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The Spatial Pattern Analyses of Natural Pure Oriental Beech (*Fagus orientalis* Lipsky.) Stands in the Bartin-Yenihan District in Turkey

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Özet

Bu araştırma Bartın-Yenihan Bölgesi 70a nolu bölmecikte bulunan saf doğu kayını (*Fagus orientalis* Lipsky.) meşceresinde gerçekleştirilmiştir. Araştırmada uygulanan konumsal analiz yöntemi Hopkins test kriterlerine göre gerçekleştirilmiştir. Meşcereden alınan örnek alanda GPS yardımıyla doğu kayını bireylerinin konumları belirlenmiştir. Ölçüm sonuçlarının istatistiksel analizi sonucunda, %95 güven düzeyinde L(r) fonksiyonu değerinin sıfırdan büyük olduğu (0.88) tespit edilmiştir. Buna göre ağaçların konumsal dağılımı rastlantısal olup, düzensizdir. Nitekim %95 güven düzeyinde uygulan T testi sonucunda da olgun bireylerin konumsal dağılımının rasgele ve düzensiz olduğu belirlenmiştir. Bu kapsamda araştırma alanında Hopkins kriterlerine bağlı kalınarak saf doğu kayını meşcerelerinde yapılacak konumsal dağılım analizleri %95 güven düzeyinde aktüel yapıyı yansıtmaktadır.

Anahtar Kelimeler: Doğu kayını, konumsal yapı, saf meşcere, Ripley'in L fonksiyonu.

Bartın-Yenihan Bölgesindeki Doğal Saf Doğu Kayını (*Fagus orientalis* Lipsky.) Meşcerelerinde Konumsal Yapı Analizi

Abstract

In this study, was carried out in the pure oriental beech (*Fagus orientalis* Lipsky) stand of 70a division in the Bartın-Yenihan district, based on Ripley's L(r) function, the spatial distribution of beech trees in natural stands indicated an aggregate pattern, because the index of pattern L(r) was more than zero (L(r)=0.88). In order to test the null hypothesis of spatial randomness, we computed a 95% confidence interval of (r) indicated that clumped pattern was acceptable (H= 2.96, the critical lower limit of the Hopkins test for aggregated pattern = 1.55). Also, based on T-Square method, results showed that the spatial pattern is clumped (Table 1). Hopkins test result with a confidence 95% indicated that the null hypothesis was unacceptable (H = 2.96, the critical lower limit of the Hopkins test for aggregated pattern =1.55).

Keywords: Oriental beech, Pure stand, Ripley's L function, Spatial pattern

INTRODUCTION

The spatial pattern of a forest stand (in other words the organization of the trees in space) plays a main role in its dynamics. It indicates the establishing fortune for seedling and renewal capacity of the stand. Thus, the relative location of young and old trees of the same species can help us to understand the dynamics of regeneration [19]. Indeed, the spatial pattern observed results from the past dynamics of the stand: establishment of young trees, competition for the different resources and death due to senescence or competition [1,4,14]. We can thus assume that some of the characteristics of the stand spatial pattern reflect the major trends in its dynamics. For example, regular spatial structures are commonly supposed to indicate high competition in the stands, whereas aggregate patterns indicate massive regeneration without subsequent strong self-thinning [6,9,7]. Therefore, the aim of this present study is describing the stand spatial pattern.

While the canopy of forest cover provides the micro-habitats for plants and animals, it affects the processes above (e.g. forest floor) and below (e.g. soil respiration) the ground[14]. Because such processes are related with composition of species it is a complex problem how the interaction of trees can change the individual properties, while individual development of trees can be well understood [18].

When evaluating the dynamics of natural or almost-natural forests by considering the growth stages, it can be seen that it consists of continuous regeneration of species in large or small spaces [6]. The juvenilities of beech and fir accumulate in small spaces under the stand cover, the big gaps are occupied by other species. Despite that regeneration dynamics of each of species in mixed stands are well known, the mutual interactions have not been clarified yet.

Up to the present, significant efforts have been made in order to define the structure of forests having various variables such as age, height, growth, and biomass. But in recent years, those studies have focused on characteristics of components and the mutual interaction and relationships between them. The authors such as and have utilized models considering the distribution of trees and their mutual interactions while determining the ecological issues such as regeneration, growth, and development of layers [16,22].

The regeneration relationships individuals of common beech's adult stands are explained through spatial pattern analysis. For this purpose, the spatial properties of oriental beech stands containing both old and young members have been determined by spatial statistic (e.g. Ripley's K function by), GIS and other land measurements. How the tree species are distributed among the stand in this period (e.g. randomly or in clusters) and whether the models are in accord with functions of species in terms of interaction between stand and species are some of the interested problems.

MATERIALS AND METHODS

Material

The study site is located in the second district of the Bartın forest in the west of Yenihan province, Western Black Sea in Turkey (Figure 1).

The forest under study has the area of 30 ha, and is occurring in oriental beech (*Fagus orientalis* Lipsky.) forest. It is a sample of pure stand of beech forest that is fortunately unmanaged and has not been harvested until now. The stand is located on a gentle (%20-40) north slope. The soils belong to brown forest soil with bedrock of siltstone conglomerated. The climate is temperate, the annual mean temperature is 7°C and the annual mean precipitation is 564mm, with maximum rain occurring in late summer and fall.

Fig. 1. Research Area

Method

The measurements in the sample plots

In the aforementioned pure beech stand, an area of 8.3 ha was determined and for all this area stem coordinates (exact to 0.1 m, using a compass and an ultrasonic distance-meter), 40species and diameters at breast height ($d_{1.30}$) of all living trees about 7 cm in $d_{1.30}$ their position in the stand were recorded by GPS.

Spatial pattern analyses method

Stand spatial pattern is complicated concept, including both horizontal and vertical use of space by trees. To simplify this approach, we focus on the horizontal location of trees in the stand and each tree is represented by a point, defined by its coordinates (x,y). In order to determine the spatial pattern of the distribution of trees in beech stand and with regards to an initial hypothesis for this research would be that in evenaged stands, a clustered or random distribution would be expected. Therefore, specific tools are necessary to characterize the structure. Many methods have been developed to study the structure [23,18,2,15,8]. Point pattern analysis, a branch of spatial pattern statistics, can be used to analyze horizontal stem scattering and quantify the spatial pattern of plant community [20]. Spatial statistics based on point processes such as Ripley's function have often been used to describe the spatial distribution of trees and seems all the more interesting as it gives a description of spatial structure at different scales at the same time [26,14], and it could be applied on each species separately. In this study, we used the Ripley's function and T- square to determine the spatial pattern of trees.

Ripley's function

The main characteristics of a point processes can be summarized by its intensity λ (the expected number of points per unit areas) and Reply's K(r) function, defined so that λ*K(r) is the expected number of the neighbors in a circle of radius r centered on an arbitrary point of the process [23,14]. We can calculate estimators of λ and K (r): λ = N/S; where N is the number of points in the pattern and S is the area of the study region.

$$K(r) = N^{-1} * N^{-1} * \sum_{n=1}^{\infty} \sum_{i\neq j}^{\infty} \text{Kij}$$

Where Kij =1 if the distance between i and j is less than r, and o otherwise.

To simplify the interpretation, a linearized function L(r) proposed by Simulauer [24] was used:

$$\text{L (r)} = \sqrt[2]{K(r) * \frac{1}{\pi} - r}$$

Then for a poison pattern, L(r)=0 at every distance r; for clustered patterns at distance r, L(r) > 0; and in the case of regularity at distance r, L(r) < 0. In order to test this « complete spatial randomness » (csr) hypothesis, we build confidence intervals using the Hopkins test [22,14].

T- Square function

The T-Square method is simpler to implement in the field than the Ripley procedure. Random points are located in the study region and at each random point two distances are measured: The distance (xi) from the random point to the nearest organism, and the distance (z_i) from the organism to its nearest neighbor [3,14]. The density estimator that utilizes T-square distances (z_i) has a different equation:

$$\hat{N_4} = \frac{2n}{\pi \sum_{i=j}^{\infty} (Zi)^2}$$

Where; $\hat{N}_4$= T-square estimate of population density, n=number of samples and z_i=T-square distance associated with random point i. This estimator should not be used unless it is known that the organisms being sampled have a random pattern. The most robust estimator of population density for use with T-square sampling was the following [14].

$$\hat{N_T} = \frac{n^2}{2 \sum_{i=j}^{\infty} (xi) \left[\sqrt{2\sum(zi)}\right]}$$

In order to test this « complete spatial randomness » (csr) hypothesis, we build confidence intervals using the Hopkins test.

RESULTS AND DISCUSSION

The first of all, the stand structure is quite dynamic. Stand density and canopy are change, even at very short distances. In this reason, the relations are variety between dominant and co-dominant beech individuals (Figure 2). Consequence, L function value is calculated as 2.2m. This value was found between 2.3-5.4m in the natural common beech (*Fagus sylvatica* L.) forests [21].

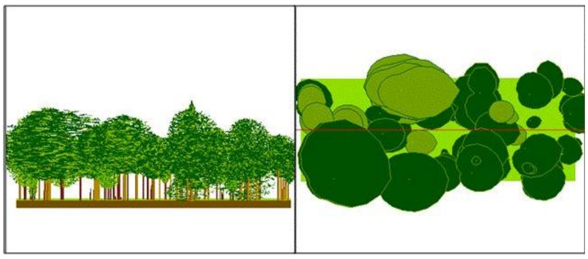

Fig. 2. Stand structure in the sample plot.

The assessment of all of the trees in both of sample plot in 99% confidence level is given with Monte Carlo simulation. All of the trees up to 1m in SP1 are pushing each other and tend to show regular distribution (Figure 3). But in SP2, all of the trees between 2.2 and 5.8m are in tendency to strong grouping; the maximum value has been obtained at 6.6m. The spatial relation between individuals of groups of small (dbh<5 cm) and large (dbh ≥5cm) trees exhibits some tendency to clustering at lower scales. However, the pattern shows some tendency to repulsion at scales r ≈ 5 and 8m. This could be an indication of intraspecific competition [12].

On the other hand, the shrub species in the stand ground vegetation layer are showed regular distribution in the sample plot in pure oriental beech stand. However, the distance is changed between 1.2-3.4m in the shrub species (Figure 4). The spatial relation between individuals of groups of small (dbh<2cm) and large (dbh≥2cm) shurb exhibits repulsion at small, intermediate and large scales. This could be an indication of either environmental heterogeneity [10].

Based on Ripley's L(r) function, the spatial distribution of beech trees in natural stands indicated an aggregate pattern, because the index of pattern L(r) was more than zero (L(r)=0.88). In order to test the null hypothesis of spatial randomness, we computed a 95% confidence interval of (r) indicated that clumped pattern was acceptable (H= 2.96, the critical lower limit of the Hopkins test for aggregated pattern = 1.55). Also, based on T-Square method, results showed that the spatial pattern is clumped (Table 1). Hopkins test result with a confidence 95% indicated that the null hypothesis was unacceptable (H = 2.96, the critical lower limit of the Hopkins test for aggregated pattern =1.55).

Therefore, we can consider that the structure pattern in beech stands is heterogeneous. It can be used as a criterion to determine the sampling method, sample size (e.g. in the stands with a clumped distribution pattern we have to use samples with areas larger than the regular pattern). In order to determine silvicultural method, this knowledge can be useful [25,17,14]. With regards to spatial pattern of trees in the study area (clumped pattern), the group selection system can be assumed as a suitable method to forest management.

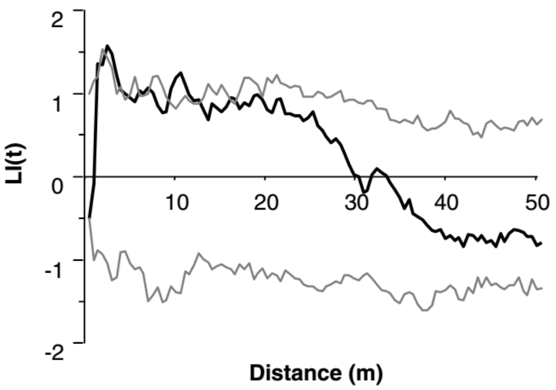

Fig. 3. L (d) function of all of the trees in SP1

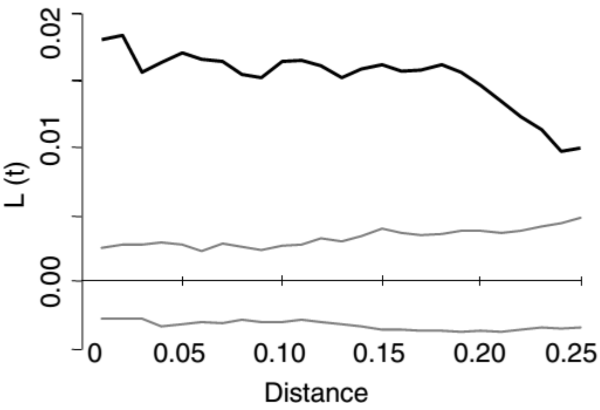

Fig. 4. L (d) function of all of the shrub species in SP2

Table 1. Values of parameters that were estimated in T-Square method

T-Square Est.	Population Estimate	Standard error of the population estimate	95% Confidence Limits	
			Lower	Upper
N_4	0.000042	18.37	0.0000425	0.0000428
N_T	0.00018	2113	0.000136	0.00185
N_T (per ha)	3.4	0.228	1.3	18.5

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