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SHORT REPORT

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BIODIVERSITY INDICES FOR THE FUTOG PARK (NOVI SAD, SERBIA)

ABSTRACT: Biodiversity and biodiversity preservation are some of the most important topics in ecology. Protecting biodiversity in urban ecosystems is especially challenging. Urban parks are a valuable part of green infrastructure in cities, as they contribute to preserving natural habitats for many species. Biodiversity can be quantified by calculating different diversity indices, and in this paper, we have calculated alpha indices (Shannon, Simpson, Fisher, Berger-Parker and Margalef index) and beta indices (Sorensen index, Jaccard distance and Bray-Curtis index) for the Futog park in Novi Sad, Serbia, within two periods, 2005 and 2020. The goal of the paper is to analyze the current values of biodiversity indices in the park and compare them with the ones from 15 years ago. In addition to the analysis of biodiversity indices values, the paper provides the comparison of taxonomic structure of flora, and the abundance of native, endemic and invasive species in the park, in 2005 and 2020. The results show that the values of biodiversity indices have decreased in the indicated period of time, and one of the main causes can be related to the spread of invasive species within the park. For calculation purposes, we have used the R program and the R package "vegan".

KEYWORDS: biodiversity, species diversity, urban parks, Futog park

INTRODUCTION

Biodiversity encompasses variability and diversity of genes, species and ecosystems on Earth (Vujić, 2008). In order to quantify the species' diversity, there are many indices defined. Biodiversity indices can be split into alpha, beta and gamma indices; alpha indices measure biodiversity in a single area;

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beta indices are used either to compare the similarity of flora composition in different areas or to compare the similarity of flora composition in the same area over different periods; while gamma indices measure biodiversity on a large spatial scale (Magurran, 2004). The most commonly used alpha diversity indices are Simpson and Shannon index (Lakićević and Srđević, 2018), but other indices such as Fisher, Berger-Parker, Margalef index are also analyzed and discussed in the prominent literature (Fedor and Zvaríková, 2019). Calculation of biodiversity indices can be performed by using different programs and computer tools, and nowadays programming language R, its interface RStudio and the R package "vegan" are commonly applied in ecological research (Lakicevic et al., 2020).

In the domain of urban ecology, it is highly important to calculate and keep track of species diversity in urban parks, as they present a habitat for many valuable and rare species (Srdjevic et al., 2019). In this paper, we analyze the biodiversity indices for the natural monument – the Futog park in Novi Sad, Serbia. There are two periods analyzed in the paper: 2005 and 2020, and the idea is to analyze the current values of biodiversity indices in the park and to compare them with the precedent ones. On one hand, calculating alpha diversity indices gives an insight into values of biodiversity, and its components, richness and evenness, in both periods separately. On the other hand, obtaining values of beta diversity indices quantifies (dis)similarities in plant species' composition between two analyzed periods, and directly reveals how much plant composition has changed over time. In this paper, the analysis of alpha and beta diversity indices are being supported with additional data such as analysis of the taxonomic structure of flora, the share of native, endemic and invasive species in both periods, etc. Gathering all of the listed data gives a detailed insight of the floristic elements in the Futog park for the period 2005–2020, and can serve as a starting point for future monitoring of changes in plant species diversity.

The main goals of the paper are: analysis of biodiversity indices in the Futog park in 2005 and 2020 and analysis of changes in the floristic composition that has occurred in the indicated time period. In addition to that, the paper aims to promote the application of the R program in urban ecology tasks, and particularly the application of the package "vegan" in calculating biodiversity indices. The paper also provides a detailed description of the most commonly used biodiversity indices that are important when keeping track of floristic elements in urban parks.

METHODS

Study area

The Futog park is situated in Novi Sad, Serbia (Figure 1). The park occupies approximately 12 ha, it was established in 1910 and therefore represents one of the oldest and the largest parks in Novi Sad (Lakićević and Srđević,

2017). The park was declared a natural monument in 2005 (*Službeni glasnik Republike Srbije / The Official Gazette of the Republic of Serbia*, 23/2005).

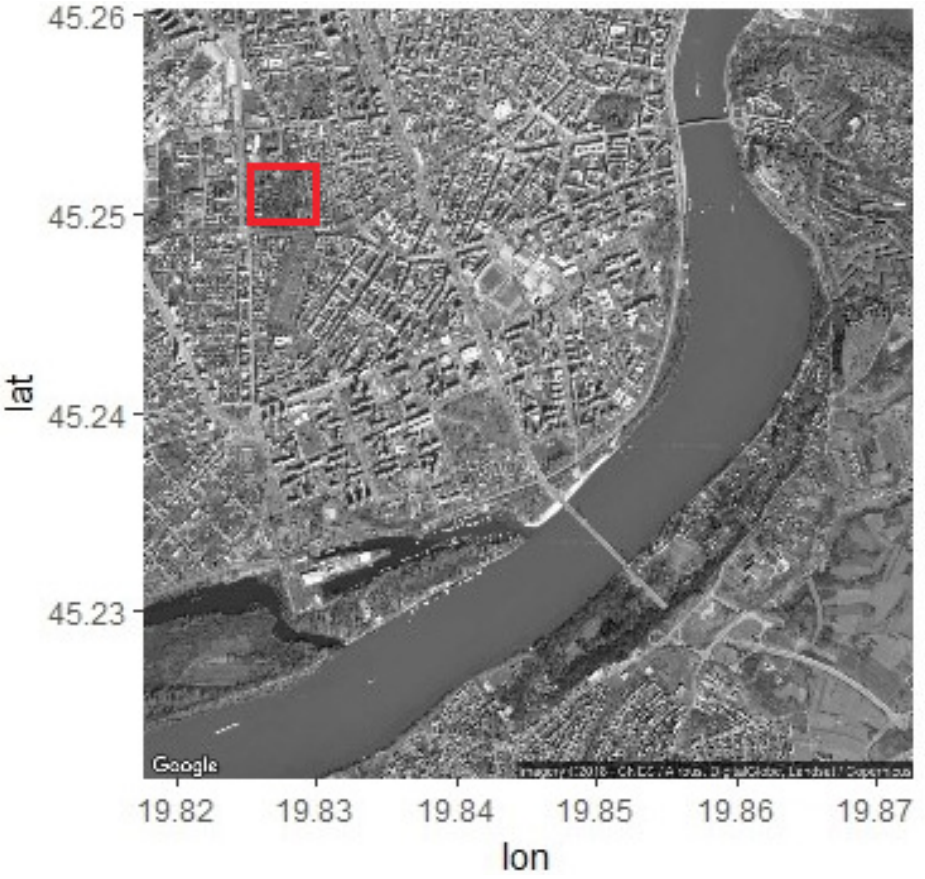

Figure 1. Location of the Futog park in Novi Sad

The Futog park was established in the first decade of the XX century, immediately after the construction of Jodna Banja. The original park design was the idea of the famous Hungarian landscape architect, Armin Pec Junior. The park was designed in a combined style that was dominant for landscape architecture projects of that period and implied mixing elements of French and English landscape style. The park was reconstructed in 1964 according to the designs of Ratibor Đorđević. Even though the outlook of the park has changed over time, the design concepts of both original and reconstruction projects are still present and recognizable.

One detailed survey of flora in the park was done in 2005 (Popović, 2005), followed by another one in 2008 (Ninić-Todorović et al., 2008). These data are compared with the current state, using a new survey from 2019 (Mlađenović, 2019), and the data collected at the site in 2020. Therefore, this research was

conducted in two phases: the first one implied fieldwork and determining all tree and shrub species that are present in the park, as well as their abundance. These data were input data for the second phase – further analysis and calculation of biodiversity indices for both time periods.

Biodiversity indices

In this section, we describe five alpha and three beta biodiversity indices used in this research. For each index, we provide a short description and a brief comment of its usual and threshold values.

Alpha biodiversity indices

We calculate one nonparametric index (Fisher index) and four parametric indices (Shannon, Simpson, Berger-Parker and Margalef index). More details about each index and corresponding formulas can be found in (Magurran, 2004).

Shannon index usually varies in the interval 1.5–3.5. Values of Shannon index over 3.5 and particularly over 4 suggest that an area is extremely valuable in terms of species' richness and evenness.

Simpson index measures evenness and varies in the interval [0,1], where the value of 0 reveals a monoculture, and higher values prove better evenness among the species.

Fisher index (α) is based on the assumption that the abundance of species follows the log series distribution. Fisher index is approximately equal to the number of individuals represented by a single species.

Berger-Parker index vary between 0 and 1, where smaller values correspond to higher diversity. This index quantifies the abundance of the most dominant species.

Margalef index is sensitive to sample size, but higher values of Margalef index prove higher biodiversity.

All of above listed alpha indices were calculated in program R, version 3.5.3. Fisher, Shannon and Simpson index were calculated by using the R package "vegan", while Berger-Parker and Margalef index were calculated by the R codes written by the first author of the paper.

Beta biodiversity indices

In this section, we present three beta biodiversity indices that have been used for a comparison of plant species composition in the Futog park in the periods 2005 and 2020. These indices are: Sorensen index, Jaccard distance and Brey-Curtis index, and a brief explanation for each of them is provided in the next paragraphs.

Sorensen index takes into account the number of species that are common for both datasets (in this case both time periods), and the number of species that are present only in one dataset, i.e. one time period. The value of the Sorensen index falls into the interval between 0 and 1, where 0 means none, and 1 means a complete overlap in plant species composition in the analyzed time periods.

Jaccard distance uses the same input data as for the Sorensen index, but measures dissimilarities in plant species composition in two datasets. The value of the Jaccard index varies from 0 to 1, where values close to 0 mean that two datasets highly overlap in the plant species composition.

Bray-Curtis index takes into account different input data compared to the two previously described indices and the necessary data for calculation are: the sum of the lesser values of the number of specimens for the species that are common in both periods, and the total number of specimens present in each period. The value of this index can vary from 0 to 1, where 0 means that plant communities in two periods differ completely, and 1 means they are the same from the perspective of shared species and their abundance.

Calculation of all listed beta biodiversity indices has been done by using the R program, and its package "vegan". The paper presents additional data and analysis, such as the taxonomic structure of flora, the share of native, endemic and invasive species in the park in both time periods, etc.

RESULTS AND DISCUSSION

The first part of the results is related to the values of biodiversity indices in the Futog park in Novi Sad, in two time periods, 2005 and 2020. Table 1 shows the values for five main biodiversity indices.

Table 1. Alpha biodiversity indices in the Futog park (2005 and 2020)

Alpha diversity index	Value	
	Year 2005	Year 2020
Shannon index	3.592	3.578
Simpson index	0.957	0.947
Fisher index	16.116	20.599
Berger-Parker index	0.088	0.150
Margalef index	11.056	13.167

Shannon index is the principal alpha biodiversity index that quantifies both richness and evenness of species within an area. Based on the values in Table 1 it can be concluded that the value of the Shannon index for the Futog park has decreased in the analyzed time period. In order to get a better insight into the changes that have occurred, one should analyze the value of the Simpson index that quantifies the changes in the evenness of species in a plant

composition. Comparing the values of the Simpson index for 2005 and 2020 proves that there was a better distribution of species in overall species composition in the first analyzed period. However, it should be noted that the current value of the Simpson index (equal to 0.947) is still considered as high. Fisher index is interpreted as an approximate number of plant specimens that belong to one plant species, and the value of this index increased over the analyzed period of time, and this means that on average, each species has more specimens now than back in 2005. However, the value of this index should be associated with the value of the Berger-Parker index, which measures the share of the most dominant species in the plant composition. The value of this index severely increased in the analyzed time period, from 0.088 and 0.15, and this change also affects the higher value of the Fisher index in 2020. The most dominant species in the park now is *Mahonia aquifolium* (Pur) Nutt, and the value of the Berger-Parker index proves that it has a high share in overall plant species composition, equal to 15% (Table 1). The value of the Margalef index is more complex for a straightforward comparison, as being sensitive to the sample size, but its values for both 2005 and 2020 prove that the Futog park is valuable from the biodiversity perspective.

Apart from analyzing alpha biodiversity indices, the research included calculation of beta biodiversity indices, that compare the similarities in the plant species composition in the Futog park, in 2005 and 2020 (Table 2).

Table 2. Beta biodiversity indices in the Futog park (2005–2020)

Beta diversity index	Value
Sorensen index	0.893
Jaccard distance	0.193
Bray-Curtis index	0.614

Table 2 shows that the value of the Sorensen index is equal to 0.893 which proves that there were moderate changes in plant species composition in the Futog park in the period 2005–2020. The same conclusion can be drawn by analyzing the value of the Jaccard distance, equal to 0.193, which quantifies the dissimilarity in plant species composition in two time periods. Sorensen and Jaccard indices measure the overlap in plant species composition by taking into account the number of common species in both periods only, and not involving the number of their specimens. That is why it is useful to include additional indices, such as the Bray-Curtis index. The value of the Bray-Curtis index is equal to 0.614 and this means that number of specimens for common species has changed moderately.

The next analysis relates to the taxonomic structure of flora in the Futog park in 2005 and 2020 (Figure 2).

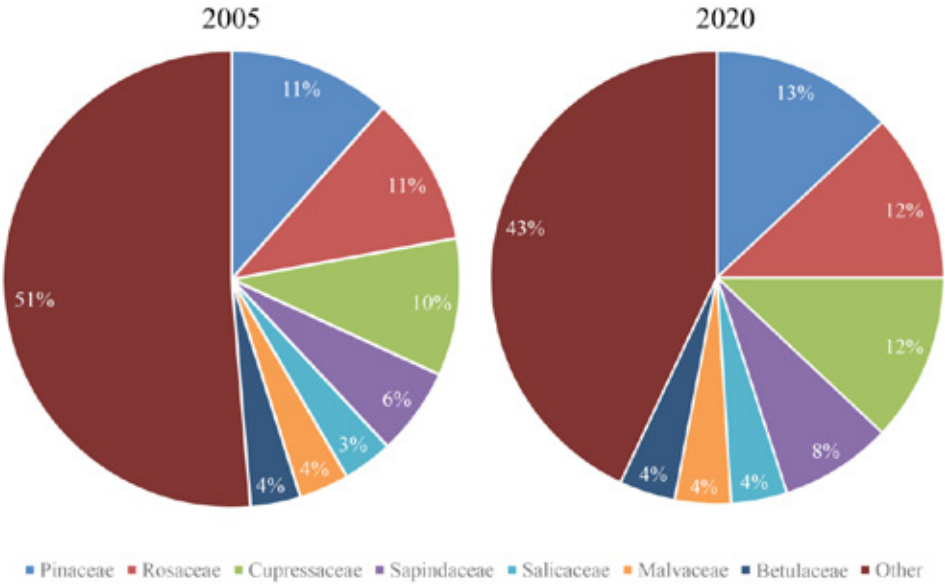

Figure 2. Taxonomic structure of flora in the Futog park

Figure 2 shows that the three most dominant plant families in 2005 were: Pinaceae and Rosaceae (each of them present with the share of 11%), and the family Cupressaceae (present with the share of 10%). In 2020, due to the changes in plant species composition, first of all, introducing the following species *Prunus avium* L., *Prunus cerasus* L., *Prunus cerasifera* Ehrh. and *Malus floribunda* Siebold., the family Rosaceae became the most dominant with a share of 13%. As in the previous period, the families Pinaceae and Cupressaceae have a high share, equal to 12%.

The next analysis considers native, endemic and invasive in the Futog park, in 2005 and 2020, by presenting the number of species and their specimens for each category (Table 3).

Table 3. Number of species and specimens for native, endemic and invasive species for the Futog park (2005 and 2020)

Description		Value	
		Year 2005	Year 2020
Native species	Number of species	86	97
	Number of specimens	7,893	4,273
Endemic species	Number of species	6	6
	Number of specimens	412	398
Invasive species	Number of species	10	10
	Number of specimens	173	277

Table 3 shows that in the past 15 years, the number of native species increased, but the number of their specimens significantly decreased – for 47%. Endemic species are present with the same number of species (5), but with a slightly smaller number of specimens. If one analyzes the invasive species, the conclusion is that the number of invasive species remained the same (10), but the number of their specimens significantly increased, for 60.1%.

The decrease in the number of native species' specimens and the increase in the number of invasive species specimens can seriously affect the structure of natural elements in the park. The spread of invasive species is one of the reasons for the slight decrease of biodiversity indices in the park in the period 2005–2020 and should be carefully monitored in the future.

CONCLUSIONS

This paper analyzes the biodiversity indices for the Futog park in Novi Sad, Serbia in the two time periods, 2005 and 2020. The park was declared a natural monument in 2005 and is one of the largest and the oldest parks in the city of Novi Sad. The flora of the park mainly consists of broadleaves (85%) and the most dominant plant families are Rosaceae, Pinaceae and Cupressaceae.

The values of five alpha biodiversity indices calculated in the paper (Fisher, Shannon, Simpson, Berger-Parker and Margalef index) prove that the flora diversity in the park is still high, including its both components: richness and evenness. However, the values of these same indices were more favorable in 2005. Since then, the plant species composition has moderately changed, encompassing both the number of common species and the number of their specimens. In the indicated period, the number of invasive species' specimens has increased by approximately 60%. In terms of expected climate change, it should be noted that invasive species have a high ability to adapt to the newly created environmental conditions, while at the same time, suppress the living niches of native and endemic species (Lakićević and Mladenović, 2018). Therefore, invasive species and their spread within the park should be carefully monitored in the future.

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ИНДЕКСИ БИОДИВЕРЗИТЕТА ЗА ФУТОШКИ ПАРК (НОВИ САД, СРБИЈА)

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РЕЗИМЕ: Биодиверзитет и очување биодиверзитета спадају у најзначајније теме у екологији. Очување биодиверзитета у урбаним екосистемима представља посебан изазов. Градски паркови су важан део зелене инфраструктуре у градовима, јер доприносе очувању природних станишта за бројне врсте. Биодиверзитет се може квантификовати рачунањем различитих индекса, и у овом раду израчунати су индекси алфа диверзитета (Шенонов, Симсонов, Фишеров, Бергер-Паркеров и Маргалефов индекс) и индекси бета диверзитета (Соренсенов индекс, Џакардово растојање и Брај-Куртисов индекс) за Футошки парк у Новом Саду, Србија, за два временска периода, 2005. и 2020. годину. Циљ рада је анализа садашњих вредности индекса биодиверзита у парку и поређење са стањем од пре 15 година. Осим анализе вредности индекса биодиверзита, рад приказује поређење таксономске структуре флоре и присуства аутохтоних, ендемичних и инвазивних врста у парку у 2005. и 2020. години. Резултати показују да су вредности индекса биодиверзитета смањене у анализираном временском периоду, и један од главних разлога може бити повезан са ширењем инвазивних врста у парку. За потребе прорачуна, коришћен је програм R и његов пакет „vegan".

КЉУЧНЕ РЕЧИ: биодиверзитет, диверзитет врста, градски паркови, Футошки парк