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Evaluation of systematic random sampling method for quantitative estimation of rare and thick trees in Caspian Forests. (Case study: Kheyroud-Kenar, Naushahr, Iran)

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Key words: full callipering method, systematic random sampling (SRS), rare and thick trees, Gorazbon.

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Abstract

Knowledge and recognition of existence or absence and real type and amount of rare and thick trees in natural stands for studying silviculture, forest management, biodiversity, etc. can be useful. Recognition of number of trees distribution in different diametric classes is necessary not only in the study of progress circumstance of forest stand but also in composing database for value tables and growing stock. Study the importance of number of trees distribution in different classes cannot be ignored in judgment quality of performed cultural operations, method selection and cultural operations appropriate to forest stands in the future. In order to evaluate SRS method for quantitative estimation of rare and thick trees, three compartments (312,313,319) of Gorazbon district in Kheyroud -Kenar, Naushahr forest were selected. SRS was employed for estimation of number & basal area per hectare in rare and thick species but full callipering methods for accurate measurement of the above-mentioned attributes. Results of this study showed that SRS method has underestimated some species such as Wild cherry (*Cerasus avium*), Mountain elm (*Ulmus glabra* Hudson), Cappadocian maple (*Acer cappadocicum* Gled), Large-leaved lime tree (*Tilia platyphyllos* Scop.) and Velvet maple (*Acer velutinum*) and overestimated others such as Chestnut-leaved oak (*Quercus castaneifolia* C.A.M.), Black alder (*Alnus glutinosa* (L.) Gaertn), and Common hornbeam (*Carpinus betulus* L.) spices. SRS method did not have an accurate estimation for number of trees distribution per hectare in diametric classes more than 100cm for Chestnut-leaved oak, Common hornbeam and Velvet maple spices.

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Introduction

Forest cover about 12 million ha in Iran (Haidari *et al*., 2013a; Haidari *et al*., 2013b; Hosseini *et al*., 2012; Kalantari *et al*., 2012) which comprise 7.4% of the whole country area. Considering this limited forest coverage, logical management and planning seem to be necessary (Hosseini *et al*., 2005). For optimal management of these natural resources, enough and accurate information is needed which are obtainable through forest inventory. Nowadays, it has been proved that any standard management and planning enjoys proper information both qualitatively and quantitatively. For this reason, forest inventory with the purpose of present condition assessment and future planning is in great importance (Eshagh Nimvari *et al*., 2003). Each forest area, based on the importance of the species and various forest stands, acquires its respective inventory. One of the inventory methods for assessment of various attributes of forest trees located in the north of Iran, is SRS method. In SRS method "any combination of n sample plots which have been designed in regular network with respect to the number of sample plots and the area of the related stand, has got an equal chance of being selected". In this sampling method, Planning of dimension network and determination of shape and area of sample plots are very important (Zobeiri, 2002).

In this method, the Diameter at Breast Height (DBH) of all trees exceeding the indicated counting limit in the sample plot is measured. The point of measuring the diameter, namely the breast height diameter, is determined over the slope and the trees with diameters over 7.5 cm are measured. Finally, the results of measurements are recorded in special forms.

The significance of natural species of forest stands has nothing to do with their frequency rate and accordingly conducting the studies towards the species with high frequency is one of the causes of gradual ruin of rare and valuable species in the north of Iran (Namiranian, 2005). It is also worth mentioning that the significance of study related to the distribution of tree numbers in different diametric classes should not be ignored in judgment of the quality of applied tending operation and selecting suitable method and tending operation for each stand in the future (Namiranian, 1990). The research hypothesis is that SRS method is not capable of accurate estimation of the number and basal area per hectare in rare and thick species. The reason is claimed to be the small number of rare and thick trees in the forest stands. On the other hand, the significance of rare and thick trees in silviculture investigation and biodiversity studies is absolutely well known (Marvie Mohadjer *et al*., 2009). In addition to, the knowledge and recognition of the existence or lack of rare & thick species in natural stands can be useful in forestry and silvicultural planning (Moradi, 2005). For this reason, nowadays, the attempts are made to preserve these species against the danger of ruin and to use them as the information sources of genetics and biodiversity. In contribution to the goals of the present study, SRS method as a common method of sampling in north forests will be evaluated for estimation of number and basal area per hectare in rare and thick species and investigating the distribution of number per hectare in diametric classes as well.

Some studies have been carried out on the comparison between SRS method and other sampling methods in Iran forests. Safi studied and compared different inventory methods in Kheyroud -Kenar forests in 1981 (Safi, 1981). Akhavan, in 2001, evaluated and compared two methods of inventory, SRS method and stratification method using aerial images with respect to cost and accuracy (Akhavan *et al*., 2001). Eshagh Nimvari, in 2000, has compared two methods: SRS with circular sample plot and transect methods in western oak trees having cost and accuracy in mind (Eshagh Nimvari, 2000). Finally, Namiranian in 1996 has investigated the way of selecting network dimensions and sample plots in the inventory of forest stands (Namiranian, 1996). However, no study has been yet carried out on the evaluation of SRS method in assessment of rare and thick trees whether inside the country or outdoors. The present study is the first one in this relevance and hence it has no literature.

Materials and methods

Area of study

The region under study has been located in Gorazbon district in Kheyroud -Kenar, Naushahr – (IRAN). This district with area of 1022 ha has been located 18 kms far from the east of Naushahr county and 23 kms from the main road along the Caspian Sea. Gorazbon district has been composed of 27 parcels with spaces variable from 20ha to 80ha. As the forest area with high diversity of species was needed for this study, parcels of 312,313 & 319 were selected by forest cruising. Fig. and table 1 shows the position, altitude characteristics and the areas of the above-mentioned parcels respectively.

Table 1. Altitude characteristics and the areas of the parcels in the area study.

Parcel number	Parcel area (ha)	Minimum altitude	Maximum altitude
312	33.52	1060	1218
313	49.67	1100	1300
319	40.89	1180	1265

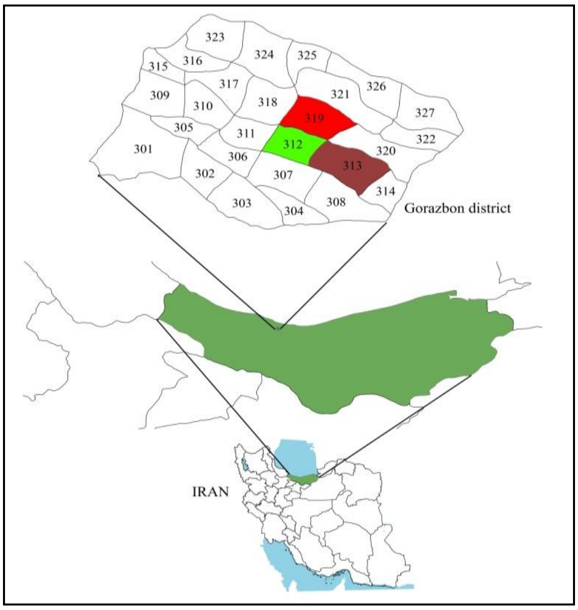

Fig. 1. Position of parcels in area of study.

Methodology

Considering that the aim of this paper is evaluating SRS method to estimate the number and basal area of trees per hectare in rare and thick species, initially full callipering method was employed for achieving real type and amount of number and basal area at breast height in rare and thick trees. The next method was SRS. It is worth mentioning that, in this study, via forest cruising and initial studies, the species with diameter over 100 cm were identified as thick species and species of Wild cherry (Cerasus avium), Mountain elm (Ulmus glabra Hudson), Large-leaved lime tree (Tilia platyphyllos Scop.), Cappadocian maple (Acer cappadocicum Gled) and Common ash (Fraxinus excelsior) as rare ones.

Full callipering

In this method, all trees in the forest stand, the diameter of which exceeds the indicated counting limit, are measured (Zobeiri, 2000). The measuring limit is 7.5 cm in this study. The inventory team involved a leader and two measure men. The leader recorded the measurements results in a special form with respect to the different species. They ought to measure the trees DBH the diameter of which exceeded the indicated measuring limit. The inventory indexes for each attribute were calculated via the following equation:

Number per hectare: it is calculated through dividing the total tree number on the area of the region under study.

$$\bar{n} = \frac{\sum S_i \times n_i}{\sum S_i} \quad (1)$$

$\bar{n}$ is the average of tree number in the whole region under study, S_i is the area of each parcel and n_i is the number of trees per hectare in each parcel.

Basal area per hectare: this attribute is calculated through dividing basal area of all trees on the area of the region under study. It has been calculated per hectare in isolation for each parcel and the whole region under study as well.

$$\overline{G} = \frac{\sum S_i \times BA_i}{\sum S_i} \qquad (2)$$

$\overline{G}$ is the average of basal area per hectare and the whole region under study as well, BA_i is the basal area per hectare of each parcel per square meter.

SRS method

In this study, just like the previous and common researches in the north forests, the shape and area of the sample plot were decided circular and 10 Ar respectively. Considering the aim and the area of the region under study and also in order to have enough sample plot in the region under study, it was decided to obtain one sample plot per each hectare via forest cruising and inspection of forest. Finally, 119 samples were obtained. Fig. 2 shows the map of parceling and the position of sample plots together with designed network.

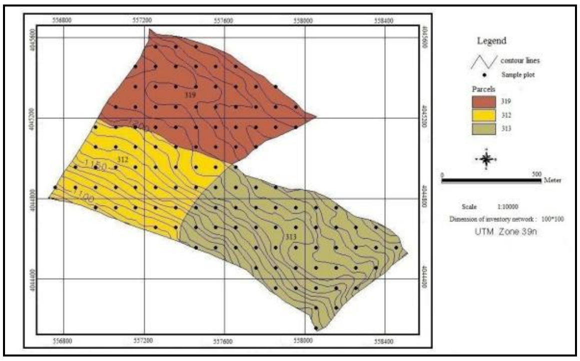

Fig. 2. Map of parceling and the position of sample plots together with designed network.

In this method, the first sample plot or the start point of inventory was selected randomly and finally the inventory operation was carried out with the help of forest network map. After determining the center of sample plot, it was established in the forest with respect to its circular shape. First, the maximum slope of the sample plot was measured and was obtained then the radius by means of which the sample plot was established so that its horizontal area is corresponded with the already determined area. To measure out the trees, the diameter of those inside the sample plot, the distances of which from the sample plot were less than the radius of sample plot, were measured via caliper or Diameter Tape (for trees having diameters over 100 cm). The point of measuring the diameter was determined above the slope. The trees with diameters above 7.5 cm were gone under measurement and finally the results of measurements were recorded in special forms.

In this inventory method, the statistic indexes for each attribute were calculated through the following equations:

Number per hectare

$$\overline{n} = \frac{\sum_{i=1}^{n} n_i}{n_t} \qquad (3)$$

$\overline{n}$ is the average of tree number in sample plot, n_t is the total of sample plots.

$$\overline{N} = \overline{n} \times 10 \qquad (4)$$

$\overline{N}$ is the average of tree number per hectares.

Basal area

$$\overline{BA_{ip}} = \frac{\sum_{i=1}^{n} BA_i}{n_t} \qquad (5)$$

That $\overline{BA_{ip}}$ is the average of basal area in sample plot per square meter.

$$\overline{G} = \overline{BA_{ip}} \times 10 \qquad (6)$$

$\overline{G}$ is the average of basal area in hectare per square meter.

Results and discussion

The number and basal area per hectare for species of Wild cherry, Mountain elm, Cappadocian maple, Velvet maple and Large-leaved lime tree obtained from SRS method are less than real amount (full callipering). This difference is significant, so that SRS method has not yield any results in number and basal area for Wild cherry. In other word, in SRS method, there has not been obtained any results for Wild cherry in the region under study; while the number and basal area obtained from full callipering method for the above-mentioned species are 0.016 trees and 0.001 m^2 respectively. By generalizing these values into the whole region under study (124.08 ha), we will have 1.98 trees and 0.124 m^2 for number and basal area respectively. The difference in number per hectare for Mountain elm obtained from the various inventory methods is 0.36 and the difference for basal area is 0.007m^2. By generalizing these values into the whole region under study, we will have 44.67 trees and 0.87m^2 for number and basal area respectively. The lower values for basal area in these two species, as compared with the values of number per hectare, are due to their small diameters. The difference in number per hectare for Cappadocian maple obtained from the various inventory methods is 0.31 and the difference for basal area is 0.021m^2. By generalizing these values into the whole region under study, we will have 38.46 trees and 2.06 m^2 for number and basal area respectively. Considering that Cappadocian maple possesses the higher diametric classes, comparing with species of Mountain elm and Wild cherry, the difference in basal area per hectare obtained from full callipering and SRS methods is significant. The difference in number per hectare for Large-leaved lime tree obtained from the various inventory methods is 0.224 and the difference for basal area is 0.059m^2. By generalizing these values into the whole region under study, we will have 27.79 trees and 7.32m^2 for number and basal area respectively. Considering that Large-leaved lime tree possesses the higher diametric classes, comparing with species of Mountain elm, Wild cherry and Cappadocian maple, the difference in basal area per hectare obtained from full callipering and SRS methods is significant.

The number and basal area per hectare for Velvet maple obtained from SRS method in diametric classes above 100cm are less than real (full callipering), But the difference is not so significant. The difference in number per hectare for the above-mentioned species obtained from the various inventory methods is 0.04 and the difference for basal area is 0.06m^2. By generalizing these values into the whole region under study, we will have 4.96 trees and 7.44m^2 for number and basal area respectively.

The number and basal area per hectare for Chestnut-leaved oak, Common hornbeam, Common ash and Black alder species obtained from SRS method in diametric classes above 100cm are more than real (full callipering). Although SRS method yields some information about number and basal area per hectare in the case of Chestnut-leaved oak, but the values of the related attributes are different from the ones obtained from full callipering method. The difference in number per hectare for Chestnut-leaved oak obtained from the various inventory methods is 0.014 and the difference for basal area is 0.208m^2. By generalizing these values into the whole region under study, we will have 1.74 trees and 25.8m^2 for number and basal area respectively. Considering that Chestnut-leaved oak possesses the higher diametric classes, comparing with species of Large-leaved lime tree, Mountain elm, Wild cherry and Cappadocian maple, the difference in basal area per hectare obtained from full callipering and SRS methods is significant.

The number and basal area per hectare for Common hornbeam in diametric classes above 100cm and Common ash in different diametric classes, both obtained from SRS method, are more than real (full callipering) and the difference rate is significant here. The differences in number per hectare for Common ash and Common hornbeam obtained from the various inventory methods are 0.21 & 0.054 and the differences for basal area are 0.18 and 0.0004m^2. By generalizing these values into the whole region under study, we will have 26.06 & 6.7 trees and 22.33 & 0.05m^2 for number and basal area respectively. The reason of small difference in basal areas per hectare obtained from various inventory methods for Common ash is claimed to be the low diametric classes of the related species in the region under study.

The number and basal area per hectare for Black alder obtained from SRS method in diametric classes above 100cm is more than real (full callipering). The difference in number per hectare for the above-mentioned species obtained from the various inventory methods is 0.41 and the difference for basal area is 0.36m^2. By generalizing these values into the whole region under study, we will have 50.87 trees and 44.67m^2 for number and basal area respectively. The number and basal area per hectare for different species have been depicted in fig.s 3&4 respectively.

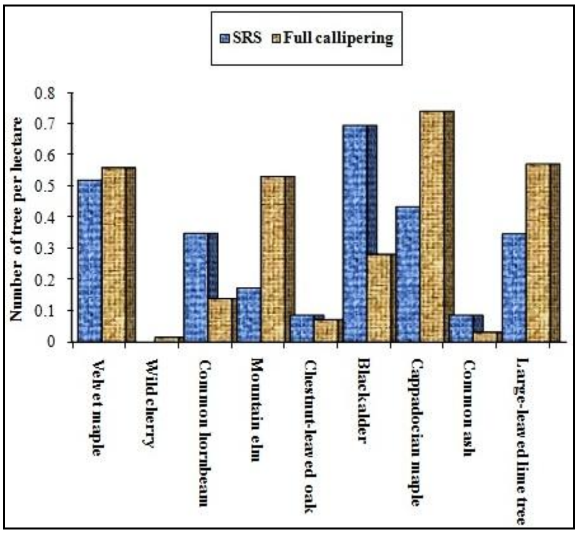

Fig. 3. Number of trees per hectare for different species resulted from inventory methods.

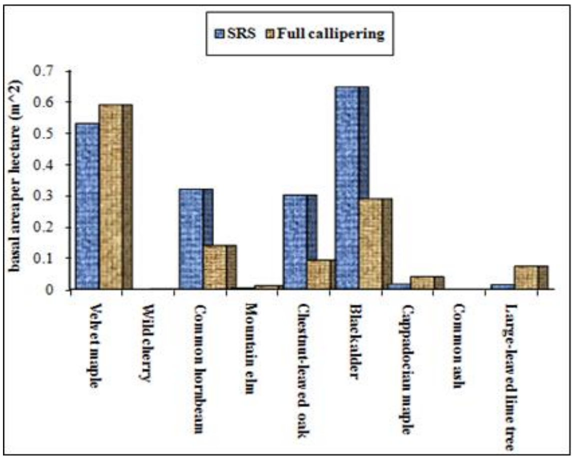

Fig. 4. Basal area per hectare for different species resulted from inventory methods.

SRS method neither yields accurate estimation of Large-leaved lime neither tree, nor can calculate the distribution of number per hectare precisely. The diagram of distribution per hectare in different diametric classes has been depicted in fig. 5 for Large-leaved lime tree in different inventory methods. It is well inferred from fig. 5 that the diagram of distribution of number per hectare obtained from SRS method ranges only in diametric classes of 15, 20, 25 & 30 cm but it ranges from 100 to 145 cm in most of diametric classes in the case of full callipering method.

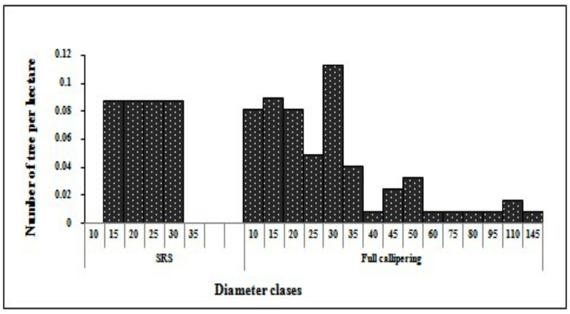

Fig. 5. Distribution of number of trees per hectare in diametric classes of Large-leaved lime tree.

SRS method yields a rather reliable estimation of number per hectare for Chestnut-leaved oak. However, it fails to calculate the distribution per hectare in different diametric classes. The diagram of distribution of number per hectare in different diametric classes has been depicted in fig. 6 for Chestnut-leaved oak in different inventory methods. It is well inferred from fig. 6 that the diagram of distribution per hectare in diametric classes above 100 cm obtained from SRS method exists only in diametric class of 210cm, but in the equal condition, the related values are 105,110,115,120,135 & 210 cm in the case of full callipering method.

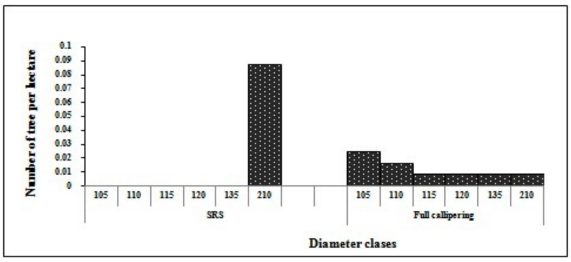

Fig. 6. Distribution of number of tree per hectare in diametric classes of Chestnut-leaved oak.

In the case of Velvet maple, the distribution of number per hectare obtained from SRS method in diametric classes above 100 cm has a significant difference from its counterpart obtained from full callipering method. The diagram of distribution of number per hectare in diametric classes above 100 cm has been depicted in fig. 7 for Velvet maple in different inventory methods. It is well inferred from fig. 7 that the diagram of distribution per hectare in diametric classes above 100 cm obtained from SRS method exists only in diametric classes of 105,110 &140cm, but it ranges among the most of diametric classes above 100 cm in the case of full callipering method.

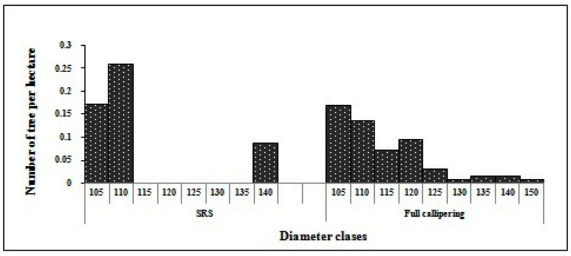

Fig. 7. Distribution of number of trees per hectare in diametric classes of Velvet maple

Conclusion and recommendation

The results obtained from this study showed that, due to the small number of rare and thick species in natural stands, SRS method fails to yield an accurate estimation of the type and quantity of the related species in forest stand and most of the times either there doesn't exist any estimation or in the case of any estimation, it will be less or more than real. Although in the few cases it may have estimation somewhat close to the one in full callipering method, the distribution of number per hectare in diametric classes are not accurately calculated. Considering that thorough knowledge on the distribution of number of trees in different diametric classes, also presence or lack of different tree species, is necessary not only in the study of the development procedure of forest stand, but also provide the basic data for value tables, production quality and volume of Residual Stands. Accordingly, the importance of investigating the procedure of distribution in different diametric classes, also information on the presence or lack of rare & thick species cannot be ignored in the judgment about the quality of applied tending operation and also in the selection of the suitable tending operation for each stand in the future.

Concerning the results of the present study and also due to the significance of rare and thick species in forestry and silvicultural planning, biodiversity studies, etc. it is recommended to collate a complementary method with SRS method in order to evaluate the type and the quantity of species accurately in the north forests of the country. For this purpose, rare and thick trees should be measured accurately through forest cruising and the results should be substituted with the ones obtained from SRS method.

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