

The Role of Urban Green Spaces in the Context of Urbanization in Europe

Yuchen Cai^{1,*},
Ziwen Su²,
Tianyi Wang³ and
Ruoyu Zhang⁴

¹ Wuhan Britain-China School,
Wuhan, Hubei, China

² Beijing Academy, Beijing, China

³ Department of Biology, Faculty
of Arts and Science, Queen's
University, Kingston, Ontario,
Canada

⁴ Hefei Thomas School, Hefei,
Anhui, China

*Corresponding author:
caiyuchen1127@outlook.com

Abstract:

Rapid urbanization has led to serious landscape fragmentation problems in metropolitan areas. Urban Green Spaces (UGS), as a key carrier connecting fragmented wildlife habitats, are considered a core component of modern cities. Currently, most research has not yet focused on the European region, so exploring the role of urban green spaces in mitigating habitat loss and supporting wildlife conservation in this area is of great significance. This study focuses on birds as the core research object (as they account for the highest proportion of urban wildlife species in the region), and chooses urban parks as the research object (as they are the most common type of urban green space in European metropolises). The study searched for relevant literature in the past 5 years through Google Scholar, combined with keyword screening and literature comparison analysis, and concluded that larger urban parks usually support higher bird diversity, which is particularly beneficial for forest related specialized bird species; Parks with more complex vegetation structures or closer to natural states can increase the richness and probability of specialized species in bird functional groups, while parks with simplified habitat structures are more likely to attract urban adaptable birds; Human interference has a significant negative impact on the stability of sensitive bird species and bird communities. This study can fill the gap in existing research in the European region and further explore the functional value of urban green spaces as supplementary habitats in human communities and as ecological corridors in fragmented landscapes.

Keywords: Urban green spaces, habitat loss, wildlife conservation, urbanization, Europe.

1. Introduction

Over the past few decades, human activities have had

a widespread impact on most regions of the Earth. The global urban population continues to grow, with over half of the global population currently residing

in cities [1]. The rapid urbanization process has led to excessive exploitation of natural resources, putting wildlife in a crisis of survival, and the rate of species extinction continues to accelerate, reaching a peak in human history [2]. The habitats of countless animals are constantly shrinking. Taking mammals as an example, habitat fragmentation caused by urbanization has posed a serious threat to their survival [3]. Ecologists, environmentalists, and governments around the world are gradually paying attention to this issue and making significant efforts towards it. The voices and opinions supporting the construction of urban green spaces are increasing day by day, and governments around the world are implementing various policies to expand green space areas. Relevant research has also emerged in large numbers to explore this field in depth.

Existing research has explored the carrying capacity of urban infrastructure for wildlife and the impact of urban green spaces on environmental health, but there has been no specialized study on the role of urban green spaces in habitat conservation, especially in the European regional context [4,5]. European urbanization and urban green space planning have a long history, with high urban density, and existing research has not focused on a specific type of urban green space. This study will further explore how urban green spaces can serve as supplementary habitats in human communities and ecological corridors in fragmented landscapes, with urban parks chosen as the core research object. By reviewing and analyzing relevant literature on “improving the consistency of urban park microhabitats” and “reducing the impact of human activities on wildlife reproduction, feeding, and migration”, the ecological functions of urban parks are clarified, filling the existing research gap[4].

The reasons for choosing urban parks as research objects are as follows: firstly, urban parks are the most common type of green space in European metropolises and have wide accessibility in the region; Secondly, urban parks are the most significant type of urban green space influenced by human activities, which can more intuitively reflect the impact of human activities on wildlife. Therefore, taking urban parks as the research object is effective and representative. This study used Google Scholar to search for relevant literature on “Urban Green Space Function and Wildlife Conservation” in the past 10 years, combined with carefully selected keywords to determine important literature that can be cited. After integrating various information and data, comparative analysis was conducted to explore the mechanism of urban parks as supplementary habitats and ecological corridors in metropolises. The research aims to clarify the core characteristics of urban parks in supplementing habitat and ecological corridor

functions (i.e. promoting wildlife reproduction, feeding, and migration), while providing scientific recommendations for policy-making. The research is expected to deepen the understanding of why urban green spaces are indispensable in metropolises and enhance public awareness of the diverse functions of urban green spaces.

2. Core Exploration of Biodiversity Conservation and Management in Urban Informal Green Spaces

Using Central European cities as research carriers, this study systematically explores the ecological value and management path of informal green spaces in cities. Its core contribution lies in emphasizing the scientific understanding of such green spaces and the necessity of their integration in urban ecological planning, providing key theoretical support and practical references for the protection of urban biodiversity and the refined management of such green spaces. From the research background, as the core of regional economy and culture, the landscape pattern evolution of cities is accompanied by issues such as intensified habitat fragmentation and loss of natural habitats, which directly lead to the continuous decline of plant diversity. Urban informal green spaces include idle land, brownfield and other types, which have irreplaceable value in maintaining urban biodiversity and ecosystem services. However, systematic research on their vegetation dynamics and management strategies is still relatively scarce. Based on this situation, the development of related research has multiple necessities. On the one hand, the vegetation development cycle of informal green spaces in cities can last for decades, and there is an urgent need for long-term management guidelines; On the other hand, the differences in biodiversity of different types of informal green spaces in Central European cities are not yet clear, and the key factors affecting the biodiversity of such green spaces at local and landscape scales still need to be clarified[4].

In terms of research design, relevant studies selected a specific city as a typical area, with a green coverage rate of about 50%, of which informal green spaces that are unmanaged and support natural vegetation growth account for 10.97%. The study divided these green spaces into two main types of plots: one is an open habitat dominated by herbaceous vegetation, managed by selective removal of trees or shrubs every 3-5 years, and the other is a type dominated by woody vegetation without artificial management intervention. The data collection process lasted for many years, covering vegetation survey, soil physical and chemical analysis, and habitat continuity tracing based on

digital aerial images. Among them, vegetation survey also conducted follow-up visits in some years, with an average of 2 surveys per year; Soil physical and chemical analysis mainly measures pH value and heavy metal content. Statistical analysis uses multiple scientific methods to ensure the scientific and reliable nature of the results[4].

The core results of the study show that there are significant differences in vegetation community characteristics between the two types of urban informal green spaces. The type dominated by woody vegetation has a significantly higher coverage of trees and shrubs than the type dominated by herbaceous vegetation, while the coverage of the herbaceous layer is lower than the latter. In terms of species composition, the types dominated by herbaceous vegetation have a richer total number of species, while the types dominated by woody vegetation have a greater advantage in the enrichment of rare species and ancient forest species. From the perspective of community type classification, green spaces dominated by woody vegetation are dominated by forest species, while green spaces dominated by herbaceous vegetation are dominated by grassland species. It is worth noting that both types of green spaces have invasive species distribution, but their spatial stratification characteristics are different. In green spaces dominated by woody vegetation, invasive species have a higher proportion in the tree layer, while in green spaces dominated by herbaceous vegetation, invasive species are concentrated in the herbaceous layer. Further analysis reveals that the key factors affecting the vegetation characteristics of such green spaces include multiple aspects. Habitat continuity is positively correlated with the richness of forest species, rare species, and ancient species in green spaces dominated by woody vegetation, as well as the total number of species in green spaces dominated by herbaceous vegetation; Historical land use types can also have an impact, with built-up areas, gardens, or orchards having a higher proportion of invasive species due to residual seed banks; The coverage of surrounding vegetation has a promoting effect on the enrichment of forest species in green spaces dominated by woody vegetation, and is correlated with the degree of human interference in green spaces dominated by herbaceous vegetation[4].

In terms of management measures and research limitations, the analysis of management intervention effects shows that completely stopping manual management can help protect rare species and ancient forest species in green spaces dominated by woody vegetation, while selective management can enhance species diversity in green spaces dominated by herbaceous vegetation at different stages of succession. In addition, urban informal green spaces that have been undisturbed for a long time and are adjacent to forests have extremely high ecological

value for maintaining urban biodiversity. The landscape structure and surrounding environment have a significant impact on the vegetation quality of green spaces dominated by woody vegetation, and adjacent forest areas can significantly increase the number of forest species. Based on these findings, relevant research has proposed multiple management recommendations. The planning and management of informal green spaces in cities should be incorporated into the overall urban landscape planning to strengthen ecological connectivity; Implement low disturbance strategies for green spaces dominated by woody vegetation, and focus on preventing and controlling the spread of invasive species in green spaces dominated by herbaceous vegetation; Maintain the mosaic spatial structure of such green spaces and promote community diversity at different stages of succession; At the same time, promote citizen science projects to enhance public awareness and participation in the protection of such green spaces. However, this study also has certain limitations as it did not include samples of urban informal green spaces in the early stages of succession; The overall pollution level in the research area is relatively low, which limits the applicability of the results to high pollution cities; Only partially considering the biological and physical factors that affect vegetation development, without fully covering ecological processes; Moreover, there is a lack of precise quantitative data on the frequency and range of tree removal, making it difficult to support the design of refined management plans[4].

3. Ecological Value, Management Strategies and Practical Challenges of Green Infrastructure in Two Cities

Based on adaptive management methods, relevant research systematically explores the core role of urban green infrastructure in coordinating urban biodiversity conservation and sustainable development. A comprehensive conceptual framework integrating ecological principles, urban planning strategies, and adaptive management methods is constructed, emphasizing the multifunctionality, connectivity, and diversity principles of urban green infrastructure. Its ecological effectiveness is verified through global case studies, and its challenges and opportunities in practice are analyzed, providing clear guidance for future research directions[5].

In terms of the value of ecosystem services, research has clarified that urban green infrastructure can support sustainable urban development through various types of ecosystem services. At the service level, utilizing vegetation evapotranspiration and shading effects can alleviate

urban heat island effects, improve air quality, and regulate hydrological processes. At the service level, promoting local food production through urban agriculture and other forms can reduce the city's dependence on external food supply, while also providing basic resources such as water and energy. At the cultural service level, it can provide leisure and recreation, aesthetic experiences, and social interaction spaces for urban residents, directly improving their quality of life. At the service level, it can maintain the basic processes of the ecosystem, including protecting urban biodiversity, maintaining soil health, supporting agricultural productivity, etc., and provide basic guarantees for other ecosystem services.

Regarding adaptive management measures, multiple core contents have been proposed to form a closed-loop management system. In the monitoring and evaluation process, it is necessary to collect ecological performance data of urban green infrastructure sites through standardized procedures. After statistical analysis, the results should be fed back to stakeholders and integrated into an adaptive management framework to provide data support for strategy optimization and experience accumulation. The feedback and learning process should integrate monitoring data with stakeholder feedback, iteratively adjust management strategies, design transparent and inclusive feedback mechanisms, and promote multi-party collaboration and continuous learning. Flexibility and iterative processes require managers to have strategic adjustment flexibility to adapt to changes in the ecological and social environment. Through iterative planning, management experiments and innovations are carried out, while integrating stakeholder opinions and dynamically monitoring and tracking implementation progress. In the process of building collaborative relationships, it is necessary to integrate resources and professional knowledge from multiple parties such as government, research institutions, and communities, establish formal or informal collaborative alliances, promote multi-party dialogue and collective decision-making through collaborative governance structures, and ensure transparency and fairness in the management process.

In terms of practical challenges, the research system has systematically sorted out multiple core issues in the promotion of urban green infrastructure. Financial and resource constraints are one of the important challenges. Most cities find it difficult to allocate sufficient funds to related projects and face priority competition with other urban infrastructure projects. If the funding gap persists for a long time, the projects may degrade in function due to lack of maintenance, or even be put on hold midway, unable to achieve long-term ecological benefits. The problem of multi institutional collaboration is also prominent, with numerous departments involved in related manage-

ment and dispersed responsibilities, which can easily lead to confusion in decision-making and policy implementation, insufficient information sharing and regulatory coordination, and ultimately result in inefficient planning, resource waste and even a "management vacuum". The risk of social equity cannot be ignored. The construction of such infrastructure may exacerbate social disparities and lead to uneven access to green spaces. If the needs of vulnerable groups are ignored, it is easy to form a phenomenon of "green segregation", where the privileged class can enjoy high-quality green resources, while low-income communities and marginalized groups face a shortage of green spaces, further widening social inequality in areas such as health and education. The difference in technical expertise is also a practical problem. There are significant differences in the level of design and implementation of technical expertise among different cities around the world, which directly affects project quality. Some cities have not achieved expected ecological functions due to insufficient technical capabilities; In addition, the challenges brought by climate uncertainty also need to be addressed. The frequent occurrence of extreme weather events and changes in ecological conditions lead to a high degree of uncertainty in the demand for ecosystem services in future cities, which may exceed the design threshold of such infrastructure, causing a decline in its ecological functions and even secondary ecological risks[5].

4. Correlation Analysis between Physical Characteristics of European Urban Parks and Bird Diversity

This study first integrated data from multiple European cities, combined with bird surveys and park information based on geographic information systems (GIS) for analysis. The sources of bird data include standardized point counts and line survey data from institutions such as the European Bird Census Council, as well as data from citizen science platforms such as eBird and the Global Biodiversity Information Facility (GBIF), in order to expand spatial coverage. GIS data includes park boundaries, total area, proportion of canopy and shrub layers, and herbaceous layers, as well as indicators such as connectivity, distance from roads and buildings. The study evaluates impermeable surfaces and surrounding vegetation corridors through satellite imagery and urban maps. These data provide support for exploring the physical characteristics of parks and their association with bird diversity in urban contexts.

In the process of quantifying diversity, research reflects species richness and evenness by calculating Shannon

Index and Simpson Index, while obtaining information on species quantity and distribution uniformity. Subsequently, the study used generalized linear models (GLMs) or simple linear regression to analyze variable relationships, such as the association between park area and species richness, vegetation structure and functional group diversity; Simultaneously analyze landscape indices such as edge core ratio, patch connectivity, and surrounding green space density to clarify the spatial background impact of biodiversity. Finally, the study uses visualization tools such as heat maps, scatter plots, and box plots to clearly present and convey research patterns.

Regarding the core issue of the correlation between park area and bird diversity, the study proposes a hypothesis that larger parks (both overall and for specialized species that require more space or specific habitats) can support more bird species. The study compares the bird richness of parks of different areas and measures the proportion of core habitats in each park. If there is a significant positive correlation between park area and species richness, the hypothesis is valid. A study in Paris has observed this pattern, which recorded the bioacoustics of 37 urban green spaces and found that bird richness increases with the increase of park area, and the richness in the central area is usually higher than that in the edge area. This result confirms the view that “maintaining a sufficiently large and undisturbed habitat core area is crucial”[6].

Regarding the impact of vegetation structure on bird functional groups, a hypothesis has been proposed that parks with complex vegetation structures (including layered structures of trees, shrubs, and herbs) can support more diverse bird functional groups, while parks dominated by herbs or lawns with a single structure are more likely to attract a wide range of species. The study evaluates tree crown coverage, shrub density, and herbaceous coverage using GIS layers and remote sensing technology, and analyzes the correlation between these structural features and the richness of different functional groups such as insectivorous birds, cave nesting birds, and terrestrial feeding birds. Existing research [7]. A research have shown that parks with rich vegetation layers are more likely to support forest specific birds, while structurally simplified vegetation is more conducive to the survival of widely adapted species[8]. Although the Paris study emphasizes the role of area and central location, these structural studies still confirm the crucial value of vegetation complexity in shaping bird communities[6].

In response to the impact of human interference on sensitive birds, this study considers human interference factors, including pedestrian flow, surrounding roads, noise levels, park infrastructure, etc. It proposes a hypothesis that an increase in interference intensity will have a negative

impact on sensitive birds, leading to a shift in the community towards tolerant species. The study collected data on road and path density, noise levels, and tourist usage, and used statistical models to analyze the association between these variables and the presence or absence of sensitive birds. Although most bird studies focus on habitat characteristics, relevant research on Eurasian red squirrels in Japanese parks provides relevant references [9-11]. The study found that green space characteristics (such as tree density, leisure facilities) can affect squirrels’ behavioral response to humans, indicating that physical structure and human activities jointly affect wildlife responses, and this mechanism may also apply to birds.

To enhance the comprehensibility of research findings, the research plan aims to present them through clear and insightful visualizations. Heatmap is used to highlight the high and low distribution areas of bird diversity in urban parks; Scatter plot combined with regression lines and statistical markers to demonstrate the correlation between park area indicators and species richness; Box plot is used to compare the richness of various functional groups under different levels of vegetation complexity; The interactive graph presents the changes in the impact of tree crown coverage on specialized birds under different levels of human interference intensity. These visualization tools can help researchers and other audiences understand core patterns while avoiding getting caught up in technical details.

In summary, this study integrates bird diversity data and park characteristics from multiple European cities to explore three interrelated issues: whether larger parks support more species and specialized birds, whether complex vegetation structures promote functional group diversity, and how human interference affects sensitive species. The study combines empirical results to demonstrate the rationality of the analysis method[4,7]. Through model analysis and visualization, it aims to provide practical conclusions for optimizing park design and urban bird protection.

5. Conclusion

This paper demonstrates that city parks play an essential role in sustaining bird diversity within European urban areas, especially in landscapes that are heavily fragmented by urbanization. Our findings indicate that larger parks with more complex vegetation structures tend to support a wider variety of birds, like the forest-specialist species, whereas parks with simplified vegetation only attract generalist species. Human disturbance, such as traffic, noise and infrastructure, clearly reduces the presence of sensitive bird species, further highlighting the need for

constructing balanced management strategies of green spaces. These results suggest several practical recommendations for future constructions of city parks. Firstly, city park planners should prioritize the preservation and expansion of larger green spaces, as size strongly influences species richness. Secondly, the design of vegetation structure for city parks should aim for layered and diverse plant species, including grasslands, shrubs and trees in order to provide suitable habitats for different bird groups. Thirdly, cooperative strategies should also be designed to minimize human disturbance through methods like reducing noise, restricting areas with heavy traffic and creating designated quiet zones, which would benefit sensitive bird species. Incorporating these approaches into the layout of city parks would help them function not only as recreational areas for humans but also as ecological corridors that connect fragmented habitats for animals. At the same time, this research still has several limitations that could be improved. The results of our research relied mainly on secondary data from related articles, which may not fully capture the long-term ecological dynamics in city parks. Our focus on bird species may also exclude other important taxa that contribute to the biodiversity of urban green spaces as well. In addition, the differences in local management policies and cultural factors across European cities can affect the results in multiple ways. Future studies should therefore include long-term monitoring processes that capture seasonal variations in observed environments, extend the research scope beyond bird species to other animal or plant groups, and consider more comprehensive analyses of how social and cultural factors may affect functions of city parks and levels of human disturbance to animals. To sum up, urban green spaces—notably city parks—are not just public stages for people but are also vital for maintaining ecological balance among increasingly urbanized landscapes. With careful planning, cultivated vegetation diversity and thoughtful management, European cities will be able to ensure that city parks continue to serve as comfortable living habitats for birds while meeting the social and cultural needs of human residents.

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