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Analysis of plant spatial characteristics based on visitors' behavioral preferences--A Case Study of Daming Lake in Jinan

Hanwen Mi

Weifang University, College of Biology and Oceanography, Shandong, China
mihanwen@foxmail.com

Abstract. The spatial characteristics of different sites in urban parks can influence the activity patterns and distribution of visitors, and visitors' activity preferences are crucial to the planning and design of urban parks. This paper takes Jinan Daming Lake as the research object; firstly, the distribution and activities of visitors in the park are recorded through behavioral observation and questionnaire; secondly, the accessibility, spatial enclosure, and plant light environment of the park are measured and recorded according to the distribution of visitors; finally, the influence of different plant spatial characteristics on the distribution of visitors' behaviors in the park is analyzed through quantitative methods. Finally, the influence of different plant spatial characteristics on the distribution of visitor behavior in the park was analyzed quantitatively to provide a reference for future renovation and construction of urban parks from the perspective of visitor preferences.

Keywords. Visitor preference; Spatial enclosure; Depression; Accessibility

1. Introduction

Jan Gehl classified outdoor activities of people in public spaces into three types: necessity activities, spontaneous activities, and social activities [1]. When the site and environment meet human needs and have certain functions, many spontaneous activities will occur, leading to the development of more social activities [2]. The park environment provides users with the opportunity to experience the outside world, which contributes to the residents' positive psychological construction. Conversely, visitors can exert their subjective initiative to create and influence the spatial environment of the park. This paper attempts to quantify the spatial characteristics of plants in the park from the spatial use preferences of Daming Lake to explore the popular space among users.

2. Research content and methodology

Daming Lake has a long history and is one of the famous tourist attractions in Jinan, which was officially established as a park in 1957. Inside the park, there are the Lixia Pavilion, the Tie Gong Ancestral Hall, the Little Canglang, the North Pole Pavilion, the Huibo Building, the Nanfeng Ancestral Hall, the Reverie Garden, the Jiaxuan Ancestral Hall and other landscapes, which make the Daming Lake present a strong cultural atmosphere and historical accumulation. Daming Lake is located in the north of the old city of Jinan, Shandong Province, and is formed by the confluence of many springs in Jinan, and the lake's water is injected into Xiaoqing River through the Lok River. The water surface area is 57.7 hectares, and the average water depth is 2~3 meters.

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This paper adopted the questionnaire survey method, behavioral place observation method (choose one day on weekdays and one day on weekends, and record the number of people watching the cultural activities and gathering and exchange activities in the park from 3 to 5 pm on weekdays and weekends, and record the number, gender, age, and content of activities of the activity crowd in real-time, and record the corresponding location of the activity crowd on the floor plan) and field interview method to investigate Daming Lake The analysis was carried out by the field interview method. Before the formal recording, two weekdays and two weekends with clear weather were chosen to investigate and record the activities of Daming Lake.

3. Analysis of results

3.1. Behavioral observation

3.1.1. Activity type analysis. The activities in Daming Lake are vibrant, including physical exercise, fun activities, music activities, communication activities and leisure activities. This survey only recorded the people who were performing cultural activities and communication activities in the venue, and did not record the people moving on the road. To study the attractiveness of the activities and the venues to the crowd, the performers and spectators of each activity were marked using the map marker method. The crowd of cultural and exchange activities at Daming Lake on weekdays and rest days is mostly male, mainly middle-aged and elderly retired people, and the number of family gathering activities on rest days is increasing, with more young people and children.

Table 1. Characteristics of the population of literary and artistic activities in Daming Lake.

Category	Male	Female	Elderly	Middle Age	Youth	Children	Total
Working day	129	68	72	65	54	6	197
Rest days	367	125	113	135	201	43	492

The activities are spread throughout the park, with the main groups of people concentrated in the forest space on both sides of the entrance, along the southern shoreline and along the park's main roads. The gathering of these activities forms a subspace with a strong sense of domain. This paper selects four areas with a large number of people gathered in the map for specific analysis.

Figure 1. Spatial distribution of weekend activities at Daming Lake

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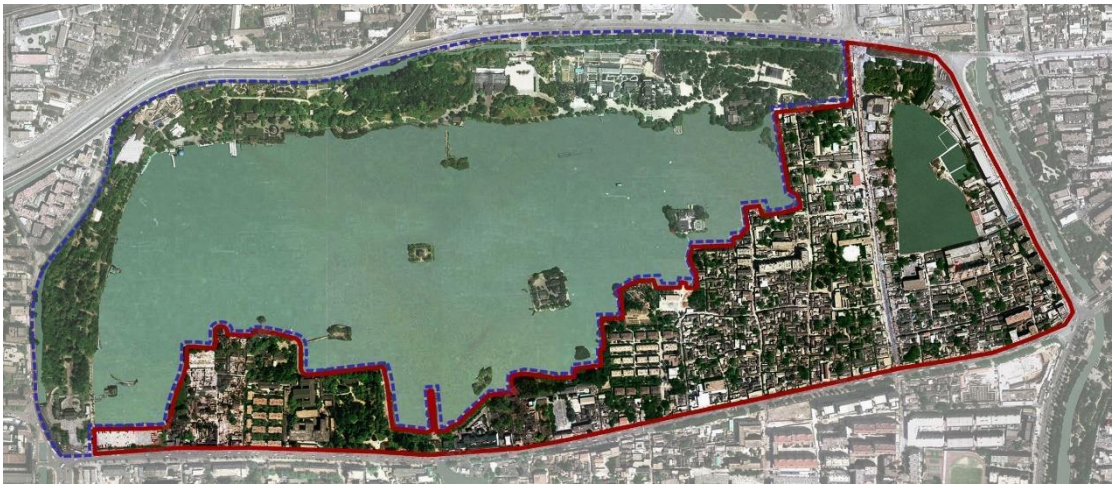

Figure 2. Satellite picture of Daming Lake

3.1.2. Choral activities and their environmental characteristics. (1) Activity characteristics: The choral activities are mainly located on the connecting islands. The crowd is mainly middle-aged and elderly, and the number of men is about twice as large as that of women. The spectators were mainly divided into participatory spectators and non-participatory spectators. The participant spectators were surrounded by the performers and were within 2m of the performers. The non-participating spectators were usually distributed in the seats outside the chorus circle, and they were paying attention to the performance while resting. (2) Environmental characteristics: Area 1 is a forested space with the spatial property of the shelter. It is located at the junction of the road and the site. It is distributed along the main walking path, which is highly accessible but avoids the main road at the entrance of the park to avoid the disturbance of pedestrian flow. From the performers' point of view, the site has the spatial independence needed for group activities while simultaneously satisfying the conditions for being viewed by passersby. From the viewpoint of the spectators, the space must not be flowing, and the spectators will not want to stop because of the unstable factor of the crowd. In addition, the seating of the venue creates a convenient space for the viewer.

Figure 3. Distribution of performers and spectators at the connecting islands

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3.1.3. Harmonica activities and their environmental characteristics. (1) Activity characteristics: The harmonica player was located in a vacant lot next to the park's main road, and the performer was a middle-aged male. The number of spectators shows that harmonica playing is more attractive to the crowd than erhu and flute playing. The erhu and flute playing activities tend to be more of an internal group communication process. In contrast, as a solo activity, the harmonica tends to be more of a performance and attracts more people to come and watch. In addition, the harmonica player is standing in a semi-open space next to the main street, and his choice of setting may be motivated by a sense of performance. (2) Environmental characteristics: Area 2 is surrounded by main park roads and is located at a crossroads, so the flow of people is obviously large. The site is a semi-open space enclosed by plants, and the open space is large enough to accommodate a large number of spectators. The whole space is open to the road, and the activities in the space can be seen by the people passing by. There is a seat in front of the plant community, which is convenient for players and spectators to stay.

3.1.4. Erhu and flute playing activities and their environmental characteristics. (1) Activity characteristic: Erhu and flute playing activities are mainly located near the tea room. Most of the participants are retired people over 55 years old. The erhu performers are located in the promenade of the tea room, and the flute players are mainly located in the seats by the flower bed. Since there are enough rest facilities, people can stay here for a long time. (2) Environmental characteristics: Area 3 is a small, semi-open space enclosed by separate buildings and plants. The outer promenade provides a stage-like architectural backdrop for the erhu player, while at the same time opening up to the outside world for presentation to the viewer. In front, the semi-open space is enclosed by flowerbeds, which face each other and have seats in front of them. If there is an event, the movers and shakers on both sides can be mutual performers and viewers. This spacious unit has six entrances, and more people will flow into this space to become observers of the event.

3.1.5. Assembly communication. (1) Activity characteristics*:* The assembly exchange was very intensive, and this population was the most numerous group activity observed in this study, still presented in groups. On weekends, large groups were around 30 people, and small groups were 10-15 people. On weekdays, large groups were around 20 people, and small groups were 7 to 8 people. Almost all of the participants were men, and only one or two were women. The age of the participants was mainly middle-aged and elderly. (2) Environmental characteristics*:* Area 4 is located on the park's main road next to the gate and the open space on both sides. After interviewing and observing, the conversations are mostly about current affairs and some social issues, which may be due to the discussants' perception of the cultural atmosphere near the statue of Liu E and the clock tower site. The entire space is highly mobile, and there are no services around the road. De Guin's Applied Transportation mentions that in the park, there is an attraction that pulls people towards the edge. Therefore, we analyze that at the beginning, this conversation may originate from a small number of people talking on the roadside, and this conversation will attract more people to participate, gradually forming a crowd of people talking and surrounding the middle of the road.

3.2. Questionnaire

The questionnaire was divided into four parts, the first part was the basic information about the visitors, the second part investigated the types of activities of the visitors in Daming Lake, and the third part was based on whether the visitors used the site as the first activity site and the reasons for the site selection, and the fourth part was the visitors' suggestions for the site renovation. The sample size of the questionnaires was 50, and 48 of them were valid. According to the questionnaires, 87.50 % of the visitors chose the venue as their first choice, which means that the reasons for choosing the venue and the suggestions are of the reference value.

3.2.1. Types of activities. According to the questionnaire, 31.25% of people often sing; 22.92% play musical instruments; 16.67% look around; 10.41% chat; 10.41% exercise and square dance; and 8.33% choose to sit quietly.

3.2.2. Reasons for activities. 20.83% chose the site because they could hear the music; 18.75% because of the proximity to the road and the high flow of people; 16.67% because of the proximity of the entrance and the shelter of plants; 12.5% because of the open view and the availability of infrastructures such as seats and a quiet environment; 10.42% because of the architectural factor; 8.33% because of other factors; 6.25% because of the smell of flowers 4.17% because other places were occupied; 2.08% because the site had markers to make it easy for friends to find him.

3.2.3. Park improvement suggestions. Among the other improvements, 2 out of 48 people thought that the area of the site should be expanded, two people thought that the safety fence should be increased, one person thought that the iconic landscape should be increased, and one person thought that the cultural exhibition board of Quancheng should be increased.

4. Analysis of the quantitative characteristics of the environment for weekend cultural exchange activities

4.1. Measurement of environmental quantity characteristics

4.1.1. Spatial accessibility. The distance between the activity space and the park entrance affects people's attention to and use of the space. There are entrances and exits on the east, west, north, and south sides of Daming Lake, with the south entrance being the main entrance and exit. The distance between the four spatial units and the nearest entrance is less than 200m, which is convenient to attract people. There are more buses at the south entrance than at the other entrances, which makes the space on the south side of the park more accessible and easier to use (Table 2).

Table 2. Spatial accessibility measurements

	Distance from the nearest entrance (m)	Distance from the main entrance (m)
Region 1	44	174
Region 2	35	189
Region 3	42	196
Region 4	32	68

4.1.2. Spatial enclosure. The size, shape, and length of the space affect people's perception of the space, the length and width constitute the base of the space, and the height determines the boundary of the space. The enclosure of space can be measured by the base surface's ratio of depth (D) to height (H). It has been suggested that when D/H is less than 1, the space produces the feeling of the enclosure; when D/H=1-3, the size scale of the space is more appropriate; when D/H is more than 3, the space has the feeling of emptiness [3]. Area 1 is located at the connecting island, there is no obvious plant boundary, and the spatial sight distance is represented by measuring the planting distance D of the tree array. Areas 2 and 3 were irregular in shape, and two representative viewpoints were selected for sampling, respectively. Details are shown in Table 3.

Table 3. Spatial enclosure measurements

Region Name	D(m)	H(m)	D/H
Region 1	10.0	9.6	1.042
Region 2	Viewpoint 1 12.0	15.2	0.724
	Viewpoint 2 10.0	15.2	

Region 3	Viewpoint 1 11.0	15.6	0.673
	Viewpoint 2 10.0	15.6	
Region 4	6.0	12.3	0.488

In terms of D/H, all four areas have a strong sense of spatial enclosure and high spatial affinity, which attract people to enter them. Area 4 has a more obvious spatial limitation as a long and narrow space. According to a study, in the plant configuration of the enclosed space, the height layer below 6m is closer to the human viewing height, and the effect of enclosing space is more obvious [4], which indicates that small trees and shrubs are more recognizable for the spatial boundary. Areas 2 and 3 are rich in planting levels, with small trees of 3-4m and shrubs of 1.5m high planted next to the seats, creating a more enclosed and independent space.

4.1.3. Plant light environment. The light environment of plants affects the perception of spatial confinement, and the stronger the spatial light permeability, the lower the spatial confinement. In this paper, we use depression degree to reflect spatial light permeability, which is a measure of the horizontal spatial area occupied by plants. It reflects the degree of coverage of the top of the space by the plant leaf layer [5]. The top layer of plants was sampled by a fisheye camera according to the size of each spatial unit, and the software was used to calculate the lushness of each point and the average value.

From Table 4, area 4 has the highest top plant depression, i.e., the highest road space top closure, followed by area 3.

Table 4. Plant light environment measurements

	Sampling value		Average Depression
Region 1	2.342	1.687	2.146
	1.980	2.173	
	1.647	3.049	
Region 2	2.198	2.541	2.206
	2.960	1.793	
	1.876	1.870	
Region 3	2.450	2.010	2.321
	2.648	2.233	
	2.322	2.262	
Region 4	2.687	2.340	2.748
	2.923	2.711	
	2.780	3.048	

4.2. Analysis of environmental quantity characteristics

4.2.1. Enclosure and depression. The degree of enclosure reflects the relationship between the height of the space and the base surface, while the degree of depression reflects the coverage of the top of the space. From Table 5, we can see that the D/H values of the four areas show an inverse relationship with the lushness, which indirectly reflects that the more open the plant space in Daming Lake, the lower the lushness of the top layer. This phenomenon can be explained by the planting spacing, where the smaller the planting spacing is, the stronger the spatial enclosure and lushness is. In addition, the leaf area and branch density of plants also have a great influence on the degree of depression.

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Table 5. Quantitative characteristics of the environment

Quantitative characteristics	Region 1	Region 2	Region 3	Region 4
Distance from the main entrance	174	189	196	68
D/H	1.042	0.724	0.673	0.488
Depression	2.146	2.206	2.321	2.748

4.2.2. Accessibility and enclosure. From Figure 4, we can see that the spatial enclosure of the four areas decreases as they move away from the main entrance in turn. The space near the main entrance is more open and rich in activities, and the crowd is easily attracted by the activities and forms a gathering. This kind of space is more likely to stimulate lively, high and infectious activities, such as chorus, ensemble, etc., and the space has a cheerful atmosphere. As the route progresses, the scale of the space is gradually reduced, and the atmosphere is gradually milder, with activities conducted by individuals or small groups, such as harmonica solos or erhu exchanges. Area 4 is the narrowest, and the atmosphere becomes quiet and serious here.*Plant light environment.* The light environment of plants affects the perception of spatial confinement, and the stronger the spatial light permeability, the lower the spatial confinement. In this paper, we use depression degree to reflect spatial light permeability, which is a measure of the horizontal spatial area occupied by plants. It reflects the degree of coverage of the top of the space by the plant leaf layer [5]. The top layer of plants was sampled by a fisheye camera according to the size of each spatial unit, and the software was used to calculate the lushness of each point and the average value.

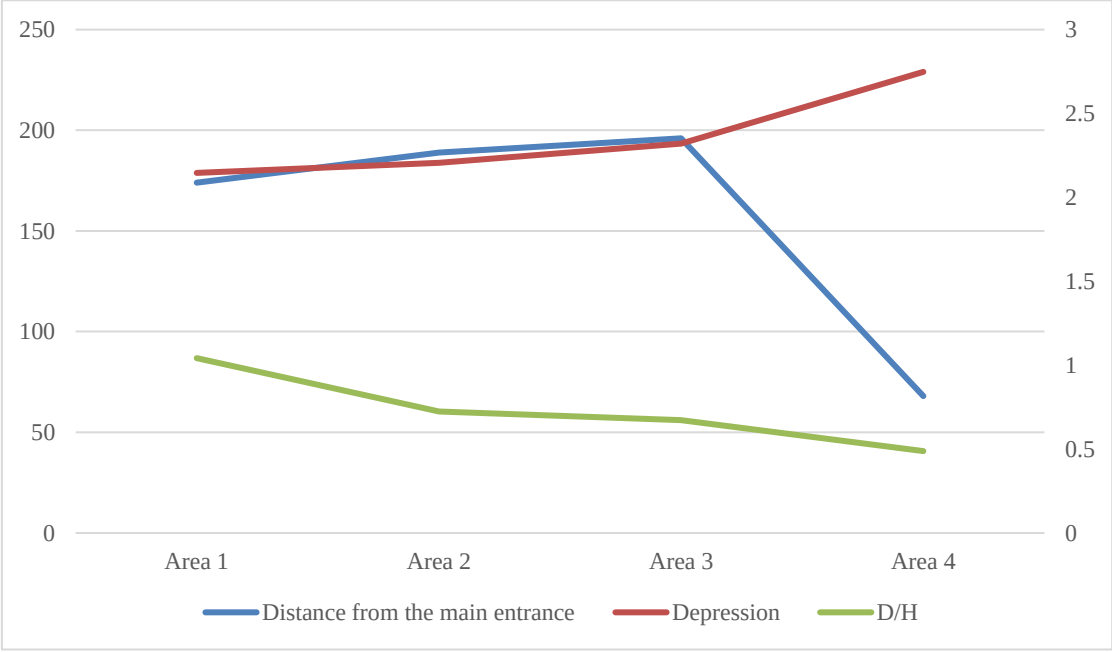

Figure 4. Relationship of environmental quantity characteristics

4.2.3. Accessibility and enclosure. With the depth of the route, the spatial top layer plant cover also showed a gradual increase. The higher top layer depression in area 1 is related to the higher planting density and the higher leaf area index of Pendula. In fact, the plant species and levels in areas 2, 3 and 4 are richer than those in the entrance space, with small trees and groundcovers defining the boundary space, thus forming identifiable base space, façade space and top space, where people can easily stop and rest and relax.

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5. Conclusion

The weekend cultural activities and exchange activities at Daming Lake are mainly for the elderly, and the activity venue is preferred the one with high accessibility, a large flow of people and shelter. The creation of plant space is crucial to the attractiveness of the site. The spatial scale near the main entrance of the park should be large, and the degree of plant enclosure and depression should not be too high, so as to divert the crowd and play the role of transition to the interior of the park, and the lively and cheerful functional partitions can be arranged near the entrance. As the park road goes deeper into the center of the park, the activity functions are gradually dispersed, and the configuration of plants should be adjusted according to the nature of the space. For example, for quiet spaces, the degree of plant enclosure and the top layer of depression should be higher to isolate the outside. For semi-open spaces where people can carry out small activities, the degree of enclosure and lushness of the top layer may need to be both long and short, so that the base, façade and top of the space are not completely closed to attract people from outside. However, in the specific design process, the site characteristics, plant characteristics, spatial sequence and other factors need to be fully considered to create a beautiful, comfortable space that meets the needs of users.

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