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Spatial distribution pattern of oak and almond trees on Chahartagh forest reservation site

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Abstract

Investigation of the spatial pattern of plant communities is essential to understanding many problems in forest ecology. Spatial patterns and spatial relationship of tree individuals with their neighbors is a practical approach to selecting the best acts for the conservation, sustainable management of resources and, the key to interpreting ecological relationships of the plant community. The purpose of this study was to investigate the spatial patterns of oak and almond trees with the Ripley's K function. This study was carried out in 50-hectare area of the Chahartagh forest reservation site by measuring distance and azimuth for all tree individuals. The results showed that the distribution patterns of oak species to 235 meters and almonds species to 115 meters were statistically significant and clustered.

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Introduction

Spatial analysis is a fundamental part of scientific inquiry, including ecological, evolutionary, and environmental science, epidemiology, geology, geography and mathematics (Rosenberg and Anderson, 2011). Ecologists study spatial pattern to infer the existence of underlying processes, such as movement or responses to environmental heterogeneity (Perry *et al*, 2002). For example, the spatial patterns of the vegetations is resulted of different processes and factors such as the dispersal of seeds and an intra- and inter-specific competition, disturbance of herbivores and environmental heterogeneity, which may have a different spatial scale (Sterner *et al*, 1978, Kenkel, 1988, Barot *et al.*, 1999, Dale, 1999, Jeltsch *et al*, 1999, Klaas *et al*, 2000). The pattern is as a set of points with no dimension that defining by their relative distance from each other (Bassiri *et al*, 2005). Spatial distribution of points belongs to one of these forms: random, uniform, or clustered (Jayaraman, 2000). From a biological perspective, the spatial pattern of forest stand is the index to plant community development; and from an operational perspective, investigation of the spatial patterns is essential to select management and inventory plan, in relation to regeneration and silvicultural problems (Tomppo, 1986, Grabarnik and Särkkä, 2009).

Basiri *et al* (2006) were studied spatial patterns of different oak species in Ghamisheleh Marivan Region and reported clustered pattern for this species. Heidari *et al* (2008) using the Hopkins index, introduced clustered pattern for Persian oak in the Sorkheh Dize forest. Shahsavari *et al* (2009) were investigated spatial patterns of snag trees using Ripley's index in managed and unmanaged forests of Kheyroudkenar, Noshahr and reported clustered pattern for these trees. Safari *et al* (2010) were reported clustered spatial pattern for pistachio species (*Pistacia atlantica*) in Bayangan forest in Kermanshah province. Akhavan *et al* (2010) using Ripley index, were studied spatial patterns of trees during three developmental stages including early growth, maturation and degradation of original natural Kelardasht beech forest. The results showed that the distribution pattern in the early stages, maturation and degradation, respectively were; very clustered, random and light clustered. Franklin *et al* (1985), Moeur (1993) also were analyzed the spatial patterns. They concluded that the clustered spatial patterns are not identical in most of forest trees and small trees tend to have a random pattern, while larger trees are following the uniform pattern. Condit *et al* (2000) were studied the spatial pattern of tropical forest trees. They analyzed patterns by the Ripley's K function. The results indicate that this function can compare directly different species and diameter classes. Hou *et al* (2004) also uses Ripley's K function to distinct the distribution pattern and the relationships between oak (*Quercus liaotungensis*) and birch (*Betula dahurica*) species in the China forest and conclude that the large trees have clustered pattern. This study aimed to identify the spatial patterns of oak and almond and species in the Chahartagh forest reservation site.

Material and methods

The Study area

The Chahartagh forest reservation site, with an area of 400 hectares nearby Chahartagh village, is located at 40 km from the Ardal city in Chaharmahal va Bakhtiari province. In terms of geographical coordinate, this area is located between 31°, 50' and 34" to 31°, 52' and 44" north latitude and 50°, 48' and 39" to 50°, 50' and 11" east longitude. The minimum elevation of this habitat is 2100 meters (above sea level) in the bank of the Sabzkooh River and the maximum elevation is 3100 meters above the Kallar Mountain. According to long term climatology station reports, mean annual precipitation in this habitat is about 530.15 mm; minimum absolute temperature and maximum absolute temperature respectively are about -19.5°C and 35°C, (Fig. 1) (Jahanbazi Goojani *et al.*, 1999).

Data collection Method

Like other characteristics, to determine the forest tree spatial pattern, there are two general methods including sampling and census that used to inventory.

The census is in need of more field operations to describe the spatial pattern of trees in the forest stand. Measuring the distance between trees and azimuth relative to each other, to map the location of trees in a coordinate's plane called stem map (Moeur, 1993, Krebs, 1999, Stoyan and Stoyan, 1994). In this study, after selecting an area of 50 hectares, azimuth and distance of all trees and shrubs with a crown diameter more than 25 cm was complete measured using a compass and meter. Because of the mountainous topography of habitat to have a precious record of each interval, the gradient was recorded with an inclinometer then distances were converted to the horizontal. Finally, using geometric relationships and consider the random starting point as the zero point, first Cartesian coordinates for each tree was calculated and then using the coordinates of the specified reference point all locations was converted to Universal Transverse Mercator.

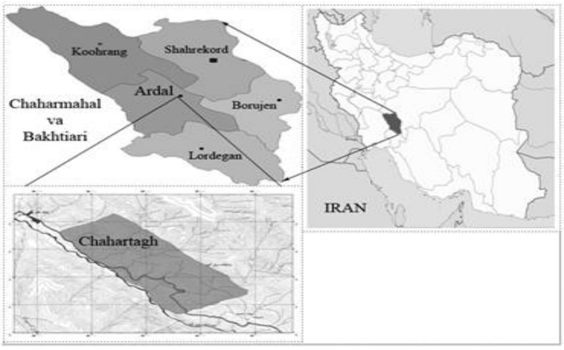

Fig. 1. View of the study area relative to the national and provincial map.

Method of determining the spatial pattern

The Ripley's K function

The Ripley's K function is a tool for analyzing spatial point data. This function is based on the variance of the point-to-point distances in a two dimensional space. This type of analysis can detect various spatial patterns and the existence of accumulative or uniformity manner. The modus operandi of this function is by counting the points around a target point buffer in the concentric circles of radius d. In the Ripley's K function, the distance between any points from the target point is measured. Equation (1) shows the formula for calculating this function for a dot pattern:

Equation (1)

$$K(d) = \frac{A}{N^2} \sum_i \sum_j w_{ij}^{-1} I(d_{ij})$$

In this equation, *K(d)* denote the value of *K* in the distance of *d*. If the distance between points *i* to *j* is less than d then the value of *K(d)* equal to 1 and otherwise would be zero. *A* indicate the area and *N* is the total number of points in the study area. W_{ij} is a weighting factor that used to correct the edges. The value of this factor assumed one, if edge correction is not performed (Ripley, 1976, 1977, 1981, 1982). This function can be used to determine the distribution pattern of a species as well as to compare the distribution pattern of a particular species to with other species. Today, modified L function use instead of the Ripley's K function due to some incompetence in K function and for simple interpretation of the results. It is a linear type of K function that fixes the variance of *K*. L function was introduced in 1977 by Besag .

The L Function is defined as equation (2)

Equation (2)

$$L(d) = \sqrt{\frac{A \sum_{i=1}^{N} \sum_{j=1, j \neq i}^{N} k(i,j)}{\pi N (N-1)}}$$

Eventually Ripley's special relationship is introduced to remove marginal effects as equation (3).

Equation (3).

$$\hat{K}(t) = \hat{\lambda}^{-1} \sum_i \sum_{j \neq i} w(I_i, I_j)^{-1} \frac{I(d_{ij} \langle t)}{N}$$

In Ripley's K function, if the observed K value is different from the expected K value (completely random pattern) and observed K value for any specified distance is greater than the expected K value then the spatial pattern will be clustered. A further difference means much-clustered pattern. However, in opposite situations, spatial distribution shows a more diffuse pattern than random ones. Obviously, where observed K value is equal to the expected K value, distribution pattern is more likely to be random. On the other hand, when observed K value is more than higher confidence envelops, clustered pattern is statistically significant and the dispersed random pattern is significant if observed K value is less than lower confident envelops for related distance. To determine the confidence envelops and draw relating curves, Monte Carlo test was used.

Results

The distribution pattern was determined for these two species, to 300 meters. The drawn graphs with a brief description were shown the results.

The distribution pattern of almond (*Amygdalus* Sp) to a distance of 115 meters was statistically significant and clustered. The intensity of clustered pattern was additive to a distance of 15 meters, but for further distances this intensity was reduced. For distances greater than 115 meters, the pattern was tended more randomly and the random pattern was statistically significant at more than of 245 meters (Fig. 2).

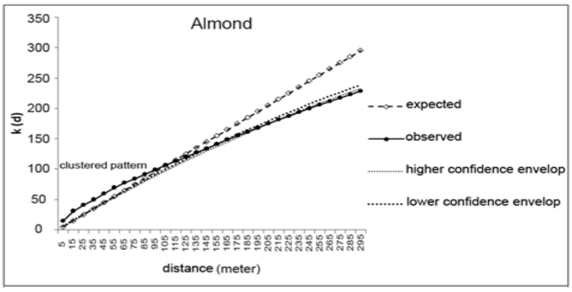

Fig. 2. Ripley graph for determining the distribution pattern of almond.

The distribution pattern of oak species (*Quercus persica* J.&.Sp.) to a distance of 235 meters is clustered and statistically significant (Fig. 3).

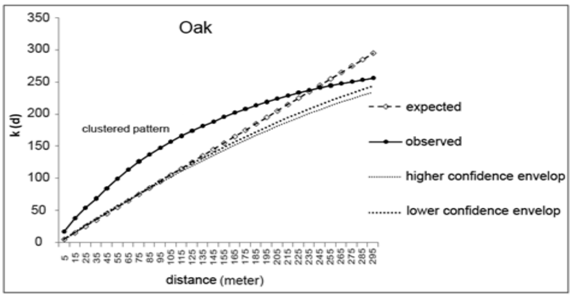

Fig. 3. Ripley graph for determining the distribution pattern of oak.

Discussion

Detailed investigation of almost any plant community reveals that species do not intermingle randomly; some species are more often in close proximity than their proportions in the community would predict, and this has direct implications for their opportunities to interact (Dale, 1999). Spatial patterns are created by various known and unknown factors. In between, the vector factors that are consequence of external forces have key roles to determine the object's appearance location. Wind, water flow, light intensity, type and state of regeneration, social factors such as maternal behavior, determining the scope and unpredicted factors that resulting from accidental changes that may be seen in any of the aforementioned factors, affected these patterns (Hutchinson, 1953). All of these are imported to interpret the results and create a multi-dimensional problem. Because of lack of information about the ecological functions, the abilities to detailed interpreting of outcome results were limited to a simple index as regeneration state of the species. Since the other studies (Bassiri *et al.*, 2006, Kunstler *et al.*, 2004, Maltez-Mouro *et al.*, 2007) have not determined the spatial pattern over 100 meters distance and to produce comparable results, pattern to this distance was assumed as the dominate pattern. In the species that regenerate from seeds such as oak and almond, the spatial pattern is related to the way of seed's distribution occurs (Calviño-Cancela, 2002). The spatial pattern of seedling survivorship also influences the long-term distribution patterns of species (Queenborough *et al.*, 2007). Elongated shape of the oak and almond seeds and drop them into clusters under tree canopies (due to lack of storm or animal that move seeds far from parent individual), could cause clustered pattern in these species. In the Zagros forest because of extreme human degradation, oak species as the dominate species mostly regenerate by coppice shoots, However the distribution of the coppice is same as seedlings (Moeur, 1993). But also on the state of seed dispersal, climate and topography of the area play a decisive role in forming patterns of species distribution. The results of this study are consistent with the studies that introduced the clustered distribution pattern for all of the various species of oak: Bassiri *et al* (2006), Kunstler *et al* (2004), Maltez-Mouro *et al* (2007).

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