Research progress of urban green space systems evaluation in China

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Abstract. Since the founding of the People's Republic of China 70 years ago, the theory of urban green space system planning have been evolving along with the urbanization process. At the same time, it also draws nutrients from the planning thoughts of western developed countries. Under the background of ecological civilization construction, urban green space is more affected by the attention of the government and the public, urban green space system planning is the overall distribution of green space resources, reasonable construction of the important means of urban ecological environment, but the study of urban green space system planning evaluation has not yet been thoroughly. Urban green space system planning in China based on the development process and the landscape architecture of self-perfection for context, from the connotation of urban green space system planning evaluation, three aspects of theory and practice, combing summing up China's urban green space system planning evaluation.

1. Research background
Throughout the development process of urban green space construction at home and abroad, urban green space system planning has become an important means to make rational allocation and overall arrangement of urban green space resources. People gradually began to summarize and review the effects produced after the implementation of the urban green space system planning. China's urban planning has gradually transitioned from the incremental planning stage to the reduction planning and stock planning stage [1]. Many large and medium-sized cities have also begun to review and reflect on the development of the city. Land use planning and urban planning implementation evaluation has been nationwide widely carried out [2-3], however, research on urban green space system planning assessment has not yet begun. This paper takes the major changes in China's social history and economic development as the context, and summarizes the evaluation of China's urban green space system planning and evaluation.

2. Development stage of urban green space system evaluation
Since the founding of New China, major changes have taken place in the international environment. The domestic social and economic structure has undergone many adjustments, which will inevitably affect the development of urban landscaping and landscape architecture. The urban green space system planning evaluation standard is gradually improved with the different stages of urban development. From the attention to the “quantity” of urban green space to the evaluation of “quality”, the measurement indicators are gradually improved. Overall, China's urban green space system planning and evaluation has experienced a development process from scratch, from quantity to quality and increasingly diversified, and can generally be summarized into the following three stages.
2.1. Phase 1: Formation Phase (1949-1976):
At the beginning of the founding of New China, the domestic environment was relatively closed. The construction of urban green space mainly draws on the experience of the Soviet Union and pays attention to the recreation function of urban green space. During the Great Leap Forward Movement, the Central Committee of the Communist Party of China proposed policies such as “land-based gardening” and “greening combined with production” [4].

In many cities, there has been a climax of production-oriented greening. Some relatively developed cities in China have proposed the concept of urban green space system. The green space system structure of domestic cities is still not perfect, and the state has not proposed urban green space system planning indicators. In terms of subject construction and education of landscape architecture, only a few colleges and universities recruited 1 or 2 years of specialized talents in landscape plant and landscape planning and design around 1960. Before the reform and opening up, the development of landscape architecture education in China is not widespread, and the development of professional education is slow [5].

2.2. Phase 2: Quantitative Evaluation Phase (1976-1993):
At this stage, the international environment and China's foreign policy have undergone great changes, and reform and opening up have promoted academic exchanges with foreign countries. The influence of international landscape ecology thoughts is evident, and domestic scholars began to study the ecological value of urban green space from the perspective of landscape ecology [5]. At the same time, a large number of landscape architecture professionals were trained in China.

By the end of 1990, 21 colleges and universities had established undergraduate education [6]. In terms of national administrative regulations, the State Urban Construction Bureau's Opinions on Strengthening Urban Greening in 1976 first proposed the requirements for urban public green space construction. The Interim Regulations on Urban Landscaping implemented in 1982 proposed that the conditional urban green coverage rate will reach more than 30%, and the per capita public green area will reach 3-5m²/person. The "Regulations on Urban Greening Planning and Construction Indicators" implemented in 1993 put forward higher requirements for various indicators of urban greening.

2.3. Phase 3: Comprehensive Evaluation Phase (1993-present)
With the deepening of reform and opening up, the construction of landscape architecture and professional education have been vigorously developed. As of 2006, the number of colleges, independent colleges and research institutes enrolled in landscape architecture has reached 449 [7]. In 2011, the landscape architecture discipline was upgraded to a first-level discipline, and together with architecture and urban-rural planning, it formed the discipline system of human settlement environment construction in China.

The urban green space construction is improving day by day, and the government and academic circles have also begun to respond to the urban green space system planning evaluation from various angles: the urban green space system evaluation gradually transitions from ecological benefit, landscape pattern, planning factor single factor evaluation to comprehensive evaluation of green space system. The evaluation subject has expanded from limited to landscape architecture practitioners to related professional researchers such as tourism planning, geographic, and remote sensing. In the same period, in order to improve the management level of urban greening construction, the Ministry of Housing and Urban-Rural Development launched a garden city selection campaign, which set off the climax of urban landscaping construction. The Ministry of Housing and Urban-Rural Development has successively formulated and promulgated garden city standards and ecological garden city standards, and in 2016 formed the “National Garden City Series Standards” covering cities, counties and towns in China. In order to establish a scientific system for urban landscaping evaluation and further guide the healthy and steady development of urban greening in China, in 2010, the Ministry of Housing and Urban-Rural Development issued the first nationally applicable “Urban Landscaping Evaluation Standard” (GB/T563-2010). This standard has created a precedent for the formulation of
comprehensive evaluation standards for urban landscaping by government departments in China, and has urged the construction of urban green space in China to shift from the demand for quantity to the quality and efficiency of greening.

3. Theory and Practice of Urban Green Space System Evaluation

3.1. Evaluation area

In the China Knowledge Network full-text database, three phrases are used to search for “green space evaluation”, “green space system evaluation” and “green space system planning evaluation”. The literature search results show that 643 papers were searched for by "Greenland + Evaluation", and 117 articles were searched for by "Greenland System + Evaluation", and 32 articles were searched for by "Greenland System Planning + Evaluation". It can be seen from the number of documents that in addition to the “green space evaluation”, the number of other two related terms is not much, and the research intensity is lacking. According to the seven regions of China's traditional geography (Northeast China, North China, East China, Central China, South China, Northwest China, Southwest China), the publication years and research area distribution of urban green space system evaluation from 1998 to 2018 are shown in Figure 1.

As shown in the graph, in 2003, 2010 and 2015, domestic scholars' research on urban green space system evaluation is a hot year. The number of urban green space system evaluation documents in East China is 2.4 times of the regional average, which is a hot spot for research.

3.2. Evaluation method

In the practice of landscape architecture, statistical analysis is commonly used to analyze some random phenomena and the spatial features of landscapes are often described by landscape indices. The analysis of landscape processes is often performed by artificial neural network method and cellular automata model [8-10]. When conducting urban green space system evaluation, the impact factor of the evaluation object is usually selected to establish an evaluation index system, and then the evaluation indicators are quantified through corresponding mathematical methods. Through the analysis of the evaluation methods of the relevant documents of urban green space system planning and evaluation, it is found that the commonly used evaluation methods are analytic hierarchy process and fuzzy comprehensive evaluation, and some scholars try to apply the human neural network and coordination degree model to urban green space system evaluation [11-13] (Table.1). At present, researchers recognize the insufficiency of a single evaluation method, and combine the method of analytic hierarchy process with fuzzy comprehensive evaluation (FAHP) into a trend [14].
Tab1. General methods of landscape evaluation \[15-18\]

| NO | Presenter  | Country | Time | Evaluation method | Main limitations                                      |
|----|------------|---------|------|-------------------|-------------------------------------------------------|
| 1  | T.L. Sasy  | USA     | 1970 | AHP               | The selection of indicators is subjective, and there is a certain error in weight assignment. |
| 2  | Zadeh      | USA     | 1965 | FCE               | Threshold setting has certain subjectivity            |
| 3  | Rumelhart  | USA     | 1986 | ANN               | The learning memory of the network is unstable and the learning rate is fixed. |
| 4  | Hermann Haken | Germany | 1971 | CSC               | Order parameter selection and order parameter component assignment have certain subjectivity |

3.3. Evaluation indicators

At present, urban green space system evaluation mainly constructs evaluation system from several aspects such as planning index, ecological benefit and ecological landscape pattern. Urban green space planning indicators and ecological benefit indicators are used as evaluation criteria, focusing on the quantitative analysis of evaluation indicators, but the evaluation of the internal layout structure of urban green space system is absent. The landscape pattern analysis method based on landscape ecology mainly obtains the urban green space information database by means of GIS/RS, and uses the Fragstats software to calculate the landscape pattern evaluation index, which makes the green space system evaluation process too pattern, and the ecological significance of the evaluation results cannot be comprehensively reflect the social and economic benefits of urban green space.

In the Chinese Knowledge Network full-text database, the author retrieves the research literature of urban green space system planning evaluation and uses the software to analyze the word frequency statistics of these documents, and obtains the word frequency map based on the visualization of the obtained 79 evaluation indicators. At present, China's urban green space system evaluation indicators can be summarized into five aspects: planning quantity index, ecological benefit index, social benefit index, economic benefit index and landscape pattern index. The statistics show the hot word frequency of urban green space system evaluation indicators, among which green space rate, green coverage rate and landscape diversity occur most frequently. In addition, landscape dominance, landscape fragmentation, greenland connectivity, water conservation, dust retention, landscape diversity, and production green space have also appeared at a higher frequency.

3.3.1. Planning indicators

In order to speed up the construction of urban green space and improve the level of urban landscaping, the Ministry of Housing and Urban-Rural Development has issued a series of standards and norms since the reform and opening up. These standards have become an important basis for urban green space system planning. In 1979, the State Administration of Urban Construction forwarded the "Opinions on Strengthening Urban Landscaping Work". For the first time, the "Green Coverage Rate" indicator was used to measure the level of urban greening construction, and the indicators greening rate and per capita green area were derived. In the past 40 years, China has been using these three indicators as the basis for urban green space system evaluation. These planning indicators have made the urban landscaping construction quantified and promoted the horizontal comparison between cities. As of 2018, among the 668 cities in China, there are 356 national garden cities, accounting for 53.29%, and 11 national ecological garden cities, accounting for 1.65% \[19\].

With the application of 3S technology in the field of landscape architecture, indicators such as green space rate, green coverage rate and per capita public green area are easily obtained \[20-23\], which continues the influence of these three planning indicators in urban green space system evaluation. However, the planning indicators of the urban green space system evaluation only reflect the "quantity" of the urban green space system, and cannot reflect the "quality" of the urban green space system, and have certain one-sidedness.
3.3.2. Ecological benefit indicators

The ecological benefit evaluation of urban green space is quantitatively analyzed from the perspective of improving urban ecological environment, and plays a role in the improvement of urban green space in purifying air, improving microclimate, reducing noise and maintaining water and soil.

In the 1980s, Chen Zixin [24] and other scholars proved through experiments that green plants and reasonable green space layout can effectively regulate urban temperature and humidity, which has caused people to pay attention to the ecological benefits of green space. Later, people conducted extensive practice research on the dust-retaining benefits, oxygen-release and carbon sequestration, heat island effect, and temperature-humidity impact factors of different cities and different types of green spaces. In 2003, Yan Xiao [25] and others selected different levels of evaluation indicators from the two aspects of green space structure and function, and proposed an evaluation index system for urban green space ecological benefits, which promoted the evaluation of ecological benefits of urban green space to comprehensive evaluation. For the first time, Li Manchun and others applied GIS/RS technology to urban ecological benefit evaluation and prediction models [26]. In recent years, Beijing, Shanghai, Shenyang and other places have used remote sensing technology, three-dimensional laser scanning anchors and low-altitude aircraft to do a lot of research work around three-dimensional green volume measurement [27].

The ecological evaluation of urban green space system based on the ecological benefits of green space and the quantitative measurement of green space makes people more intuitively recognize the value of urban green space to improve and enhance the urban ecological environment [28-29], and provides a reference for the country to formulate urban green space planning indicators.

3.3.3. Landscape pattern indicators

The landscape ecology theory was proposed by the German geographer Troll in 1939, and subsequently had a wide and far-reaching impact on the landscape architecture discipline. The most widely used theory in landscape ecological analysis is the “plaque-corridor-matrix” model proposed by Forman and Goldman. The landscape ecology theory was mainly applied to the regional landscape ecological analysis under the macro scale in the early stage [30]. The landscape ecology research in China began in the 1980s.

In general, the evaluation of urban green space landscape pattern from static analysis to dynamic research, from macroscopic scale to mesoscale, from current situation analysis to spatial optimization. The evaluation of urban green space landscape pattern is supported by landscape ecology, focusing on the analysis of the ecological safety of urban green space system. The evaluation indicators are mainly indicators reflecting green plaque and landscape characteristics. The development and extensive research of landscape ecology theory has made people have a more systematic understanding of the structure, layout and function of urban green space system, which has greatly promoted the development of landscape architecture and the enrichment of connotation.

Urban green space is a composite system involving multiple factors. The evaluation index system can be roughly divided into four aspects: urban green space planning index evaluation, urban green space system ecological benefit evaluation, urban green space system landscape pattern evaluation and urban green space system comprehensive evaluation. The comprehensive evaluation of urban green space system can reflect the connotation and extension of urban green space value. At present, research on the implementation evaluation of urban green space system planning has been carried out [31], which has gradually become a hot spot of research.

4. Conclusions and prospects

In China, urban green space system planning is a special plan under the overall urban planning, and also the core carrier of urban artificial ecological environment. Urban green space accounts for about one-third of the urban construction land area, and urban green space construction is becoming an important part of ecological civilization construction. Due to various social, political and economic factors, it is difficult to strictly implement urban green space system planning, and the legal effect
documents for ensuring the implementation of urban green space system planning are also weak. At present, the research on urban green space system evaluation mainly stays at the level of current status evaluation. The research work on urban green space system planning and implementation evaluation needs to be carried out urgently. The monitoring and evaluation mechanism has yet to be promoted by the government from the legislative level.

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