Optimization of Green Space Form Assessment in Beijing-Tianjin-Hebei Cities under "Carbon Reduction - Quality Improvement" Green Innovation

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ABSTRACT: Under the background of the "two-carbon" goal, balancing the demand for land for economic development and ensuring the ability of urban green ecological carbon sink is the key issue of urban sustainable development. Based on the synergy theory, this paper uses the morphological spatial pattern analysis (MSPA) method to calculate the area ratios of seven landscape types in 13 cities within the Beijing-Tianjin-Hebei urban agglomeration, and forms an assessment system (factor evaluation) for green space forms of cities that are not carbon neutral, near carbon neutral and already carbon neutral based on relevant indexes, and then gives optimization suggestions: First, the larger the proportion of the area of urban construction land intersecting or contacting with natural patches and corridors, the easier it is to improve the carbon storage capacity of green space. Second, on the basis of ensuring a certain proportion of development space after, landscape types with a high degree of aggregation have a certain effect on the score improvement of the urban innovation index. Fourth on the basis of ensuring a certain proportion of development space, a reasonable ratio of green space between the core area and the fringe area is beneficial to the realization of the coordinated development mode of economy and ecology.

1 INSTRUCTIONS

The rough urban development model that accompanied China's rapid economic development has led to an extremely fragmented layout of urban green spaces, which in turn has exacerbated a series of problems such as fragmentation and poor resistance to disturbance, making it impossible for this important natural ecological and physical environment to fulfil its innate function as a carbon sink [1]. With the advent of the green transformation era, the quality of urban green space is gradually being recognized as an external representation of sustainable urban economic development and is even receiving unprecedented attention in proposals to achieve a green rise. Research area and research method [2].

2 RESEARCH METHODOLOGY

Using the carbon sequestration module of the InVEST model, the total carbon stocks of common urban carbon pools, such as above-ground carbon stocks, below-ground root carbon stocks, soil carbon stocks and dead organic matter carbon stocks, were estimated to calculate the total regional carbon stocks, which were calculated using the following equations.

$$C_{tot} = C_{above} + C_{below} + C_{soil} + C_{dead} \tag{1}$$

MSPA is an image processing method calculated through Guidos Toolbox software, which can identify hubs and corridors from a single land-use type map, and then analyse the degree of fragmentation and edge effects of the existing green space pattern in the Beijing-Tianjin wing, i.e. the raster image is accurately identified and segmented into seven important landscape categories using a mathematical morphological sequence of operations, and the possible connectivity index (PC) and patch importance index (dPC) are then selected using Conefor software to assess landscape connectivity, i.e. the dPC calculation formula is as follows.

$$PC = \left(\sum_{l=1}^{n}\sum_{j=1}^{n} a_i \cdot a_j \cdot p_{ij}^*\right)/A_L^2 \tag{2}$$

$$dPC = (PC - PC_{rem})/PCx100 \tag{3}$$

where PC is the possible connectivity index, n is the total number of patches in the landscape, a_i and a_j are the areas of patches i and j, p_{ij}^* is the maximum probability of species being distributed directly between patches i and j, A_L^2 is the total area of the entire landscape, PC_{rem} is the connectivity index of the remaining patches after removing individual patches, and dPC is the importance of the patches, where the larger the dPC value, the higher the importance of the patches in landscape connectivity [3].

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Table 1. MSPA-based landscape pattern types and connotations

Classification of landscape types by MSPA method	Inclusions
CoreCore	As ecological sources, mostly large natural or semi-natural patches
BridgeBridge	Natural or semi-natural corridors connecting two different core areas in closed proximity
Silo islet	Generally small, fragmented patches with low connectivity
EdgeEdge	Transition area between the edge of the core area and the surrounding non-green landscape area, which takes the role of protecting the core area and reducing disturbance
Ring Loup	Connecting channels for ecological flows within the same core area
PorosityPerforation	Transition area between core area and background, with edge effect
BranchBranch	Communication channel of ecological flow, only one end is connected to the core area, mainly the extension of green areas

3 ANALYSIS OF RESULTS

3.1 Analysis of the Beijing-Tianjin-Hebei Urban Green Space Morphology Index

The area ratio of urban land use types accounted for by each of the seven landscape types was calculated for each of the 13 cities in the Beijing-Tianjin wing region through the GIS platform [4] In terms of the regional area, the core and bridging landscape areas are the main landscape types for each type of city, with forest and grassland accounting for a higher proportion of the core landscape types and arable land accounting for a significant proportion of the bridging landscape types, indicating that the two land use types of forest and grassland in the Beijing-Tianjin wing region assume an important ecological conservation role as large ecological source areas, while arable land both serves as an important natural ecological corridor for wildlife migration [5] The spatial distribution of the core patches of land use in the Beijing-Tianjin region is very different. In general, the smaller the proportion of bridging areas in the semi-natural corridor space, the higher the degree of aggregation of core areas. In terms of the regional layout, the economic primacy of the city is not only the most important, but also the most important. In terms of regional layout, the core natural patches in Beijing and Tianjin, which have a high economic primacy, are concentrated in the periphery of the built-up areas of the cities, and the inter-regional spacing is greater, whereas the natural patches in the prefecture-level cities of Hebei Province are more closely linked to the built-up areas of the cities, and their impact on the urban structure and the coercion of natural ecological source areas often leads to the fragmentation of natural patches from the built-up areas within the cities [6].

3.2 A quantitative test of green space form factor indicators under green innovation

In this study, a Stata 16.0 multiple regression model was used to process and analyse the data, and to reduce the model covariance and heteroskedasticity, the area share of urban greenspace morphological landscape types was reduced by 1012. The logarithm of the urban carbon stock and urban green space carbon stock values were taken as the dependent variables, and a stepwise regression was used to find the correlation between them and the independent variables, i.e. the area of the seven urban green space landscape types.

Where Carbon is the total carbon storage value of the urban area, and Carbon green is the carbon storage value of the green space within the urban construction land, where Core, Perforation, Bridge, Loup and islet correspond to the core, porosity, bridging, roundabout and isolated island of the seven landscape types mentioned in the previous section. The results of the better-fitting models calculated by the stepwise regression method show that total urban carbon stocks are positively correlated with the area occupied by bridging landscape types at the 0.01 level of significance, negatively correlated with porosity and edge at the 0.05 level of significance, positively correlated with roundabouts and negatively correlated with isolated island landscape types at the 0. 1 level of significance. The total carbon storage in urban green spaces is positively and negatively correlated with the area occupied by core, pore and edge landscape types at 0.1 level of significance, which supports that the pore and edge landscape types in urban green spaces have a significant incremental effect on the total carbon storage value or the carbon storage value of urban green spaces [7]. It is worth noting that the area of landscape types occupied by edge areas shows a significant negative correlation with the total regional carbon stock, and a positive correlation with the total urban green space carbon stock, while the area of landscape types occupied by porosity shows an inverse correlation with the urban carbon stock and green space carbon stock. The result is that for every $10^{\wedge(-12)}$ km^2 reduction in the area of the edge zone between the reduced anthropogenically disturbed core area and the surrounding non-green landscape areas, the total urban carbon stock increases by 2.612% and the urban green space carbon stock decreases by 9.684% of its original value. In order to maximise the increase in carbon stock, it is necessary to consider whether a base value of close to 3% of the total urban carbon stock is sufficient to compensate for a base value of close to 10% of the greenfield carbon stock. A reduction of $10^{\wedge(-12)}$ km^2 in the pore area between the core and the background, which has an edge effect, increases the total urban carbon stock and the greenfield carbon stock by 3.067% and 22.268% respectively.

In the same way, the correlation between the urban innovation and entrepreneurship index and the area of the seven greenfield landscape types was calculated by reducing the area of the seven landscape types by 1012 in order to reduce the covariance and heteroskedasticity of the model.

Table 2 Correlation statistics between the city-region innovation and entrepreneurship index and the area share of relevant landscape type

Variables	Innovation and Entrepreneurship Index
Edge Zone	-115.483**
	(-2.82)
Bridging Area	4.460
	(1.84)
Spur	235.567*
	(1.97)
Core area	34.579**
	(2.61)
Constants	54.995***
	(9.24)
Observations	13
R-squared	0.659

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The regression equation of the urban innovation and entrepreneurship index and the area of the seven green space landscape types was obtained by stepwise regression results, and the model R2 could reach a fit of 65.9%, indicating that the urban innovation and entrepreneurship index and the area of the seven green space landscape types have a certain correlation, and the equation is as follows.

$$Innovation = -115.483Edge + 235.567Branch + 34.579Core + 54.995 \quad (4)$$

Where Innovation is the total city innovation and entrepreneurship index score, Edge, Branch and Core are the edge, tributary and core respectively. The urban innovation index is negatively and positively correlated with the edge and core areas respectively at the 0.05 significant level, and positively correlated with the branch at the 0.1 significant level, and from the magnitude of the coefficients it can be concluded that the change in the size of the branch and edge landscape types compared to the core area has a more significant effect on the increase or decrease of the urban innovation and entrepreneurship index, such as the tributary area connected to the core area at only one end compared to For every $10^{\wedge(-12)}$ Km^2 increase in the core landscape type of the ecological source, the Urban Innovation and Entrepreneurship Index score can be increased by 2.00988 points, while for every $10^{\wedge(-12)}$ Km^2 decrease in the edge area, which is responsible for protecting the core, the total Urban Innovation and Entrepreneurship Index score will increase by 1.115483 points.

3.3 Construction of indicators for assessing green space form under green innovation

Cities that have not achieved carbon neutrality should gradually focus on the structural characteristics of green spaces and green efficiency while maintaining the proportion of bridging, roundabout and edge zone landscape types [8]. The cities that are ahead of the carbon neutral sites are striving to improve green efficiency while maintaining green efficiency. The structural characteristics of the landscape types are judged by the Fragstats index of landscape ecology. At the same time the green spaces within and outside the built-up area assume different ecological services within the same system. The core areas and roundabouts are mostly located outside the built-up area, as the source of large natural habitat quality, emphasising the degree of aggregation, integrity and diversity of natural patches: the bridging, pore and edge areas are mostly used as transition areas from the built-up area to the core ecological source, emphasising the degree of connectivity and connectivity with the external ecological corridors, i.e. the connection from 'source' to 'sink' [9]. The bridging, pore and edge areas are mostly used as transition areas from the built-up land to the core ecological sources, with more emphasis on the connectivity and connectivity with the external ecological corridors, i.e. the "source" to "sink" articulation and coupling: the isolated islands are mostly within the built-up area with more emphasis on their stability and uniformity.

4 CONCLUSION

This study further reveals and supports the possible dual attributes of urban green space in relation to economic and ecological development. However, this study focuses on 13 cities in northern China, including Beijing, Tianjin and Hebei, and the universality of the findings for all cities in China is not confirmed, while the scale of the study is large due to the lack of data on innovation indices and other factors influencing innovation capacity at the city district and county scale. To this end, the path of this study can be extended to national regions to provide a comprehensive assessment of the effects of urban green space form on carbon stock and innovation capacity, while more alternative data or other measurement models of urban innovation capacity should also be explored to improve the spatial precision of the study's findings and strategies.

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