

## URBAN FORESTS AS BIODIVERSITY REFUGEES IN CULTURAL LANDSCAPES

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### Abstract

Urban forests provide many ecosystem services for people, including recreational activities. As biodiversity in rapidly changing urban areas is very dynamic, we need a better understanding of long-term biodiversity changes in urban forests. This study analysed the long-term change in bird-species richness in a temperate Central European urban forest over a time span of 37 years. Bird community investigated in 2023–2024 was compared with older field data from 1987. The high local alpha diversity of the bird community as well as the high long-term stability in bird richness indicates the importance of the studied urban forest as a stable biodiversity refugium in a dynamic urbanized landscape. Therefore, urban forests can be considered very stable biodiversity refugia in dynamically changing urban areas.

**Key words:** Birds as bioindicator, bird counting, floodplain forest, urban recreational park.

### Introduction

Urban forests (UF) are essential for recreational activities of people living in cities. The cultural ecosystem services (including recreation) of urban forests are based on biodiversity functioning of these managed forest ecosystems (Yang et al., 2020). Thus, understanding biodiversity patterns in UFs is vital for sustainable urban forest management strategies aimed at maintaining and developing ecosystem services as well as for urban planning aimed at urban green infrastructure.

Birds are valuable bioindicators in environmental assessments of how management practices affect biodiversity in urban forests (Sallabanks et al., 2000). Environmental heterogeneity is a major predictor of high bird-community diversity in European cultural landscapes (Vickery et al., 2012). In urbanized areas, habitat heterogeneity is significantly supported by the preservation of biological heritage. The main biological heritage features in urban areas are very large old trees (Barth et al., 2015). Other types of biological heritage (e.g., remnants of large dead trees standing or lying on the ground, uprooted trees, etc.) are very rare in managed forests.

Urban forests are located in highly dynamic urbanized landscapes. Various ecological and socioeconomic drivers have an impact on cities and their surroundings. Land cover and land use in urban areas change rapidly on both temporal and spatial scales. Additionally, changes in the biodiversity of urban forests can occur relatively quickly, reflecting landscape changes and the synantropization of many forest bird species (Evans et al., 2011). Despite our current detailed knowledge of bird diversity in urban parks, we still know little about patterns of bird diversity change in urban forests.

Understanding such long-term changes in urban forests ultimately requires long-term ecological studies (Lindenmayer et al., 2012). But long-term bird studies on bird diversity changes in urban green areas are still very rare in Central Europe; all of them that have been conducted are limited to urban parks, which are managed differently than urban forests. Thus, we focused on the case study of birds in a temperate Central European urban forest. This study is based on assessment of long-term data, over a 37-year period, by comparing the findings of a 1987 bird census and a 2023–24 bird census.

### Material and methods

The study area was the Michalov urban forest (13.73 ha) located in the town of Prerov, Czech Republic (49.4624400N, 17.4574767E). The forest habitat type is a Central European temperate lowland (210 m a. s. l.) hardwood floodplain forest, managed as urban forest with important recreational function.

In the 2023 and 2024 breeding seasons, a bird census was conducted in the study area using the line-transect counting method. The field data from the line-transect census was used to calculate the absolute counts and relative dominance (%) of bird species in the study area.

Data from the 2023–2024 census were compared to the findings of the 1987 census, which was conducted in the same area using the identical line-transect method. This comparison revealed changes in bird-species richness in the urban forest study area over a 37-year timespan (1987–2024). Sørensen's index (QS) was calculated based on the critical value of this index for Central Europe to analyze changes in the species diversity and Jaccard's index (Ja) to compare the faunistic similarity of bird communities in the study area between the compared years (1987 and 2023–2024). Data were statistically analysed using a standard t-test for two samples.

## Results

A total of 42 bird species were recorded during the 2023–2024 breeding season in the study area. There were six dominant species (with a dominance value > 5 %) in the urban forest's bird community: *Sturnus vulgaris*, *Parus major*, *Fringilla coelebs*, *Turdus merula*, *Phylloscopus collybita*, and *Columba palumbus*. This result was predictable in the study area, because all the dominant species are common in Central European green spaces in urbanized areas. The high availability of suitable nesting cavities in old trees in the study area for the first two dominant species and the generally high numbers of the other four dominant species in the cultural landscape clearly explain these results. The dominance of most species is typically low ( $\leq 5\%$ ), as is visible in the dominance distribution curve (Figure 1). The lack of significant breaks in the curve suggests a well-balanced distribution of dominance and species composition of the current bird community in the study area.

A statistical comparison of current bird-species richness (2023–2024) with the older bird-species richness recorded 37 years ago, using a t-test, did not indicate any statistically significant differences ( $P > 0.05$ ).

The bird-species richness in the study area increased; 36 bird species were recorded in 1987 and 42 species in 2023–2024 (Table 1). In 2023–2024, six bird species present in 1987 were not detected, whereas 14 bird species were identified that were not recorded in the earlier study. The results of the analysis of bird-community change in the study area over a 37-year period, based on the calculation of faunal similarity indices, are shown in detail in the Table 1. The Sørensen similarity index for species richness reached a value of  $QS = 74,44$ , which means a significant similarity between the species diversity of the compared bird communities in 1987 and 2023–2024. The calculated Jaccard's faunal similarity index (as a modification of the QS index) revealed a value of  $Ja = 59.2\%$ , confirming a similarity in bird- species richness in 1987 and 2023–2024.

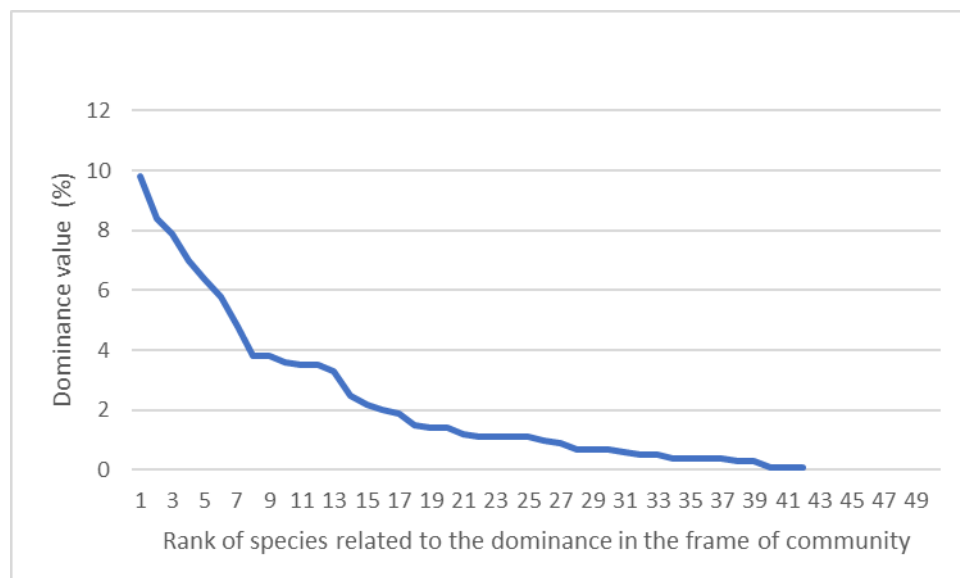


Fig. 1: Distribution of dominance values in the study area's bird community

Tab. 1: Changes in bird-species richness in the study area (from 1987 to 2023–2024)

Total number of bird species in 1987	Total number of bird species in 2024	Number of identical bird species in both years	QS index calculated as comparison of both years	Jaccard index (%) calculated as comparison of both years
36	42	29	74.4	59.2

## Discussion

The results of this study (in details see also Machar, 2025) are clearly limited by the methodology we chose to conduct the bird census. Line transect is not considered the best ornithological method for precise bird counting compared to territory mapping. Traditionally, the method for determining the species diversity of birds nesting in a specific location is the mapping of nesting territories combined with direct nest searching (Nielsen et al., 2014). However, as we aimed to compare recent results (from 2023–2024) with previously published data from 1987, we had to use the same method, that is, the line-transect method. On the other hand, line transect is an adequate method for determining bird abundance and dominance, which was the focus of our study.

The results of this study do not provide any information about long-term continuous changes in bird diversity, but only a comparison between two different period of time. Nonetheless, such long-term comparison is valuable because it offers basic insights into long-term trends in bird-species richness.

In the studied urban forest, bird species richness was higher in 2023–2024 (42 species) than in 1987 (36 species). The predominant species (with dominance  $\geq 5\%$ ) in 2023–2024 were common bird species, which are the most abundant bird species in urban areas in the Czech Republic (Reif et al., 2010). The species composition of urban bird communities usually refer to an urbanization level in the frame of urbanization gradients—for example, the most abundant species in more urbanized sites in neotropical cities is *Passer domesticus*, and urban parks in Eastern Europe are dominated by *Columba palumbus* and *Streptopelia decaocto* (Sakhvon et al., 2010); our findings confirm the latter.

The results of this study revealed that bird-species richness in the urban forest has been relatively stable (without significant changes) for over 37 years. The quantitative characteristics (abundance and dominance) of the urban bird species in the study area are highly similar to those of nesting bird communities in natural broadleaf lowland forests in the Morava River basin (Horak et al., 2013). This observation indicates that the human-made mosaic of habitats in urban forests may be as valuable in terms of bird biodiversity as semi-natural lowland forests.

Ornithologists have long been known that large urban green habitats, such as historic manor parks, are exceptionally valuable locations in terms of bird biodiversity within the cultural landscape. This fact has gained importance, especially in the context of the creation of the European Natura 2000 network of protected areas, where it has been shown that the biodiversity of Central European lowland broadleaf forests is strongly linked to the open structure of habitats similar to open “savanna-type” forests. Modern conservation efforts are therefore focused on finding methods for restoring and managing deciduous forests. Urban forests, with large areas resembling open forests with a high proportion of very large old solitary trees, can contribute to maintaining the biodiversity of species that were originally associated with historic forest management.

## Conclusion

The results of the study revealed that bird-species richness in an urban forest has been relatively stable (without significant changes) for over 37 years. It supports the emerging awareness of the high importance of urban forests as a key structure of urban green spaces for biodiversity maintenance in urbanized areas. If urbanization continues to progress at its current rate, the importance of urban forests as biodiversity refugees will increase.

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### Souhrn

Tato studie analyzovala dlouhodobé změny v druhové rozmanitosti ptáků v městském lese mírného středoevropského podnebí v časovém rozpětí 37 let. Ptačí společenstvo zkoumané v letech 2023–2024 bylo porovnáno se staršími terénními údaji z roku 1987. Vysoká lokální alfa diverzita ptačího společenstva i vysoká dlouhodobá stabilita druhové bohatosti ptáků naznačují význam studovaného městského lesa jako stabilního útočiště biodiverzity v dynamické urbanizované krajině. Městské lesy lze proto považovat za velmi stabilní útočiště biodiverzity v dynamicky se měnících městských oblastech. Výsledky této studie odhalily, že druhová bohatost ptáků v městském lese je již více než 37 let relativně stabilní (bez významných změn). Městské lesy jsou nejheterogennějšími biotopy v rámci městské zelené infrastruktury. Vysoká heterogenita biotopů velkých městských lesů vysvětluje skutečnost, že tyto biotopy, stejně jako městské parky, jsou hotspoty biodiverzity v urbanizovaných krajinách. To podporuje rostoucí povědomí o vysokém významu městských lesů jako klíčové struktury městských zelených ploch pro zachování biodiverzity v urbanizovaných oblastech. Pokud bude urbanizace pokračovat současným tempem, význam městských lesů jako útočišť biodiverzity poroste.

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