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Study on Ancient Chu Town Urban Green Space Evolution and Ecological and Environmental Benefits

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ABSTRACT

In order to deeply analyse the law of urban green space evolution, this paper discusses the change of urban ecological environment effect brought about by green space evolution and its interaction and mechanism. Based on 2007-2018, four remote sensing images of GUI area, the application of remote sensing and GIS spatial information technology, the basic data and sample plot survey, realized based on green space classification diagram. The landscape index, gradient analysis, spatial dynamic analysis methods, such as statistics, quantitative analysis of the urban green space landscape spatial structure evolution and its law of development, with the urban development of green space change of gradient explicit study can be a deeper understanding of the process of landscape pattern, provides the basis for the research of function. The experimental results show that from 2,031 square kilometres in 2007 to 1,364 square kilometres in 2018, the proportion of farmland in urban suburbs decreased by more than 50%. Urban green space has a rising trend in the core urban areas, but changes in the fringe urban areas and suburban areas are complex. With the advancement of urbanization, the total vegetation coverage has decreased by more than 50%, in which the area with high and full vegetation coverage levels has decreased significantly, while the area with no, low and medium vegetation coverage levels has increased.

INTRODUCTION

City is a kind of socio-economic natural complex ecosystem composed of urban built-up area and its surrounding suburbs. Compared with natural ecosystem, urban ecosystem has prominent characteristics of vulnerability, instability, opening and dependence. Green space is an important component of urban ecosystem with important ecological functions. With the acceleration of urbanization worldwide and a series of environmental problems caused by it, people pay more and more attention to the important role of urban green space in coordinating urban space development, controlling urban sprawl, adjusting ecological balance, improving environmental quality and beautifying landscape. As a living urban infrastructure, urban green space is the key to the coupling of urban space development and ecological environment, and also an important symbol to measure the level of urban sustainable development and civilization (Schell 2018). Urban green space research is an important component of urban planning, urban environmental construction, and the enhancement of urban ecosystem self-regulation and self-balancing ability. The enhancement of research on ecological function, structural layout and spatial correlation of green space, as well as the development and application of ecological planning concept, green network concept and ecological infrastructure concept, make the construction of green space system become an important way to balance the contradiction between urban ecosystem and urbanization and restrain urban expansion (Chu et al. 2018).

The innovation of this article is from the perspective of ecological integrity and overall space based on landscape ecology theory and method and related disciplines, building town scale evolution of green space and ecological environment effect of fit on methodology, the research framework and system build based on multi-source data of urban green space landscape structure, spatial pattern evolution and the response of ecological environment of diversified and multi-level comprehensive quantitative evaluation techniques and methods. From the space-time dimension of the rapid urbanization process, the comprehensive evaluation of urban green space evolution and ecological environment effect is carried out, which provides a reference case for the quantitative research on the process and function of urban green space landscape pattern in other rapidly urbanized regions.

EARLIER STUDIES

A study proposed that urban green space is a kind of artificial or natural ecological system with soil as the matrix, vegetation as the main body, human disturbance as the feature, and symbiosis with biological community. It is a green space network including urban garden, urban forest, urban agriculture, waterfront green space and three-dimensional space greening, etc. (Chu et al. 2018, Dey et al. 2017). Previous research believed that urban green space is the space covered with living plants in urban areas, and it is the sum of forests, shrubs, hedges, flower beds, grasslands and other plants in urban areas, and its scope includes the central city and surrounding areas, which is a narrow understanding of green space (Steyven et al. 2018). In foreign urban planning, landscape planning and relevant laws and regulations, the concept of green space is rarely mentioned, while the concept of urban open space is often mentioned. British, American, Japanese and Polish scholars have proposed different concepts of urban open space (Archibald et al. 2017). In China's accelerating urbanization process, under the guidance of policies such as urban-rural overall planning and regional overall planning, especially in the process of increasingly transforming the urban-rural dual opposition structure into urban integration, green space should become an important carrier for the overall regional development and harmonious development between man and nature.

SYSTEM DESIGN METHOD

Urban Green Space Information Extraction Design

In this study, four annual remote sensing data were used, and the data were acquired on April 11, 2007, April 27, 2010, August 15, 2014 and March 24, 2018, respectively. The evolution process and laws of green space in Shanghai were studied through the analysis of multiple annual data. The four U.S. Landsat TM and ETM+ images with different phases have the orbital number of 118/38. TM images have a total of 7 bands. The resolution of TM6 thermal band is 120 meters, and the resolution of other bands is 30m. The four images are of low cloud cover and good quality, providing a good data basis for the interpretation of green space in different periods. A series of auxiliary data were used in the extraction process of green space information, including the land use classification map of Shanghai, the map of Shanghai administrative region, the greening map of Shanghai urban area, field survey data, relevant research results and statistical data. Basic contents and processes of pre-processing of original remote sensing images include atmospheric correction, geometric correction, image enhancement, colour synthesis and image cutting of research area. The Landsat TM/ETM+ data obtained was a coarse corrected image of the satellite receiving station using the calibration data of the standard calibration field. Because the extraction of the biological indicators of green land resource objects, such as temperature, vegetation leaf area index, chlorophyll, etc. requires accurate atmospheric correction to enhance the minor differences in the reflectivity of important components. In this paper, the ATCOR2 atmospheric correction module in ERDAS9.2 was used for image radiometric correction to eliminate the influence of atmospheric factors. Image registration was conducted based on the 1:250,000 map of Shanghai administrative region (Pham & Labbe 2017, Hendry et al. 2017). The topographic map was used as the reference data source to carry out geometric correction for TM images in 2007. The bilinear interpolation method was adopted for the correction resampling to carry out the geometric correction of the images, and the geometric precision correction error was controlled within 1 pixel. The corrected image is projected on the map to the local coordinate system of Shanghai urban construction (Kuebbing et al. 2018). TM/ETM+ images in 2010, 2014 and 2018 were precisely registered with the corrected 1997 TM image as the reference image, and the geometric precision correction error was within half of the pixel, providing assurance and strong operability for spatial information superposition and analysis in the future. Treated with the support of ENVI4.6 good image, the application subset function cut out the image of Grind Gui area, to enhance the image and colour composite processing, to improve its interpretation as far as possible to ensure the precision of image interpretation (Parker et al. 2018).

Urban Green Space Interpretation Classification System

The establishment of land use classification system affects the result analysis and the corresponding follow-up research. Released in 2001 by the ministry of land and resources of land use can be divided into the national land classification of farmland (including cultivated land, garden land, forest land, grassland and farmland), construction land, industrial and mining warehouse (Shang Fu land use of land, land for public facilities, public building land, residential land and transportation land, land for water facilities and special) and unused (unused land and other land types). The "classification standard of urban green space" issued by the ministry of construction divides the urban green space into five categories, including park green space, production green space, protection green space, attached green space and other green space. The urban green space system includes forest land, highway greening, farmland forest network, scenic and historic interest area, water source protection area, country park, forest park, nature protection area, wetland, landfill restoration green space, urban green belt and urban green land, etc. To the present situation of land use classification, the urban green space classification standard and area green space system on the basis of the connotation, considering the research on Gui basic data source of remote sensing image spatial resolution is low, and this study focuses on the research under the influence of urbanization, urban green space, it will grind Gui area divided into two categories, green space and non-green space; green space including woodlands, shrubland, farmland and water body and non-green space includes construction land and other land use type as a background for the analysis (Meade et al. 2017, Brashears et al. 2017, Villegas et al. 2017).

Green space remote sensing interpretation refers to the corresponding classification rules (Table 1) and adopts the supervised class method. The principle of supervised classification is to determine the discriminant function and the corresponding discriminant criterion according to the prior knowledge of the category. The main process is to first select a certain number of training areas for each category on the image, determine the undetermined parameters in the discriminant function according to the observed values of a certain number of known samples, calculate the statistics or other information of each category, and construct the discriminant criteria. Each pixel is divided into different categories according to the criterion. The maximum likelihood method is based on the probability of the pixel values of each category obtained by calculation, and the corresponding probability density function is applied to classify the undetermined pixel. The scatter diagram on the schematic diagram shows the circular "isprobability" line, and the shape of isprobability line shows the sensitivity and coordination of the maximum likelihood method to classification. 250 training samples were selected for each image, and the method of combining field sampling points and random sampling points was adopted. The main principle was to evenly distribute the sample points in the study area and ensure that each coverage category was included.

Research Methods of Ecological Environmental Effects

Regional Ecosystem Analysis (RCA) is an urban forest ecosystem assessment method proposed by the US forest service. It is proposed in the context of better understanding of the contribution of green space to urban environment and urban construction in urban areas. REAs help local policy makers make the most of the region's natural capital in order to develop better public policies. This method combines remote sensing image and sample land survey statistical data, applies GIS technology to analyse and research area forest coverage information, uses the model formed by the analysis to calculate the ecological value and economic value of urban forest sample area in the research area, and applies to different scope areas through scale conversion. The basic analysis process of REAs can be divided into five steps:

(1) To determine the scope of research area, CITYgreen software needs to first determine a research area with a boundary range when conducting large-scale analysis, and then all environmental effects and ecological benefits are only carried out within the boundary range of the research area.

(2) Determine the land use/cover map and forest cover map of the research area to obtain the urban land use/cover map by using remote sensing images. The land use type can be set according to the situation of the research area and the precision of remote sensing images, mainly including forest, shrub, water body, farmland, urban construction land, etc., and the required format is grid format.

(3) Generate CITYgreen ecological structure map of the research area by combining land use/cover information map and urban forest cover map. Ecological structure is a landscape type, which describes the ecological components of land and the characteristics of building land. CITYgreen provides the types of ecological structure matching different land types. For example, woodland corresponds to three types of ecological structure: Woodland with dead branches and deciduous layers, woodland with shrub grassland, and woodland with impermeable ground. Ecological structure map can be combined with land cover data to make green space planning.

Table 1: Urban green space interpretation classification system.

The primary classification	The secondary classification	Contains the content
Green space	Woodland	Including all areas with a certain forest coverage, the main types are park green space, protective green space, forest, etc.
	Shrubland	Including shrubs, grass, and so on, generally no trees or few trees
	Farmland	Include farmland, paddy field, vegetable field to wait
	Water body	Including natural and artificial lakes, canals, reservoirs, ponds and tidal flats and other waters
Non-green space	Urban construction land	All kinds of land have been built, including land for urban and rural residential areas, mining, transportation facilities and other construction land
	Other land	Including bare soil, bare rock, toil land, saline-alkali land and other land under construction or unused

(4) Set the parameters of the evaluation model CITYgreen. The default parameters of the software are the configuration of regional climate characteristics and urban forest characteristics in North America. These evaluation parameters are empirical values, applicable to North America. Therefore, it is necessary to adjust these evaluation parameters, including rainfall parameters, soil parameters and slope, according to the survey data.

(5) Transform the ecological benefit value of green space in the research area. Select the corresponding module of CITYgreen software and calculate the corresponding value of green space environmental effect and ecological effect. For different countries and regions, the value of ecological effect can be changed year on year to better adapt to the local situation.

RESULT ANALYSIS

Urban Green Space Information Analysis

According to the statistics of TM remote sensing image classification results, the urban green space area of Shanghai has decreased significantly in recent 10 years. By 2018, the total area of green space in the research area is 1364.7 square kilometres, which is 666.5 square kilometres less than that in 2007. Farmland fell the most, by 22% over the same period. According to the statistical results of the structure composition of green space types in the study area, the total amount of urban forest land and irrigated grassland did not change much in the past 10 years from 2007 to 2018. This has a lot to do with the fact that Shanghai attaches great importance to the planning and construction of urban ecological space and landscape. In particular, under the guidance of the new round of planning of green space system in a large urban area, under the influence of the Shanghai world expo, the greening construction of downtown and suburban areas of Shanghai has made great progress. However, in the context of rapid urban development, there are still many problems in the development of urban green space.

Classification Result Analysis

After the maximum likelihood method was used to interpret the four Langsat remote sensing images from 2007 to 2018, the basic information of urban green spatial distribution in

Table 2: Structure composition of urban green space types in the study area.

Year	Area/percentage	Woodland	Farmland	Bringing to	Waters	Green space	Non-green space
2007	Area (km^2)	351.7	1177.2	175.7	326.6	2031.2	884.4
	Percentage (%)	12.1	40.4	6.0	11.2	69.7	30.3
2010	Area (km^2)	331.3	1016.6	181.3	361.6	1890.8	1025.1
	The percentage (%)	11.4	34.9	6.2	12.4	64.8	35.2
2014	Area (km^2)	313.6	719.8	153.4	332.4	1519.2	1396.7
	The percentage (%)	10.8	24.7	5.3	11.4	52.1	47.9
2018	Area (km^2)	349.23	512.99	164.25	338.2	1364.7	1579.5
	The percentage (%)	12.0	17.6	5.6	11.6	46.8	54.2

Table 3: Evaluation of land use classification accuracy in the study area.

	BL	CL	FL	SL	WL	OL
BL	41	0	0	0	0	6
CL	0	45	7	7	0	0
FL	0	7	35	6	0	0
SL	0	6	8	25	0	0
WL	0	0	0	0	18	0
QL	9	0	0	0	0	30
The overall accuracy (%) 73.6						
The coefficient of Kappa 0.73						

Note: BL= construction land, CL= farmland, FL= woodland, SL= irrigated and grassy land, WL= water body, OL= other land

Shanghai was obtained. The test of classification accuracy of remote sensing image is generally to compare and analyse the classification image with the standard map, data or ground measured value, etc., and to express the classification accuracy with the percentage of correct classification (Table 2). With the support of ENVI4.6, the error obfuscation matrix was established by using the function of middle and middle obfuscation matrix in the classification module post processing, and the overall accuracy and Kappa coefficient were calculated. Taking 2018 as an example, the results show that the overall classification accuracy is 73.6%, and the Kappa coefficient is 0.73 (Table 3). Among them, the mixed classification of woodland, shrub grassland and farmland is larger, and the probability of misclassification of building land and woodland landscape is smaller.

Analysis of Ecological Environment Effect

According to the calculation of carbon sequestration module, air pollution removal module and rainstorm runoff reduction module of CITYgreen software, the total ecological effects in the research area were obtained. According to the afforestation cost of 250 yuan/tc proposed by Xue Dayuan, the carbon sequestration value was evaluated. The benefit of water and soil conservation can be replaced by the shadow project price, that is, the cost of each $1m^3$ of reservoir construction calculated by the national reservoir construction investment from 1988 to 1991 is 0.67 yuan. The carbon sequestration effect and air pollutant removal effect in the study area generally show a monotonic downward trend. The specific analysis results are as follows: the annual carbon storage, absorption and consumption decreases from 5650636.31t in 2007 to 4965038.55t in 2018, and the ecological benefit value generated decreases by 171399440 yuan. The capacity of purifying air includes the amount of absorbing O_3, SO_2, NO_2, PM_{10} and CO, which decreased from 5481391.69kg in 2007 to 4816328.56kg in 2018, and its ecological benefit value decreased by 21911571.49 yuan. The rainstorm runoff reduction capacity decreased from 48861311.68cm in 2007 to 43996315.86cm in 2018, and the ecological benefit value decreased by 3259547.20 yuan. The total value of ecological benefits decreased by 196,570,558.68 yuan.

CONCLUSION

Overall, the total area of urban green space in Shanghai during the study period decreased significantly, from 69.7% in 2007 to 46.8% in 2018, among which farmland saw the largest decline. In the process of urbanization, the urban green space in the core urban area shows the trend of first rising and then falling, and the overall trend of rising. During the study period, farmland has basically disappeared in the core urban area, and there is little left in the fringe urban area. The water landscape shows an overall upward trend in each administrative region of the study area. Vegetation coverage in the study area decreased rapidly due to the shrinking of green space. From the change of vegetation coverage grade composition, the areas of no vegetation coverage, low vegetation coverage and medium vegetation coverage, all showed an overall upward trend, while the areas of high vegetation coverage and total vegetation coverage all showed a sharp downward trend. From the perspective of the transfer trend, the whole vegetation coverage level and the high vegetation coverage level are mainly transformed to the middle and low vegetation coverage level. The middle vegetation cover grade was mainly transformed to low vegetation cover grade and no vegetation cover grade. Low vegetation cover grade is mainly transformed into no vegetation cover grade. Outlook is due to the impact of human activities in the rapid urbanization area, green space dramatic evolution of a complex series of mutual interaction of ecological environment effect, the response to the specific process and mechanism of research, needs the support of the basis of more detailed data, under the effect of multidisciplinary collaboration, a more comprehensive exploration on different spatial and temporal scale of landscape ecological process and mechanisms.

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