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Landscape Features Impact the Spatial Heterogeneity of Visitation Density within a Comprehensive Park: What Are the Seasonal and Diurnal Variations?

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Abstract: Urban parks are the main place for physical activities, generating numerous benefits to enhance human well-being. Many studies have investigated the impacts of landscape features on park visitation but ignored their seasonal and diurnal variations. Taking the Hunan Martyr Park in China as an example, this study aims to assess the seasonal and diurnal variations in the impacts of landscape features on visitation density. We quantified visitation density for 109 activity zones for both daytime and nighttime in summer and winter and investigated the impacts of landscape features of the activity zone and the surrounding environments on visitation density based on 16 quantitative indicators. The results show that: (1) The impacts of ground condition, connection to water, distance to park entrances, and distance to stores were consistent in different periods. Paved activity zones, zones close to water, zones further away from the park entrances, and zones closer to the stores had significantly higher visitation density. (2) Shading degree, connected pathway, and distance to toilets had contrasting impacts between summer and winter. Zones with a higher shading degree attracted more visitors in summer and deterred visitors in winter. Zones with fewer pathways connected and zones farther away from toilets had higher visitation density in summer but not in winter. (3) Shading degree, number of trees, presence of facilities (e.g., benches, tables, pavilion, and light devices), and connected pathway had contrasting impacts between daytime and nighttime. Zones with a high shading degree, zones with benches and pavilions, and zones without trees had higher visitation density in the daytime. Zones with light devices, zones with more connected pathways, and zones without tables had higher visitation density at nighttime. These findings highlighted the seasonal and diurnal variation of the impacts of landscape features on park visitation and can help to improve urban park design, especially for cities with hot summers and cold winters.

Keywords: activity zone; landscape features; seasonal and diurnal variations; urban park; visitation density

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1. Introduction

Urban parks mostly covered by vegetation and water are the major natural components of the urban ecosystem. They provide numerous ecosystem services and are strongly associated with residents' health and human well-being [1–3]. Visiting parks can increase physical activity [4,5], promote social interaction [6,7], enhance positive emotions [8], and

improve visitors' psychological health [9,10]. Promoting park visitation (i.e., visitation density) is, therefore, critical to public health and urban sustainability. The visitation to urban parks (for example, frequency and duration) is highly related to the personal and socioeconomic characteristics of the residents [11,12]; however, landscape features of the park also play a significant "pull" or "refuse" effects.

Previous studies showed that visitation density varied significantly among parks and is highly related to the park characteristics and the surrounding environment of the park [13]. Firstly, park size and park type matter. For example, larger parks usually host more visitors than smaller ones but may be not related to higher visitation density [14]. A comprehensive park usually provides more recreation opportunities than a community park [15]. Secondly, landscape features in the park impact the visitations. For example, park greenery and tree coverage usually increase visitation density [16–18]. Parks with high vitality usually have diversified facilities, for example, sports fitness [19], recreational facilities [7,20], and amenities [21]. Landscape features also indirectly impact visitation density by changing the visitors' perception of safety, especially for women [22]. Thirdly, the surrounding environment of the park also impacts visitation density. Parks located in high-density areas usually have more visitation and parks with better accessibility can usually attract more visitors [23,24].

Visitors within the park are not uniformly distributed but also show significant spatial heterogeneity. Investigating the spatial heterogeneity of visitation density within the park has received increasing concern as the findings are a prerequisite for both designing new parks and revitalizing old parks. The size of the activity zone is a basic indicator [25–27]. Facilities within the activity zone are important factors when visitors decide to stay or leave [27]. For example, a study in Zhengzhou, China showed that areas with more service facilities had higher spatial vitality (e.g., visitation density) [28]. The shaded areas provided either by trees or buildings usually have more visitors in summer [27,29]. People prefer well-paved areas for recreational activities [30,31]. Additionally, the surrounding environment of the activity zones also significantly impacts visitation density [32,33]. For example, zones close to shopping malls, retail shops, and water features usually have higher visitation density [24].

Thermal comfort is an important factor affecting human outdoor physical activities [29,34]. Therefore, the effects of landscape features on visitation density may be mediated by climate. On hot days, people prefer zones with less heat stress, for example, the areas under trees, covered by shelters, or shaded by buildings [29,34,35]. On cold days, people desire zones that can be directly heated by the sunshine [36,37]. Areas with a higher sky view factor (SVF, a measure of how much sky can be seen from a certain point) are uncomfortable places for outdoor activities in summer but are favorable places in winter [38]. This raises a great challenge for effective planning and designing the activity zone to increase visitation density in different climate conditions, especially in cities with severely hot summers and extremely cold winters.

Taking the Hunan Martyr Park in Changsha, China, as an example, this study aims to investigate the consistency and inconsistency of the intra-city variation in visitation density and the related driving factors. Specifically, we tried to answer two questions: (1) What are the intra-park variations in visitation density in a hot summer and cold winter? (2) Are the impacts of landscape features on visitation density the same in these two seasons and in daytime and nighttime? We selected 109 activity zones with different landscape features measured by 16 indicators, observed the number of visitors for each activity zone, and investigated the impacts of landscape features on visitation density and their difference between summer and winter and between daytime and nighttime. The findings can extend our understanding of the impacts of landscape features on the intra-park variations in visitation density, which are valuable for park planning and management to promote park visitation in regions with hot summers and cold winters.

2. Study Area and Methods

2.1. Study Area

Changsha, the capital city of Hunan province, is located in southeastern China (Figure 1). It has a subtropical monsoon climate, with an annual average temperature of 17.50 °C (63.5 °F). The climate varies significantly between the four seasons. The summer is long and hot (more than 30 days with a temperature higher than 35 °C and an average maximum temperature of 28 °C), and the winter is very cold (more than 10 days with a temperature less than 4 °C and an average maximum temperature of 10 °C). The vegetation is dominated by subtropical evergreen broad-leaved forests. Changsha is the most populous city in Hunan province, hosting 10.06 million inhabitants and with an urbanization rate of 82.6% in 2020.

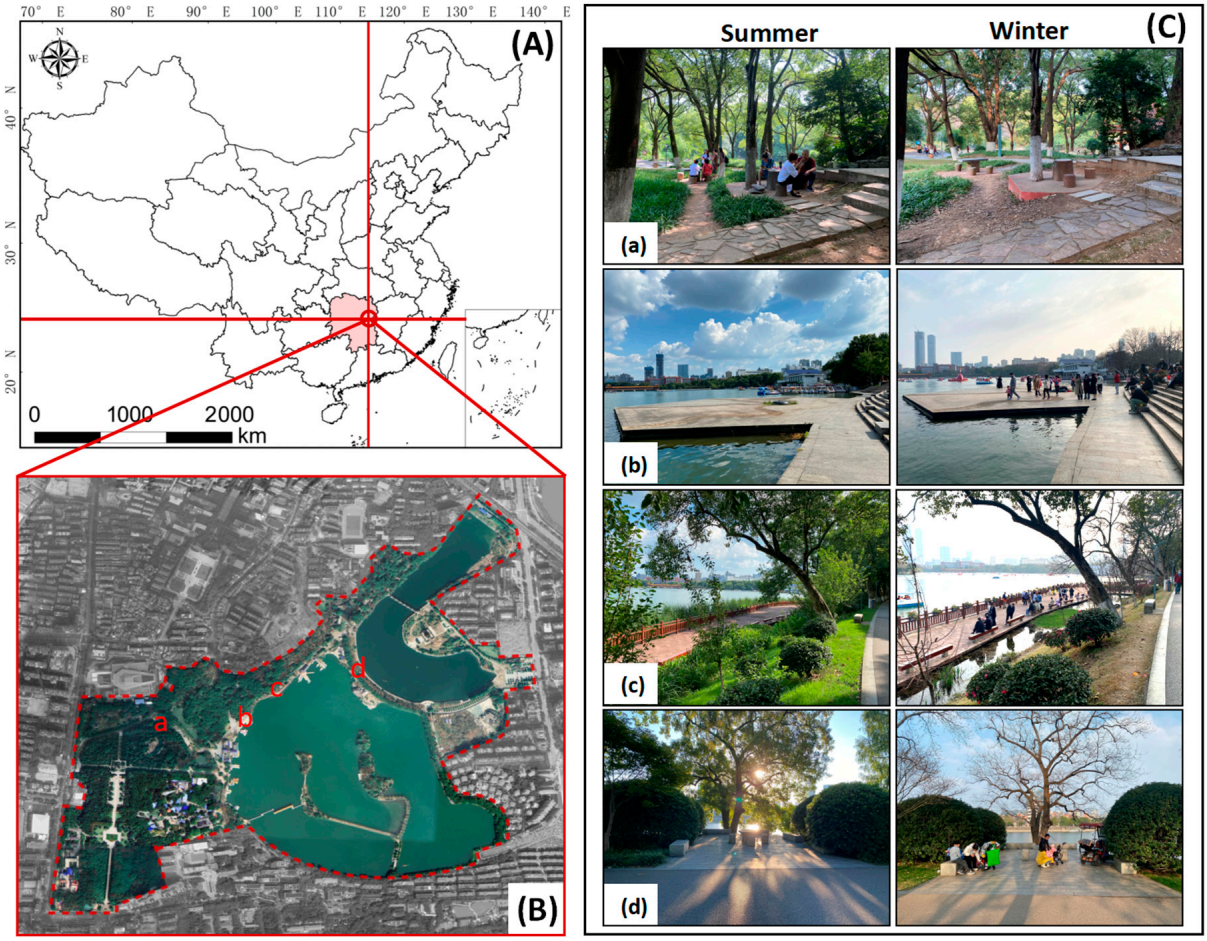

Figure 1. Location of the study area (**A**), map of the Hunan Martyr Park (**B**), and photos of four representative activity zones in summer and winter (**C**).

We conducted our study in the Hunan Martyr Park, the largest urban park in Changsha. It has a total area of 153.3 ha with 62.42 ha covered by water. Open in 1951, Hunan Martyr Park is designed not only for daily recreation but also for memorializing the martyrs who devoted their lives to the Chinese people's liberation. The park has a green cover ratio of 98.5% with more than 326 species and more than 150 thousand trees. It was awarded the "National Key Park" by the Ministry of Housing and Urban–Rural Development of China in 2009. Hunan Martyr Park hosts more than 7 million visitors each year and during the National Holiday, the average daily visitors can reach 44 thousand.

2.2. Characterizing Landscape Feature

We selected 109 activity zones with diverse landscape features. The activity zones had an average size of 0.03 ha, ranging from 0.0003 to 0.25 ha. Following previous studies [31] and several environmental assessment tools [39–42], we measured the landscape features of the activity zones using 16 variables (Table 1). Among them, 10 variables characterized landscape features of the activity zone itself (i.e., ground cover, shading degree, and presence of facilities), and 6 variables measured the surrounding environment of the activity zone (i.e., presence of water, connected pathway, and distance to infrastructure, such as toilets). Table 1 shows the detailed description and measurement of these variables.

Table 1. Description of the variables and the number of corresponding activity zones.

No	Variable	Categories	Number of Activity Zone	%	Reference Measurement Tool
1	Ground cover: record ground surface material.	Impervious surface Grass Bare soil	84 9 16	77.1 8.2 14.7	EAPRS
2	Shading degree: ratio of shaded area by trees and pavilions to the total area.	Less than 0.3 0.3 to 0.7 More than 0.7	26 30 53	23.9 27.5 48.6	EAPRS
3	Tree cover ratio: percent of tree cover to the total area of the activity zone.	Less than 30% 30% to 70% More than 70%	31 39 39	28.4 35.8 35.8	EAPRS
4	Number of trees: number of trees.	No trees 1–10 trees 10–30 trees More than 30 trees	59 32 13 5	54.1 29.4 11.9 4.6	NA
5	Presence of benches: number of benches (eighty centimeters is counted as one seat).	No benches 1–8 benches 8 above benches	20 27 62	18.3 24.8 56.9	EAPRS
6	Presence of tables: whether there are tables.	No Yes	71 38	65.1 34.9	EAPRS
7	Fitness facilities: whether there are fitness facilities.	No Yes	108 1	99.1 0.9	CPAT
8	Court: record whether there is a court.	No Yes	101 8	92.7 7.3	PARA
9	Presence of pavilion: whether there are pavilions.	No Yes	82 27	75.2 24.8	EAPRS
10	Presence of light devices: whether there are artificial lighting devices.	No (Summer) No (Winter) Yes (Summer) No (Winter)	76 73 33 36	69.7 67.0 30.3 33.0	BRAT-DO
11	Visual connection with water: whether the water surface (e.g., pond, lake) can be seen in the activity zone.	No Yes	54 55	49.5 50.5	POST
12	Water adjacent: weather there is water surface within a 50 m buffer.	No Yes	76 33	69.7 30.3	CPAT
13	Connected pathway: how many pathways connected to the activity zone?	1 2 3 and above	38 45 26	34.9 41.3 23.9	CPAT
14	Distance to stores: nearest walking distance to the store.	Less than 300 m (Summer) Less than 300 m (Winter) 300 to 500 m (Summer) 300 to 500 m (Winter) Higher than 300 m (Summer) 300 to 500 m (Winter)	27 36 24 23 58 50	24.8 33 22 21.1 53.2 45.9	EAPRS
15	Distance to park entrances: nearest walking distance to the nearest park entrance.	Less than 300 m 300 to 500 m More than 500 m	43 45 21	39.4 41.3 19.3	EAPRS
16	Distance to toilets: nearest walking distance to the nearest toilet.	Less than 300 m (Summer) Less than 300 m (Winter) 300 to 500 m More than 500 m (Summer) More than 500 m (Winter)	91 94 13 5 2	83.5 86.2 11.9 4.6 1.8	CPAT

EAPRS: Environmental Assessment of Public Recreation Spaces [39]; CPAT: Community Park Audit Tool [40]; BRAT-DO: Bedimo-Rung Assessment Tool—Direct Observation [43]; POST: Quality of Public Open Space Tool [41]; PARA: Physical Activity Resource Assessment [42].

2.3. Measuring Visitation Density

We counted the number of visitors for each activity zone through field observation. The observations were conducted over four sunny days in a hot summer (two weekdays and two weekend days, i.e., 29 July to 1 August 2021) and three sunny days in a cold winter (three weekdays, i.e., 11 and 13 January 2022). It should be noted that the COVID-19 pandemic occurred in Changsha on 31 July and visitation to the park was not encouraged after that. The weather conditions of the observation days are listed in Table 2.

Table 2. The climate during the experimental observation period.

Date	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean Temperature (°C)	Wind Level and Direction
29 July 2021	36	26	31	North wind level 2
30 July 2021	36	27	31.5	West wind level 1
31 July 2021	36	27	31.5	Southeast wind level 2
1 August 2021	40	26	33	Northeasterly wind level 1
11 January 2022	10	0	5	Southeast wind level 1
12 January 2022	12	5	8.5	North wind level 0
13 January 2022	10	4	7	Northwesterly level 1

The observation period in summer included eight hours (6:30 a.m.–11:30 a.m. and 4:30 p.m.–7:30 p.m.) in the daytime and two hours at nighttime (7:30 p.m.–9:30 p.m.). The period between 12:30 a.m. and 4:30 p.m. was not considered because it is so hot that very few people visit the park. In winter, the observation was conducted in three periods. (i.e., 7:30 a.m.–12:30 a.m. and 2:30 p.m.–5:30 p.m. for daytime and 6:30 p.m.–8:30 p.m. for nighttime).

We calculated the visitation density in each activity zone during the daytime and nighttime, respectively, as in the following Equation (1):

$$D = \frac{N_D}{A_Z} \quad (1)$$

where D is the visitation density, N_D is the number of visitors, and A_Z is the size of the activity zone.

2.4. Statistical Analysis

As visitation density is not normally distributed, we conducted the Kruskal–Wallis H-test to check whether visitation densities are significantly different among activity zones with different landscape features (for example zones with and without trees). A post hoc test was applied to further check the impacts of landscape features on visitation density. All the statistical analyses were performed using the R software, version 4.1.2.

3. Results

3.1. Spatiotemporal Variations in the Visitation Density

Visitation density showed strong spatiotemporal variation in the Hunan Martyr Park. The average summer daytime visitation density was 4388 people per ha (p/ha), ranging from 15 to 62,083 p/ha with a standard deviation of 7641 p/ha. The average winter daytime visitation density was 5902 p/ha, ranging from 0 to 83,333 p/ha, with a standard deviation of 10,037 p/ha. The average summer nighttime visitation density was 758 p/ha, ranging from 0 to 17,083 p/ha, with a standard deviation of 1808 p/ha. The average winter nighttime visitation density was 410 p/ha, ranging from 0 to 6337 p/ha, with a standard deviation of 763 p/ha (Table 3). Figure 2 shows the spatial pattern of visitation density in different periods. The visitation densities are randomly distributed with insignificant and low values of Moran's I (Table 3).

Table 3. Descriptive statistics of visitation density (p/ha) in four time periods.

Periods	Median	Mean	Standard Deviation	Minimum	Maximum	Moran's I
Summer daytime	2353	4388	7641	15	62,083	0.0128
Winter daytime	2963	5902	10,037	0	83,333	−0.0051
Summer nighttime	248	758	1808	0	17,083	0.0128
Winter nighttime	67	410	763	0	6337	0.0055

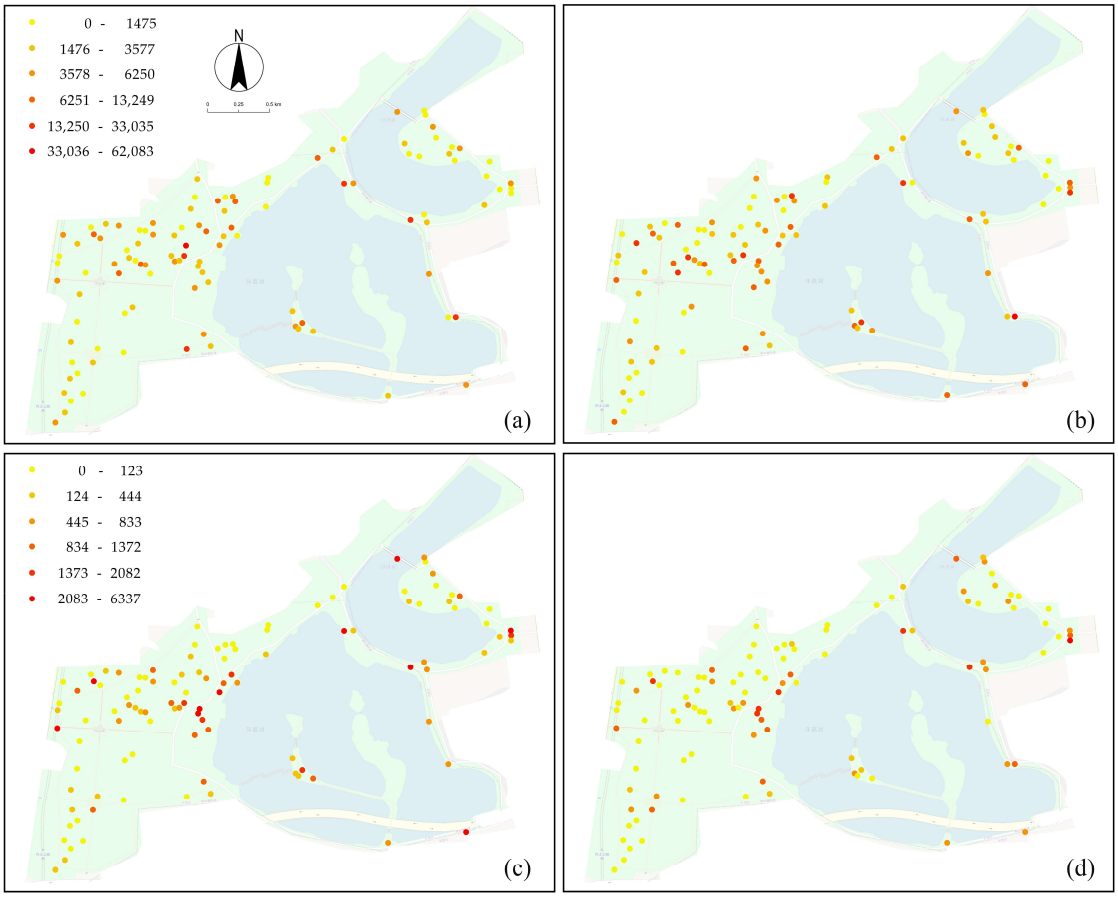

Figure 2. Distribution of visitation density (p/ha): summer daytime (**a**), winter daytime (**b**), summer nighttime (**c**), and winter nighttime (**d**). Daytime share the same legend and nighttime share the same legend, respectively.

3.2. Characteristics of Landscape Features

Landscape features of the 109 activity zones show strong variations in terms of tree cover, ground cover, facilities, and surrounding environments. The detailed information can be found in Table 1.

3.3. Impacts of Landscape Features on Visitation Density

Zones with paved surfaces had significantly higher visitation density than zones covered by grass and bare land in all periods (Table 4 and Figure 3a). Visitation density in zones with a shading degree higher than 0.7 was significantly higher than that in zones with a shading degree lower than 0.3 in summer daytime, but there was no significant difference in winter daytime. Significantly higher visitation density was observed for activity zones with a tree cover ratio of less than 30% in winter daytime, but significantly higher visitation density was not observed for activity zones with a tree cover ratio high than 70% in summer daytime. During the nighttime in both seasons, significantly higher visitation density was observed for activity zones with a shading degree and a tree cover ratio of less than 30% (Table 4 and Figure 3b,c).

Table 4. Kruskal–Wallis H-test of visitation density.

No			Day			Night		
			Test Statistic	df	*p* Value	Test Statistic	df	*p* Value
1	Ground cover	Sum.	14.656	2	0.001 **	18.218	2	<0.001 ***
		Win.	20.748	2	<0.001 ***	20.887	2	<0.001 ***
2	Shading degree	Sum.	7.079	2	0.029 *	12.968	2	0.002 **
		Win.	3.260	2	0.196	12.593	2	0.002 **
3	Tree cover ratio	Sum.	3.541	2	0.170	18.995	2	<0.001 ***
		Win.	11.398	2	0.003 **	23.157	2	<0.001 ***
4	Number of trees	Sum.	15.159	3	0.002 **	6.410	3	0.093
		Win.	20.557	3	<0.001 ***	6.012	3	0.111
5	Presence of benches	Sum.	12.700	2	0.002 **	1.085	2	0.581
		Win.	7.191	2	0.027 *	0.774	2	0.679
6	Presence of tables	Sum.	0.237	1	0.627	7.574	1	0.006 **
		Win.	1.930	1	0.165	24.786	1	<0.001 ***
7	Presence of fitness facilities	Sum.	0.445	1	0.504	1.404	1	0.236
		Win.	0.365	1	0.546	1.722	1	0.189
8	Presence of court	Sum.	0.439	1	0.508	1.135	1	0.287
		Win.	0.261	1	0.609	1.805	1	0.179
9	Presence of pavilion	Sum.	20.882	1	<0.001 ***	0.919	1	0.338
		Win.	7.649	1	0.006 **	2.217	1	0.136
10	Presence of light devices	Sum.	0.141	1	0.707	19.709	1	<0.001 ***
		Win.	3.185	1	0.074	34.213	1	<0.001 ***
11	Visual connection to water	Sum.	6.175	1	0.013 *	14.222	1	<0.001 ***
		Win.	6.159	1	0.013 *	12.671	1	<0.001 ***
12	Water adjacent	Sum.	0.113	1	0.737	0.354	1	0.552
		Win.	0.031	1	0.861	0.968	1	0.325
13	Connected pathway	Sum.	6.972	2	0.031 *	7.001	2	0.030 *
		Win.	2.889	2	0.236	14.506	2	0.001 **
14	Distance to stores	Sum.	11.677	2	0.003 **	4.017	2	0.134
		Win.	5.721	2	0.057	10.915	2	0.004 **
15	Distance to park entrances	Sum.	8.612	2	0.013 *	12.193	2	0.002 **
		Win.	9.987	2	0.007 **	17.685	2	<0.001 ***
16	Distance to toilets	Sum.	6.730	2	0.035 *	7.143	2	0.028 *
		Win.	1.180	2	0.554	5.034	2	0.081

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Sum.: Summer, Win.: Winter.

Activity zones without trees showed significantly higher visitation density during the daytime but not during the nighttime in both seasons (Table 4 and Figure 3d). Zones with benches and pavilions also showed significantly higher visitation density during the daytime but not during nighttime in both seasons (Table 4 and Figure 3e,i). Zones without a table and with light devices had significantly higher visitation density during nighttime but not during the daytime in both seasons (Table 4 and Figure 3f,j).

Significantly higher visitation density was observed for activity zones that have a visual connection to water in all periods (Table 4 and Figure 3k). Activity zones adjacent to one pathway showed significantly higher visitation density in summer daytime. Activity zones adjacent to more than two pathways showed significantly higher visitation density during nighttime in both seasons (Table 4 and Figure 3m). Visitation density in zones more than 500 m from the park entrances was significantly higher than that in zones less than 300 m during daytime and nighttime in both seasons (Table 4 and Figure 3o). Significantly higher visitation density was observed for activity zones more than 500 m from the toilets

during daytime and nighttime in summer but not in winter (Table 4 and Figure 3p). Zones more than 500 m from the stores showed significantly higher visitation density in summer daytime and winter nighttime (Table 4 and Figure 3n).

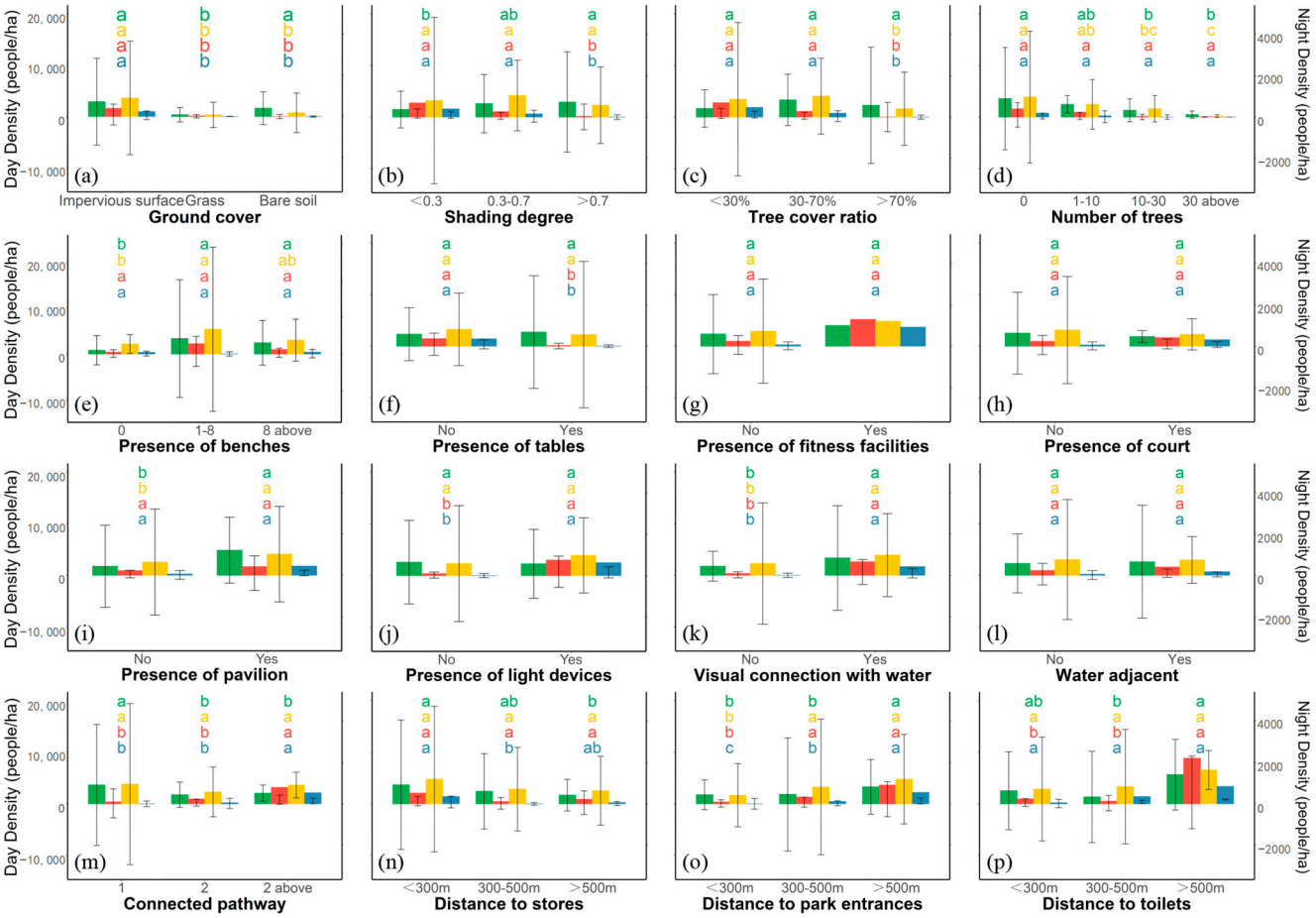

Figure 3. Kruskal–Wallis H-test (K samples) multiple comparisons analysis of visitation density during four time periods (n = 109), respectively. Green indicates summer daytime, red indicates summer nighttime, yellow indicates winter daytime, and blue indicates winter nighttime. Different letters indicate significant differences ($p < 0.05$). (**a**) indicates ground cover, (**b**) indicates shading degree, (**c**) indicates tree cover ratio, (**d**) indicates number of trees, (**e**) indicates presence of benches, (**f**) indicates presence of tables, (**g**) indicates presence of fitness facilities, (**h**) indicates presence of court, (**i**) presence of pavilion, (**j**) indicates presence of light devices, (**k**) indicates visual connection with water, (**l**) indicates water adjacent, (**m**) indicates connected pathway, (**n**) indicates distance to stores, (**o**) indicates distance to park entrances, (**p**) indicates distance to toilets.

4. Discussion

4.1. Landscape Features in the Activity Zone Impact Visitation Density

4.1.1. Utilization Ability Impacts Visitation Density

We found that paved activity zones had significantly higher visitation density than unpaved zones (i.e., zones covered by grass and bare soil) for both seasons. This is consistent with previous findings that visitors prefer paved pathways compared to unpaved pathways [31]. The paved surfaces are specifically developed for recreational activities with special materials and are very suitable for physical activities. The undeveloped bare land is only spontaneously used by a limited number of visitors. Grassland is usually a popular space for recreation in Western countries [44,45]. However, we obtained very low visitation density for zones covered by grass. This is mainly because grassland in China is usually developed for scenery and people are not allowed to enter for recreation [46].

Significantly higher visitation densities were observed for zones without trees in both seasons. Specifically, the visitation density decreases faster with the increase in tree density, especially during the daytime. This is consistent with the findings that activity zones with high tree density are associated with lower physical activity diversity [18]. The presence of trees decreases the utilization ability of the activity zone and cannot support physical activities with a larger number of people, for example, Tai Chi, chorus, and dancing.

4.1.2. Shading Degree Impacts Visitation Density

The impact of shading degree on daytime visitation density showed seasonal differences. Zones with a higher shading degree showed significantly higher summer daytime visitation density. This is because the shaded areas are usually cooler, with better thermal comfort, and can attract more visitors in the hot summer [29]. Zones with a high shading degree deterred nighttime visitors in both seasons, showing lower visitation density than the less shaded zones. The possible reason may be that a higher shading degree decreases the visitors' security perception in the evening.

The shading degree showed no significant impact on winter daytime visitation density. This is not consistent with our expectation that people prefer outdoor spaces with more sunshine and the unshaded zones should have more visitations in the cold winter [37]. In this study, the shading degree is determined by either the tree canopy or manmade shelters, such as pavilions. Spaces under the tree canopies and pavilions are not comfortable spaces in winter from the perspective of thermal comfort. However, the pavilions can attract visitors, as they are important spaces for recreational activities, for example, playing cards, playing chess, resting, and chatting. In other words, the shade generated by the tree canopy deters visitors, and the shade generated by pavilions attracts visitors. The total effects of shading degree on visitation density are not significant.

Surprisingly, we did not find a significant impact of tree cover ratio on summer daytime visitation density. This is contradictory to our knowledge that a higher tree cover ratio can provide more shade and attract more visitation during the hotter summer daytime. In our study, the effect of the tree cover ratio on visitation density was distorted by the shade generated by the pavilion. Five of the studied activity zones had a tree cover ratio of zero but had pavilions that served many visitors. If these five zones are excluded, zones with a higher tree cover ratio showed a significantly higher visitation density in summer and lower visitation density in winter (Figure 4). This can also be supported by the photos of site D in summer and winter, as shown in Figure 1.

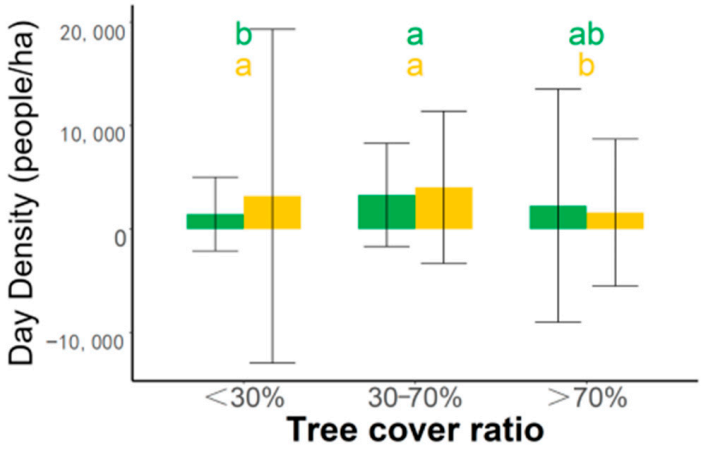

Figure 4. Kruskal–Wallis H-test (K samples) multiple comparisons analysis of visitation density during summer and winter daytime (n = 104). Green indicates summer daytime, and yellow indicates summer nighttime. Different letters indicate significant differences ($p < 0.05$).

4.1.3. Facilities Impact Visitation Density

The presence of benches significantly increased daytime visitation density in both seasons. The daytime physical activities are usually intensive with high energy costs, and benches are important infrastructure for visitors to recover. However, nighttime visitation density showed no significant differences among zones with different provisions of benches in both seasons. This may be caused by different types of physical activities between daytime and nighttime. Most low-intensity activities, such as playing cards, sitting and chatting, playing musical instruments, and singing require benches and are mainly performed during the daytime. During the nighttime, physical activities are usually highly intensive and do not require benches, such as running, walking, and square dancing. In addition, the daytime is usually longer, and visitors have enough time to sit down.

There was no significant difference in daytime visitation density between zones with and without tables in both seasons; however, zones with tables showed lower visitation density than zones without tables during the nighttime in both seasons. Tables in the park are mainly used for activities, such as playing cards and picnics. These activities are not common during the nighttime compared with the daytime, as discussed in the previous paragraph.

Light devices significantly increased nighttime visitation density in both seasons. This is consistent with our expectation that people prefer zones with light for both physical and psychological safety [26].

4.2. The Surrounding Environment of the Activity Zone Impacts Visitation Density

Zones with less connected pathways showed higher summer daytime visitation density but there was no significant difference for winter daytime. During the warmer summer, people may undertake more intensive physical activities and usually require quiet places to rest, while during the colder winter, people have less chance to participate in physical activities and want to increase their connection with others instead. Increasing the connected pathways can significantly increase nighttime visitation density in both seasons. This is mainly caused by the visitors' safety perception.

The visual connection to water showed significantly higher visitation density for all four time periods. This is consistent with previous findings [31]. Water bodies provide many psychological benefits, such as reducing stress and restoring attention [47].

Activity zones closer to the toilets attracted fewer visitors in summer. This contrasts with our expectation that people prefer zones with better infrastructure, such as the toilet. A possible reason is that during the hot summer, the toilets send out bad smells which push the visitors away from activity zones close to the toilets. Visitation density was always significantly lower in zones close to the park entrances, indicating that people prefer to stay in space further away from the park boundary. This is understandable, as the edge of the park usually suffers from stronger environmental stress, such as higher temperature, higher air pollution, and higher noise levels. There was a consistent pull effect of shopping stores on visitors in both the daytime and nighttime in summer and in winter.

4.3. Management Implications

The obtained spatiotemporal variation in visitation density and the driving factors have important implications for urban park planning and management to enhance the recreation service.

Firstly, paved zones showed significantly higher visitation density, suggesting that paved zones are highly recommended in the park to increase the vitality. However, it should be noted that the paved zones may generate many adverse effects on the health of vegetation and decrease ecosystem services [48,49]. The paved surfaces (including numbers and size) in the park should be carefully designed to balance the benefits of recreation and the adverse effects on vegetation. A zoning-based solution, including preserved core zones and surrounding recreational zones, has been proposed to solve the trade-off between human recreation and biodiversity conservation in urban parks [50]. This solution may be

valuable to solve the trade-off between recreation demands and vegetation conservation. Another solution is paving the zones with permeable or semi-permeable materials to decrease the adverse impacts to the vegetation and environment.

Second, the negative effects of tree density on visitation density inform us that more trees cannot increase visitation density at the activity zone level. However, we also find that a higher tree cover ratio can increase visitation density, especially in the hot summer daytime. This trade-off suggests to us the importance of the big trees which can provide high tree cover with low tree density.

Thirdly, the effects of tree cover ratio on visitation density show a trade-off between summer and winter that canopy cover increases visitation density in summer but decreases visitation density in winter. We suggest deciduous trees, especially big deciduous trees, in the activity zone to create comfort thermal environment in Changsha and cities with similar climates (hot summer and cold winter).

Fourthly, a waterbody is highly recommended in the park, as the related variables (e.g., visual connection with water) are significantly related to high visitation density. We alert the designer that safety should be given special attention for the space around the waterbody. Setting safety warning signs and adding ecological barriers around waterbodies can improve safety.

Fifthly, types of facilities are of great importance to increase visitation density. Enough benches should be provided at the proper place to facilitate recreational activities. Light devices are required to increase park usage during the nighttime. The negative relationship between visitation density and distance to the toilets indicates that not only the provision of infrastructure but also the maintenance and management of infrastructure significantly impact visitation density. Therefore, the environment should be well-cleaned, and the infrastructure should be carefully maintained.

5. Conclusions

This study uncovered the seasonal and diurnal variations in the landscape feature impacts on visitation density at the activity zone level in the Hunan Martyr Park of Changsha, China, with a hot summer and a cold winter. We observed that well-paved activity zones, close to water and further away from park entrances, always had higher visitation density in all periods (i.e., summer daytime, summer nighttime, winter daytime, and winter nighttime). Shading degree, connected pathways, and distance to toilets had contrasting impacts between summer and winter. Zones with s higher shading degree attracted more visitors in summer but deterred visitors in winter. Zones with fewer connected pathways and zones farther away from toilets had higher visitation density in summer but not in winter. Shading degree, number of trees, presence of specific facilities (e.g., benches, tables, pavilions, and light devices), and connected pathways had contrasting impacts between daytime and nighttime. Zones with a high shading degree attracted visitors in daytime but deterred visitors in nighttime. Zones with benches and pavilions and zones without trees have higher visitation density in the daytime but not at nighttime. Zones with light device, zones with more connected pathways, and zones without tables had higher visitation density at nighttime but not in the daytime.

We raised the following suggestions to increase visitation density. First, providing well-paved zones but carefully considering vegetation conservation is important. The zoning-based solution, including preserved core zones and surrounding recreational zones [50], can be an effective strategy. Using permeable or semi-permeable materials to pave the activity zones is another solution. Second, conserving big trees can benefit park usage. Third, planting deciduous trees can create comfortable thermal environments in both summer and winter. Fourth, increasing waterbodies can increase visitation density. Fifth, the environment should be well-cleaned, and the infrastructure should be carefully maintained.

The methodology used in this study can be applied to other parks in different cities and climates, enabling result comparisons and facilitating evidence-based decision-making for park planners and researchers.

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