Assessment of spatial patterns and relations between trees of Głuchów forest; exploring appropriate indices and methods.

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“When you can measure what you are speaking about, and express it in numbers, you know something about it but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science.”
Lord Kelvin

Introduction

- The quantitative description of forest spatial pattern and relation is studied by way of three structural characteristics: intensity, positioning and mixture.
  - *Positioning* or the random spatial distribution of trees on the stand area(*Poisson forest)*, where all trees occur independently and do not influence each other (Tomppo, 1986).
  - *Mixture* or the description of the mutual position & relationship of different tree species within the stand.

Why Spatial Pattern ?

- Spatial patterns and size distributions bear the finger-print of growth, competition, and habitat heterogeneity (Harms et al. 2001, Chen et al. 2004).
- Its understanding is necessary to reconstruct the forest by computer (Pretzsch, 1992; Von Gadow and Hui, 1999)
- It provides a wide range of possible applications in forest inventory work, forest management, forest development research.

Objective & Research Questions

Intensity

What is the average density of trees in an area?

What does a map of tree density look like?

spatial pattern

Are the locations spatially clustered, regularly distributed or random

relations

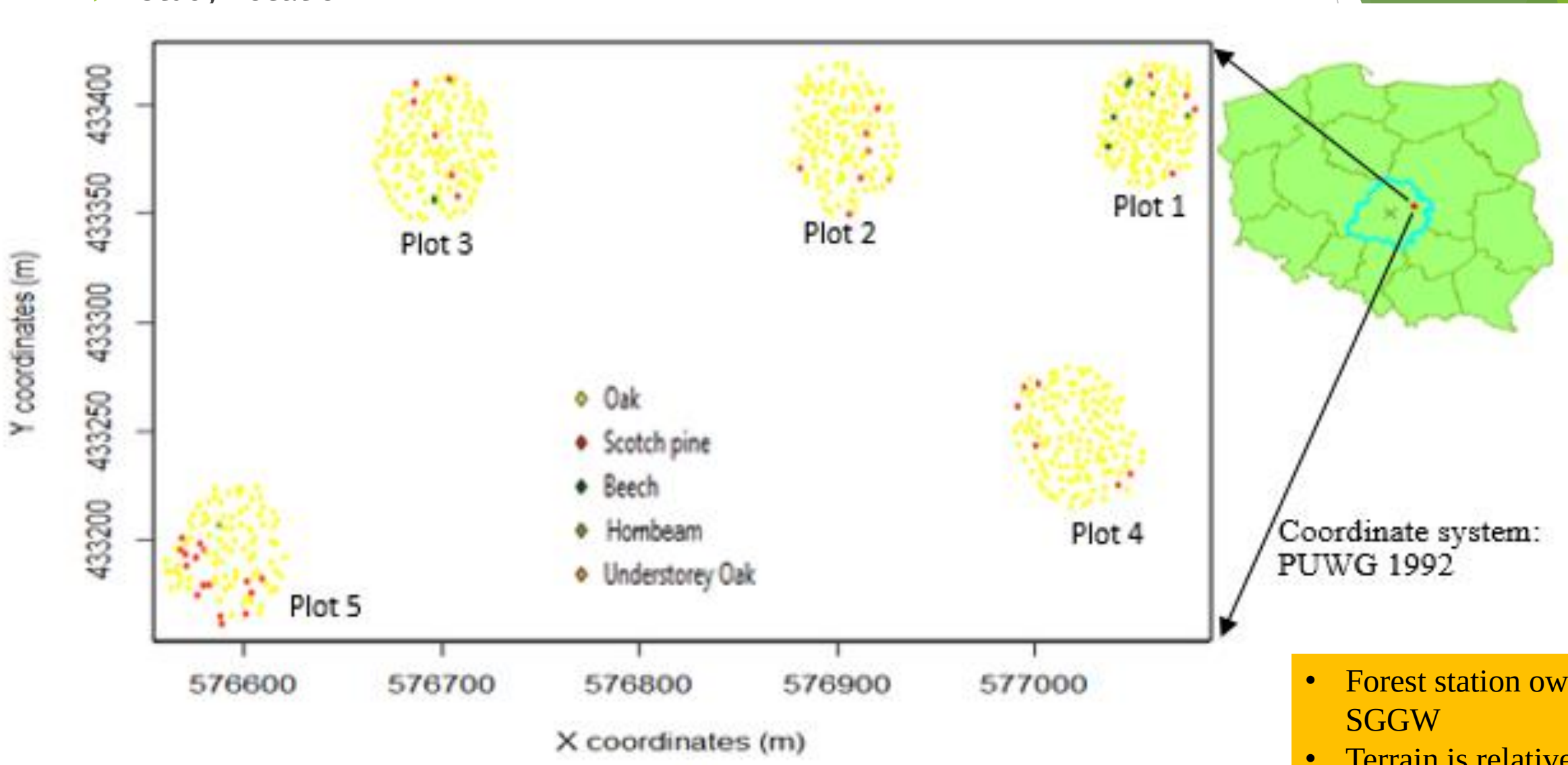
Do two different species tend to occur together or

exhibit spatial segregation?

To assess the spatial pattern and relations between trees of ‘Głuchów’ forest by explored available indices and methods

Materials & Methods (1)

- Study Location



- Forest station owned by SGGW
- Terrain is relatively flat (~185m)

Fig. 1 Study location with distribution of sample plots and trees in the Gluchow Forest

Materials & Methods (2)

Data Collection

Table 1. Summary of tree counts in the five sample plots.

Plot	Plot Size (sq. m)	First Storey		Second Storey			∑
		Oak spp.	Scotch pine	Oak	Beech	Horn-beam	
1	2426.88	117	4	-	6	-	127
2	3064.46	109	6	4	-	-	119
3	3357.47	128	6	-	-	2	136
4	3037.90	121	6	-	-	-	127
5	2611.20	84	17	-	-	-	101
Sum	**14497.91**	559	39	4	6	2	610

- Coordinates of each tree location was mapped
- DBH was measured in two directions (N-S and E-W) with a Vernier calliper and averaged.

Materials & Methods (3)

Intensity

- Contour & kernel density estimations were explored
- both methods are based on the density or mean number of trees per unit area.
- Intensity may be constant (i.e. homogeneous) or may vary from location to location (i.e. inhomogeneous).

Spatial pattern

- The commonly used aggregation index (*R*) of Clark and Evans (1954) expresses the extent to which a forest stand deviates from the Poisson forest
  - $R = \frac{\text{Observed MNN distance}}{\text{Expected MNN distance}} = \frac{\bar{r}_{obs}}{\bar{r}_{exp}}$
  - Typical range of *R* index: 0 and 2.1491
  - $R < 1$ means a tendency towards clustering, $R = 1$ implies random occurrence, and $R > 1$ implies a tendency towards regularity.
  - To test the significance of deviation from the Poisson forest(R=1), the proposed statistic of Clark and Evans (1954) was applied where the null hypothesis (H_0: $R = 1$ and H_1: $R \neq 1$)

Materials & Methods (4)

Spatial Relation

- The segregation index *S* by Pielou (1977) is commonly used to describe the intermingling of two tree species from a contingency table.
- $S = 1 - \frac{\text{Observed number of mixed pairs}}{\text{Expected number of mixed pairs}}$
- The ***S*** index theoretically lies between -1 and +1.
- a distinction can be made between association, segregation or neutral relation between two tree species.

Materials & Methods(5)

pattern analysis and modelling

- The 2nd order univariate pair correlation function g(r) was used for its easy intrepretation,

  $G(r) = (2\pi r)^{-1} dK(r)/dr.$ (Stoyan and Stoyan, 1994)

- It's related K-function by Ripley (1976) was also estimated and modelled because of its wide usage as a powerful descriptive and modelling tool originally suggested by Bartlett (1964)

  $K(r) = 2\pi \int_0^r g(\acute{r})\acute{r}\,d\acute{r}$

- 95% confidence envelopes were determined by 40 Monte Carlo simulations relative to the CSR null model (Dale et al., 2002; Wiegand and Moloney, 2004) By this any departure from CSR can be determined.

- Spatstat package in R software will be used for all spatial tree pattern analyses

Results & Discussion (1)

Intensity

- The average intensity are 0.0523, 0.0388, 0.0405, 0.0418 and 0.0387 for plot 1, plot 2, plot 3, plot 4 and plot 5 respectively.

- By visual inspection, intensity is inhomogeneous within each plot. Such observation is not unusual (Baddeley, 2008)

- With the lowest intensity around the edges of the sample window. This phenomena suggest some kind of edge effects at work.

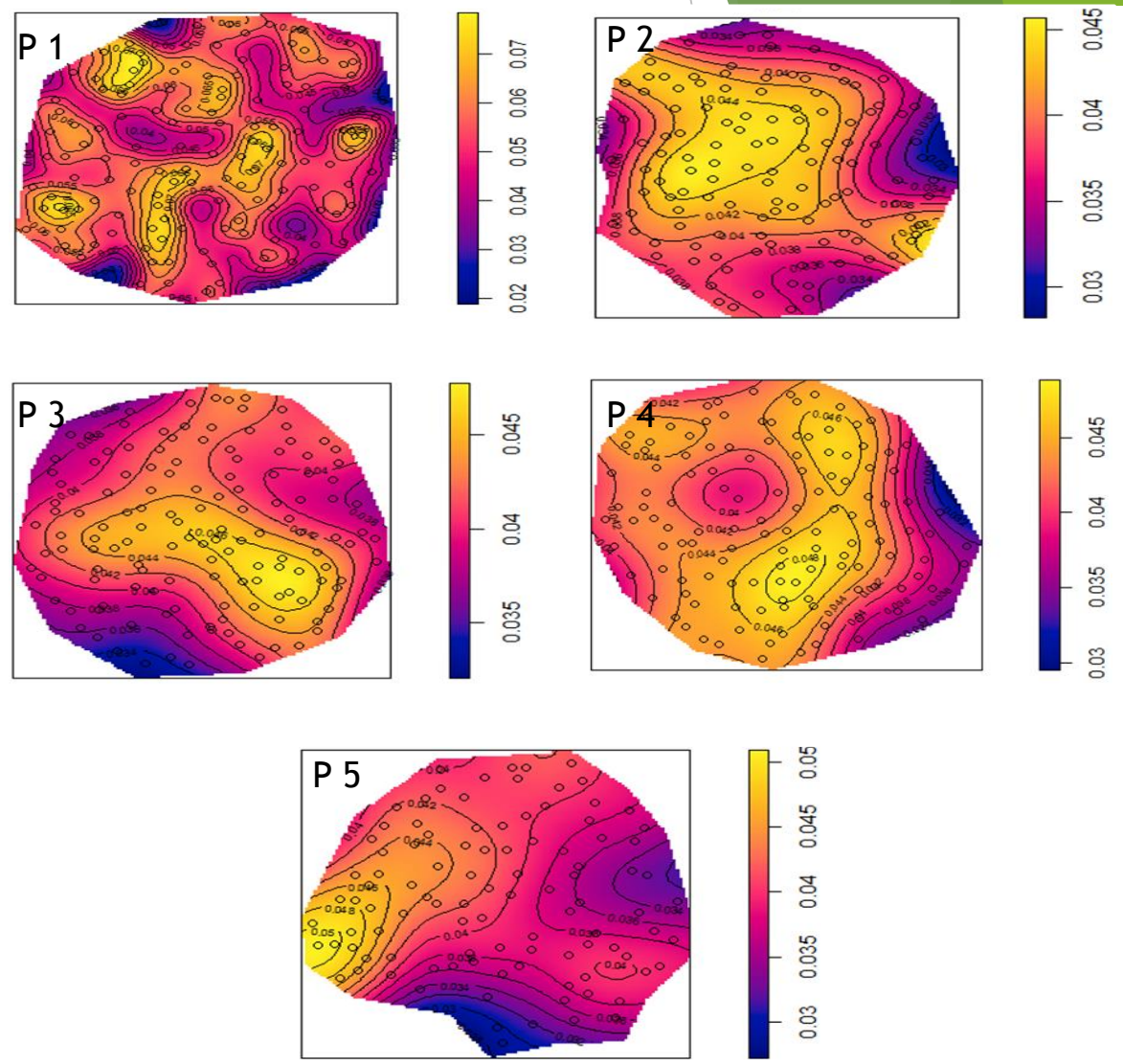


Fig. 2. Spatial tree pattern intensity

Results & Discussion (2)

Table 3. Spatial pattern and relations

PLOT	N	Mean NND (m)	S	R without edge effect correction	R With cdf correction	R index of DBH classes			
						Class 1	Class 2	Class 3	Class 4
1	127	2.989	0.0565***	1.3676	1.3383*	1.1594	1.0793	1.0770	_
2	119	3.322	-0.0420***	1.3092	1.2676*	1.1232	0.9556	1.0398	_
3	136	3.153	0.2478***	1.2690	1.2729*	1.0381	0.9255	1.0683	0.9299
4	127	3.308	-1.0650***	1.3528	1.3022*	1.0937	1.0200	1.1317	1.0208
5	101	3.221	0.3844***	1.2668	1.2457*	0.8781	1.0615	1.0453	0.9121

*N= number of trees in a plot, Mean NND= average nearest neighbor distance for each plot, S = segregation index S by Pielou, R = Aggregation index R by Clark and Evans, cdf = cumulative distribution function, Class 1 = 10-19.9cm, Class 2 = 20-29.9cm, Class 3 = 30-39.9cm and Class 4 = 40-49.9cm, * = significance at p < 0.05, ***= significance at p < 0.001*

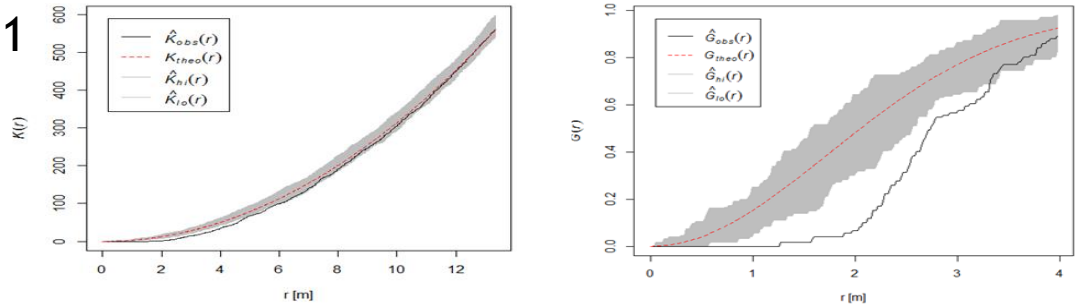
- regularity in tree pattern at stand level (Füldner 1995)
- DBH classes are rather random in occurrence
- Edge effects correction importantly reduce *R*-values (Pommerening and Stoyan, 2006)
- intensively managed practices focused on the liberation of future trees from conspecific competitors.
- As *S* is calculated using only one nearest neighbour for each tree, this effect is reflected in negative index values Kint et. al. (2000)

Results & Discussions (3)

Spatial tree pattern analysis and modelling

- **Complete Spatial Randomness (CSR)**
  - ✓ the Complete Spatial Randomness (CSR) is usually taken as the appropriate 'null' model for a point pattern.
  - ✓ The basic task in analysing tree pattern is to find evidence against CSR.

P1



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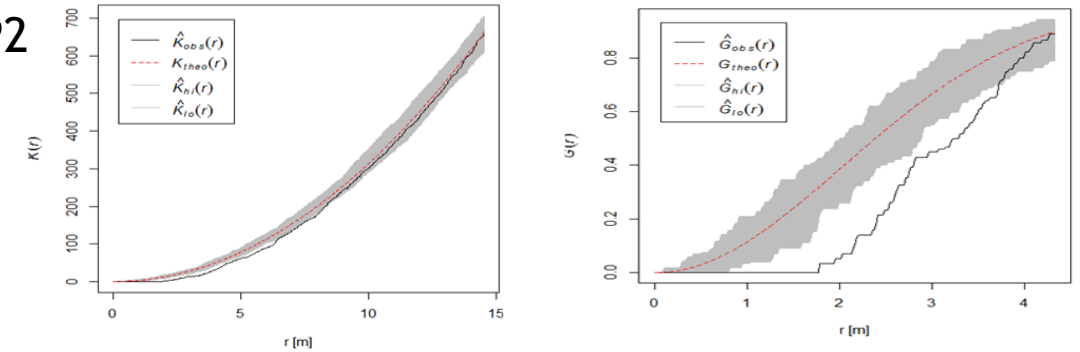

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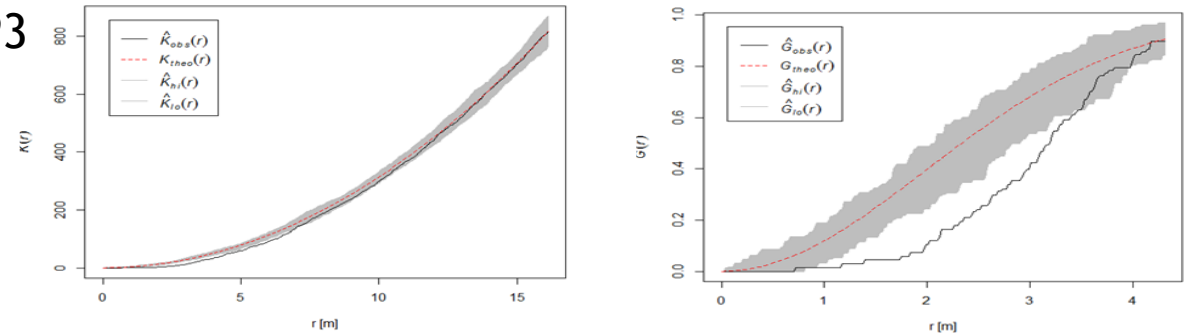

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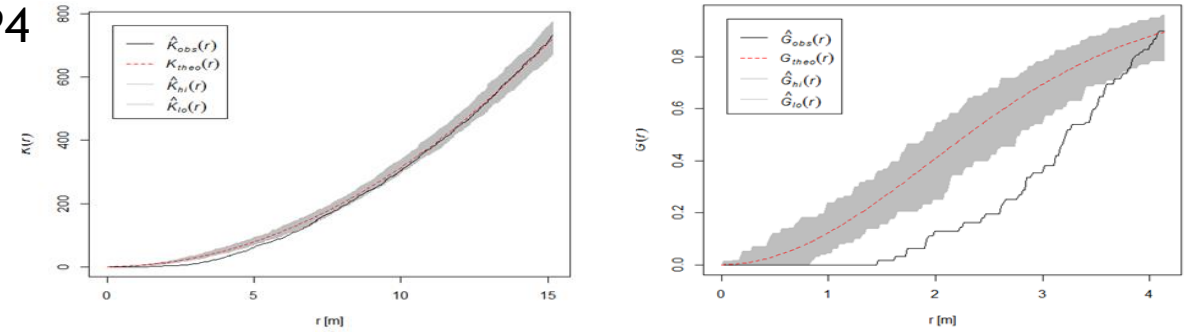

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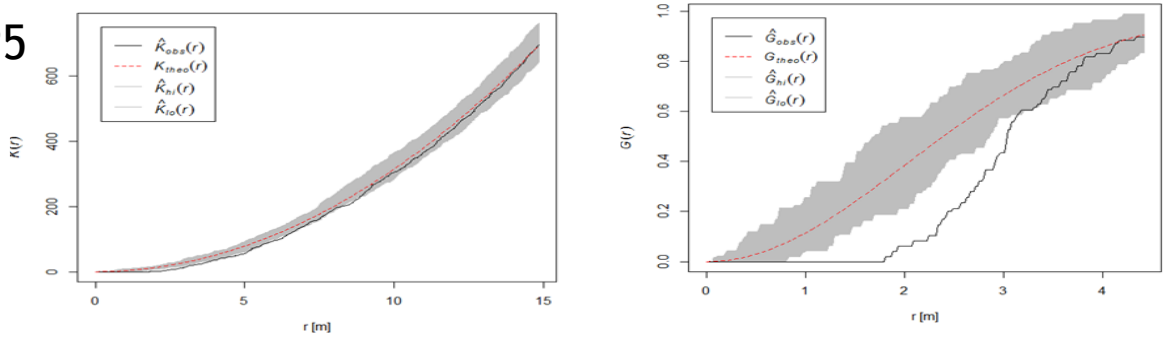

Fig. 3. Spatial tree pattern analysis against CSR (red line) by K(r)-function and G(r)-function with nsim=40 showing the extent of deviation by observed pattern(black) compared to the CSR. The G(r) function clearly shows that at a small scale of observation the trees may not be enough to show any CSR pattern.

Conclusion & Recommendation

Conclusions

The findings of the study show that:

- (1) there is a rather an inhomogeneous spatial intensity of trees in the Głuchów forest as local intensity vary from location to location even within the same sample plot.
- (2) the spatial distribution pattern of the forest show a high tendency towards regularity rather than random and
- (3) both association and spatial separation characterise the kind of spatial relation existing between the dominant Oak species and the remaining species of the Głuchów forest

Recommendations

- The study underscores the importance of considering edge effect during experimental plot design.
- Inconsistencies in the results of Pielou's segregation index therefore further studies should consider complementing Pielou's index with the German *Durchmischung* (DM) or mixture index of Von Gadow (1993),
- Why?
  - (i) not only the first, but multiple neighbours are accounted for and
  - (ii) the index is not restricted to the mixture of two (groups) species but can be determined for all the species together as well as for each species separately.

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THANK YOU