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Urban ecological corridors construction: A review

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ABSTRACT

An ecological corridor, with both ecological and cultural functions, is a symbol of urban ecological or green civilization, and has therefore become one of the major topics in the fields of landscape ecology, urban ecology, and ecological planning. On the one hand, along with the prominent contradiction between regional ecological protection and economic development, as well as between the growing ecological demands of urban residents and the destruction of natural ecosystems, the construction of urban ecological corridors is very challenging. On the other hand, with contemporary urbanization and ecological civilization development, the standards and requirements for the construction of urban ecological corridors are set higher and higher. Constructing an urban ecological corridor is therefore particularly important, and must adopt a spatial approach that balances the relationship between ecological protection and economic development. In this study, the classification of urban ecological corridors was firstly conducted according to the structural or functional differences. Secondly, research progress on the construction of urban ecological corridors was systematically summarized and the main inadequacies were indicated. Following the analysis of the main methods employed in the construction of urban ecological corridors, existing methods were classified into three kinds, i.e. qualitative analysis, quantitative analysis, and spatial analysis. In addition, the advantages and disadvantages of the methods of subjective judgment, suitability and sensitivity analysis, network analysis, and minimum cost path analysis were compared. To provide theoretical support for the construction and management of urban ecological corridors, four key research directions were also pointed out, i.e. the identification of key nodes of urban ecological corridor, the determination of the width of urban ecological corridor, the measurement of integrated effect of urban ecological corridor, and the multi-scale integration of urban ecological corridor. The present study will aid in accelerating and improving the process of ecological corridors construction in China's new-type urbanization.

1. Introduction

As an inherent part of urban ecological security patterns, urban ecological corridor plays an important role in promoting the variety natural flows and resisting negative effects of human activity, especially in guarding against the unidirectional diffusion of human influences. At the same times, urban ecological corridor meets the needs of urban residents towards the recreation and ecological green living open space. Ecological corridor has the heterogeneity characteristic when compared to the surrounding landscape. Urban ecological corridor refers to a linear or ribbon ecological landscape, which has the functions of natural habitat, green open space or human habitat isolation in the artificial eco-environment of the city or urban area [1–2]. In recent years, in the context of China's rapid urbanization and regional integration, urban ecological corridor plays a vital role, especially for transportation green corridors, and green belts in city or intercity, which can not only accelerate regional natural species flow, but also effectively isolate or filter environmental pollutions. As a result, ecological corridor has become an essential part of ecological construction in urban agglomeration.

Urban ecological corridor has the basic characteristics of the ecological corridor, and it is also a symbol of urban ecological or green civilization. Thus, it has been a hot topic in the field of landscape ecology, urban ecology, and ecological planning in a long time. However, on the one hand, there is a sharp increase in the demand for urban construction land in the background of China's rapid urbanization. On the other hand, urban ecological corridor has the unique advantages compared to other non-construction land, such as lower re-development cost, relatively complete transportation facilities, while at the same time, there is a lack of strict control measures in the planning and management of urban ecological corridor. Hence, in the driving of maximum economic benefits, urban ecological corridor can be easily transformed into construction land [3]. Faced with the contradiction between the economic development and ecological protection, and the outbreak of urban

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environmental problems and the increasing human ecological demands, the effective construction and management of urban ecological corridor becomes a possible way to resolve this contradiction. Therefore, in this study, a comparison of ecological corridor and related concepts was conducted, with the classification of urban ecological corridor from the structural and functional perspectives, respectively. Then, a brief history of urban ecological corridor construction in China and the world was summarized. It was also focused on comparing the advantages and disadvantages of the main construction methods. Finally, based on the inadequacies of the current research, key research directions for the future were discussed, in order to effectively promote the scientific construction and effective management of urban ecological corridor in the process of rapid urbanization.

2. Concept of urban ecological corridor

Currently, the concepts related to ecological corridor include greenway, green belt, green corridor, ecological network, habitat network and ecological infrastructure. The comparative analysis of the connotation, origin, focus and main application areas of those concepts, can make great contribution to a better understanding of the conceptual connotation and denotation of ecological corridor (Table 1): (1) Greenway. Its first thought can date back to the Boston Park System in the 1860s, which refers to the channel for local residents to be close to the nature originally. It sets off a worldwide craze of greenways movement since the 1990s when the term of greenway was officially recognized by President's Commission on Americans Outdoor [4]. The most representative definition of the greenway in all the understandings is Ahern's, who pointed out that the greenway is the land network system which is consisted of linear elements, designed to achieve a variety of utilizations with ecological, cultural, recreational, aesthetic and other functions [5]; (2) Greenbelt. This concept was first proposed in the 1600s by the William Petty, but it attracted wide attention in 1898 when Howard proposed the concept of garden city [6]. Greenbelt is a green open space outside the city established for dividing urban and rural areas, focusing on the function of playing its suppression on urban sprawl and providing recreational areas for residents [7]; (3) Ecological network and habitat network. Sourced from biological protection field, both concepts are defined as a network-like landscape which is consisted of eco-nodes or eco-core areas, ecological corridors, buffer zones and other nature reserve areas [8]. Constructing the regional ecological networks to enhance the connectivity of natural habitats, is considered to be an effective way to protect wildlife habitats and biodiversity, and a basic skeleton to maintain the regional ecological security system [9]; (4) Ecological infrastructure. This concept was firstly released in urban ecological planning report of Man and Biosphere Programme (MAB) in 1984 [10]. It refers to the resource allocation network system which includes supporting points, lines, surface and networks supporting for human system operation and durable survival. The concept of ecological infrastructure stresses the priority to protection and aims to maintain the important ecological resources and critical ecosystem structure [11], so as to keep sustainable provision of regional ecosystem services with guaranteed ecological security; (5) Ecological corridor. It is a kind of ecological landscape with the line or strip configuration with the integrated ecological, social, cultural and other functions. Ecological corridor was originally proposed to connect isolated habitats of wild animals by establishing migration corridors, so as to achieve the purpose of wildlife protection. International Union for the Conservation of Nature (IUCN) in 1980 applied the concept of ecological corridor to global conservation strategy [12]. From then on, the ecological corridor began to change from the sole function of natural habitat to multi-function direction. Furthermore, green corridor and ecological corridor, particularly close to each other, are not clearly distinguished in the current academic research and practical applications in China.

In summary, it is not difficult to find that the development of related concepts of ecological corridors essentially reflects the change of different human needs. For example, the construction of urban green space system in China initially only focused on the construction of individual parks and green belts. However, along with the rapid development of urban expansion, biodiversity loss and landscape fragmentation, the constructions of small-scale neighborhood greenways and greenbelt have not met the real needs. It is necessary to focus on urban ecological corridor at a larger-scale of urban and rural space level, and its ecological, social, cultural and other features began to be widespread concerned [13]. The habitat/ecological networks, are proposed when ecological function of a single point-like or linear natural habitat highly degraded due to the habitat fragmentation, and it is urgent to realize the integration of ecological function by means of the connection in space. In the framework of this network, important point and line elements are defined as ecological nodes and ecological corridors respectively, and especially the latter has become an important component to deal with fragmentation, and to significantly enhance the connectivity of the network. The connotation of ecological infrastructure is consistent with ecological network, but it emphasizes more on the initiative and antecedence of ecological construction. In the construction of ecological infrastructure, the ecological corridor is also an important indispensable component.

3. Classification of urban ecological corridors

There are diverse classifications of urban ecological corridor because of its complexity in the structure and function. At the same time, accurately identifying and classifying the type of urban ecological corridor can be a great help for its scientific management. At present, with the continuous connotation extending of urban ecological corridor, a variety of urban ecological corridor classification systems have been proposed, but in essence all are classified according to the structure or function of urban ecological corridor.

Table 1
The contrast of ecological corridor and related concepts.

Concept	Connotation	Source	Focus	Application
Greenway	The linear landscape owning multiple functions such as ecological, cultural, recreational and aesthetic functions	1860s Boston Park System	Landscape recreational, aesthetic function and spatial pattern optimization	Landscape planning
Green belt	Green open space set up in urban peripheral, used for urban and rural segmentation	1890s Garden City	Urban boundary and sprawl, and recreation function	Urban planning
Ecological corridor	Linear or strip landscape with the ecological, social, cultural and other functions	1980 IUCN	Ecological, recreational and aesthetic function, and urban growth boundary control	Natural protection and ecological planning
Habitat/ecological network	Reticular landscape consisting of ecological node, corridor, buffer and nature reserve area	1980s Europe	Biodiversity and conservation	Ecological planning
Ecological infrastructure	Reticular landscape or open space with basic ecosystem services consisting of point, line, and surface	1984 MAB	Conservation and ecosystem services provision	Ecological planning