Analysis of Urban Green Space Landscape Pattern in Suzhou

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Abstract. Based on the landscape ecological methods, GIS software and aerial images of 2018a, this paper studies the spatial pattern of urban green landscape of Suzhou via landscape ecological theory. The green landscape was consists of several kinds of patches according to the size. Landscape ecological indexes such as the number of patches, landscape fragmentation, and landscape separation were selected to study the landscape pattern of green space in the main urban area of Suzhou. The results show that the biggest green area is in Wuzhong District, the minimum is Gusu District; the green landscape fragmentation of Gusu District is the highest, but the lowest is in Wuzhong District; the landscape separation degree is the largest in Wuzhong District, and the industrial park is the smallest. Comprehensive analysis shows that the landscape pattern of green space in Wuzhong District is more desirable. Finally, some suggestions are given on how to optimize the green space construction in Suzhou.

1. Introduction

Urban green space landscape is one of the urban landscapes that coupling artificial greening and natural greening [1]. It has the functions of promoting social development, optimizing the ecosystem, and beautifying the environment. The spatial pattern of urban green space plays an important role in the ecological benefits of urban green space, the supporting role of urban systems, and it is important to meet the needs of residents [2]. The spatial pattern of green space is the result of the combined action of natural, social and biological factors. The function of urban green space and the exertion of its ecological effects are largely influenced and controlled by the size, type, quantity and spatial distribution of green space. In recent years, with the expansion of the field of landscape ecology research, it has become a trend to use the theory and methods of landscape ecology to study the urban green space landscape pattern. Based on landscape ecology, the green space landscape is divided into four types of space: patch, corridor, matrix and edge, reflecting the spatial characteristics of urban green space unit cells. With the improvement and development of remote sensing technology and geographic information system, new breakthroughs have been made in the study of urban greening has been made [3].
2. Survey Area and Research Methods

2.1. Study Area Overview
Suzhou is located in the southeast of Jiangsu Province, near the middle and lower reaches of the Yangtze River and into the sea. It is located between 119°55′~121°20′ east longitude and 30°47′~32°02′ north latitude. Suzhou has a subtropical monsoon marine climate. The scope of the study is Suzhou's main urban area, including Gusu Area, Industrial Park, Huqiu District, Xiangcheng District and Wuzhong District. The research area is about 3415.4km². Suzhou is located in the Yangtze River Delta region with the fastest economic development in China. Due to its location advantage and the attention of relevant government departments, the level of urban green space construction has increased rapidly and the process of urbanization has accelerated. At present, Suzhou's urbanization rate has reached more than 73%, and it is expected to exceed 80% in 2020 [4]. However, due to the dense water network, shortage of land resources, population expansion, and increasing of construction land in Suzhou, the development of urban green space has been limited, which has severely affected the urban ecosystem.

2.2. Research Methods
The data source of this study is the 2018 landsat8 satellite image (30m resolution). The green space information of Suzhou city was extracted by the support of ARCGIS software and adopting ENVI5.3 to supervise and classify the satellite image. It combines artificial visual interpretation and computer image classification, the error was minimized.

According to the Landscape Ecology, the green space landscape is divided into 4 categories: patch, corridor, matrix, and edge [5]. The urban green space landscape is mainly distributed in various places in the city with different sizes and types of green patches. According to the size of the green patches, they are divided into four categories. Studying the number, layout and area of patches in the city can more intuitively understand the status quo of urban green space landscape in Suzhou, and is of great significance to the ecological construction of green space landscape in Suzhou.

3. Types and Spatial Distribution Patterns of Green Patches

3.1. Quantitative Characteristics of Green Patches
From the perspective of urban green space landscape, the green patches within the study area can be divided into the following 4 types according to the size of the patch. In urban ecosystems, patches of different sizes have different functions. Large patches, such as scenic spots and large urban parks, serve as the “green lungs” of the city. They not only have a variety of ecological functions, but also bring many benefits to the landscape of the city. Small patches, such as green spaces along the street and green areas in residential areas, are closely related to citizens' lives, enrich the visual landscape level, and enhance the heterogeneity of the landscape. They can be used as a supplement to large patches, but they cannot replace it.

| Type of green patches          | Size (km²) | Proportion (%) | Number (piece) | Proportion (%) |
|-------------------------------|-----------|---------------|----------------|---------------|
| Small patch (Within 500m²)    | 0.17      | 0.03          | 12110          | 39.50         |
| Medium patch (500-3000m²)    | 13.49     | 2.30          | 9684           | 31.59         |
| Large and medium patch (3000-10000m²) | 19.44 | 3.32          | 4428           | 14.44         |
| Large patch (Beyond 10000m²) | 553.43    | 94.36         | 4437           | 14.47         |
| Total                         | 586.53    | 100           | 30659          | 100           |
Note: Due to the large scope of this study, the accuracy of the satellite image is not high enough, and the number of small patches is difficult to count, so there is a certain error in the absolute numerical data. This data is for comparative analysis only, and the absolute values are for reference only.

From Table 1, it can be seen that in 2018, the total area of green patches in 5 major urban areas of Suzhou was 586.53 km², and the total number of patches was 30659. The area of large green patches in the study area accounts for 94.36%, but the number of large patches is only 14.47%. They are mainly distributed in scenic areas such as Dayang Mountain, Tianping Mountain, Xishan, Tianchi Mountain, and Wangshan, and some forest parks and wetland parks. Although the area of small green patches only accounts for 0.03%, the number of small patches is as high as 12,110, accounting for 39.5% of the total, which is the highest proportion of the four types of green patch patches. Not only small patches have a large number, but also widely distributed. It is mainly distributed along roads and residential areas, which has a close connection with the daily life of citizens. The number of small and medium patches accounts for more than 70%, but its area accounts for less than 3%. Although the number of large and medium patches accounts for only 30%, its area accounts for 97%. It can be seen that the area of green space in Suzhou urban area shows the phenomenon of polarization, compared with large green space, the proportion of other green space types is seriously insufficient, and large patches have obvious advantages in area.

3.2. Characteristics of the Spatial Distribution of Green Patches

![Figure 1](image-url)

Figure 1. The distribution of urban green landscape of Suzhou in 2018a.

From the perspective of Fig.1, large patches are mainly distributed in the major scenic areas of the western lakeside section and the Xishan Island Scenic Area. Small patches are concentrated in the middle, and medium and large and medium patches are distributed in the east and north. Due to the high density of population and building, and the area of green space in the central urban area is small, the green space is divided by roads and buildings, so this area is mostly small patches.

4. Analysis Indicators of Green Landscape Pattern

4.1. Landscape Fragmentation

Landscape fragmentation, the density index of patches, can be calculated by the ratio of the total number of patches to the total area of green space.

The landscape fragmentation is calculated by

\[
C = \frac{\sum N_i}{A}
\]
Where $C$ is the fragmentation of the green space landscape (pcs/km²), $\sum N_i$ is the total number of all patch types in the landscape (pcs), $A$ is the total area of the green space landscape (km²). The larger the ratio, the higher the degree of fragmentation.

4.2. Landscape Separation

Landscape separation refers to the degree of separation of individuals of different patch types in a regional landscape.

The landscape separation is calculated by

$$F_i' = \frac{A_i}{A} \sqrt{\frac{S}{N_i}}$$

Where $F_i'$ is the separation of patch type $i$, $A_i$ is the area of patch type $i$, $A$ is the total area of green landscape, $S$ is the total area of the study area, and $N_i$ is the number of patches of patch type $i$.

5. Results of the Analysis of Green Landscape Pattern

5.1. Analysis of Landscape Fragmentation

Due to the city depends on transportation and energy, the urban landscape unit cuts the urban green space landscape into many patches of different sizes, in contrast to large-scale continuous distribution of farmland, forests and other natural landscapes. In order to make human life and work more convenient, the development of urban construction is gradually decentralized, resulting in the urban green space landscape has a high fragmentation.

Table 2. Statistics of urban green space landscape fragmentation in Suzhou.

| Type of green patches | Industrial Park | Gusu Area | Huqiu District | Wuzhong District | Xiangcheng District |
|-----------------------|-----------------|-----------|----------------|------------------|-------------------|
| Small patch           | 186211.76       | 30071.66  | 126043.22      | 29476.39         | 335582.46         |
| Medium patch          | 718.62          | 721.62    | 708.86         | 718.71           | 719.80            |
| Large and medium patch| 195.43          | 184.83    | 176.15         | 182.76           | 332.47            |
| Large patch           | 8.78            | 58.61     | 13.86          | 5.54             | 8.52              |
| Average (pcs / km²)   | 62.24           | 394.76    | 59.10          | 30.86            | 75.73             |

The calculation results of the landscape fragmentation of the green patches in the five major urban areas of Suzhou (Table 2) show that the average green patch density in the study area is 124.5381 pcs / km², only the Gusu area is much higher than the average. This is mainly because Gusu District is an old city in Suzhou, with a long history, a large population density, a small area. It is located in the middle of Suzhou City, which prevents it from expanding outward like other urban areas. The height of all buildings in the area cannot exceed 24 meters, which is one of the reasons for its high building density. Therefore, with the increase of human activities, the original large natural green patches are divided by roads and buildings, the number of small patches is increasing, and the area of the patches is getting smaller and smaller, which leads to the increasing of landscape fragmentation.

5.2. Analysis of Landscape Separation

Landscape separation degree refers to the separation degree of individual element distribution of different elements in a certain type of green space landscape. The greater the degree of separation, the more discrete the geographical distribution of green space landscape. Statistics on the urban green space landscape separation (Table 3), the following results can be obtained. Because small patches are
large in number and high in density, the separation in each region is the smallest. Conversely, large patches have the largest separation in each region because of their large area and small number. Judging from the total value of the degree of separation of each urban area, they can be arranged in order from large to small: Wuzhong District > Gusu Area > Xiangcheng District > Huqiu District > Industrial Park. To some extent, the degree of separation reflects the impact of human activities on the spatial structure of green space landscapes. Overall, the landscape pattern of suburban green spaces is better than that of the downtown, which is closely related to urban development and human activities.

Table 3. Statistics of urban green space landscape separation in Suzhou.

| Type of green patches | Industrial Park | Gusu Area | Huqiu District | Wuzhong District | Xiangcheng District |
|-----------------------|-----------------|-----------|----------------|------------------|--------------------|
| Small patch           | 0.00004         | 0.00173   | 0.00008        | 0.00035          | 0.00003            |
| Medium patch          | 0.01127         | 0.10472   | 0.01108        | 0.01226          | 0.01222            |
| Large and medium patch| 0.02743         | 0.21870   | 0.02530        | 0.02842          | 0.02190            |
| Large patch           | 0.51682         | 0.41477   | 0.53279        | 1.21048          | 0.64404            |
| Total                 | 0.55556         | 0.73992   | 0.56926        | 1.25152          | 0.67819            |

6. Conclusions and Recommendations

In summary, there are problems with uneven distribution, high degree of fragmentation, high degree of separation, and unreasonable landscape patterns in green patches of Suzhou. The characteristics of Suzhou green landscape pattern are as follows:

1. From the perspective of the spatial distribution of green patches, the greenbelt coverage rate in the central area of the city is very low, especially in the area surrounded by the outer city river, where the building and the population density is high, the streets are narrow. In these areas, greening construction should be strengthened, greening space should be set up as much as possible, and the number of urban parks should be set up reasonably. Wuzhong District and Huqiu District have large numbers of large patches. In the process of urban expansion, it is necessary to avoid excessive conversion of green land into building land, and to avoid damage to the original natural scenic area.

2. Due to the small and medium patches have advantages in quantity, and the large patches have advantages in area, the indicators of green space landscape are not reasonable, the green space landscape lacks integrity and do not exert its overall ecological function. Therefore, the layout of medium and large patches should be appropriately increased to make the green landscape reasonable.

3. Overall, both the landscape separation and fragmentation in Gusu District are very high, and the landscape pattern and green area are not ideal. Under the objective condition that the green area cannot be increased significantly, attention should be paid to the use of road greening to strengthen the connectivity of different patches and to reduce the patch density to increase the landscape ecological function of urban green space.

Using GIS as a technical means and applying landscape ecology theory and quantitative methods, studying the landscape pattern of urban green space from the patch level of green landscape, which helps to discover the change of green landscape during the process of urban expansion and succession, and it also provides decision-making basis for urban planning and development.

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