maleknia, R., Amiraslany, A., Mirarab Razi, J. 2013. An ecological capability evaluation model for recreation, conservation and protection functions of Iran's Zagros forests: Javanrood region. *African Journal of Agricultural Research*, 8(17): 1629-1635.
- [13] Mohagheghi, M., Azarnoosh, M. R., Sheikholeslami, A. 2014. Application of time and accuracy criteria in determining of optimum method in forest inventory. *Proceeding of 1st national conference of environment engineering and sustainable development*. Tehran, Iran.
- [14] Morisita, M., 1957. A new method for the estimation of density by the spacing method applicable to one randomly distributed populations. *Physiological Ecology*, 7(2): 134-144.
- [15] Shanks RE. 1954. Plotless sampling trials in Appalachian Forest types. *Ecology*, 35:237-244.
- [16] Pukkala, T. 2004. Introduction to multi-objective forest planning, in: Timopukkala, multi objective forest planning, Kluwer Academic publisher. 1-19.