Optimization of Urban Green Space Landscape Pattern and 3D Numerical Simulation

Honglei Wang[1], Zhihong Wang[2*]

wxt0819@163.com[*]

[1]Jinan Landscape and Forestry Science Research Institute, Jinan, China
[2]Shandong Agriculture and Engineering University, Jinan, China

Abstract: In order to maintain the urban ecological function, improve the urban ecological environment and realize the sustainable development of the city, this paper puts forward an optimization scheme for the landscape pattern of urban green space, and carries out three-dimensional numerical simulation. On the basis of considering the types of urban residential land and the spatial distribution of population, based on QuickBird satellite remote sensing data and GIS spatial analysis technology, this study quantitatively characterized and simulated the optimal pattern of green space in the study area by using the population weight model, and quantitatively analyzed and evaluated the optimal results of green space pattern by combining buffer analysis method. In the optimized scheme, the population of urban park green space increased by 104.7% when the area of urban park green space increased by 39.9%. It can be seen that through optimization, a smaller green space area can be used to bring into play a larger green space benefit.

Keywords: urban green space; Optimization of landscape pattern; Three-dimensional numerical simulation

1 INTRODUCTION

Landscape pattern analysis is a classic method to analyze the spatial and temporal changes of urban landscape and understand the interaction between urban regional pattern and process. In the past few decades, with the rise of remote sensing technology, the landscape pattern analysis developed by two-dimensional landscape has become more and more perfect [1]. As a complex of urban artificial landscape, in the process of rapid urbanization, the relationship between urban spatial structure and organization is rapidly developing towards three-dimensional. The architecture landscape is significantly higher than the green landscape, which has a significant impact on the pattern and functional characteristics of the urban landscape, as shown in Figure 1. The three-dimensional landscape features and the three-dimensional networking of landscape functions have changed the ecological characteristics of three-dimensional urban landscape. To understand the relationship between urban landscape structure and function, it is necessary to break through the traditional planar mosaic pattern of two-dimensional landscape space and increase the analysis of vertical elevation landscape pattern, so as to effectively understand the ecological characteristics of three-dimensional urban landscape. With the improvement of three-dimensional spatial information acquisition technology, the ecological characteristics of urban three-dimensional landscape are paid attention to. The analysis of three-dimensional landscape

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pattern and its changing characteristics has become a hot issue in the current landscape pattern research, and it is also a hot point to deepen the measurement of urban landscape pattern[2].

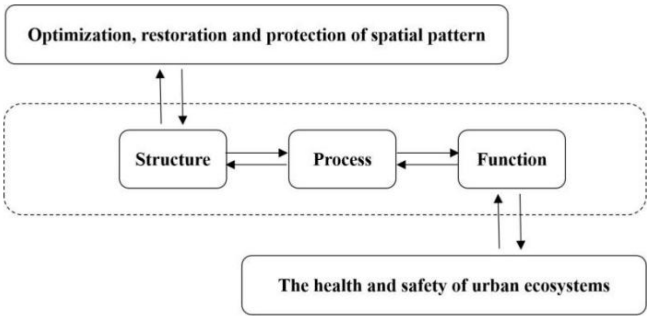

Figure 1. Landscape pattern of urban green space.

2 METHODS

The main task of landscape pattern optimization is to determine the location and area of newly added parks. The per capita park green space index and the population number of each plot are calculated, and the location is determined by the population center of gravity calculation[3]. The per capita park green space index refers to the current urban greening planning and construction index regulations and garden city standards, and the per capita park green space standard of 6 m2, and counts the population of each plot separately. Green space area is calculated by the following formula:

$$Agl = Np \bullet Aglm \tag{1}$$

In the formula, Agl -- the green area of the park (m^2); $Aglm$ -- Per capita park green area (m^2 person-1); N_p --Population (person).

Considering the economic principle of green space construction, the construction of new green space will not be considered for the time being in areas with small population[4]. According to the standard of park green space area of 6 m2 per capita, according to the park area of 2.5, 10 hm2 and 20hm2, the population of each plot should be counted separately, as shown in Table 1.

Table 1. Estimation of population based on park green space area.

Park area per capita/(m^2 person -1)	Park area/hm^2	Population/person
6	20	33333
6	10	16667
6	5	8333
6	2	3333

The plots with population of 3,333 ~ 8,333, 8,333 ~ 16,667, 16,667 ~ 33,333 and > 3,333 were selected as the plots to be optimized to increase the green area by 2, 5, 10 hm^2 and 20 hm^2. Considering that the park green space has a certain radius, the actual service area may exceed the plot area[5]. Therefore, the lower limit of park green space area is adopted in the determination of park area, that is, the planned new park area is 2hm^2 with a population of more than 3,333 and less than 8,333, and the planned new park area is 5hm^2 with a population of more than 8,333 and less than 16,667, and so on. The circle is used to approximate the shape of the park. According to the park area of 2, 5, 10 hm^2 and 20 hm^2, the park radius is calculated, and the park radius is determined to be 80, 126, 178m and 252 m respectively[6].

The concept of population center of gravity can indicate the general trend or central location of regional population distribution. The population center of gravity is calculated based on each 1000m×1000m plot, which is the center of optimized green space[8]. The calculation of the center of gravity of the population is completely modeled after the law of decomposition and composition of gravity. In actual calculation, formula 2 is used to calculate:

$$\bar{x} = \frac{\sum x_i w_i}{\sum w_i}, \bar{y} = \frac{\sum y_i w_i}{\sum w_i} \tag{2}$$

In the formula, x_i and y_i are the coordinate values of the geometric center of the i th plot, and W_i is the weight added to the i th plot. The population of the i th plot is used here.

The new green status is realized by calculating the population center of gravity[7]. Based on the centroid analysis, the centroid of each residential land plot is generated respectively, and then the centroid of each plot unit (with an area of 1 km^2) is calculated by taking the population of each plot as the weight, which is the population center of gravity, that is, the central position of optimizing the newly added green space. This part is realized by the spatial statistical analysis function of GIS (mean center). Taking the location of green center, which is generated based on the population center of gravity, as the center, and based on the buffer analysis method, the optimized new green space layout maps are generated with radii of 80, 126, 178 and 252 m respectively[9].

2.1 Simulation of urban atmospheric environmental effects based on remote sensing and CFD

Determination of calculation basin: during CFD simulation, first create a zoo of urban space, and determine the length, width, and height of the zoo in CFD. Generally, it should be appropriately larger than the whole city model for CFD simulation environment simulation. After the parameters are set, you can start the calculation of the model. It will simulate the spatial operation of urban wind speed, SO2, temperature and other atmospheric environmental factors under the spatial layout of urban green space. For the study of urban scale, it is necessary to select the appropriate grid precision according to the spatial form, structural composition and other factors of urban modules. In the area with relatively complex module structure, local grid encryption is also required. The finer the grid division, the higher the calculation precision. The basic equations of the incompressible and non-isothermal flow field simulated by the CFD model are as follows:

$$\frac{\partial(u_i)}{\partial x_i} = 0 \tag{3}$$

$$\frac{du}{dt} = -\frac{1}{\rho}\frac{\partial P}{\partial X_j} + \frac{\partial\left(v\frac{\partial(u_i)}{\partial_{Xi}}\right)}{\partial X_j} - g\beta\Delta\theta \tag{4}$$

Where, ui: instantaneous speed (m/s); Xi: spatial coordinate (m); t: Time (s); ρ: Density (kg/m^3); ρ: Instantaneous pressure (N/m^2); ν: Molecular kinematic viscosity (m^2/s); g: Acceleration of gravity (m/s^2); β: Volume expansion coefficient (℃-1).

3 RESULTS AND ANALYSIS

In order to further study the interaction between green landscape and built landscape, the change of landscape types was analyzed by using transfer matrix, as shown in Table 2,figure 2. During 2008-2021, 1.38km^2 of woodland and 4.59km^2 of grassland landscape were transformed into built landscapes, and the main transfer type was impermeable landscape. At the same time, 6.99 km^2 and 1.28 km^2 of impervious landscape are converted into woodland and grassland. The ratio of built landscape to green landscape was adjusted from 1.20:1 to 0.99:1, the optimization of built landscape decreased by 4.03km^2, and the green landscape increased by 2.80km^2. The vertical growth of architectural landscape reduced the demand of built landscape and released the green landscape space[10]. From the perspective of spatial distribution of landscape types, it is mainly manifested in the transformation of grassland landscape into woodland landscape, the expansion of growth crown of urban street trees and the cultivation of garden lawns in residential areas[11].

Table 2: Landscape Type Transfer Matrix from 2008 to 2021.

		2021						
		woodland	lawn	water body	Push the uncultivated land.	Impervious landscape	Architectural landscape	Transfer out
2008	woodland	-	0.72	0.24	0.27	1.20	0.24	2.23
	lawn	9.63	-	1.45	0.46	3.94	0.52	15.56
	water body	0.45	0.33	-	0.13	0.20	0.13	0.81
	Push the uncultivated land.	0.86	0.37	0.29	-	1.26	0.60	2.94
	Impervious surface	7.10	1.39	0.33	0.57	-	1.77	10.72
	building site	0.26	0.17	0.12	0.18	0.78	-	1.07
	Transfer into	14.86	2.54	1.99	1.17	6.94	2.82	-

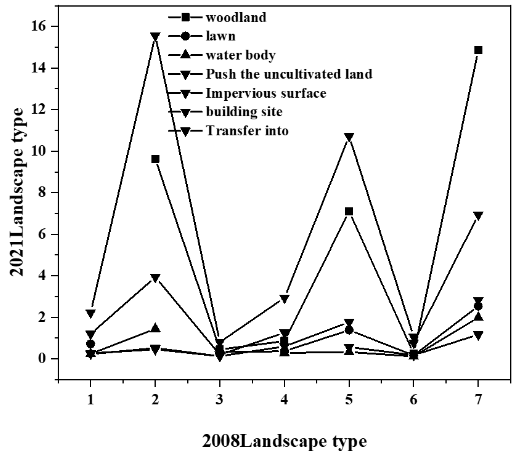

Figure 2: Landscape Type Transfer Matrix from 2008 to 2021.

It shows that the study of three-dimensional urban spatial pattern can better reflect the change of urban landscape pattern and enhance the understanding of urban landscape complexity[12]. High-rise buildings in cities can reduce the occupied area of buildings, help optimize the development of existing land and the allocation of space resources, promote the internal renewal of cities, control the spread of cities, and provide reference for the rational adjustment of urban layout and the improvement of urban functions[13]. The existing three-dimensional landscape research mainly focuses on architectural landscape, ignoring the interaction between the overall landscape pattern and landscape types[14].

4 CONCLUSION

The center position of optimized urban park green space is determined by the population center of gravity model, and the spatial distribution of newly added urban park green space is generated based on the buffer analysis method. The existing green space and the optimized new urban green space are spatially superimposed to generate the optimized urban park green space pattern. Using the population-centered model to optimize the green space pattern has obvious effect on improving the accessibility of green space. Optimize the urban park green in the scheme. With the increase of land area of 39.9%, the accessible population of urban parks increased by 104.7%. It can be seen that through optimization, a smaller green space area can be used to bring into play a larger green space benefit. At present, the urbanization process is accelerating, and the urban circle is expanding outward, which brings about the harmonious development of urbanization and ecological environment. How to improve the quality of living environment while building urban green space has become a key issue to be studied in various disciplines. At the same time, it also belongs to a comprehensive problem that can be solved only by integrating multiple disciplines.

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