論 文 の 内 容 の 要 旨

論文題目 Evaluation of urban green space in developing Beijing:
based on the matrix of landscape connectivity and bird communities
（景観連結性と鳥類群衆状態とのマトリックス解析による開発下北京市の
都市緑地評価）

氏　名　　郭 詩怡

Urbanization has been regarded as the main reason for habitat fragmentation and biodiversity loss. Particularly in urbanized areas, urban green space plays an important role in biodiversity conservation. With the increase in human population and land cover change, the evaluation of urban green space is an essential step in landscape planning, which should be conducted based on a deep understanding of the impact of urbanization.

Previous studies have paid considerable attention to the evaluation of urban green space from the perspective of landscape pattern: for instance, landscape connectivity. Green spaces with high connectivity are often considered to provide better conditions for species migration and gene exchange, which contributes to biodiversity conservation. Landscape connectivity has been widely used as an indicator to evaluate the capacity of green space to support biodiversity, referred to as ecological efficiency in this study.

An increasing number of studies have argued that ecological processes should be involved in the evaluation of green space: for example, considering the fact that different species respond to environmental changes at different scales. However, the methods of applying ecological and biological knowledge to the evaluation of green space needs to be explored further. Several studies have modeled the evaluation of green space from the point of view of focal species; however, there are still some limitations to the existing research. First, studies using empirical data of species census in the evaluation of urban green space are limited because the acquisition of empirical data is time-consuming and laborious. Second, long-term observation is necessary to identify the mechanism by which environmental changes resulting from urbanization affect biodiversity. However, most studies use various spaces instead of time to measure the effects of urbanization. Third, since environmental factors in a complex ecosystem vary and interact with each other, multiple spatial scales should be considered in quantifying the response of species to

environmental changes.

To fill these gaps in the research, this study attempts to evaluate the green spaces of Beijing, which has been undergoing rapid development and urbanization for decades, by examining species response to environmental changes at multiple spatial scales. The objectives of this study are: 1) to test the advantages and necessity of introducing species in evaluating ecological efficiency of urban green spaces, compared with the widely used landscape connectivity assessment; 2) to explore the variations in bird abundance, richness, and diversity as a function of environmental changes resulting from rapid urbanization at both local and landscape levels; and 3) to identify influential environmental variables that can best account for the variations in bird communities at multiple scales based on long-term observation.

Chapter 1 introduces the academic background, existing research on the effects of urbanization, evaluation of urban green spaces, and the response of bird communities to environmental changes. The literature review revealed some research gaps, and the aims and objectives of this research were defined based on these gaps.

Chapter 2 describes the current situation of urbanization and biodiversity conservation in Beijing and the current green space planning concerning ecological conservation in China. In addition, land cover was interpreted from remote sensing images of Beijing in 1995, 2000, 2005, 2010, and 2015 and the results were used to demonstrate the process of land cover change.

Chapter 3 proposes a multi-species approach synthesizing biological traits of two focal species (i.e., *Nyctereutes procyonoides* and *Phasianus colchicus*) to evaluate urban green spaces in Haidian District, Beijing. Specifically, the range of green space for analyses and the distance threshold of landscape connectivity were defined by the habitat type and dispersal ability of each species, respectively. Finally, the most important green space cores and corridors for each species were identified and overlaid to obtain a final evaluation of urban green spaces. The results supported the hypothesis that the evaluation of urban green space should involve specific species and their biological characteristics to achieve a functional evaluation, not just a structural one.

Chapter 4 presents a case study using riparian areas of the Tsing River to clarify the responses of bird communities to environmental variables at both local and landscape scales along the river. Bird surveys were conducted from May 2016 to April 2017 once a month along 18 transect lines, while local habitat characteristics (i.e., vegetation structure and human disturbance) were collected from field surveys conducted in September 2018. In addition, the surrounding land cover and landscape connectivity were extracted and calculated from Gaofen-2 remote sensing images. Finally, a redundancy analysis was applied to identify important environmental variables that significantly affect the biodiversity of bird communities in urban riparian areas. Results showed that local variables tend to have a more significant effect on bird communities, especially the coverage of grassland and the number of pedestrians passing by.

Conversely, Chapter 5 explores a general linear mixed model that synthesized long-term responses of bird communities to environmental changes resulting from urbanization in central Beijing. First, long-term bird observation data were obtained from the China Bird Report, a citizen science database, where observers can upload and share bird observation information. Second, historical land cover changes from 2005 to 2015 surrounding each observation site were interpreted from remote sensing images, with the surrounding areas defined by multiple buffers (500 m, 1000 m, 3000 m, and 5000 m). Third, a generalized linear mixed model was built to examine the responses of bird communities to environmental changes at multiple spatial scales, including land cover change and landscape pattern change. Finally, the model was used to evaluate urban green spaces from the point of view of birds. Urban green spaces were assessed from the perspective of landscape connectivity and bird communities using the 2015 data. To highlight the advantages of using birds as indicators for urban green space assessment, the two methods of evaluation were compared by building a matrix.

Chapter 6 presents the conclusions. First, influential environmental variables affecting the biodiversity of bird communities are summarized and discussed in comparison with previous studies. Second, suggestions are put forward for future urban green space planning. Moreover, the literature contribution, limitations, and prospects for future research are clarified to obtain a comprehensive understanding of this study.

This study optimized the existing approach of urban green space evaluation by including empirical data of species living in urban areas. Compared with the traditional landscape pattern analysis, this approach provides a more detailed ecological conservation function for urban green spaces. The results suggest that it is necessary to include species information in the evaluation of urban green spaces, as well as their biological characteristics, such as residential type, diet, home range, and dispersal ability. In addition, the influential variables were identified at both the local and landscape scales. In the case of local biodiversity conservation, field and species surveys are needed to clarify the effects of environmental changes. In terms of biodiversity conservation at the regional level, long-term species census data and remote sensing data will contribute to a comprehensive understanding of the impact mechanism of urbanization on species, which may contribute to more environmentally friendly urban planning in the future.