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Landscape Evaluation Method Design of Garden Plant Community Based on SBE Method

Abstract: - As an important component of urban gardens, plant communities not only maintain urban ecology and enhance the landscape effect, but also communicate with people through their own morphology, color, and other aspects. Evaluating the landscape of garden plant communities can provide a basis for the construction and development of urban gardens. This study selected ten urban gardens in a certain area as the research objects. Through field investigations, the plant species, sources, community structure, and community stability of these ten gardens were analyzed, and the quantitative and diverse characteristics of the garden landscapes were deeply explored. Based on the Scenic Beauty Estimation (SBE) method, the plant community landscapes were evaluated through expert and public scoring. The results showed that the plant community landscapes were at a moderately high level, but there were relatively few high-quality landscapes in plant communities, leaving considerable room for improvement.

Keywords: SBE method; plant community landscapes; urban gardens

Urban gardens are one of the main places for urban residents to recreate, and the quality of garden landscapes directly affects residents' recreational experiences. By evaluating the plant community landscapes in gardens, we can not only gain a deep understanding of the basic situation of garden landscapes but also analyze the dynamic changes of landscapes, providing references for upgrading and renovating garden landscapes and plant configuration. Currently, there is a relatively large amount of research on garden landscapes both domestically and internationally. Some studies have focused on the scenic beauty (SBE) of a particular garden landscape, finding that student landscape evaluations can represent popular aesthetics [1]. In another study examining a garden plant community landscape, the landscapes were evaluated based on the SBE method, and the results showed that the quality of natural forests in the garden landscape is relatively high. Additionally, some studies have used the SD method to analyze human perceptions of different plant landscapes, demonstrating the semantics reflected by plant-composed landscapes [2]. Other research has analyzed the diversity of plant communities based on the SD method, using a particular urban garden as the research object [3]. In yet another study analyzing garden plant community landscapes, the aesthetic value of the landscapes was examined, and

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the role of landscape aesthetics in garden plants was elaborated [4]. Compared to foreign countries, domestic research on garden plant community landscapes started relatively late. However, with the acceleration of urbanization in China, research in this area has gradually deepened and achieved corresponding results. Some studies have analyzed a particular garden plant landscape based on the Analytic Hierarchy Process (AHP) and constructed a corresponding landscape analysis model. The results showed that this model can be used for plant landscape evaluation [5]. Other research has focused on plant landscapes, using a particular street landscape as a research sample to construct a plant landscape evaluation model based on the AHP method. This study deeply analyzed the problems existing in the landscape configuration process and proposed targeted improvement plans [6]. Another study evaluated the configuration of plant landscapes based on the AHP and SBE methods, using a particular garden plant landscape as the research object [7].

In this study, ten urban gardens in a specific region were selected as research objects, and the scenic beauty of plant landscapes was evaluated based on plant community surveys.

1.Characteristics of Species Composition in Urban Garden Communities of the Study Area

The study area covers approximately 7,500 square kilometers and experiences a typical temperate semi-humid continental monsoon climate, with dry springs and rainy summers. The annual average temperature ranges from 9-12℃, and the annual average precipitation is 680mm. Due to the influence of the monsoon climate, precipitation in this area is unevenly distributed, with relatively heavy rainfall in summer, accounting for 65.19% of the annual precipitation, and less rainfall in winter, accounting for only 3.59% of the annual precipitation.

In the course of this study, field research was conducted to investigate the species, origin, community structure, and community stability of the urban garden communities in this area. The survey results are as follows:

1.1Plant Community Composition

According to field investigations, there are a total of 500 plant species in the area, mainly including 123 cultivated plants and 377 wild plants. Meanwhile, angiosperms are relatively common in the gardens and account for a relatively large proportion.

1.2 Plant Family and Genus Hierarchy

Among the 10 gardens surveyed, plant families and genera are mainly divided into three levels: large, medium, and small. Among them, the proportion of dominant families and genera such as Gramineae, Asteraceae, and Fabaceae is relatively large, accounting for 1/3 of the total number of plants. In addition, the number of small plant genera is relatively high in these 10 gardens, indicating relatively strong differences among species.

1.3 Species Origin

During the investigation, it was found that there are 276 native plant species, accounting for a relatively large proportion of 54.02% of the total plant species. Among the various plant life forms, the proportion of native plants is herbs > vines > bamboos > trees > shrubs, which are widely used in gardens. Meanwhile, the proportion of exotic plants in the gardens is also significant, accounting for 45.99%.

1.4 Plant Community Structure

In the 10 gardens surveyed, the plant communities are mainly composite, mainly divided into three forms: tree-shrub composite, tree-herb, and shrub-herb. At the same time, there are also a few single-layer structures, such as tree-shrub and tree types. However, shrubbery and herbaceous layers are rarely seen in these gardens.

1.5 Plant Community Appearance

In the surveyed gardens, trees, shrubs, and herbaceous plants account for a relatively large proportion. The former mainly has high buds as the dominant feature, while the latter mainly has ground buds as the advantage. The leaf ecological characteristics are mainly reflected in single leaves and small leaves, which also reflects the monsoon climate in the region.

1.6 Plant Diversity Characteristics

Among the 10 gardens, plant diversity shows a general level, with herbs having higher richness and shrubs having the lowest. In terms of plant diversity, the diversity of plants ranges from small to large: street gardens < specialized gardens < community gardens < comprehensive gardens.

1.7 Plant Health Status

During the field investigation, it was found that the garden plants are growing well, but maintenance work still needs to be done.

1.8 Plant Community Stability

In terms of plant community stability, most gardens are relatively stable. This is mainly due to the strong efforts in greening maintenance and management in the area, and there is less human interference in the plant growth process.

2 Evaluation of Garden Plant Community Landscapes Based on the SBE Method

The SBE method primarily relies on scoring results from several individuals on selected sample site photos to obtain the average evaluation of the site. This approach assesses garden plant community landscapes in a quantitative manner, ensuring objectivity, rationality, and scientific rigor[8]. The details are as follows:

2.1 Selection of Evaluation Photos

To fully capture the characteristics of the plant communities in the sample sites, photographs were taken from different angles. After taking the photos, those with high clarity and representativeness were selected. In this study, two photos were used to represent the landscape of each sample site, and the selection of evaluation photos needed to meet the following conditions:

(1) Exclude photos with unclear landscape types or insufficient information.
(2) Exclude photos with glaring apertures.
(3) Control the number of photos taken to avoid affecting the judges' evaluation.
(4) Select photos that typify the landscape types of the sample sites.

Based on the above conditions, 166 valid photos were selected. The order of the photos was shuffled and renumbered, as detailed in Table 1.

Table 1 Comparative Table of Comprehensive Evaluation Sample Points for Urban Garden Plant Community Landscapes

Garden Name	Garden Type	Garden Number	Photo Number
Garden A	Comprehensive	01	010
Garden B	Garden	02	012
Garden C		03	013
Garden D	Community	04	014
Garden E	Garden	05	015
Garden F		06	016
Garden G	Specialized	07	017
Garden H	Garden	08	018
Garden I	Street Garden	09	019
Garden J		10	020

2.2 SBE Landscape Evaluation

Research has indicated that groups from different cultural backgrounds and upbringing environments demonstrate consistency in aesthetic evaluation results. Therefore, in this study, 166 photos that fully reflect the four seasons of the landscape of the sample site were selected. After numbering them, a slideshow was created, and 50 professionals and 50 non-professionals were invited to rate the photos.During the scoring process, scenic beauty was measured by preference, and scores were assigned using the "Likert Scale", as detailed in Table 2. In this process, a higher score indicates a better overall scenic beauty effect of the sample site's plant landscape.

Table 2: Scoring Criteria for Plant Landscape Communities

Degree of Appreciation	Extremely Like	Quite Like	Like	Dislike	Extremely Dislike
Scoring Criteria	10	8	6	4	2

Before starting the evaluation, the judges need to be briefly explained about the evaluation object, and then proceed with scoring. After scoring is completed, collect the scoring sheets and eliminate those that show no difference in scoring for all sample plots or those that have not completed scoring for all sample plots. Finally, 100 valid questionnaires were collected.

2.3 Standardization of SBE Scores and Model Establishment

The scoring results were tallied and verified through an EXCEL spreadsheet. Since each evaluator may have different experiences with the landscape, it is necessary to standardize the evaluation grade values to facilitate subsequent analysis [9]. In this study, the SBE value is considered the ideal value, unaffected by various factors. Therefore, traditional standardization methods can be used to normalize it, which can be specifically expressed as:

$$z_{ij} = (R_{ij} - R_j) / S_j \quad (1)$$

$$SBEi = \sum z_{ij} / N_i \quad (2)$$

In formulas (1) and (2), Z_{ij} represents the standardized value of the j th evaluator's score for the i th sample site photo, Z_{ij} represents the standard deviation of the Jth evaluator's scores for the i th sample site photo; R_i and S_j represent the average score and standard deviation of scores respectively, given by the i th evaluator for all sample sites in the garden; $SEBi$ represents the standardization of the SBE value for the i th sample site; and N_i represents the total number of evaluators for the ith sample site.

3 Evaluation Results and Analysis

The standardized SBE values are detailed in Table 3.

Table 3: Standardized SBE Values for Urban Garden Plant Community Landscapes in Various Cities

Garden Name	Average Non-professional SBE	Average Professional SBE	Average Value	Ranking
Garden A	0.510	0.460	0.480	1
Garden B	0.370	0.301	0.340	4
Garden C	0.430	0.330	0.380	2
Garden D	0.380	0.279	0.330	5
Garden E	0.390	0.350	0.370	3
Garden F	0.040	-0.130	-0.050	6
Garden G	-0.070	-0.210	-0.140	7
Garden H	-0.120	-0.302	-0.210	9
Garden I	-0.340	-0.040	-0.179	8
Garden J	-0.270	-0.470	-0.370	10

Through analysis of Table 3, it is found that Garden A has the highest average score for plant landscape scenic beauty, which is 0.480. There are 6 gardens with a non-professional average score exceeding 0.00, and 4 gardens with a score below 0.00. For the professional SBE average, there are 5 gardens with a score exceeding 0.00 and 5 gardens with a score below 0.00. This indicates that the proportion of urban garden plant landscapes in the region is relatively balanced.

Based on the data in Table 3, a curve of standardized SBE values for plant landscapes was plotted, as

shown in Figure 1.

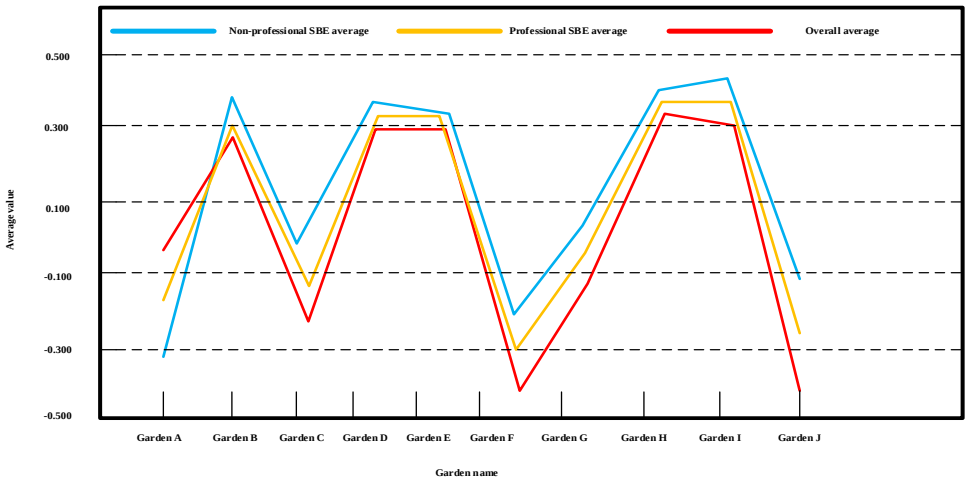

Figure 1: SBE Evaluation Curve of Plant Community Landscapes in Various Urban Parks

From Figure 1, it can be seen that the plant landscape scores of non-professionals and professionals are relatively close, which indicates consistency in their aesthetic evaluations.

3.1 Analysis of Professionals' Preferences

In this study, the average scores given by experts on plant seasonal phases and color changes, level of richness, plant morphology and texture, etc., were used as a comprehensive rating for scenic beauty preferences. To facilitate subsequent analysis, this study arranged representative garden photos on a coordinate axis, with the coordinate value corresponding to the center of each photo representing the score for that sample site, as shown in Figure 2.

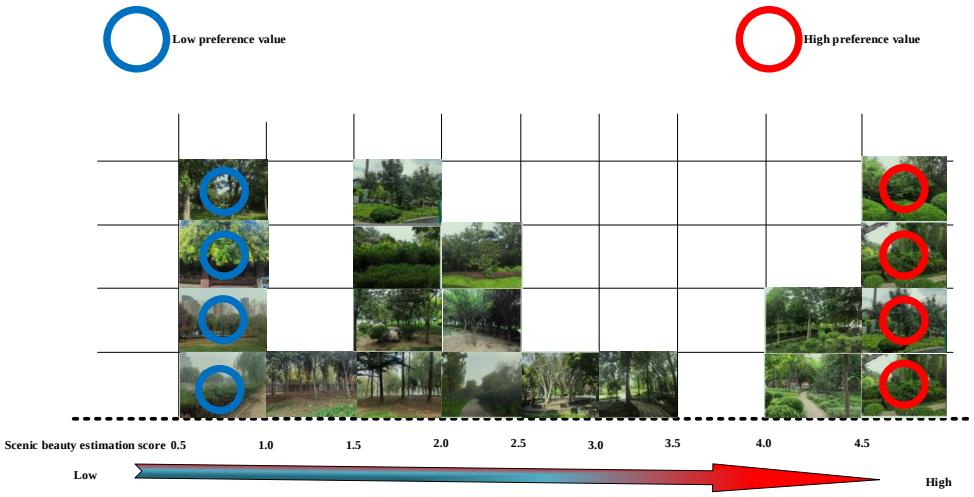

Figure 2: Expert Scenic Beauty Preference Ranking Chart

From Figure 2, it can be seen that professionals gave relatively high scores to some gardens, with scenic beauty scores ranging from 4.0 to 4.5. For some gardens with relatively low scores, the scenic beauty scores ranged from 1.0 to 3.0. Meanwhile, the concentration of evaluation factors in the inner and outer rings is

relatively high. The communities with high scenic beauty preference values are Garden A, Garden C, and Garden D, in descending order, while the community with a low scenic beauty preference value is Garden J.

Analyzing different elements, it is evident that communities with strong seasonal and color aesthetics not only exhibit diverse colors but also maintain unity. For instance, in various combinations of greens with different brightness levels, the background is predominantly dark green, the midground is mainly medium green, and the foreground is light green.

At the same time, some communities have lower color aesthetics, lacking uniformity in color and brightness. This combination typically features a dark purple background, a deep green foreground, and reduced ground cover, resulting in an overall dark and dull appearance.

For communities with strong morphological aesthetics, they are mainly dominated by trees of the same specifications, arranged neatly, giving a strong sense of rhythm visually. For communities with relatively weak morphological aesthetics, although their plant morphologies have strong contrasts, the plant types are not uniform[10]. For example, pairing metasequoia with weeping willows provides diversity, but there is a lack of harmony.

For plant communities with relatively strong textural beauty, there is a clear distinction between primary and secondary elements, and the contrast is stark. For instance, using evergreen bamboo as a backdrop for metasequoia's falling leaves creates a sharp contrast in texture. Plant communities with weaker textural beauty mainly combine coarse and fine textures, lacking a clear distinction between primary and secondary elements, resulting in a more chaotic relationship.

Plant communities with relatively high levels of hierarchical richness are dominated by a well-arranged structure of trees, shrubs, and grasses that is prominent and coordinated. This not only achieves a high landscape effect but also exhibits relatively high structural stability and resistance to external environmental influences during growth[11].

In terms of spatial sequence and compositional art, the higher-scoring types are mainly U-shaped and L-shaped, which not only form spatial entities composed of plant communities but also guide the viewer's line of sight.

Overall, experts place significant emphasis on the rhythmic sensibility of plant landscape communities during the scoring process, and the combination of plant morphology and color is key to improving scores. Therefore, in the process of landscape design, special attention should be paid to the configuration of plant landscapes, which should not only possess a certain rhythmic sensibility but also exhibit strong unity and contrast. This approach can further enhance the aesthetic appeal of the garden.

3.2 Analysis of Non-Professionals' Preferences

The non-professionals participating in the evaluation were mainly members of the public. Before analyzing the preferences of this group, a normal distribution test was conducted on the survey questionnaire data. After passing the test, formulas (1) and (2) were used to standardize the preference values. The results are detailed in Table 4.

Table 4: Public Aesthetic Preference Scores for Plant Communities

Garden Name	Minimum Standardized Value	Maximum Standardized Value	Average Value	Standard Deviation	Ranking
Garden A	-0.809	2.628	0.509	0.756	1
Garden B	-1.738	2.236	0.368	0.801	5
Garden C	-0.901	2.565	0.426	0.708	2
Garden D	-0.801	2.317	0.375	0.168	4
Garden E	-0.210	2.420	0.390	0.820	3
Garden F	-1.790	1.320	0.040	0.959	6
Garden G	-0.290	2.310	-0.070	0.940	7
Garden H	-1.910	2.360	-0.120	0.897	8
Garden I	-2.430	1.580	-0.330	1.080	10
Garden J	-2.370	1.001	-0.270	0.959	9

Based on the analysis of Table 4, it can be observed that preference scores are mainly distributed within the range of -0.330 to 0.510. Among them, there are 6 garden communities with positive scores and 4 with negative scores. Additionally, there is a garden community A with a score greater than 0.500. Based on the scoring results, public preferences are divided into three levels: Level I gardens with 5, Level II gardens with 1, and Level III gardens with 4.

Two typical photos from each of the 10 gardens were selected and sorted accordingly, as shown in Figure 3.

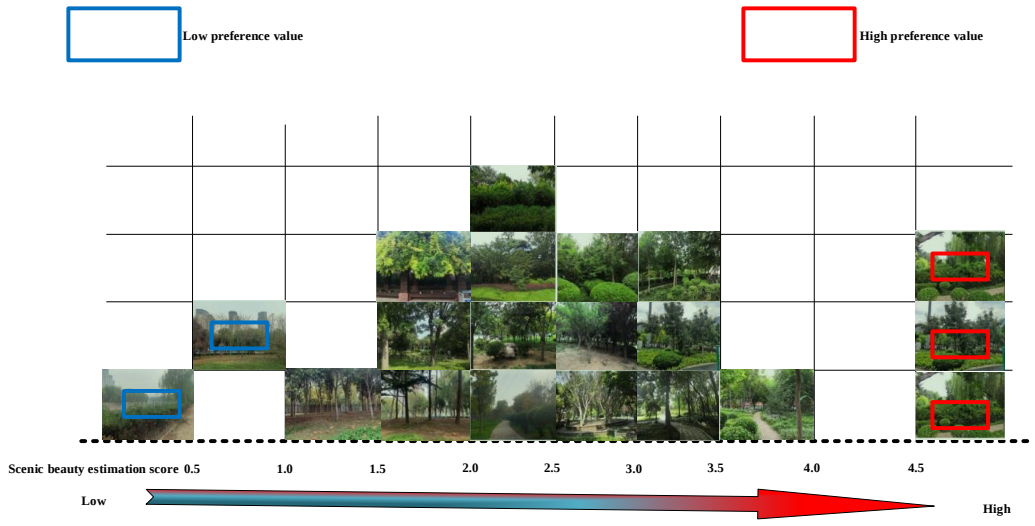

Figure 3: Public Preference Ranking of Scenic Beauty

In Figure 3, yellow circles represent plant communities with relatively high scenic beauty, while black circles represent those with relatively low scenic beauty. As evident from Figure 3, compared to expert preferences, public preferences for scenic beauty are more concentrated, with notable differences between the two. Communities highly rated by the public tend to have a predominantly green color palette, exhibit high species

diversity, feature compact plant arrangements, and adhere to principles of visual design with overlapping spatial layouts, creating a strong sense of rhythm among the plant communities. Communities with lower public aesthetic ratings tend to have a predominantly brownish-yellow color palette, lower species diversity, and a more uniform community composition[12]. Additionally, there is a relatively high number of evergreen tree species, while the richness is primarily attributed to shrubs, and harmony is emphasized during their configuration.

For a detailed correlation between public aesthetic preferences and evaluation factors, refer to Table 5.

Table 5: Correlation Analysis between Public Aesthetic Preferences and Evaluation Factors

	Unstandardized		Standardized			Correlation	
	B	Standard Error	Beta	t	Significance	Zero-Order	Partial
Seasonal and color changes	1.359	0.165	1.536	6.664	0.039	0.789	0.829
Level of richness	4.268	0.148	1.454	6.408	0.018	0.700	0.857
Form and texture	1.178	0.145	1.365	5.474	0.008	0.638	0.796
Spatial sequence and compositional art	1.08	0.126	1.217	4.975	0.036	0.585	0.658
Landscape artistic conception	-1.650	0.320	-1.580	-5.076	0.109	0.168	-0.908
Environmental coordination	-1.030	0.270	-1.030	-3.810	0.018	0.189	-0.836
Environmental diversity	-0.390	0.230	-0.440	-1.320	0.030	0.088	-0.508

Through the analysis of Table 5, it is found that there is a significant positive correlation between public visual aesthetic preferences and color aesthetic, level of richness, and spatial sequence. However, there is a significant negative correlation with form and texture, landscape artistic conception, and environmental coordination. This suggests that the public has a strong perception of color, level, form, and texture. Therefore, in the landscape design of garden plant communities, it is necessary to focus on the color coordination of plants, enhance the shaping of plant texture, and improve the aesthetic quality of garden plant communities through

reasonable spatial structural relationships and layout forms, thereby increasing the beauty of garden plant communities.

3.3 Analysis of Expert and Public Preference Results

For a detailed correlation between public aesthetic preferences and expert aesthetic preferences, refer to Table 6.

Table 6: Correlation Analysis between Public Aesthetic Preferences and Expert Aesthetic Preferences

		Public Aesthetic Preference	Expert Aesthetic Preference
Public Aesthetic Preference	Pearson Correlation	1	0.460*
	Sig. (2-tailed)	——	0.001
	Number of Cases	155	155
Expert Aesthetic Preference	Pearson Correlation	0.460	——
	Sig. (2-tailed)	0.001	——
	Number of Cases	155	155

Note: *. Correlation is significant at the 0.05 level (2-tailed).

Through the analysis of Table 6, it is found that there is a significant correlation between public preferences and expert preferences. Combining the preferences of professionals and non-professionals mentioned above, it can be observed that the visual aesthetic preference values of experts are relatively scattered, but there are no corresponding extreme values.On the other hand, the distribution of visual aesthetic preference values in public evaluation is more concentrated.

From this, it can be inferred that experts are relatively strict in distinguishing the quality of plant communities, resulting in a more scattered distribution. However, through public evaluation, it is possible to better screen out the advantageous and disadvantaged communities in the sample plots.

A comparison of aesthetic preferences between expert and public evaluations is shown in Figure 4.

Figure 4: Comparison of Aesthetic Preferences between Expert and Public Evaluations

As seen in Figure 4, there is a high degree of consistency between public and expert preferences, but significant differences exist in terms of advantages and disadvantages. From the experts' perspective, their aesthetic preferences for plant communities are relatively high, while the public's are lower. Communities with higher aesthetic preferences among experts possess a certain morphological beauty and have a sharp contrast with evergreen plants. From the public's standpoint, they have a higher preference for evergreen plants and have a poorer understanding of the coordination among communities, resulting in relatively lower scores. The main reasons for this can be summarized as follows:

(1)During the expert evaluation process, comprehensive considerations are given to morphology, color, and texture, and the evaluation process is relatively rational. On the other hand, the public tends to place more emphasis on visual effects during the evaluation process, such as the color and shape of the plant communities.

(2) There are differences in the perception of plant communities among different groups of people. For experts, who have rich experience and knowledge of plant communities, viewing photographs may evoke associations with the original spatial distribution patterns. However, for the general public, who lack knowledge of plant communities, viewing photographs is primarily for appreciation and does not generate corresponding associations.

Conclusion:

With the accelerated process of urbanization, garden plant communities, as an essential component of the urban ecosystem, have a direct impact on the quality of life of urban residents and the city's image. However, traditional evaluation methods for garden plant community landscapes often suffer from issues such as strong subjectivity and a lack of scientific and systematic approaches, making it difficult to accurately reflect the true state of garden plant communities. This article focuses on ten gardens in a specific region as research subjects. Based on field research, it analyzes the species, sources, and community structures of the plant communities in these ten gardens. Using the SBE method, the landscapes of these ten garden plant communities are evaluated, and the research findings are summarized as follows:

(1)In the process of designing garden plant community landscapes, special attention should be paid to the color coordination of plants and enhancing the texture of plants. Additionally, the aesthetic quality of garden plant communities should be improved through reasonable spatial structural relationships and layout forms, thereby increasing the beauty of garden plant communities.

(2) In the process of garden design, emphasis should be placed on the configuration of plant landscapes, which should not only possess a certain rhythm but also exhibit strong unity and contrast, thereby enhancing the beauty of the garden.

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