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Article

Composition and morphological elements of habitat quadrat in urban green space: A case study of Xi'an

Hui Liu*, Shuo Cao, Yu Chen

Xi'an University of Architecture and Technology, Xi'an 710000, China
*** Corresponding author:** Hui Liu, liuhui@sina.com

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Abstract: The habitat quality and connectivity structure of urban small and medium-sized green space play an important role in promoting urban biodiversity. Under the influence of community life circle services, the urban green space construction in China has formed a typical and repetitive green space pattern. Exploring the minimum quadrat of green space composition and its habitat elements and morphological structure is an important way to improve the urban ecological quality and green space planning and design. This research, based on the basic achievements of urban site habitat construction and ground cover plant community design in northwest China, takes the green space in the old and new urban areas of Xi'an City as the objects. It puts forward the basic scale quadrat of "2 km × 2 km" urban block green space habitat network by using the research paths of review, geographic information interpretation-field surveys and cluster analysis. It has found four typical patterns, which are single-core radiation, multi-core dispersion, corridor crossing and scattered distribution. It also analyzes the coupling relationship between the form, elements and spatial pattern of the quadrat, and explores the ways to improve the construction of green spatial habitat network in the quadrat system.

Keywords: urban green space; urban landscape mosaic; block scale; research quadrat; site habitat; urban biodiversity

1. Introduction

Unlike "urban green space" [1] which focuses on the nature and type of urban construction land, urban green space pays more attention to the spatial pattern formed by all green sites on which the plant life system in the urban environment depends, and is the main body of the urban ecosystem. Urban green space system has spatial hierarchy and systematicness [2], and affects the quality of urban ecosystem.

Under the influence of China's urban construction model, urban green space presents the characteristics of dispersion, independence and repetition, forming urban habitats with rich scale, elements, morphology and structure. Urban habitat diversity and connectivity are the necessary conditions for urban biodiversity. Among them, the urban block scale green space system is an important level connecting the overall urban area and site greening, and ensuring its integrity and connectivity is an important content of green space system planning at the block scale. It is of great theoretical and practical significance to study the spatial matching of urban block green space, site habitat types and plant communities.

2. Green space on the scale of urban blocks in China and its influencing factors

2.1. Urban green space and urban green space

The concept of urban green space is gradually improved along with urban green space system, open space, green infrastructure and other related concepts. Due to the different backgrounds of urban construction and development at home and abroad, scholars pay different attention to urban green space. In foreign countries, urban green space evolved from urban open space, which is broadly understood as the space covered by vegetation in the urban environment, emphasizing the natural and ecological attributes of vegetation elements and spatial elements [3,4]; in China, the concept of urban green space and "urban green space" is usually equated at first. However, with the continuous deepening and expansion of research, its connotation is no longer limited to the five categories of green space covered in the classification standard of urban green space (cjj/t85–2017), but also includes various urban spaces covered by green space and the urban green space system that is constantly tending to be networked [5–7].

In this study, the green space of urban blocks is mainly aimed at the four types of urban green space in the meso and micro scales, namely park green space, protective green space, square green space and subsidiary green space, as well as various types of three-dimensional green space and other green spaces. More attention is paid to the ecological system formed by the spatial matching and connectivity of the site habitat and its plant communities in the green space.

2.2. Spatial distribution and pattern of urban green space under the guidance of human behavior

The amount of urban block green space is mainly affected by urban construction norms such as land type and green space rate, and its scale, type and distribution are formed according to the urban green space system planning. At the block scale, the layout of urban green space is dominated by people's social function needs, and the planning basis mainly comes from the control index system of community life circle and urban greenway. In July 2018, the Ministry of housing and urban rural development proposed in the standard for planning and design of urban residential areas, which was approved and issued: residential areas are divided into 15 minutes, 10 minute and 5 minutes living circles and residential neighborhoods based on the principle that residents can meet basic living needs within a reasonable walking distance. At the same time, the standard defines the hierarchical control scale of residential areas such as walking distance, residential population, number of dwellings, per capita residential land area and other public green space control indicators such as per capita public green space area and residential park scale, which affect the pattern characteristics of green space in the block with the control mechanism of total amount control and service distance.

According to the construction norms of urban road network density, residential area planning and community life circle, the basic units and theoretical models of green space at the block scale can be established. Firstly, according to the index

requirements of the 15 minute community life circle, the amount of public green space in the study sample is calculated, and it is determined that the public green space in the 15 minute community life circle should not be less than 20h m^2; secondly, according to the index requirements for the block scale of residential areas in the planning standard for urban comprehensive transportation system (gb/t51328–2018), 200 m × 200 m is selected as the basic block unit of the new planned urban area. Due to the early planning time and uneven road network density in the old urban area, the block unit has multiple scales; finally, the green space layout structure of the research sample is constructed according to the hierarchical control index of public green spacein residential areas and the minimum cost path method (**Figure 1**).

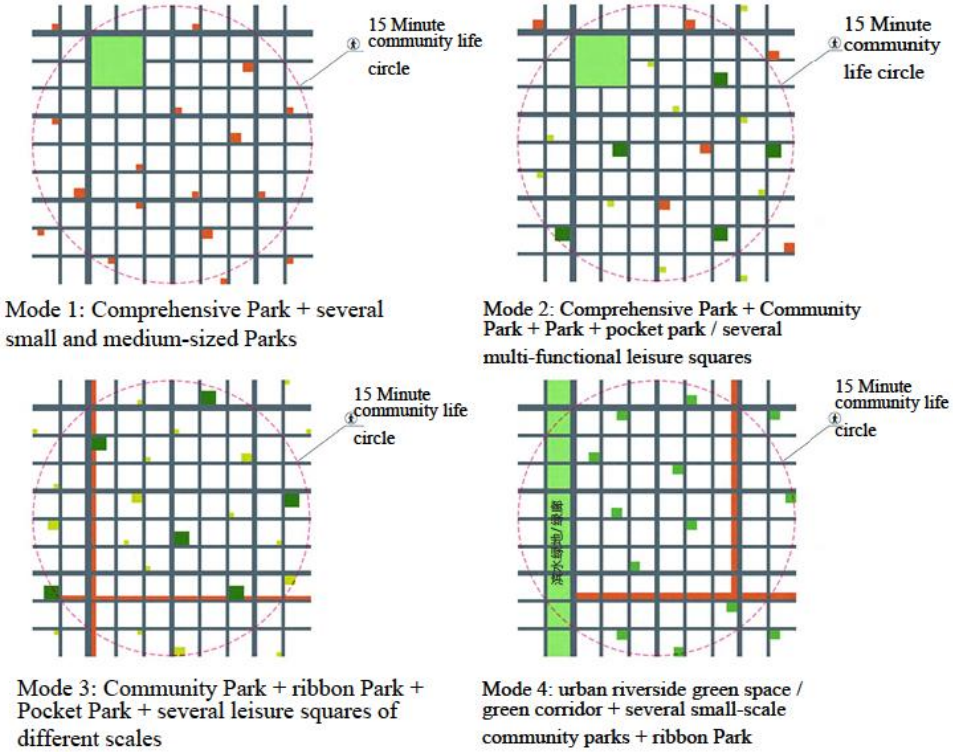

Figure 1. The theoretical model of public green space layout in new planning areas.

3. Basic research quadrat and typical layout mode of green space

3.1. "Sample method" as the basic research method of urban green space

In the study of landscape ecology, it is proposed that various landscape patches are staggered and organically combined to form a "landscape mosaic" with nested hierarchical structure [8]. In landscape ecology, spatial amplitude and granularity are used to express the analysis scale of different nested levels of landscape mosaic. Spatial granularity refers to the characteristic length, area or volume (such as quadrat and pixel) represented by the smallest identifiable unit in the landscape [9]. The "sample method" is often used for observation and analysis in field investigation, for example, the element composition and spatial structure characteristics of different types of plant communities are observed and analyzed by using corresponding scale research quadrats. As a type of landscape mosaic, the constituent elements of the city

also have a multi-scale nested hierarchical structure. Therefore, this study attempts to use the sample method to analyze the spatial constituent elements of the urban landscape mosaic, and explore the urban green space elements and their spatial structure characteristics.

3.2. Determination of 2 km × 2 km study quadrat scale

The landscape mosaic has the characteristics of scale and grade. The quadrat scale in the sample method research is usually determined according to the nested hierarchical structure of the element patches in the landscape mosaic to ensure the element integrity of the landscape mosaic. Landscape ecology mentioned in the definition of landscape that from the perspective of urban construction, urban landscape should include not only biological habitat, but also human living environment. Therefore, the urban landscape mosaic should include geographical entities with obvious visual characteristics, such as ecology, economy and culture, such as various types of urban green space, education, medical treatment, commerce and other spatial elementDetermining the scale of the smallest identifiable unit (i.e. Research quadrat) of the urban landscape mosaic is the primary task to study the urban green space elements and their spatial structure characteristics. It has been proved that the scale of human behavior affects the layout of urban green space. There is a distance gradient effect when residents use urban green space. The distance scales of 1 km and 5 km are the most comfortable behavior scales and threshold behavior scales when people use urban green space respectively [10,11]. According to the relevant regulations of the community life circle, the 15 minutes walking distance (800–1000 m) is the scale range of the basic community life circle, covering multiple complete blocks, including relatively complete ecological, economic, cultural and other spatial elements.

Therefore, in this study, circumscribed squares with a radius of 1 km (i.e. Square research quadrats with a scale of 2 km × 2 km) are selected as the basic research quadrats of urban landscape mosaic and urban block green space. This scale research quadrat can be used as a basic unit to analyze the urban morphological structure, urban function and urban management, and can also reflect the integrity of the constituent elements of urban block green space and its nested hierarchical structure.

3.3 Typical mode and element scale of green space in new and old urban areas of Xi'an City

Taking the "2 km × 2 km" scale as the research quadrat, the coverage of the new and old urban areas of Xi'an city is divided, the green spatial structure characteristics of the research quadrat are extracted through the geographic information system (GIS) technology, and the green spatial structure of the research quadrat is classified through the cluster analysis method, and the single core radiation type, multi-core dispersion type, corridor crossing type There are four typical structural patterns of green space in urban blocks with scattered distribution.

Within the research scope, four typical urban block green spaces were selected as the research objects, and the green space of urban blocks was refined and extracted through field investigation, and the proportion of green space at different scales was

analyzed (**Table 1**). The analysis shows that the overall proportion of green space in the old urban area of Xi'an is relatively low, about 9.83%–25.50%; the overall proportion of green space in the new urban area is higher than that in the old urban area, reaching 3219%; compared with linear and banded green space elements, point and block green space elements account for a larger proportion in both old and new urban areas; in multi-core scattered quadrats and corridor crossing quadrats, the proportion of point and block elements is balanced with linear and strip elements. In general, the green space of urban blocks is mainly composed of small and medium-sized green space, and the green space elements are characterized by small scale and scattered distribution as a whole.

Table 1. Analysis of the scale proportion of elements of typical urban green space layout.

Element characteristics			Single core radial type			Multi core distributed			Corridor crossing type			Scatter type		
			Quantity/pcs	Total area/m^2	Area ratio/%	Quantity/pcs	Total area/m^2	Area ratio /%	Quantity/pcs	Total area/m^2	Area ratio/ %	Quantity /pcs	Total area/m^2	Area ratio/ %
Punctate Lump Essential factor	Element area/ m^2	0–10	43	262.20	0.01	26	179.90	0	0	0	0	80	526.80	0.01
		10–50	103	2409.70	0.06	32	862.80	0.02	18	531.20	0.01	76	1958.80	0.05
		50–100	63	4770.60	0.12	23	1747.40	0.04	18	1313.40	0.03	75	5574.00	0.14
		100–500	267	65,524.90	1.64	101	29,530.10	0.74	109	32,613.60	0.82	269	69,196.50	1.73
		500–2000	156	146,705.00	3.67	126	134,121.60	3.35	148	157,234.00	3.93	122	111,000.50	2.78
		2000–10,000	33	126,243.70	3.16	59	216,210.50	5.41	48	171,552.80	4.29	23	91,808.50	2.30
		10,000–100,000	1	477,745.90	11.94	11	271,103.10	6.78	0	0	0	2	24,146.10	0.60
		>10,0000	0	0	0	1	100,171.30	2.50	0	0	0	0	0	0
	Subtotal of element area ratio /%				20.60			18.84			9.08			7.61
Linear Ribbon feature	Element width/ m	<7	153	29,388.90	0.74	191	37,894.50	0.95	119	29,364.16	0.73	99	21,108.30	0.53
		7–12	140	57,776.20	1.44	62	28,115.70	0.70	96	36,697.76	0.92	28	19,386.10	0.49
		> 12	123	109,298.80	2.73	36	467,669.00	11.69	68	280,365.78	7.01	41	48,643.30	1.22
	Subtotal of element area ratio/%				4.91			13.34			8.66			2.24
Proportion of element area in total/%					25.51			32.18			17.74			9.85

4. Discussion on the construction of habitat network in green space research quadrat

4.1. Spatial scale and morphological characteristics of site habitat and its landscape elements

Quantifying the scale relationship between plant communities and green space in urban blocks is the key to the habitat diversity of construction sites. Plant community patterns and construction mechanisms are different at different spatial scales, and a plant community may be regulated by multiple scale processes at the same time [12]. The combination of community ecosystem and site design, and the use of suitable plant community habitat to form a diversified urban block green space is an important way to improve the quality of urban habitat [13]. In the field of community ecology, "species area curve" is often used to determine the "minimalarea" of plant communities [14], that is, a complete plant community unit can always be included at this scale. The basic design scale of the site habitat shall ensure the integrity of the plant community and facilitate the construction in the city

Repetition and combination in the planning and design of block green space [15]. The scale of site habitat is directly related to the selection of plant community types. This study considers that the basic scale of plant community, as a landscape design element, can be well involved in the site ecological design. In the study of plant ecology, the quadrats of plant community research are divided into: forest community 100–2500 m^2; shrub or tall grass community 25–100 m^2; medium low herbaceous community: 1–25 m^2 [16]. In the construction of green space sites and habitats in urban blocks, the composition of ground cover plant communities can be applied but not limited to flower beds, flower borders, flower pools, green spaces attached to buildings (structures) and courtyard green spaces, while the scale of forest and shrub communities is more suitable for urban parks, community parks and garden green spaces.

Different site habitats have different effects on the process of confluence and the interception of nutrients. At the same time, the diffusion and foraging of animals are closely related to the morphology of patches И. Therefore, the habitat types and morphological characteristics of green space in urban blocks have an important impact on the ecological benefits of green space. The morphological characteristics of site habitat can be translated with the patch and corridor theory in landscape ecology, and serve the construction of green space habitat network in urban blocks through manual intervention of its spatial layout.

4.2. Site habitat type analysis

In the green space of the urban block, the spatial scale and form of the site habitat are characterized by diversity [17] due to the comprehensive influence of artificial design intervention, microclimate distribution, hydrological spatial process, soil type distribution and other factors. In the practice of green space planning and design of the urban block, the diversity characteristics of the site habitat types can be flexibly used in combination with suitable plant communities to create habitats, serve the functional needs of people and enhance the ecosystem service function at the same time.

1) Patch type site habitat. Patch site habitat not only accounts for a large proportion in the green space of urban blocks, but also has rich types, such as habitat Garden (artificial habitat Island), urban forest land, artificial lake wetland, biological detention facilities, roof greening, etc. Patch type site habitats also have diversity in scale and function (**Table 2**).

2) Corridor type site habitat. Corridor type site habitat mainly refers to the type of habitat green space distributed in line or strip in urban green space, such as urban greenway vegetation belt, mall belt, waterfront interface, intermittent catchment path, etc. The corridor site habitat mainly supports the species' habitat, migration function and the barrier or filtration between landscape elements in the urban green space (**Table 3**).

Table 2. Patch type site habitat and its characteristics.

Site habitat type	Patch size (side length/m)	Suitable plant community	Function
Habitat Garden (artificial habitat Island)	1–50	Shrub or high grass community, medium and low grass community	It can be used for rest and viewing, and has ecological functions such as supporting biodiversity and regulating microclimate
Urban woodland	10–200	Forest community	It can be used for sightseeing and rest, and has ecological functions such as supporting biodiversity, regulating microclimate, carbon fixation and oxygen release
Artificial lake wetland	5–50	Shrub or high grass community, medium and low grass community	Artificial lake wetland is an important resource-based patch in urban green space. It can control the hydrological spatial process by absorbing runoff, regulating rain and flood, and infiltrating recharge. At the same time, it can regulate the local microclimate
Biological detention facilities	1–20	Shrub or high grass community, medium and low grass community	Biological detention facilities have the basic functions of infiltration, detention, storage, purification, utilization and drainage of rainwater, and their special habitat conditions can serve the diversity of animals and plants
Roof greening	1–20	Medium low herbaceous community	Roof greening can beautify the urban three-dimensional space, balance the building and environmental temperature and humidity, reduce building energy consumption, and provide habitat for specific species through the construction of plant communities

Table 3. Corridor type site habitat and its characteristics.

Site habitat type	Corridor dimensions	Suitable plant community	Function
Urban greenway vegetation belt	Generally, the width can reach more than ten meters to 100 Meters, and the length can connect multiple urban block units	Forest community, shrub or tall grass community, medium and low grass community	It can be used for recreation and recreation, undertake the flow of information, energy and materials, promote the effective circulation within the landscape ecosystem, and strengthen the connection between adjacent patches
Boulevard belt	The width ranges from several meters to more than ten meters, and the length connects multiple urban block units	Forest community, shrub or tall grass community, medium and low grass community	It can be used for cooling and shuttling, can reduce noise, filter pollution, and bear Certain information, energy and material flow
Waterfront interface	The width ranges from a few meters to a hundred meters, and the length can span multiple block units along the river or form a circular distribution along the edge of the lake wetland	Forest community, shrub or tall grass community, medium and low grass community	It can provide leisure, recreation and other functional spaces. At the same time, it can provide habitats for all kinds of wet animals and plants
Intermittent	The width ranges from tens of	Shrub or high grass	It mainly supports the connectivity and transportation

catchment Path	centimeters to several meters, and the length connects multiple catchment spaces or multiple catchment units in the catchment unit according to the vertical conditions of the site	community, medium and low grass community	of water, nutrients and other material information among various habitat elements

4.3. Connectivity of urban site habitat

The relevant theories of green space ecological network can be used to guide the layout of green space in urban blocks, and make various types of site habitats form a stable whole. The urban block green space habitat network refers to the spatial organization pattern formed by the connection of various types of site habitats according to the natural law. When the total amount of ecological land is limited, the pattern of green space becomes an important factor affecting its ecological function.

In the green space quadrat of urban blocks, patch type site habitat and corridor type site habitat form the green space habitat network of urban blocks, and the site habitat often presents the characteristics of nesting layers. In patch type site habitat, bioretention facilities are often nested in larger scale Habitat gardens or urban woodland patches; in the corridor type site habitat, the intermittent catchment path relies on the urban greenway vegetation belt, the mall forest belt and the waterfront interface.

Patch site habitats are often "source" and "sink" of each other, carrying rich material information and animal and plant resources; the corridor type site habitat is an important path for the exchange of material information in the patch type site habitat. The material information is exchanged and circulated by relying on the site hydrological process, wind, biological carrying and other media. Corridor type and patch type site habitats are coupled to form a habitat network system to enhance the service function of urban ecosystem. In the green space pattern of urban blocks, areas beyond the radiation range of existing corridor type and patch type sites can form an area of ecological service coverage by increasing or adjusting the spatial layout of point like habitat elements (such as urban parks, street green space, roof greening); or the exchange and circulation of material information flow in the green space of urban blocks can be improved by increasing and adjusting the zonal habitat elements such as urban greenway vegetation belt, shade road forest belt and catchment path.

5. Discussions

In the spatial scale matching relationship of ecology involved in urban planning and design, the diversity and systematicness of urban block green space habitat have irreplaceable ecological value. The research methods and basic research scales of urban block green space, the spatial matching between urban green space and site habitat types and plant communities, and the connectivity of site habitat patches are the three key issues in the construction of urban block green space habitat network.

1) The feasibility of "sample method" as a basic research method of urban landscape mosaic and urban block green space is demonstrated through a comprehensive study. From the perspective of influencing factors of block scale green space layout, this paper discusses the "2 km × 2 km" as the basic quadrat scale of urban landscape mosaic and urban block green space research. Through the sample

method to observe and analyze the green space in the built-up area of Xi'an, four typical layout modes of green space are obtained: single core radiation type, multi-core dispersion type, corridor crossing type and scattered point distribution type. As the methods and contents of this study are based on Xi'an, the quadrat scale and typical green space model of urban blocks obtained from the study are applicable to the plain cities represented by Xi'an, while the representativeness and applicability of cities with different geomorphic characteristics need further demonstration and research.

2) In the study, the elements of four typical pattern quadrats of Xi'an block green space were refined and extracted, and the spatial matching of urban block scale green space, site habitat types and the existing scale and morphology of plant communities were compared and analyzed. Urban green space is the main carrier of urban ecosystem. Relying on urban block green space and based on the ecological stepping stone principle, identifying and organizing patch habitat and corridor habitat can form a habitat network of patches in series and improve the ecological benefits of urban green space. However, how to transform the construction of neighborhood habitat network into planning and design methods, and how to serve the old city renewal and incremental development planning of stock optimization need to be further explored.

6. Conclusions

Sampling method is an effective method to observe and analyze urban landscape mosaic. In the plain city represented by Xi'an, the basic scale of the research quadrat is "2 km × 2 km". The scale quadrat can be used to effectively observe and analyze the scale, elements, morphology, structure, habitat types and plant communities of green space in urban blocks. The element composition and spatial characteristics of the green space in Xi'an block within the "2 km × 2 km" quadrat are similar, showing four typical layout modes: single core radiation type, multi-core dispersion type, corridor crossing type and scattered point distribution type. The green spaces of urban blocks under the four typical models are characterized by small scale and scattered distribution.

Habitat patch elements and corridor elements are the basic morphological elements of urban block green space, and their scale characteristics confirm that there is spatial matching between urban block green space and site habitat types and plant communities. At the same time, it is proved that it can be involved in the planning and design of block green space by identifying different site habitat types, building corresponding plant communities, and combining the characteristics of scale, morphology and other elements. Urban ecology studies believe that the ecosystem services provided by cities depend on the spatial arrangement of urban habitat patches, especially the area, heterogeneity and connectivity of patches. The method of constructing the habitat network of urban block green space needs to be further explored based on the ecological principle of site habitat patch connectivity.

Based on the practical advantages of landscape architecture in urban green space planning and design, as well as the basic theories of landscape ecology and urban ecology on urban ecosystem, the research group of the author explores the construction method of urban block green space habitat network that points to landscape architecture planning and design. It aims to solve the practical problem of the

transformation of China's urban green space system planning from a single goal focusing on the social function needs of people and the optimization of spatial structure to the promotion of ecosystem services based on the coexistence of man and nature. The purpose of the study is to provide goal orientation for the construction and restoration of urban habitats, so that the green space of urban blocks can not only meet the needs of human social functions, but also provide a wider range of ecosystem service functions, and make continuous contributions to human health and well-being.

Conflict of interest: The authors declare no conflict of interest.

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