

Article

Ecological Characteristics and Landscape Preference of Waterfront Wilderness in Mountainous Cities

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Abstract

Waterfront wilderness landscapes in mountainous cities, such as Chongqing, play a vital role in sustaining urban biodiversity and human well-being amid steep topography and hydrological variations that create unique habitats. However, public recognition of their ecological values and potential ecological–aesthetic conflicts remain underexplored. This study investigated biodiversity features and public preferences in Chongqing’s central urban waterfront wilderness through field surveys of 218 quadrats for biodiversity assessment (e.g., Shannon–Wiener and Simpson indices, cluster analysis identifying 12 typical communities) and two questionnaire surveys (N = 260 and 306) evaluating spatial features and plant attributes, with correlation and regression analyses examining relationships between ecological indices and preference scores. Results recorded 116 plant species from 41 families, dominated by herbaceous plants (77.6%), with herbaceous, shrub–herbaceous, and tree–herbaceous communities prevalent. No significant correlations existed between objective diversity indices and preference scores; instead, structure ($\beta = 0.444$, $p < 0.001$) and color ($\beta = 0.447$, $p < 0.001$) drove preferences (explaining 96.7% variance), favoring accessible mid-successional shrub–herbaceous structures over dense, low-diversity evergreen types. These findings reveal ecological–aesthetic conflicts in mountainous settings where aesthetic dominance limits biodiversity recognition. Implications include user-centered zoning: restrict access in low-preference steep areas with buffers for conservation, while enhancing high-preference flat zones via selective pruning and native colorful species introduction, supplemented by educational signage. This research provides a mountainous city archetype, enriching global urban wilderness studies and informing sustainable management in rapidly urbanizing regions.

Keywords: urban waterfront wilderness; community characteristics; landscape preference; ecological–aesthetic conflicts; mountainous cities



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1. Introduction

With the accelerating pace of urbanization, urban green spaces are increasingly compressed, leading to the loss and fragmentation of natural habitats, severe damage to urban biodiversity, and a drastic weakening of human–nature connections. Urban residents are

experiencing an “extinction of experience”, with a growing urgency for access to green nature [1]. Urban wilderness, operationally defined here as lands within or around urban areas where natural processes dominate, with relatively low levels of human development and control, allowing natural succession and ecological processes to occur to some extent, and enabling various wild species to coexist and thrive with humans [2], such as abandoned industrial or agricultural lands, parks, and riverine ecosystems, which serve as critical components of urban ecosystems [3,4]. These landscapes provide significant ecological and aesthetic values, including biodiversity conservation, habitat connectivity, and ecosystem services that enhance human well-being [5–8]. In recent years, pandemic-related isolation and urban life stresses have heightened the demand for closer contact with nature, underscoring the importance of wilderness areas in reconnecting humans with natural ecosystems [9].

In the context of rapid urbanization, integrating public preferences and needs for urban wilderness landscapes into urban planning and green space design is essential for promoting harmonious human–nature coexistence [10]. However, the disordered and untamed appearance of urban wilderness often hinders public recognition of its ecological value, creating a potential “ecological–aesthetic conflict” where ecological features clash with aesthetic preferences [11]. For instance, Phillips and Lindquist’s research shows that while urban wilderness offers positive ecological benefits, its wild and unmanaged appearance frequently elicits resistance and negative perceptions [12]. Other studies indicate that the public can discern biodiversity differences across habitats, yet high biodiversity does not significantly correlate with preferences [13]; instead, people may favor low-biodiversity, well-maintained artificial green spaces over minimally managed, high-biodiversity woodlands [14]. Shwartz et al. (2014) proposed the “human–biodiversity paradox”, where humans desire species richness but often underestimate plant diversity in natural settings [15]. Thus, the relationship between wilderness plant diversity and aesthetic perceptions/preferences is complex, influenced by factors such as demographic backgrounds, landscape elements, and vegetation structure [10,16–18].

Despite these insights, comprehensive analyses of urban wilderness value recognition, biodiversity perception, and landscape preferences remain scarce. Existing research on urban wilderness perception and preference primarily focuses on spontaneous vegetation in formal green spaces [16,19] or wetland wilderness in plain cities, such as lakeside or coastal areas [20–22], leaving significant gaps in studies of riverine wilderness landscapes, particularly in mountainous urban contexts. Unlike previous work on wetlands or general urban wilderness, which often overlooks the dynamic influences of topography and hydrological fluctuations on vegetation habitats and public experiences, this study addresses these gaps by examining waterfront wilderness in a mountainous city setting. This approach contributes to the literature by providing a novel perspective on how mountainous terrain and seasonal water-level changes shape unique biodiversity patterns and perceptual experiences, which differ markedly from those in flat terrains.

Chongqing, a typical mountainous city in China, exemplifies these dynamics: its steep topography and hydrological variations influence vegetation distribution and microclimates, creating distinctive habitats that support biodiversity connectivity, species conservation, and unique wilderness experiences [23–25], which highlight Chongqing’s role as a biodiversity hotspot in urban riverine systems. These waterfront wilderness areas not only compensate for the limited formal green spaces constrained by terrain but also offer residents distinct experiences compared to plain cities. However, research on mountainous urban waterfront wilderness has mainly emphasized ecological restoration in hydro-fluctuation zones and planning of waterfront green spaces, with insufficient attention to ecological values and public perceptions. Key questions remain: Can the

public recognize the ecological features and values of waterfront wilderness? Does an ecological–aesthetic conflict exist?

Building on these gaps, this study assumes that public preferences for waterfront wilderness prioritize perceived aesthetic and accessibility features over objective biodiversity metrics, potentially leading to ecological–aesthetic conflicts in mountainous settings. To test these assumptions and fill the literature gaps, we employ a mixed-methods approach: field surveys of 218 quadrats to assess biodiversity, combined with two questionnaire surveys to evaluate public preferences for spatial features and plant attributes. Correlation analyses will explore relationships between ecological indices and preference scores. Using Chongqing’s central urban waterfront wilderness as a case study, we analyze biodiversity characteristics, public preferences, and their interrelations. This work aims to enhance understanding of public ecological value recognition and landscape preferences in mountainous waterfront wilderness shaped by topography and hydrological succession, thereby improving public acceptance and informing user-centered wilderness landscape construction. The results provide a mountainous city archetype for global urban wilderness research, enriching regional diversity in the field. In the context of accelerating urbanization, incorporating public perceptions into scientific planning can mitigate ecological–aesthetic conflicts, balancing urban development with wilderness protection and offering transferable insights for other rapidly urbanizing regions.

2. Materials and Methods

2.1. Study Area and Field Plot Selection

Our study site is located in the central urban area of Chongqing, a typical mountainous city in southwestern China (106°14′36″–106°59′53″ E, 29°7′44″–30°11′21″ N), characterized by a subtropical humid monsoon climate with hot summers, mild winters, and overlapping rainy and hot seasons. The area has abundant water resources, with an annual average temperature of 18.9 °C and precipitation of 1083.0 mm. The Yangtze and Jialing Rivers flow westward through the study area, shaping a polycentric urban development pattern across a total area of 4779 km², with a population of 7.4 million and an urbanization rate of 93.3% [26]. The waterfront wilderness in Chongqing’s central urban area exhibits unique regional features, influenced by the flood storage operations of the Three Gorges Reservoir, which cause significant water-level fluctuations and drive periodic dynamic changes in riparian wilderness communities, forming flood- and erosion-resistant wetland herbaceous or shrub-herbaceous communities (Figure 1).

This study employs quadrat surveys to analyze habitat characteristics and biodiversity patterns of waterfront wilderness, uses photo-based scoring to assess public preferences toward wilderness, and examines the relationship between objective ecological values and subjective public preference to evaluate the public’s ability to recognize ecological significance, aiming to enhance public awareness of waterfront wilderness conservation and inform landscape planning that integrates ecological integrity with human preferences.

2.2. Wilderness Vegetation Survey

Based on preliminary reconnaissance surveys of waterfront wilderness areas in Chongqing’s central urban district, 14 typical habitat segments were selected to encompass all representative plant communities across diverse elevation gradients and habitat types. Specifically, the sites spanned elevations from 145 m to 200 m above sea level—the primary altitudinal range where Chongqing’s waterfront wilderness landscapes are distributed—including Hydro-fluctuation zones and some stable riparian zones, with major typical habitats comprising soil-based habitats, rocky-soil habitats, and stony habitats. This selection ensured comprehensive coverage of ecological variability, informed by prior

studies in similar urban wilderness contexts [27]. Field surveys of these plant communities were conducted from April to June 2023, during the peak growing season to capture representative vegetation states. Quadrats were established as follows: 10 m × 10 m for tree layers, and 5 m × 5 m for shrub and herbaceous layers. Basic information, including species names, abundance, growth status, and photographs, was recorded for tree, shrub, and herbaceous layers. A total of 218 quadrats were surveyed, comprising 133 soil-based habitats, 64 rocky-soil habitats, and 21 stony habitats, with the sample size determined to fully represent all typical communities identified in the preliminary surveys, thereby ensuring robust habitat variability coverage [28].

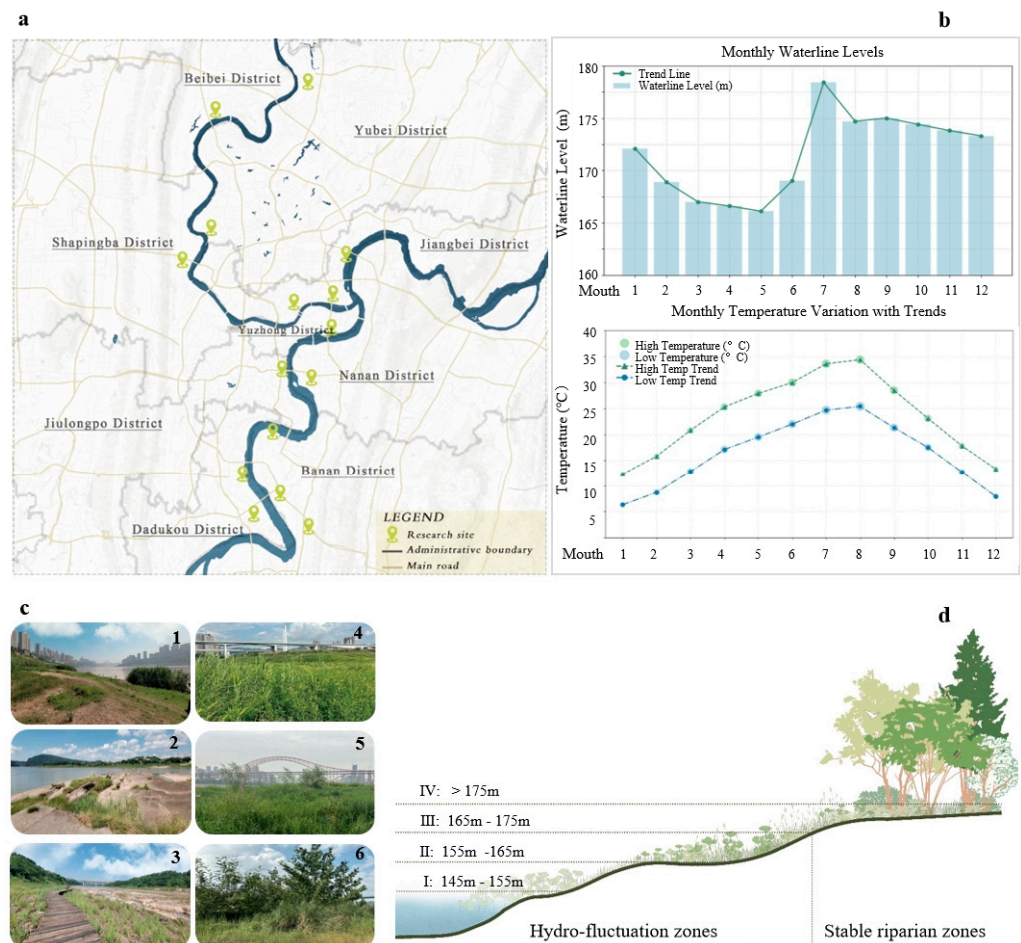


Figure 1. Location of the 14 selected sample sites of waterfront wilderness in central district of Chongqing and their environmental characteristics. (a): Location of the 14 selected sample sites. (b): Dynamics of mean air temperature and water table line in the study area. (c): Habitat and plant community structure types; pictures 1–3 represent typical soil-based habitats, rocky-soil habitat, and stony habitat, respectively; pictures 4–6 represent typical herbaceous, shrub-herb and tree-herb communities, respectively. (d): Division of elevation intervals for sample plots.

2.2.1. Importance Value Calculation

Based on quadrat survey data, the importance value (IV) of each species was calculated to characterize its dominance within the plant community [28]. The formulas are as follows:

$$\text{Tree layer IV} = (\text{Relative Abundance} + \text{Relative Frequency} + \text{Relative Dominance})/3 \quad (1)$$

$$\text{Shrub/Herb layer IV} = (\text{Relative Coverage} + \text{Relative Frequency} + \text{Relative Height})/3 \quad (2)$$

$$\text{Vine layer IV} = (\text{Relative Coverage} + \text{Relative Frequency})/2 \quad (3)$$

Relative Abundance (RA, %) = (Individual count of a species/Total individual count of all species) $\times$ 100%; Relative Frequency (RF, %) = (Occurrence frequency of a species in quadrats/Total occurrence frequency of all species) $\times$ 100%; Relative Dominance (RD, %) = (Basal area at breast height of a species/Total basal area of all species) $\times$ 100%; Relative Coverage (RC, %) = (Mean coverage of a species in quadrats/Sum of coverage values for all species) $\times$ 100%; Relative Height (RH, %) = (Mean height of a species/Sum of mean heights of all species) $\times$ 100%.

Basal area was measured at breast height (1.3 m above ground) using a diameter tape (DBH tape) to calculate cross-sectional area (basal area = $\pi \times (\text{DBH}/2)^2$), a standard protocol in forest ecology to ensure accurate dominance assessment.

2.2.2. Identification of Typical Communities and Diversity Calculation

Four clustering methods—UPGMA (Unweighted Pair Group Method with Arithmetic Mean), single-linkage agglomerative clustering, complete-linkage agglomerative clustering, and Ward's minimum variance—were applied to cluster 218 surveyed quadrats. The optimal clustering method was determined by comparing Cophenetic correlation coefficients, enabling the identification of typical communities [29]. Plant diversity was characterized using the following indices [30]:

$$\text{Species richness (S)} = \text{Total number of species} \quad (4)$$

$$\text{Pielou's evenness Index (J)} = H/H_{\max}, \text{ where } H_{\max} = \ln(S) \quad (5)$$

$$\text{Simpson's Dominance Index (SP)} = 1 - \sum P_i^2 \quad (6)$$

$$\text{Shannon-Weiner Index (H)} = -\sum (P_i \ln P_i) \quad (7)$$

Definitions of Parameters: P_i = Probability of a sampled individual belonging to species i ($P_i = n_i/N$); N = Total number of individuals in the community; n_i = Number of individuals of species i .

All calculations were performed using the Vegan package in R 4.3.1.

2.3. Preference Survey

Landscape preferences arise from human–environment interactions, where viewers process sensory stimuli from landscapes through attention, personal background, culture, and psychological states to form subjective evaluations [31,32]. Photo rating, a common method in landscape perception and preference studies due to its reliability and efficiency in simulating real-world views [33,34], was employed here to assess public preferences for waterfront wilderness landscapes.

Surveys were conducted in two parts, with a total of 566 respondents ($N = 260$ for the first survey and $N = 306$ for the second). Prior to participation, all respondents were informed of the study's privacy standards, objectives, and their right to withdraw at any time. Demographic information (age, gender, education level, and engagement in ecological or environmental professions) was collected to analyze group differences.

Photographs were selected from 2079 field images captured on-site during the surveys, prioritizing those that best represented the six landscape dimensions (habitat type, topographic features, naturalness, accessibility, openness, and vegetation structure) and the 12 plant communities (identified through cluster analysis). To minimize bias, all photographs adhered to standardized shooting protocols: they were taken during the same season (April to June 2023), synchronized with vegetation surveys for consistency, and maintained uniform focal length, angle, height, and water-to-land ratio. On this basis, post-processing was performed using Adobe Lightroom Classic CC to ensure uniformity in size,

proportions, color, clarity, and color temperature across the selected images. Additional adjustments were made with Adobe Photoshop (Beta) to refine elements such as weather tones, removal of conspicuous structures, and seasonal plant color adjustments. This standardization process mitigates variability in lighting, seasonal effects, and perspectives that could influence perceptions.

The first survey (N = 260) assessed preferences for six indicators: habitat type, topographic features, naturalness, accessibility, openness, and vegetation structure, selected based on prior research in urban wilderness perception [18,34,35]. These indicators were justified as they capture key spatial and vegetative elements influencing preferences in dynamic waterfront environments [31]. Three photos per indicator were used to reduce error. Photos were printed on A4 sheets or presented via PowerPoint on a computer, with participants ranking them by personal preference and recording serial numbers on a scoring sheet featuring five tiers (1 = lowest preference to 5 = highest preference, Figure 2).

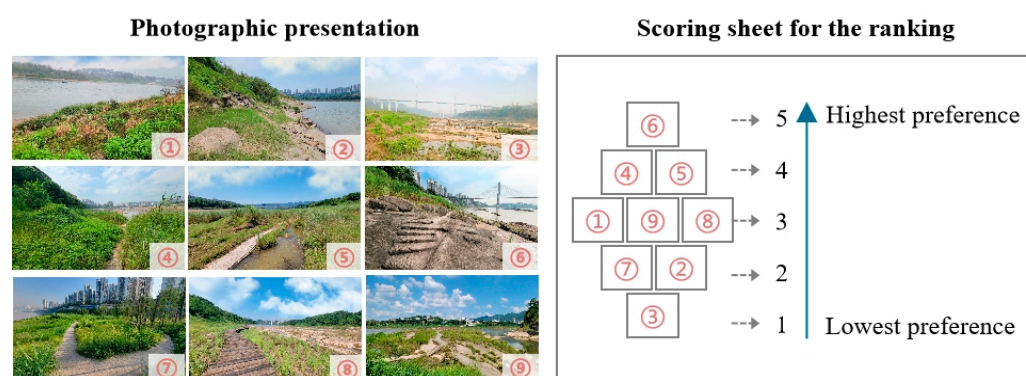


Figure 2. Example of a photo sorting score. On the **left** side are the photos to be sorted and their corresponding numbers, on the **right** side is a blank rating scale. Participants were asked to rank the photographs according to degree of preference and to fill in the corresponding box on the blank rating scale with the serial number of the photograph. In this example, photo number 6 had the highest preference score of 5, photo numbers 4 and 5 had a preference score of 4, and so on, and photo number 3 had the lowest preference score of 1.

The second survey (N = 306) evaluated preferences for 12 representative plant communities selected from the 218 quadrats based on cluster analysis results. Ratings covered overall community evaluation, natural beauty, structure, color, and perceived species richness, using a 5-point Likert scale. Perceived richness was assessed relative to an objective scale provided to participants (e.g., low: 1–5 species; medium: 6–10; high: >10, calibrated against actual diversity indices from surveys) to validate subjective perceptions against empirical data.

Participants were recruited via convenience sampling at public sites in Chongqing (e.g., parks, universities) to capture a broad urban demographic. While the sample size is adequate for statistical power, representativeness may be limited, with potential bias toward educated urban residents. To mitigate this, recruitment targeted diverse age groups and occupations, though future studies could employ stratified sampling for broader generalizability.

The final analysis involved calculating the mean scores for each photograph using SPSS 29.0.2.0. Prior to data processing, the Kolmogorov–Smirnov test for normality and Levene’s test for homogeneity of variance were conducted to verify statistical significance. The results indicated that all *p*-values exceeded 0.05 in the normality test, confirming a normal distribution and confirming the statistical significance of all items. Reliability analysis was performed to assess internal consistency using Cronbach’s Alpha coefficient, where higher values indicate stronger inter-item correlations and greater reliability. In

this study, all sections of the questionnaire demonstrated Cronbach's Alpha coefficients exceeding 0.9, confirming high questionnaire quality.

3. Results

3.1. Biodiversity Characteristics of Waterfront Wilderness

The waterfront wilderness in Chongqing's main urban area is significantly influenced by the mountainous terrain and hydrological dynamics, resulting in a vertical distribution of vegetation belts shaped by elevation gradients and seasonal water fluctuations. From water level to bank, distinct plant communities emerge in a zoned pattern reflecting hydrological succession. A total of 116 plant species from 102 genera and 41 families were recorded. Among these, 43 species (37.1%) were annual/biennial herbs, and 47 species (40.5%) were perennial herbs, demonstrating the absolute dominance of herbaceous plants, which collectively accounted for 77.6% of all recorded species. These herbaceous plants were widely distributed across various elevation zones within the waterfront spaces (Table 1).

Table 1. Plant life form composition.

Life Form	Number of Species	Percentage	Typical Plants (Important Value)
Tree	15	12.9%	<i>Broussonetia papyrifera</i> (23.21%), <i>Pterocarya stenoptera</i> (17.96%), <i>Taxodium distichum</i> (18.07%), <i>Salix alba</i> (9.13%)
Shrub	8	6.9%	<i>Buddleja asiatica</i> (19.97%), <i>Salix variegata</i> (19.04%), <i>Indigofera tinctoria</i> (17.34%), <i>Debregeasia orientalis</i> (13.80%)
Vine	3	2.6%	<i>Humulus scandens</i> (78.27%), <i>Pueraria montana</i> (17.06%), <i>Ampelopsis glandulosa</i> (4.67%)
Annual and Biennial herb	43	37.1%	<i>Persicaria lapathifolia</i> (3.19%), <i>Melilotus officinalis</i> (3.05%), <i>Daucus carota</i> (2.79%), <i>Erigeron canadensis</i> (2.67%)
Perennial Herb	47	40.5%	<i>Cynodon dactylon</i> (3.98%), <i>Phragmites australis</i> (3.75%), <i>Cortaderia selloana</i> (3.63%), <i>Arundo donax</i> (3.13%)

Through cluster analysis of plant communities, 12 representative waterfront wilderness communities were identified, with their diversity indices calculated as shown in Table 2. The primary community types were classified into three categories: herbaceous, shrub-herb, and tree-herb. Herbaceous communities were the most prevalent, Shrub-grass and tree-grass communities followed in frequency. The calculations for typical communities and their corresponding diversity indices are as shown in Table 2.

Table 2. Typical community types and their diversity index.

Number	Community Name	Community Ecological Characteristics					
		Structure	Color	Species Richness	Pielou Evenness	Simpson	Shannon-Weiner
1	<i>Cortaderia selloana</i> + <i>Melilotus officinalis</i> + <i>Cynodon dactylon</i>	Herbaceous	Green-dominated	11.67	0.80	0.81	1.95
2	<i>Melilotus officinalis</i> + <i>Polypogon fugax</i> + <i>Vicia cracca</i>	Herbaceous	Yellow-green dominant	7.67	0.74	0.77	1.71
3	<i>Bolboschoenus yagara</i> + <i>Chenopodium album</i> + <i>Veronica anagallis-aquatica</i>	Herbaceous	Green-dominated	7.05	0.80	0.71	1.52

Table 2. Cont.

Number	Community Name	Community Ecological Characteristics					
		Structure	Color	Species Richness	Pielou Evenness	Simpson	Shannon–Weiner
4	<i>Polypogon fugax</i> + <i>Chenopodium album</i> + <i>Persicaria lapathifolia</i>	Herbaceous	Green-dominated	4.00	0.51	0.35	0.71
5	<i>Debregeasia orientalis</i> – <i>Pueraria montana</i> var. <i>Lobata</i> – <i>Cynodon dactylon</i> + <i>Cortaderia selloana</i>	Shrub-herb	Green-dominated	14.00	0.71	0.75	1.87
6	<i>Salix variegata</i> – <i>Erigeron canadensis</i> + <i>Phalaris arundinacea</i> + <i>Persicaria chinensis</i>	Shrub-herb	Green-dominated	7.60	0.69	0.64	1.39
7	<i>Lantana camara</i> – <i>Cortaderia selloana</i> + <i>Melilotus officinalis</i> + <i>Daucus carota</i>	Shrub-herb	Polychromatic mix	7.00	0.66	0.60	1.28
8	<i>Buddleja asiatica</i> – <i>Cynodon dactylon</i> + <i>Cortaderia selloana</i> + <i>Daucus carota</i>	Shrub-herb	Green-dominated	6.86	0.57	0.50	1.08
9	<i>Leucaena leucocephala</i> – <i>Cynodon dactylon</i> + <i>Melilotus officinalis</i> + <i>Daucus carota</i>	Tree-herb	Yellow-green dominant	9.50	0.25	0.23	0.54
10	<i>Pterocarya stenoptera</i> – <i>Cynodon dactylon</i> + <i>Cortaderia selloana</i> + <i>Persicaria lapathifolia</i>	Tree-herb	Green-dominated	8.00	0.59	0.60	1.23
11	<i>Salix alba</i> – <i>Cynodon dactylon</i> + <i>Miscanthus floridulus</i> + <i>Erigeron canadensis</i>	Tree-herb	Green-dominated	8.63	0.61	0.62	1.27
12	<i>Broussonetia papyrifera</i> – <i>Cynodon dactylon</i> + <i>Imperata cylindrica</i>	Tree-herb	Green-dominated	5.50	0.49	0.41	0.80

3.2. Public Preference of Waterfront Wilderness Landscapes

3.2.1. Participants

There were 270 respondents who participated in the first part of the photo scoring, with a total of 260 valid questionnaires. The sample included 127 males and 133 females. More than half of the participants were 18–45 years old. In terms of education level, the largest proportion of people had a university education or above; 32.7% of them worked in related industries, such as the environment, landscape, ecology and design, while 67.3% of them worked in other industries.

In the second section, a total of 306 valid questionnaires were collected from respondents, including 150 males and 156 females. The age distribution and education level of the respondents are broadly consistent with the first part. Regarding education level, 154 individuals hold a university degree or higher, and 97 have completed senior education. In terms of engagement in landscaping or related industries, the distribution is relatively balanced (Table 3).

Table 3. Participant characteristics.

Category		Part 1		Part 2	
		Frequency	Percentage	Frequency	Percentage
Gender	Female	133	51.15%	156	50.98%
	Male	127	48.85%	150	49.02%
Age	18–45	148	56.92%	174	56.86%
	46–69	43	16.54%	81	16.01%
	<18	36	13.85%	51	16.67%
	>69	33	12.69%	33	10.46%
Education background	University	148	56.92%	154	50.33%
	Senior	65	25.00%	97	31.70%
	Junior	47	18.08%	55	17.97%
Professional relevance	No	175	67.31%	159	51.96%
	Yes	85	32.69%	147	48.04%

Although the surveys were initially planned with similar target sample sizes (approximately 250–300 per part, the second survey yielded a slightly larger number of valid responses due to higher participation rates during data collection. To ensure comparability, we compared demographic compositions between the two samples using chi-square tests, confirming no significant differences in distributions across gender, age, education, or occupation. This similarity supports the robustness of cross-survey comparisons.

3.2.2. Public Preferences for Waterfront Wilderness Landscape

Figure 3 illustrates public preferences for the spatial characteristics of waterfront wilderness. It shows significantly higher favorability for soil-based habitats than for rocky-soil or stony ones. This is likely due to sparse vegetation in the latter two.

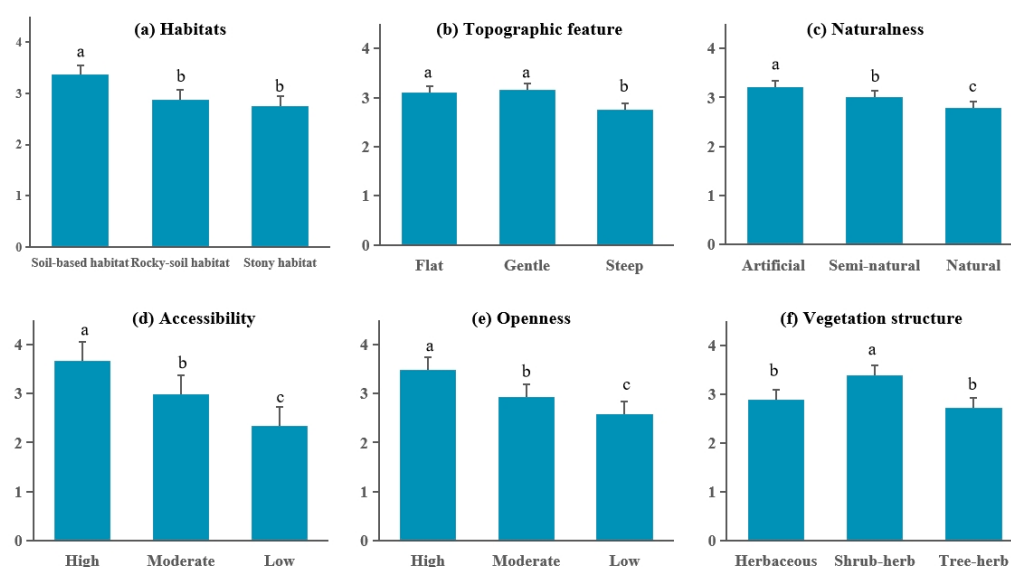


Figure 3. Preference scores for waterfront wilderness landscape in Chongqing’s central urban area. Subfigures represent: (a) Habitat types; (b) Topographic features; (c) Naturalness levels; (d) Accessibility levels; (e) Openness levels; (f) Vegetation structures. Bars indicate mean preference scores. Different lowercase letters (a, b, c) above bars denote significant differences between groups within each subfigure, determined by one-way ANOVA followed by Tukey’s honestly significant difference (HSD) post hoc test at $p < 0.05$. Error bars represent standard error of the mean (SEM).

Preferences for flat and gentle slopes were much stronger than for steep slopes. Landscape naturalness inversely correlated with preference—it declined as human disturbance increased. This trend often occurs at higher elevations, where artificial landscapes dominate. It indicates a public inclination toward orderly, human-modified environments. Higher accessibility and openness consistently boosted preference. For community structure, the public most favored shrub-herb communities (mid-successional stages), followed by herbaceous and tree-herb structures.

3.2.3. Public Preferences for Waterfront Wilderness Plant Communities

As shown in Table 4, the *Melilotus officinalis* + *Polypogon fugax* + *Vicia cracca* community received the highest score. This is due to its vibrant color variations and strong visual appeal. In contrast, the *Polypogon fugax* + *Chenopodium album* + *Persicaria lapathifolia* community scored lowest. It is mainly distributed at elevations of 145–155 m. There, environmental stressors cause stunted growth and monotonous evergreen dominance. Group comparisons showed that shrub-grass communities consistently earned the highest preference ratings across structural metrics. This aligns with prior findings on landscape spatial feature preferences. Color composition significantly influenced public preferences

(Figure 4). Multicolored and yellow-green-dominated communities scored much higher than monochromatic green ones. This highlights the key role of chromatic diversity in shaping aesthetic appeal. Preference score differences were relatively small (ranging from 3.0 to 3.9). However, these variations were statistically significant. They are sufficient to inform management implications, reflecting consistent perceptual patterns despite the compressed scale.

Table 4. Ecological characteristics and preference scores of waterfront wilderness plant communities (Mean $\pm$ SD).

Number	Community Name	Community Preference Scores				
		Overall Evaluation	Aesthetic Feeling	Color	Structure	Perceived Richness
1	<i>Melilotus officinalis</i> + <i>Polypogon fugax</i> + <i>Vicia cracca</i>	3.89 $\pm$ 0.98	3.91 $\pm$ 0.93	3.85 $\pm$ 0.88	3.67 $\pm$ 0.97	3.74 $\pm$ 0.83
2	<i>Lantana camara</i> – <i>Cortaderia selloana</i> + <i>Melilotus officinalis</i> + <i>Daucus carota</i>	3.71 $\pm$ 0.99	3.62 $\pm$ 0.99	3.61 $\pm$ 0.95	3.51 $\pm$ 1.05	3.57 $\pm$ 0.94
3	<i>Buddleja asiatica</i> – <i>Cynodon dactylon</i> + <i>Cortaderia selloana</i> + <i>Daucus carota</i>	3.63 $\pm$ 1.00	3.66 $\pm$ 0.93	3.55 $\pm$ 0.98	3.58 $\pm$ 0.98	3.58 $\pm$ 0.91
4	<i>Bolboschoenus yagara</i> + <i>Chenopodium album</i> + <i>Veronica anagallis-aquatica</i>	3.61 $\pm$ 0.97	3.61 $\pm$ 0.91	3.49 $\pm$ 1.00	3.43 $\pm$ 1.03	3.60 $\pm$ 0.92
5	<i>Pterocarya stenoptera</i> – <i>Cynodon dactylon</i> + <i>Cortaderia selloana</i> + <i>Persicaria lapathifolia</i>	3.58 $\pm$ 0.99	3.65 $\pm$ 0.91	3.41 $\pm$ 0.94	3.61 $\pm$ 0.98	3.62 $\pm$ 0.95
6	<i>Debregeasia orientalis</i> – <i>Pueraria montana</i> var. <i>Lobata</i> – <i>Cynodon dactylon</i> + <i>Cortaderia selloana</i>	3.58 $\pm$ 0.96	3.53 $\pm$ 0.94	3.43 $\pm$ 1.00	3.52 $\pm$ 0.98	3.61 $\pm$ 0.93
7	<i>Leucaena leucocephala</i> – <i>Cynodon dactylon</i> + <i>Melilotus officinalis</i> + <i>Daucus carota</i>	3.55 $\pm$ 1.03	3.56 $\pm$ 0.93	3.48 $\pm$ 0.97	3.49 $\pm$ 0.99	3.47 $\pm$ 0.97
8	<i>Broussonetia papyrifera</i> – <i>Cynodon dactylon</i> + <i>Imperata cylindrica</i>	3.42 $\pm$ 1.02	3.53 $\pm$ 0.95	3.28 $\pm$ 1.05	3.62 $\pm$ 0.95	3.45 $\pm$ 0.97
9	<i>Salix variegata</i> – <i>Erigeron canadensis</i> + <i>Phalaris arundinacea</i> + <i>Persicaria chinensis</i>	3.40 $\pm$ 1.07	3.33 $\pm$ 1.03	3.34 $\pm$ 1.02	3.32 $\pm$ 1.06	3.26 $\pm$ 1.08
10	<i>Cortaderia selloana</i> + <i>Melilotus officinalis</i> + <i>Cynodon dactylon</i>	3.45 $\pm$ 1.04	3.35 $\pm$ 0.99	3.26 $\pm$ 0.97	3.33 $\pm$ 1.06	3.33 $\pm$ 1.02
11	<i>Salix alba</i> – <i>Cynodon dactylon</i> + <i>Miscanthus floridulus</i> + <i>Erigeron canadensis</i>	3.32 $\pm$ 1.08	3.21 $\pm$ 1.07	3.25 $\pm$ 1.08	3.42 $\pm$ 1.04	3.34 $\pm$ 1.11
12	<i>Polypogon fugax</i> + <i>Chenopodium album</i> + <i>Persicaria lapathifolia</i>	3.00 $\pm$ 1.26	2.98 $\pm$ 1.22	2.92 $\pm$ 1.21	2.89 $\pm$ 1.24	2.95 $\pm$ 1.17

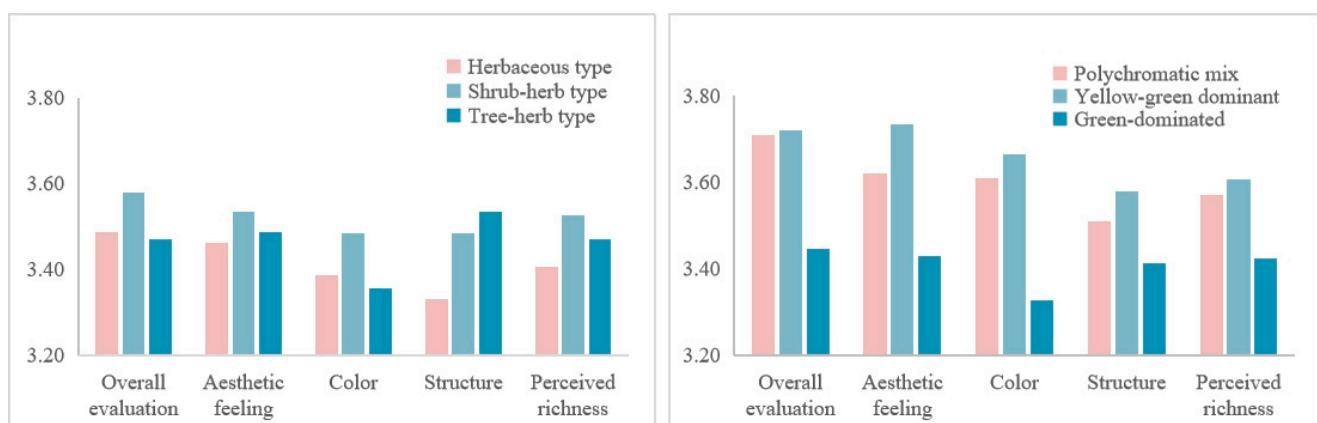


Figure 4. Preference Scores for Different Community Structures and Color Compositions.

3.3. Correlation Analysis Between Ecological Characteristics and Public Preference of Waterfront Wilderness Plant Communities

Significant correlations were consistently observed among biodiversity indices of typical waterfront wilderness plant communities (Table 5). For instance, species richness showed a significant positive correlation with the Shannon–Weiner index ($R = 0.63$, $p < 0.05$), while Pielou evenness exhibited highly significant positive correlations with both

the Simpson ($R = 0.95, p < 0.01$) and Shannon–Weiner index ($R = 0.90, p < 0.01$). Additionally, a significant positive correlation was found between the Simpson and Shannon–Weiner index ($R = 0.98, p < 0.05$). Public preference scores for overall evaluation, aesthetic feeling, color, structure, and perceived richness demonstrated strong intercorrelations (all $R > 0.8, p < 0.01$). Notably, no significant associations were detected between biodiversity indices and public preference metrics, indicating that public perceptions and evaluations of plant communities are not influenced by species richness, evenness, or diversity but are predominantly shaped by structural characteristics, color patterns, and perceived richness.

Table 5. Correlation analysis between community ecological characteristic indicators and public perception feature scores.

Indicator	Species Richness	Pielou Evenness	Simpson	Shannon-Weiner	Overall Evaluation	Aesthetic Feeling	Color	Structure	Perceived Richness
Species Richness	1.00								
Pielou Evenness	0.26	1.00							
Simpson	0.49	0.95 **	1.00						
Shannon-Weiner	0.63 *	0.90 **	0.98 **	1.00					
Overall Evaluation	0.28	0.27	0.42	0.41	1.00				
Aesthetic Feeling	0.15	0.14	0.27	0.26	0.96 **	1.00			
Color	0.20	0.21	0.35	0.33	0.98 **	0.93 **	1.00		
Structure	0.26	0.04	0.24	0.21	0.84 **	0.88 **	0.79 **	1.00	
Perceived Richness	0.31	0.22	0.37	0.36	0.94 **	0.95 **	0.89 **	0.91 **	1.00

Note: * significant correlation ($p < 0.05$); ** extremely significant correlation ($p < 0.01$).

To rigorously test the drivers of public preference and move beyond simple correlation, a multiple linear regression analysis was conducted. The overall preference score (Overall evaluation) was set as the dependent variable, with scores for aesthetic feeling, color, structure, and perceived richness as potential independent variables. The full model, including all four predictors, was highly significant (Adjusted $R^2 = 0.972$, $F(4, 7) = 95.83$, $p < 0.001$), explaining 97.2% of the variance in overall preference. However, only structure ($\beta = 0.354$, $p = 0.011$) and color ($\beta = 0.248$, $p = 0.057$) had statistically meaningful effects. Aesthetic feeling and perceived richness were not significant predictors, likely due to strong multicollinearity among the variables (VIF values > 10 for aesthetic feeling and perceived richness), suggesting that some predictors were redundant (Table 6) [36].

Table 6. Multiple linear regression results of four predictors on overall evaluation.

Variable	Coefficient (β)	std. Error	T Value	p Value	95% CI (Lower–Upper)	VIF
Intercept	0.287	0.162	1.77	0.118	(−0.091, 0.665)	/
Aesthetic feeling	0.249	0.168	1.48	0.180	(−0.158, 0.655)	25.13
Color	0.248	0.110	2.25	0.057	(−0.016, 0.512)	5.75
Structure	0.354	0.103	3.44	0.011	(0.116, 0.592)	4.09
Perceived richness	−0.027	0.188	−0.14	0.890	(−0.466, 0.412)	11.23
Model Fit	$F(4, 7) = 95.83, p < 0.001, \text{Adj. } R^2 = 0.972$					

Note: High multicollinearity was detected (VIF > 10 for Aesthetic feeling and perceived richness). VIF ≥ 10 indicates severe multicollinearity.

To improve model stability and interpretation, variables with high multicollinearity and non-significant effects (aesthetic feeling and perceived richness) were removed. The refined model retained structure and color as the most significant predictors. This revised model remained highly significant (Adjusted $R^2 = 0.967$, $F(2, 9) = 159.6$, $p < 0.001$). In

this model, both structure ($\beta = 0.44$, $p < 0.001$) and color ($\beta = 0.45$, $p < 0.001$) were highly significant positive predictors of overall preference.

This final model clearly shows that color and structure are the dominant factors shaping overall evaluation scores for plant communities. Together, they explain 96.7% of the variation in public preference. Both variables had nearly equivalent predictive weights ($\beta \approx 0.44$). This suggests that respondents simultaneously prioritize visual richness (color) and spatial layering (structure) in their aesthetic judgments. The result statistically confirms that structural characteristics and color patterns drive public preference for waterfront wilderness (Table 7).

Table 7. Simplified multiple regression model with two key aesthetic predictors.

Variable	Coefficient (β)	Std. Error	T Value	p Value	95% CI (Lower–Upper)	VIF
Intercept	0.322	0.148	2.18	0.056	(−0.009, 0.653)	/
Color	0.447	0.084	5.33	<0.001	(0.250, 0.644)	1.9
Structure	0.444	0.091	4.88	<0.001	(0.221, 0.667)	1.9
Model Fit	F(2, 9) = 159.6, $p < 0.001$, Adj. $R^2 = 0.967$					

4. Discussion

4.1. Methodological Limitations

This study is geographically limited to Chongqing, where unique mountainous topography and riverine hydrology shape waterfront wilderness landscapes, potentially influencing public perceptions in ways not generalizable to other regions. For instance, preferences observed here may differ from those in flatter urban settings or non-mountainous river areas. Methodologically, the use of static photographs in questionnaires may introduce “photo bias”, as they fail to capture the immersive, multi-sensory experiences of on-site visits, including sounds, scents, and seasonal changes [37]. Additionally, data collection focused on spring and summer vegetation, neglecting seasonality that could influence perceived aesthetics and accessibility [38]. The sample size and respondent demographics may also limit representativeness, with possible self-selection bias in online questionnaires. Future studies should incorporate field visits, multi-seasonal assessments, and larger, diverse samples to mitigate these issues.

4.2. Main Results

The study’s assumptions posited that public preferences for waterfront wilderness would prioritize perceived aesthetic and accessibility features over objective biodiversity metrics, potentially leading to ecological–aesthetic conflicts in mountainous settings. Our findings support this hypothesis: no significant correlations emerged between ecological indices (e.g., species richness, diversity) and overall preference scores, indicating that the public does not strongly recognize or value objective biodiversity in these areas. Instead, multiple regression analysis identified structural hierarchy ($\beta = 0.444$, $p < 0.001$) and color composition ($\beta = 0.447$, $p < 0.001$) as primary drivers, explaining 96.7% of variance, while perceived richness had minimal impact. This aligns with the assumption of aesthetic dominance, as layered vegetation structures provide perceived safety and openness—echoing evolutionary theories like the “prospect-refuge” hypothesis [39], which posits that humans prefer landscapes offering visibility and safety cues [40,41], like layered vegetation structures that provide openness without overwhelming density [14,17]. In Chongqing’s context, hydrological succession and steep slopes amplify these preferences, with respondents favoring accessible, mid-successional zones over dense, inaccessible ones.

4.3. Implications of the Results

These results imply that in Chongqing and similar mountainous urban contexts, ecological–aesthetic conflicts arise when objective biodiversity (e.g., high-density habitats on steep slopes) clashes with public demands for aesthetic appeal and accessibility, leading to an underestimation of diversity and ecological value [15], potentially undermining conservation efforts. To mitigate this, urban planners should integrate user-centered strategies: for high-preference flat terrains, enhance aesthetics and incorporate native colorful species, with hydrological monitoring to maintain succession. For low-preference steep areas, implement access buffers, educational signage on biodiversity values to educate on ecological value, reducing “ecological–aesthetic” conflicts [42], and zoning to balance protection with recreation. This approach compensates for limited formal green spaces in mountainous cities, fostering public acceptance and sustainable human–nature interactions [43]. By providing a Chongqing archetype, the study enriches global urban wilderness research with regional diversity, offering transferable insights for rapidly urbanizing areas to harmonize development with wilderness protection.

5. Conclusions

This study examined public perceptions and preferences for plant communities in Chongqing’s mountainous urban waterfront wilderness, employing field surveys of 218 quadrats for biodiversity assessment and questionnaires to evaluate spatial and aesthetic preferences. Building on the assumption that public priorities favor perceived aesthetic and accessibility features over objective biodiversity metrics—potentially exacerbating ecological–aesthetic conflicts in steep, hydrologically dynamic settings—our results strongly support this hypothesis. No significant correlations were found between ecological indices and preference scores, with structural hierarchy and color composition emerging as dominant predictors, explaining 96.7% of variance. This indicates limited public recognition of ecological values in these unique habitats, where topography and hydrological succession create biodiversity hotspots yet prioritize accessible, visually appealing landscapes over dense, objective richness [44–46].

The added value of this research lies in providing a mountainous city archetype that compensates for gaps in urban wilderness studies, particularly in rapidly urbanizing regions with constrained green spaces. By highlighting aesthetic-driven preferences and ecological–aesthetic conflicts, it informs user-centered planning to enhance public acceptance and balance conservation with development. Implications include tailored interventions, such as zoning for aesthetic enhancements in accessible zones and educational measures in steep areas, offering transferable insights for other mountainous riverine cities globally. Future research should investigate multi-seasonal dynamics, incorporate virtual reality for immersive assessments, and explore physiological responses to deepen understanding of human–nature interactions in diverse urban contexts.

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