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EDITED BY

Shixian Luo,
Southwest Jiaotong University, China

REVIEWED BY

Tabarak A. Al-Mashhadani,
University of Baghdad Institute of Laser for
Postgraduate Studies, Iraq
Yang Ye,
Beijing Forestry University, China

*CORRESPONDENCE

Zhizhong Xing,
✉ xingzhizhong@kmmu.edu.cn
Lin Wang,
✉ lwang1974@163.com

RECEIVED 03 March 2026

REVISED 17 May 2026

ACCEPTED 18 May 2026

PUBLISHED 11 June 2026

CITATION

Zhu X, Xing Z, Chen X, Wang J, Yang X,
Yang L, Wang L, Li R and Wang Y (2026)
Mixed diversity of spontaneous and
landscape plants in urban linear informal
green spaces: adaptive configuration
patterns and functional evaluation.
Front. Environ. Sci. 14:1796169.
doi: 10.3389/fenvs.2026.1796169

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Mixed diversity of spontaneous and landscape plants in urban linear informal green spaces: adaptive configuration patterns and functional evaluation

Xingxiao Zhu¹, Zhizhong Xing^{2*}, Xia Chen¹, Jing Wang¹,
Xinyue Yang¹, Lei Yang¹, Lin Wang^{1*}, Ruimin Li³ and Yayu Wang⁴

¹College of Horticulture and Landscape, Yunnan Forestry Technological College, Kunming, China,

²School of Rehabilitation and Yunnan Key Laboratory of Plateau Thermal Medical Rehabilitation and Wellness, Kunming Medical University, Kunming, China, ³Faculty of Architecture and City Planning, Kunming University of Science and Technology, Kunming, China, ⁴College of Landscape and Horticulture, Southwest Forestry University, Kunming, China

Urban informal green spaces (IGS) are an important component of urban ecosystems. They play a significant role in biodiversity conservation and enhancing residents' quality of life. However, research on IGS plant configuration patterns, especially those based on plant diversity characteristics, is still insufficient. This study selected three linear informal green spaces along the Panlong River in Kunming, the Yunnan Vietnam Railway, and the Changchong Mountain Ring Road as research objects. Based on this, 29 evergreen, fruit and leaf viewing, and flower viewing garden plants were selected from the "Recommended List of Garden Plants in Kunming City". A multidimensional evaluation model was constructed using the Analytic Hierarchy Process, which includes ecological adaptation, aesthetic value, social benefits, cultural value, aesthetic effects, and ecological diversity protection. The results show that *Grevillea robusta*, *Pistacia chinensis*, and *Albizia kalkora* outperformed other species in comprehensive performance, receiving the highest scores among the three tree types. Further analysis also revealed the close relationship between various factors in the evaluation model and the advantages of various plants in a single performance. Based on these results, we have drawn plant configuration pattern diagrams for three study areas to visually demonstrate the optimization direction of plant configuration at each research point. This study enriches the theoretical system of urban plant community ecology, provides practical guidance for the configuration of mixed plant communities in linear informal green spaces, and assists in the standardized transformation of informal green spaces and the improvement of urban ecological resilience.

KEYWORDS

ecological corridor, informal green space, landscape design, landscape ecology, plant diversity, urban planning

1 Introduction

Against the dual backdrop of accelerated global urbanization and intensified ecological stress, building sustainable urban ecosystems has become a core issue for achieving clean production and high-quality urban development. Urban green spaces, as an important component of urban ecosystems, not only carry ecological functions such as beautifying the environment, purifying the air, and regulating microclimates, but also increasingly become important places for urban residents to relax, entertain, and find solace in their souls. Among them, Informal Green Spaces (IGS), as areas in the urban green space system that have not been formally planned or managed but have naturally formed and possess certain ecological and landscape values, are increasingly gaining prominence (Ta et al., 2025; Wang et al., 2025; Biernacka et al., 2023; Kumar and Rajak, 2024). These spaces are often embedded in urban crevices, providing valuable habitats for urban biodiversity (Neate-Clegg et al., 2023; Shen et al., 2024; Zhang et al., 2023). As “invisible oases” in the city, they encourage spontaneous activities and social interactions among urban residents, promoting the formation of community cohesion and a sense of belonging (Anna et al., 2021; Ullah, 2024; Kiss et al., 2022). They are important carriers of diverse and inclusive urban greening strategies in urban planning and design (Lourdes et al., 2022; Ma et al., 2024). Based on their formation reasons and spatial forms, Informal Green Spaces can be divided into categories such as waterfront, transportation corridor, and mountain trail. These linear spaces also serve as important ecological corridors in the city, supporting the migration and diffusion processes of species.

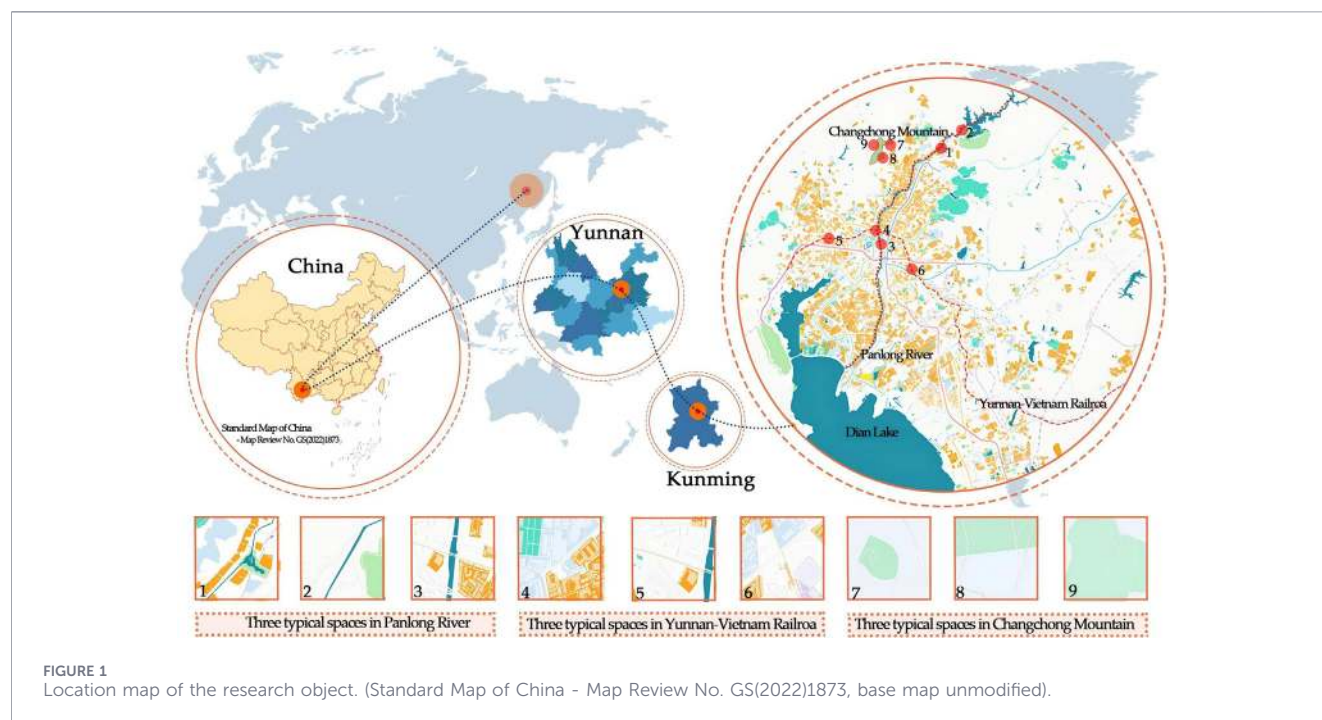
However, despite the irreplaceable ecological and social functions of urban informal green spaces, their current plant configuration is often overlooked or poorly managed. The existing research on urban plant configuration mainly focuses on formal green spaces, and there is a significant lack of attention to informal green spaces (IGS). Secondly, previous research on IGS has mainly focused on the diversity of spontaneous plants and their ecological value, with less exploration of how to mix spontaneous plants with garden plants through human intervention. Some areas may be excessively occupied by a certain type of plant, while other plant species are relatively few, leading to a decrease in ecological diversity (Hatton et al., 2024; Hu et al., 2023). It also reduces its ecological value as an important component of urban ecosystems. It is worth noting that although there are many problems with the plant configuration in informal green spaces, these spaces still have enormous potential and value, with vegetation dominated by natural succession sites. There are significant differences in vegetation structure and species composition among different types of urban green spaces, among which informal green spaces often maintain a high proportion of spontaneous plants and unique community structures. Through moderate transformation and scientific planning, these spontaneous plants can be combined with garden plants to form rich and diverse plant communities (Liu et al., 2021; Evans et al., 2022; Threlfall et al., 2016).

Kunming, as the capital city of Yunnan Province, is renowned for its unique geographical location and abundant natural resources.

In the urban green space system of Kunming City, green spaces along the Panlong River, Yunnan Vietnam Railway, and Changchong Mountain Trail are typical linear informal green spaces that not only carry important ecological functions but also contain rich historical and cultural connotations (Ha et al., 2022; Wang, 2025). It is worth noting that Kunming has abundant resources of garden plants, especially the 29 key and backbone tree species listed in the “Recommended List of Garden Plants in Kunming”. They are not only important elements that constitute the unique urban landscape of Kunming, but also have the potential to enhance the diversity of informal green space plants and improve the quality of the ecological environment (Liu et al., 2022; Yuan and Kim, 2024; Wang et al., 2023). More and more evidence suggests that the shape, connectivity, and relationship between green spaces and surrounding land have a significant impact on plant diversity (Ye et al., 2025).

This study focuses on three typical urban informal green spaces along the Panlong River in Kunming, the Yunnan Vietnam Railway, and the Changchong Mountain Trail. The study analyzes the characteristics of their plant community composition, including the types, distribution, and ecological functions of spontaneous plants, as well as the current status and problems of garden plant applications (Li et al., 2024). On this basis, based on the 29 key tone and backbone tree species in the “Recommended List of Landscape Plants in Kunming City”, combined with the environmental conditions, ecological needs, and landscape goals of various green spaces, explore reasonable plant configuration (Xu et al., 2023). Using the Analytic Hierarchy Process (AHP) to construct an evaluation model for garden plants, this model integrates dimensions such as ecological adaptation and function, aesthetic value, social benefits, cultural value, ornamental effects, and ecological diversity protection, quantitatively analyzes the weights of each factor, and provides scientific basis for plant selection and configuration. Based on field investigations and data analysis, draw a plant configuration pattern diagram for urban linear informal green spaces, visually display the ideal community structure and layout, and provide operational guidance for future green space planning and design.

This study reveals the unique value and potential of urban linear informal green spaces in terms of plant diversity through in-depth field investigations, emphasizing their importance for urban ecosystem services and sustainable development (Mitchell and Devisscher, 2022; Filyushkina et al., 2022; Santiago Ramos and Hurtado Rodriguez, 2021). Secondly, an innovative linear informal green space garden plant evaluation model has been constructed, which integrates multidimensional indicators such as ecological adaptability, aesthetics, social and cultural value, and ornamental effects, providing scientific and objective decision-making basis for plant landscape planning and promoting the application and development of quantitative decision-making methods in this field. Finally, based on the evaluation data and research results, the key focus of plant selection was summarized, and a plant configuration pattern diagram with guiding significance was drawn, providing a new perspective and methodological path for green space configuration practice and related research, promoting the scientific and standardized construction of urban green spaces.



2 Research objects and methods

Our research focuses on three major linear informal green spaces within Kunming city, namely the waterfront-type green spaces along the Panlong River, the transportation corridor-type green spaces along the Dian-Yue Railway, and the mountain trail-type green spaces along the Changchongshan Trail. The study location map is shown in Figure 1. These three types of spaces represent typical linear informal green space types in the city and all possess functional characteristics as potential ecological corridors, capable of supporting species migration and gene flow within the city and between urban and rural areas. Each of them has unique geographical features and ecological values, making them ideal samples for studying plant configuration patterns in urban informal green spaces. On this basis, we used the Analytic Hierarchy Process to construct an evaluation system for 29 garden plants. On this basis, we further analyzed the diversity and rationality of plant configuration in these linear informal green spaces, aiming to explore how to optimize green space design to meet the leisure and recreation needs of urban residents while protecting the natural ecology. It should be pointed out that the green spaces along the Panlong River have been included in Kunming's greenway system in recent years, and not all of them are informal green spaces.

2.1 Research object and current status

As the mother river of Kunming, the Panlong River's green spaces along its banks are an important component of the urban ecosystem. This study selected three representative research sites, namely the No.1 space located next to the village, which has a relatively natural appearance; The second space located in the urban space, with a modern surrounding style; And the third space, which

intersects with the Panlong River, has a natural and leisurely plant landscape. The plants in these spaces are mainly spontaneous plants, with fewer garden plants, mainly shrubs, weeds, and other ground cover plants. There are relatively few types of trees, and the overall plant landscape style is weak.

As a historical relic, the green spaces along the Yunnan Vietnam Railway carry rich cultural and ecological values. The fourth spatial plot selected in this study is relatively wide, with abundant native low shrubs and herbs, presenting a wild railway style; On both sides of Space five are residential buildings, with a small spatial scale but full of warmth; On both sides of Space 6, there is an urban pastoral style, and some residents spontaneously grow vegetables, forming a unique landscape. The plants in these spaces are mainly spontaneous plants, and the variety of garden plants is limited, but the ecological diversity is relatively high.

The green space of Changchong Mountain Trail is a great place for Kunming citizens to relax and exercise, and the green spaces along its route also have rich ecological value. The selected spaces of No.7, No.8, and No.9 in this study all present a relatively wild landscape of mountains, forests, herbs, and shrubs. The plant species in these spaces are relatively abundant, but still dominated by spontaneous plants, with fewer garden plants. Compared with the areas along the Panlong River and the Yunnan Vietnam Railway, the plant landscape in the green space of the Changchong Mountain Trail is more natural and primitive, making it a rare and pristine land in the city.

Based on the current situation investigation of the three major linear informal green spaces mentioned above, this study selected 29 key tree species and backbone tree species from the "Recommended List of Landscape Plants in Kunming City" as research objects. These tree species include 11 evergreen trees, 10 deciduous trees for viewing leaves and fruits, and 8 deciduous trees for viewing flowers. Through on-site investigation, we found

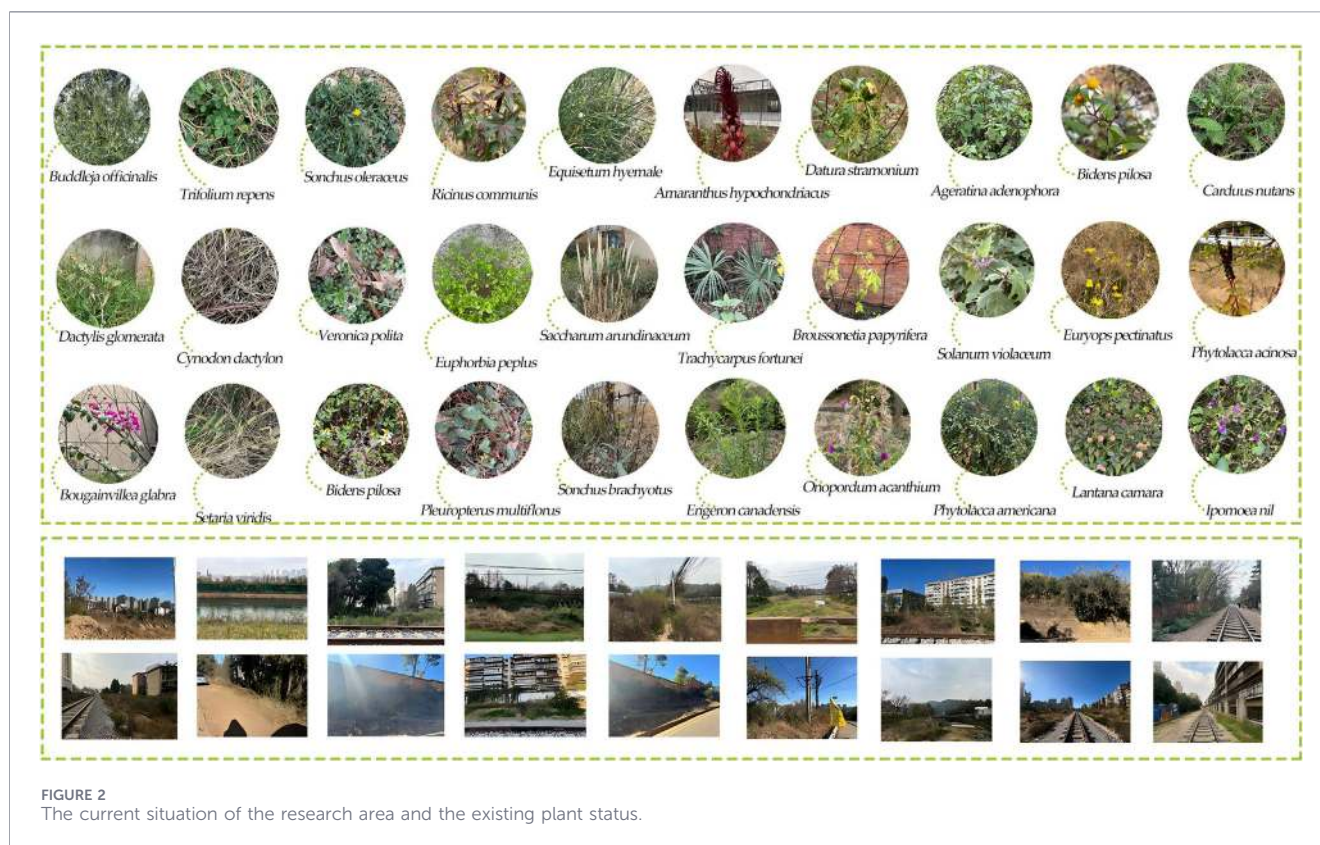


FIGURE 2
The current situation of the research area and the existing plant status.

that the selected research area is mainly dominated by spontaneous plants, with fewer and limited types of garden plants, as shown in Figure 2. Based on in-depth research and analysis of the research area, and fully utilizing the abundant garden plant resources in Kunming, this study aims to explore the optimal combination configuration mode of spontaneous plants and garden plants in terms of diversity. The core purpose is to provide solid scientific basis and practical guidance for the ecological restoration and landscape beautification of urban informal green spaces, which constitutes the core topic of this study.

2.2 Selection of evaluation methods

Linear informal green spaces not only involve material elements such as plant diversity, but are also closely related to cultural values and residents' leisure needs (Gong et al., 2024; Fang et al., 2023). When selecting the method for evaluating linear informal green space landscape plants, we comprehensively considered multiple potential evaluation techniques, aiming to find the most suitable method for the background and purpose of this study. These techniques include several commonly used methods in multi criteria decision analysis (MCDA), such as TOPSIS based on ideal solution similarity, Vise Riterijumska Kompromisno Rangiranje (VIKOR), fuzzy comprehensive evaluation method, and ultimately selected Analytic Hierarchy Process (AHP).

The TOPSIS method is suitable for multi criteria decision-making problems, but when dealing with the hierarchical structure and qualitative indicators in this study, it is difficult to intuitively reflect the logical relationships between various factors (Onar et al., 2022; Ciardiello and Genovese, 2023). The VIKOR

method is suitable for solving conflicting standard problems, but its weight setting and standard correlation mechanism are relatively complex, making it difficult to clearly reflect the evaluation hierarchy of this study (Falch and Silva, 2022; Wang and Wang, 2021; Runtuk et al., 2025). The fuzzy comprehensive evaluation method can effectively handle uncertainty problems, but constructing a fuzzy relationship matrix and weight system requires strong professional background and computational resources (Wu et al., 2024; Xiong et al., 2024; Hu et al., 2021). In contrast, Analytic Hierarchy Process (AHP) can decompose complex problems into clear hierarchical structures, combine qualitative and quantitative analysis, and transform subjective judgments into quantifiable weights through pairwise comparisons. It is suitable for the evaluation needs of this study, which are mainly based on multi factor, multi-level, and qualitative indicators, and has good operability and transparency (Panchal and Shrivastava, 2022; Sivrikaya and Küük, 2022; Saini et al., 2023). Therefore, this article chooses AHP as the main evaluation method.

In addition, the Analytic Hierarchy Process is highly suitable for conducting in-depth analysis and evaluation of the comprehensive and diverse ecosystem of linear informal green spaces in Kunming. By constructing a multi-level analysis structure, detailed analysis can be conducted on various aspects of plant ecological adaptability, aesthetic value, social benefits, cultural value, ornamental effects, and ecological diversity protection, ensuring the comprehensiveness and depth of the evaluation. Sensitivity analysis serves as a critical tool for assessing the stability of multi-criteria evaluation models, particularly in the context of AHP, where it helps determine whether the ranking outcomes remain consistent when input weights are subject to reasonable fluctuations. Being able to score qualitative

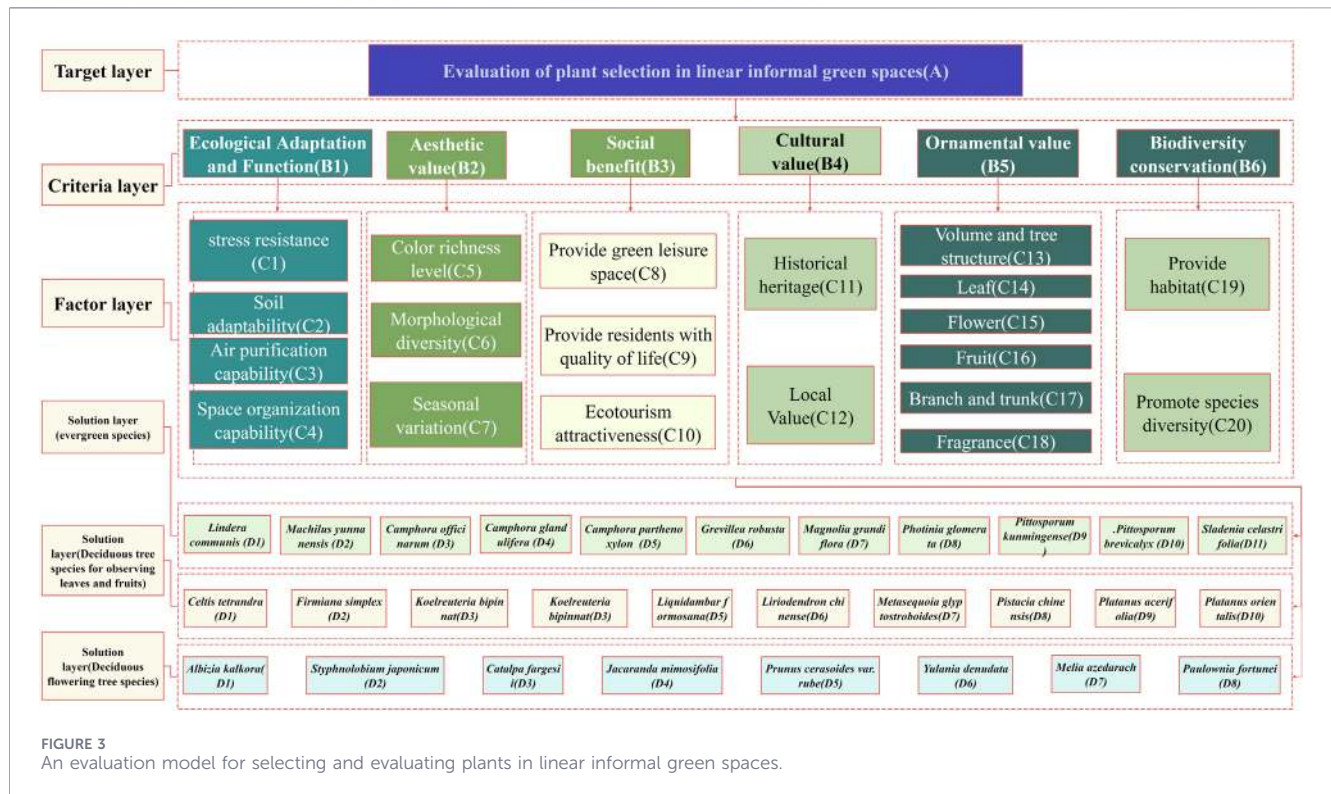


FIGURE 3
An evaluation model for selecting and evaluating plants in linear informal green spaces.

factors and convert them into quantitative data, making the evaluation results more objective and comparable, achieving a perfect combination of qualitative and quantitative analysis.

In order to ensure the scientificity and rationality of the research, we invited experts from multiple fields such as urban planning and design, landscape plants, landscape design, ecology, etc., To participate in the screening and adjustment of indicators. These experts have rich practical experience and profound academic backgrounds, and their participation ensures the accuracy and credibility of the evaluation model. By integrating expert opinions and suggestions, we have constructed an evaluation system that includes multiple dimensions such as ecological adaptation and function, aesthetic value, social benefits, cultural value, viewing effect, and ecological diversity protection, and assigned reasonable weights to factors under each dimension.

In summary, the Analytic Hierarchy Process (AHP) has been selected as the core evaluation method in this study due to its advantages of being structured, systematic, and flexible. It can effectively handle the complexity and ambiguity of linear informal green space plant configuration patterns, ensuring the accuracy and credibility of evaluation results.

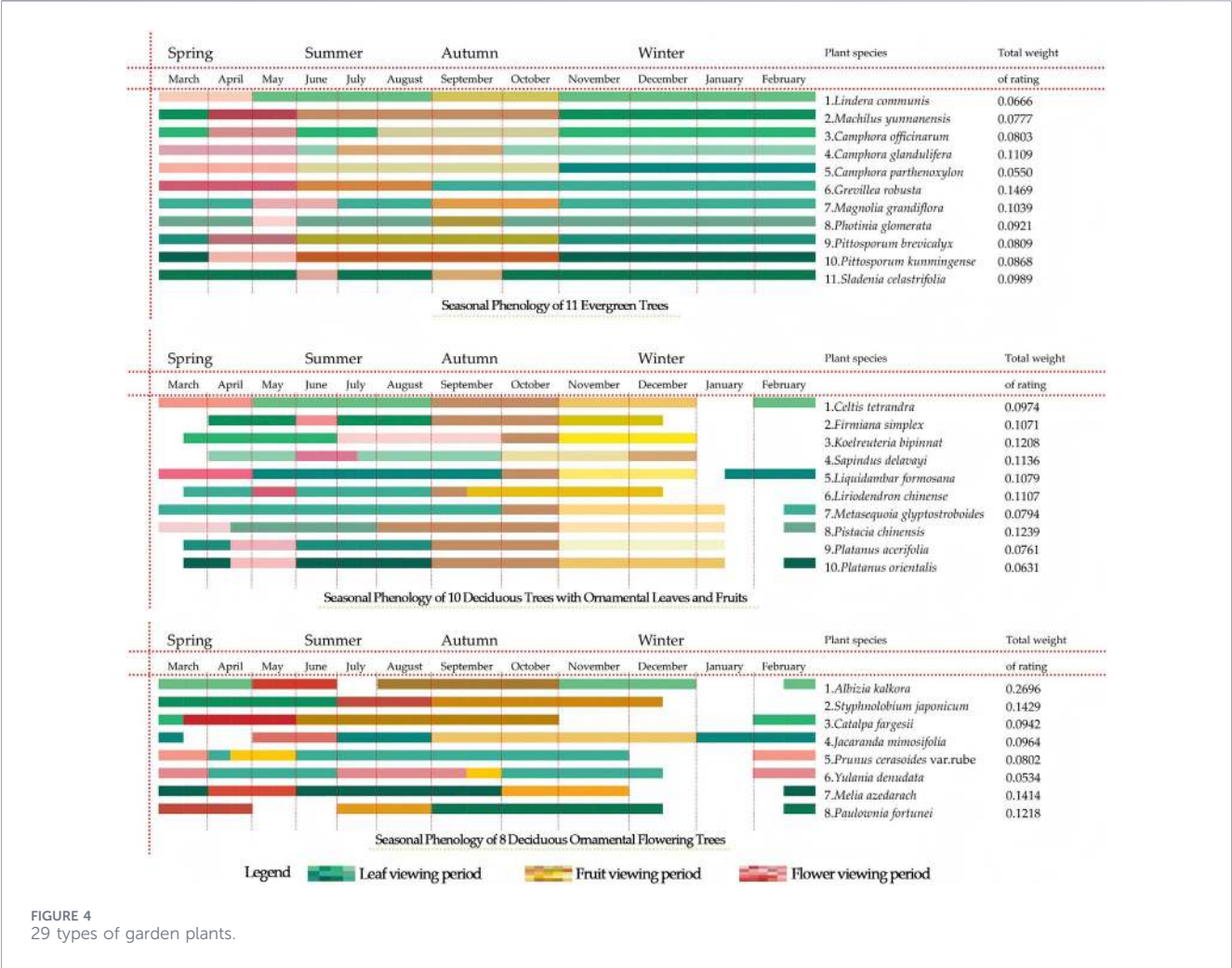
2.3 Evaluation factors and evaluation models

In this study, in order to further explore the plant configuration patterns in urban linear informal green spaces based on plant diversity characteristics, we carefully constructed a multi-level evaluation system. This system is based on field investigations of the current status of three linear informal green spaces and 29 candidate plant characteristics in Kunming City, combined

with literature review and expert brainstorming, to preliminarily screen evaluation indicators covering ecology, aesthetics, society, culture, and biodiversity conservation. The Delphi method was used to solicit opinions from experts in urban planning, landscaping, landscape design, ecology, and other fields. The indicators were screened and adjusted, and finally an evaluation model consisting of 6 criteria layers, 20 impact layer factors, and 3 scheme layers, totaling 29 plant species, was established, as shown in Figure 3.

The target layer (A) of the evaluation model is "linear informal green space garden plant selection evaluation". The six criteria layers are: ecological adaptation and function (B1), aesthetic value (B2), social benefits (B3), cultural value (B4), ornamental value (B5), and ecological diversity protection (B6). The selection criteria for each criterion layer are as follows: B1 reflects the survival ability and ecological service function of plants in urban environments, which is the basis for IGS plant configuration; B2 and B5 reflect the visual appeal of plant landscapes and the aesthetic needs of the public; B3 focuses on the promoting effect of green spaces on residents' wellbeing and social interaction; B4 considers the historical and local cultural value carried by plants; B6 highlights the core function of IGS as a habitat for urban biodiversity. The factors of each influencing layer (C1-C20) further refine the above criteria, including stress resistance (C1), soil adaptability (C2), air purification capacity (C3), and space organization capability (C4) under B1.

The application process of Analytic Hierarchy Process (AHP) is as follows: Firstly, a judgment matrix for each level is constructed based on expert ratings, and a 1-9 scale is used to represent the relative importance between two factors. To integrate the opinions of multiple experts, this study invited experts from urban planning



and design, landscaping, landscape design, ecology, and other fields to participate in the evaluation. The geometric mean of expert ratings was taken for each level of judgment matrix elements to form a group decision-making matrix. Secondly, calculate the weight vectors of each judgment matrix and obtain them through column normalization, row summation, and normalization processing. Finally, a consistency check is performed to calculate the maximum eigenvalue, consistency index CI, and consistency ratio CR. The CR values of all judgment matrices are less than 0.1, indicating satisfactory consistency in weight allocation. On this basis, a weighted comprehensive scoring model is used to calculate the comprehensive scores of each plant, and sorting and selection are carried out according to the high or low scores. In terms of the specific quantification of each evaluation factor, this study developed grading standards for core factors based on the plant characteristic database and field observation records referenced by experts during evaluation, in order to ensure the objectivity and repeatability of the evaluation.

29 plant species are classified into three groups based on their characteristics: evergreen tree species, deciduous tree species for viewing leaves and fruits, and deciduous tree species for viewing flowers. As shown in Figure 4.

Among them, *Cinnamomum camphora* and *Pistacia chinensis* are species included in the Yunnan Provincial Recommended Catalogue of Precious Tree Species (2025). *Cinnamomum glanduliferum* is a species listed in the Yunnan Provincial Key Protected Wild Plants List. Except for five introduced species, namely *Grevillea robusta*, *Magnolia grandiflora*, *Platanus × acerifolia*, *Platanus orientalis*, and *Jacaranda mimosifolia*, the remaining 24 species are native species recorded in the Yunnan Provincial Catalogue of Main Native Tree Species (First Batch), accounting for approximately 82.8%.

The evaluation was implemented in three steps. First, expert scoring determined the weights of each criterion layer relative to the target layer and each factor layer relative to its corresponding criterion layer. Second, 29 tree species from the Recommended List of Garden Plants in Kunming City were selected and classified into three groups: evergreens, deciduous foliage/fruit trees, and deciduous flowering trees. Third, each species was scored against all factors, and its comprehensive score was calculated using a weighted summation model (Equation 1).

In the weighted comprehensive scoring model constructed by selecting linear informal green space garden plants for evaluation, the comprehensive score of tree species *i* is divided into S_i . In this

model, each tree species is evaluated on multiple criteria layers (such as ecological adaptation and function, aesthetic value, social benefits, etc.), and each criteria layer includes multiple factors (such as stress resistance, soil adaptability, air purification ability, etc.). The comprehensive score S_i of tree species i can be calculated using formula 1.

$$S_i = \sum_{j=1}^n \left(W_j \times \sum_{k=1}^{m_j} (w_{jk} \times s_{ijk}) \right) \quad (1)$$

Among them, n is the number of criterion layers, which is 6 in this evaluation model. W_j is the weight of the j -th criterion layer, and $\sum_{j=1}^n W_j = 1$ and m_j are the number of factors under the j -th criterion layer. w_{jk} is the weight of the k -th factor under the j -th criterion layer, and for each j , there is $\sum_{k=1}^{m_j} w_{jk} = 1$. s_{ijk} is the score of tree species i on the N th factor under the j -th criterion layer.

Calculate the comprehensive evaluation score for each plant in the case layer using the above formula. Finally, sort the plants based on their scores and select the ones with the highest scores as the optimal choices.

2.4 Determination of indicator weights

In the Analytic Hierarchy Process (AHP), determining the weights of indicators is one of the key steps. The following are the specific calculation steps for determining the weight of indicators (Hsueh et al., 2022; Bindajam et al., 2021; Min et al., 2024).

Firstly, we need to construct a judgment matrix that represents the relative importance between different factors at the same level. In this study, it is necessary to construct judgment matrices for the criterion layer and factor layer (Sivrikaya and Küük, 2022; Li and Zheng, 2023). The elements of the judgment matrix are represented using the 1-9 scaling method, as shown in Formula 2.

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} \quad (2)$$

Next, we need to calculate the weight vector. The first step is to normalize each column element of the judgment matrix A to obtain the normalized matrix B , as shown in Formula 3.

$$B_{ij} = \frac{A_{ij}}{\sum_{k=1}^n A_{kj}} \quad (3)$$

The second step is to sum the elements in each row of the normalization matrix B , and add them together to obtain the weight value (unnormalized) W' of each factor, as shown in Formula 4.

$$W'_i = \sum_{j=1}^n B_{ij} \quad (4)$$

The third step is to normalize the weight values. Normalize the weight value W' obtained in the previous step to obtain the final weight vector W , as shown in Formula 5.

$$W_i = \frac{W'_i}{\sum_{k=1}^n W'_k} \quad (5)$$

TABLE 1 The random consistency index values corresponding to the ninth order judgment matrix.

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

To ensure the rationality and reliability of the judgment matrix, consistency testing is required. Calculate the maximum eigenvalue λ_{max} of the judgment matrix, and then calculate the consistency index CI , as shown in Formula 6, where λ_{max} can be calculated using Formula 7, where $(AW)_i$ is the i -th component of vector AW , A is the judgment matrix, W is the weight vector, and finally calculate the consistency ratio CR , as shown in Formula 8.

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (6)$$

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{(AW)_i}{W_i} \quad (7)$$

$$CR = \frac{CI}{RI} \quad (8)$$

The RI value is obtained by searching for the average random consistency index based on the order of the judgment matrix from the table, as shown in Table 1.

If $CR < 0.1$, it is considered that the judgment matrix has satisfactory consistency; Otherwise, it is necessary to adjust the judgment matrix and recalculate. Otherwise, it is necessary to adjust the elements of the judgment matrix until consistency requirements are met. The construction of the evaluation matrix for the selection of plants in linear informal green spaces and the consistency testing rate are shown in Tables 2, 3.

After passing the consistency test, the synthesized weights combine the weight vectors of each level to obtain the final indicator weights. This usually involves multiplying the weight vector of the criterion layer with the weight vector of the factor layer to obtain the weight of each factor in the entire evaluation system.

3 Research results and discussion

In this section, we will provide a detailed introduction and discussion of the results obtained from the evaluation model regarding the plant configuration pattern of urban linear informal green spaces. It covers the weight allocation of each evaluation factor and its sub factors, the correlation between each evaluation factor, and the performance of each research point on a single plant landscape factor. Finally, based on the above analysis results, we will provide plant configuration suggestions for green spaces along the Panlong River, Yunnan Vietnam Railway, and Changchong Mountain Trail. At the same time, we will draw corresponding plant configuration pattern diagrams to visually demonstrate the characteristics and optimization directions of each research point in plant configuration.

TABLE 2 Evaluation matrix construction and consistency check rate.

Hierarchical model	Index	Matrix						Consistency check
A-Bi	Bi	B1	B2	B3	B4	B5	B6	CR = 0.0795 < 0.1
	B1	1.0000	2.0000	4.0000	3.0000	2.0000	2.0000	
	B2	0.5000	1.0000	4.0000	4.0000	2.0000	2.0000	
	B3	0.2500	0.2500	1.0000	2.0000	2.0000	2.0000	
	B4	0.3333	0.2500	0.5000	1.0000	0.3333	0.3333	
	B5	0.5000	0.5000	0.5000	3.0000	1.0000	0.5000	
	B6	0.5000	0.5000	0.5000	3.0000	2.0000	1.0000	
B1-Ci	Ci	C1	C2	C3	C4			CR = 0.0720 < 0.1
	C2	1.0000	0.5000	3.0000	4.0000			
	C3	2.0000	1.0000	5.0000	4.0000			
	C4	0.3333	0.2000	1.0000	3.0000			
B2-Ci	Ci	C5	C6	C7				CR = 0.0915 < 0.1
	C5	1.0000	5.0000	0.3333				
	C6	0.2000	1.0000	0.1667				
	C7	3.0000	6.0000	1.0000				
B3-Ci	Ci	C8	C9	C10				CR = 0.0176 < 0.1
	C8	1.0000	3.0000	4.0000				
	C9	0.3333	1.0000	2.0000				
	C10	0.2500	0.5000	1.0000				
B4-Ci	Ci	C11	C12					CR = 0.0000 < 0.1
	C11	1.0000	0.5000					
	C12	2.0000	1.0000					
B5-Ci	Ci	C13	C14	C15	C16	C17	C18	CR = 0.0795 < 0.1
	C13	1.0000	4.0000	0.5000	2.0000	3.0000	2.0000	
	C14	0.2500	1.0000	0.1667	0.2500	4.0000	0.3333	
	C15	2.0000	6.0000	1.0000	4.0000	7.0000	3.0000	
	C16	0.5000	4.0000	0.2500	1.0000	3.0000	0.5000	
	C17	0.3333	0.2500	0.1429	0.3333	1.0000	0.5000	
	C18	0.5000	3.0000	0.3333	2.0000	2.0000	1.0000	
B6-Ci	Ci	C19	C20					CR = 0.0000 < 0.1
	C19	1.0000	3.0000					
	C20	0.3333	1.0000					

3.1 Evaluation model total weight analysis

In the study of plant configuration patterns in urban linear informal green spaces based on plant diversity characteristics, the total weight analysis of the evaluation model is a key step in understanding the impact of various evaluation factors on plant selection decisions. The following is a specific analysis of the total weight of the evaluation model, as shown in [Table 4](#).

The weight of ecological adaptation and function (B1) is 0.3011, which is the highest among all criterion layers, indicating that in plant configuration patterns, the ecological adaptation and function of plants are fundamental and crucial. This includes plant stress resistance (C1), soil adaptability (C2), air purification ability (C3), and space organization capability (C4), which directly affect whether plants can survive and exert ecological effects in specific environments.

TABLE 3 Consistency check rate.

Evergreen species		Tree species for viewing flowers and fruits		Flower viewing tree species	
Hierarchical model	Consistency check	Hierarchical model	Consistency check	Hierarchical model	Consistency check
C1-Di	CR = 0.0978 < 0.1	C1-Di	CR = 0.0843 < 0.1	C1-Di	CR = 0.0437 < 0.1
C2-Di	CR = 0.0968 < 0.1	C2-Di	CR = 0.0972 < 0.1	C2-Di	CR = 0.0222 < 0.1
C3-Di	CR = 0.0689 < 0.1	C3-Di	CR = 0.0773 < 0.1	C3-Di	CR = 0.0235 < 0.1
C4-Di	CR = 0.0954 < 0.1	C4-Di	CR = 0.0847 < 0.1	C4-Di	CR = 0.0261 < 0.1
C5-Di	CR = 0.0639 < 0.1	C5-Di	CR = 0.0764 < 0.1	C5-Di	CR = 0.0197 < 0.1
C6-Di	CR = 0.0623 < 0.1	C6-Di	CR = 0.0827 < 0.1	C6-Di	CR = 0.0440 < 0.1
C7-Di	CR = 0.0688 < 0.1	C7-Di	CR = 0.0678 < 0.1	C7-Di	CR = 0.0282 < 0.1
C8-Di	CR = 0.0694 < 0.1	C8-Di	CR = 0.0887 < 0.1	C8-Di	CR = 0.0852 < 0.1
C9-Di	CR = 0.0826 < 0.1	C9-Di	CR = 0.0910 < 0.1	C9-Di	CR = 0.0293 < 0.1
C10-Di	CR = 0.0988 < 0.1	C10-Di	CR = 0.0963 < 0.1	C10-Di	CR = 0.0099 < 0.1
C11-Di	CR = 0.0582 < 0.1	C11-Di	CR = 0.0969 < 0.1	C11-Di	CR = 0.0238 < 0.1
C12-Di	CR = 0.0499 < 0.1	C12-Di	CR = 0.0949 < 0.1	C12-Di	CR = 0.0296 < 0.1
C13-Di	CR = 0.0865 < 0.1	C13-Di	CR = 0.0817 < 0.1	C13-Di	CR = 0.0280 < 0.1
C14-Di	CR = 0.0961 < 0.1	C14-Di	CR = 0.0978 < 0.1	C14-Di	CR = 0.0603 < 0.1
C15-Di	CR = 0.0653 < 0.1	C15-Di	CR = 0.0531 < 0.1	C15-Di	CR = 0.0219 < 0.1
C16-Di	CR = 0.0736 < 0.1	C16-Di	CR = 0.0911 < 0.1	C16-Di	CR = 0.0390 < 0.1
C17-Di	CR = 0.0933 < 0.1	C17-Di	CR = 0.0991 < 0.1	C17-Di	CR = 0.0404 < 0.1
C18-Di	CR = 0.0835 < 0.1	C18-Di	CR = 0.0708 < 0.1	C18-Di	CR = 0.0339 < 0.1
C19-Di	CR = 0.0836 < 0.1	C19-Di	CR = 0.0903 < 0.1	C19-Di	CR = 0.0247 < 0.1
C20-Di	CR = 0.0944 < 0.1	C20-Di	CR = 0.0937 < 0.1	C20-Di	CR = 0.0259 < 0.1

The weight of aesthetic value (B2) is 0.2475, ranking second, reflecting the importance of plant configuration in beautifying urban environments and enhancing visual aesthetics. Color richness (C5), morphological diversity (C6), and seasonal variability (C7) are key factors that constitute aesthetic value, and they work together to create a rich and diverse plant landscape.

The weight of the ornamental value (B5) is 0.1132, which is lower than the ecological adaptation, functional and aesthetic value, but still an important part that cannot be ignored. The ornamental effect is mainly reflected in the size and tree shape (C13), leaves (C14), flowers (C15), fruits (C16), branches (C17), and aroma (C18) of plants, which directly affect people's direct perception and experience of plant landscapes.

The weight of biodiversity conservation (B6) is 0.1417, emphasizing the role of plants in protecting urban biodiversity. Providing habitat (C19) and promoting species diversity (C20) are two core factors in biodiversity conservation, and plant configuration patterns need to consider how to provide living space for other organisms in urban ecosystems.

The weight of social benefits (B3) is 0.1377, reflecting the social value of plant configuration in improving the quality of life of urban

residents, providing green leisure places (C8), and attracting ecotourism (C10).

The weight of cultural value (B4) is 0.0587, which is relatively low, but historical value (C11) and local value (C12), as manifestations of cultural value, are of great significance for enhancing urban cultural identity and regional characteristics.

In the factor layer, stress resistance (C1), soil adaptability (C2), and air purification capacity (C3) are components of ecological adaptation and function, with high weights, indicating that plant ecological adaptability is the primary consideration factor. The richness of color (C5) and the distinctiveness of seasonal changes (C7) dominate the aesthetic value, reflecting the aesthetic charm of plant landscapes that change over time. Providing green leisure spaces (C8) as a key factor in social benefits reflects the direct contribution of plant configuration in improving the quality of life of urban residents. Providing habitat (C19) has the highest weight in biodiversity conservation, emphasizing the core role of plants in maintaining the balance of urban ecosystems.

In the scheme layer, different plant species are given different weights due to their unique ecological and ornamental characteristics. For example, *Grevillea robusta*, *Camphora glandulifera*, and *Magnolia grandiflora* have the highest

TABLE 4 Analysis of total weights for evaluation models.

Target layer	Criteria layer	Total weight	Factor layer	Weight	Total weight	Solution layer total weight of the solution layer					
						Evergreen species	Tree species for observing leaves and fruits		Flower viewing tree species		
(A)	(B1)	0.3011	(C1)	0.0896	0.0896	D1	0.0666	D1	0.0974	D1	0.2696
			(C2)	0.1461	0.1461	D2	0.0777	D2	0.1071	D2	0.1429
			(C3)	0.0239	0.0239	D3	0.0803	D3	0.1208	D3	0.0942
			(C4)	0.0416	0.0416	D4	0.1109	D4	0.1136	D4	0.0964
	(B2)	0.2475	(C5)	0.0720	0.0723	D5	0.0550	D5	0.1079	D5	0.0802
			(C6)	0.0200	0.0200	D6	0.1469	D6	0.1107	D6	0.0534
			(C7)	0.1552	0.1552	D7	0.1039	D7	0.0794	D7	0.1414
	(B3)	0.1377	(C8)	0.0858	0.0858	D8	0.0921	D8	0.1239	D8	0.1218
			(C9)	0.0330	0.0330	D9	0.0809	D9	0.0761		
			(C10)	0.0189	0.0189	D10	0.0868	D10	0.0631		
	(B4)	0.0587	(C11)	0.0196	0.0196	D11	0.0989				
			(C12)	0.0391	0.0391						
	(B5)	0.1132	(C13)	0.0241	0.0241						
			(C14)	0.0085	0.0085						
			(C15)	0.0445	0.0445						
			(C16)	0.0143	0.0143						
			(C17)	0.0056	0.0056						
			(C18)	0.0162	0.0162						
	(B6)	0.1417	(C19)	0.1063	0.1063						
			(C20)	0.0354	0.0354						

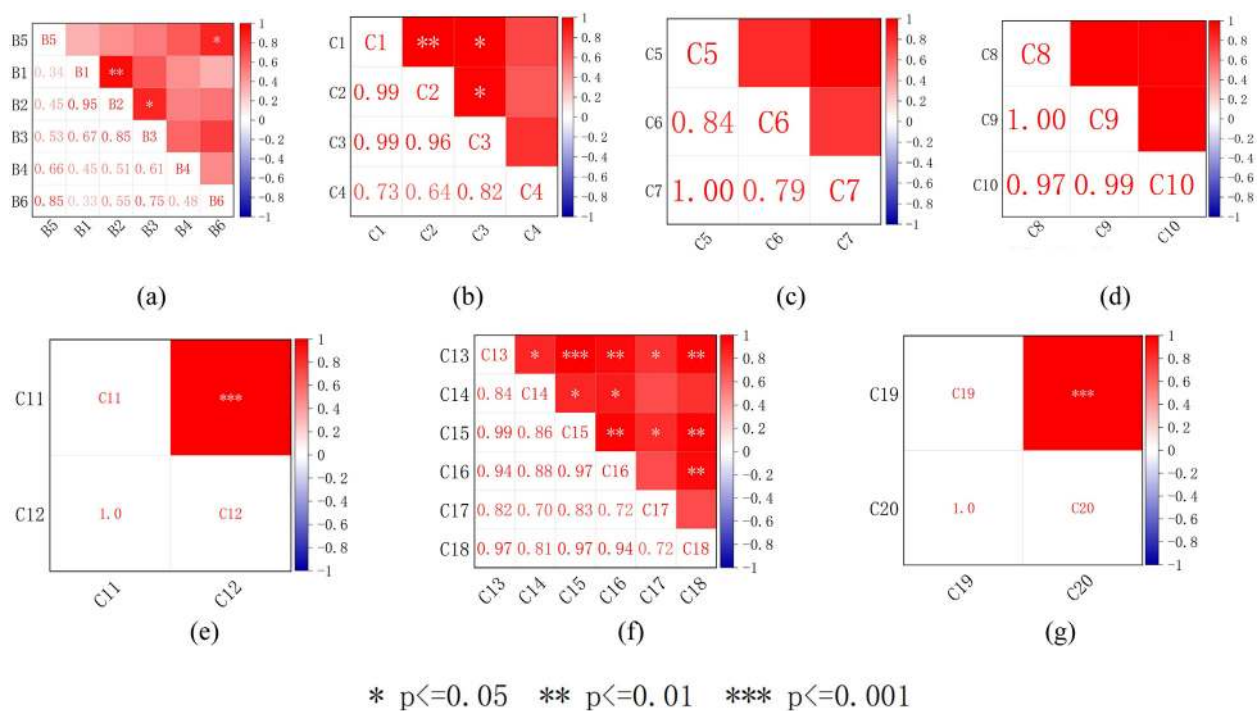


FIGURE 5

Correlation analysis of evaluation factors for the selection of plants in linear informal green spaces. (a) Correlation analysis of criterion level factors, (b) Correlation analysis of various factors under Ecological Adaptation and Function (B1), (c) Correlation analysis of various factors under Aesthetic Value (B2), (d) Correlation analysis of various factors under Social Benefit (B3), (e) Correlation analysis of various factors under Cultural Value (B4), (f) Correlation analysis of various factors under Ornamental Value (B5), (g) Correlation analysis of various factors under Biodiversity Conservation (B6).

comprehensive scores among evergreen tree species, while *Pistachia chinensis*, *Koelreuteria bipinnata*, and *Sapinda delavayi* have the highest comprehensive scores among foliage and fruit trees. *Albizia kalkora*, *Stypholobium japonicum*, and *Melia azedarach* have the highest comprehensive scores among flowering tree species.

3.2 Correlation analysis between evaluation model factors

When constructing a linear informal green space garden plant selection evaluation model, we identified six criteria layers including ecological adaptation and function (B1), aesthetic value (B2), social benefits (B3), cultural value (B4), ornamental effect (B5), and ecological diversity protection (B6). In order to further understand the intrinsic connections between various factors under these criteria, we conducted Pearson correlation analysis. As shown in Figure 5.

When analyzing the correlation between various factors in the evaluation model, we focus on the performance of plants in multiple dimensions and their interrelationships. Firstly, we found that the correlation coefficient between aesthetic value (B2) and social benefits (B3) reached 0.85, indicating that the beauty of plant landscapes has a positive effect on improving residents' quality of life (C9), providing green leisure places (C8), and enhancing the attractiveness of ecotourism (C10). At the same time, there is a significant positive correlation between historical value (C11) and local value (C12) in cultural value factors, which reflects the unique value of garden plants as carriers

of urban culture, carrying the historical memory and regional characteristics of the city.

In addition, the correlation coefficient between the ornamental effect (B5) and ecological diversity protection (B6) is 0.85, revealing that plants not only provide ornamental value, but also undertake the responsibility of protecting biodiversity. The size and ornamental characteristics of plants, such as tree shape (C13), leaves (C14), flowers (C15), and fruits (C16), not only enrich the hierarchical sense of urban landscapes, but also provide habitats and food sources for birds, insects, and other organisms, promoting the development of species diversity.

The color richness (C5) and morphological diversity (C6), as well as the degree of seasonal change (C7), all show a strong positive correlation in aesthetic value factors. This means that the color, shape, and seasonal changes of garden plants are important components of the aesthetic value of green spaces, complementing each other and jointly shaping the visual beauty of green spaces. In addition, there is a significant positive correlation between color richness (C5) and ornamental factors such as leaves (C14), flowers (C15), and fruits (C16), further emphasizing the importance of plant aesthetic characteristics in green space design.

Within the factor layer, we also discovered some interesting correlations. For example, there is a high positive correlation between the three factors of stress resistance (C1), soil adaptability (C2), and air purification ability (C3), indicating that the ecological adaptability of plants is closely related to their functions of purifying air and improving the environment. Similarly, the correlation coefficient between color richness (C5)

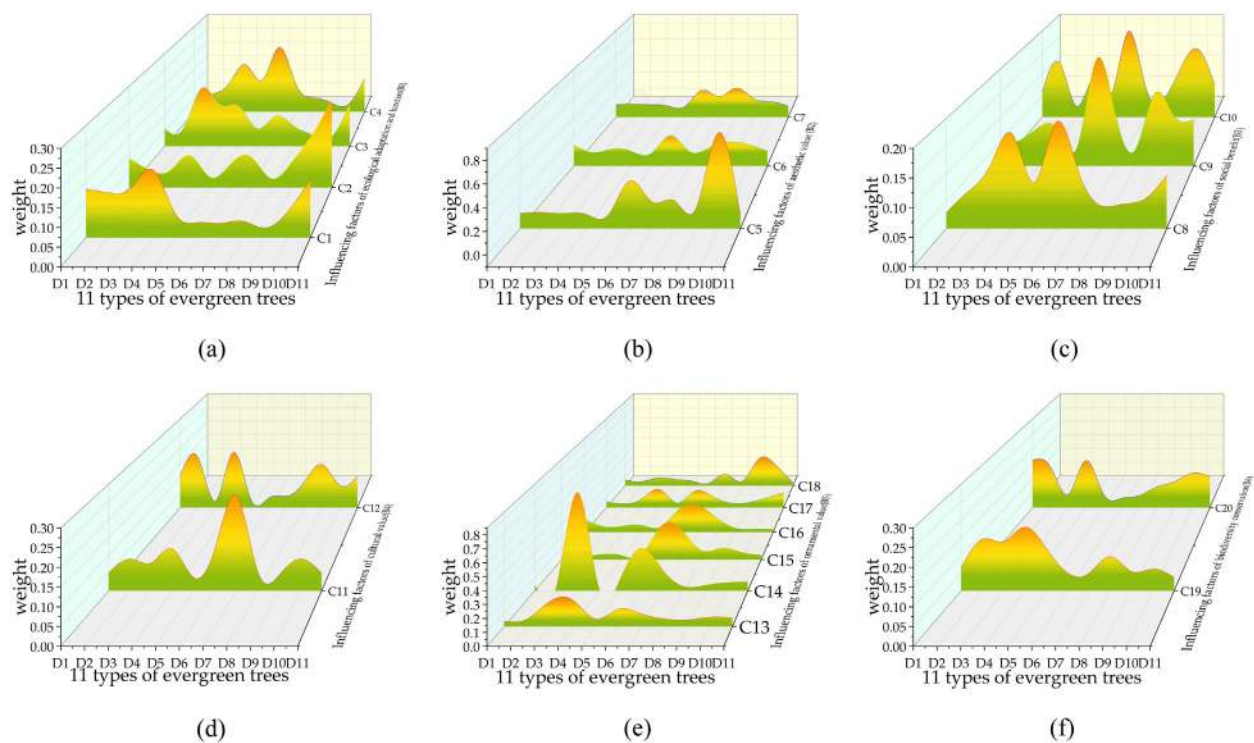


FIGURE 6

The scores of 11 evergreen trees corresponding to each factor of C1–C20. (a) Analysis of tree scores for various influencing factors under Ecological Adaptation and Function (B1), (b) Analysis of tree scores for various influencing factors under aesthetic value (B2), (c) Analysis of tree scores for various influencing factors under social benefit (B3), (d) Analysis of tree scores for various influencing factors under cultural value (B4), (e) Analysis of tree scores for various influencing factors under ornamental value (B5), (f) Analysis of tree scores for various influencing factors under biodiversity conservation (B6).

and seasonal change salience (C7) is 1, indicating that color changes in plant landscapes are an important manifestation of seasonal changes, adding dynamic beauty to urban spaces.

From the perspective of ecological mechanisms, there is a high positive correlation between various factors (C1, C2, C3) in ecological adaptation and function (B1), which may reflect the functional synergy strategy of plants in resource limited environments: species with strong stress resistance usually enhance soil adaptability and air purification capacity through physiological characteristics such as deep roots or high photosynthetic efficiency. This phenomenon is consistent with the expectation of “co variation of functional traits” in niche theory.

In summary, the correlation analysis between various factors in the evaluation model reveals the interrelationships and joint effects of plants in multiple dimensions. These findings not only help us to gain a deeper understanding of the functions and values of plants in urban ecosystems, but also provide useful references and inspirations for future urban green space planning and design.

3.3 Analysis of the tree species with the highest score in a single landscape factor

In the comprehensive evaluation model based on the Analytic Hierarchy Process, we have provided detailed ratings for each

landscape factor (C1–C20) for each tree species in the scheme layer. The following is a specific analysis of the tree species with the highest score in a single landscape factor, aiming to reveal which tree species have significant advantages under different ecological and landscape functional requirements.

Analyze the single landscape factor scores of 11 evergreen trees in Plan Layer 1, as shown in Figure 6.

The plant with the highest stress resistance (C1) score is *Camphora glandulifera* (D4). *Camphora glandulifera* has strong stress resistance and can adapt to various stress conditions in urban environments, such as pollution, drought, etc.. The plant with the highest soil adaptability (C2) score is *Sladenia celastrifolia* (D11). *Sladenia celastrifolia* does not have strict requirements for soil types and can grow well in various soil conditions, demonstrating a wide range of soil adaptability. The plant with the highest air purification ability (C3) score is camphor tree (D3). *Camphora officinarum* has significant air purification capabilities, effectively absorbing harmful substances in the air and improving urban environmental quality. The plant with the highest score in space organization capability (C4) is *Grevillea robusta* (D6). *Grevillea robusta* has a tall and upright tree shape, with dense branches and leaves, which can effectively organize space, provide shade and landscape focus. In terms of the degree of seasonal change (C7), evergreen tree species do not show significant seasonal changes.

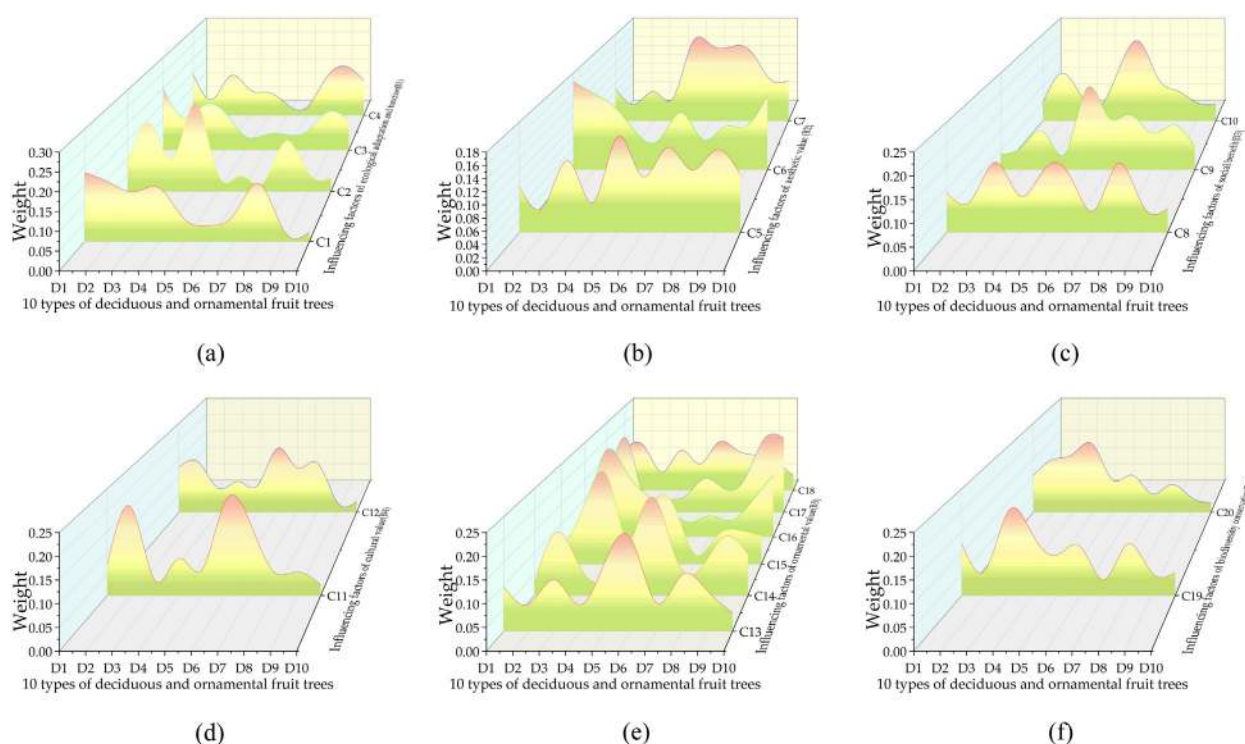


FIGURE 7

Scores for 10 deciduous and deciduous fruit trees corresponding to each factor of C1-C20. (a) Analysis of tree scores for various influencing factors under Ecological Adaptation and Function (B1), (b) Analysis of tree scores for various influencing factors under aesthetic value (B2), (c) Analysis of tree scores for various influencing factors under social benefit (B3), (d) Analysis of tree scores for various influencing factors under cultural value (B4), (e) Analysis of tree scores for various influencing factors under ornamental value (B5), (f) Analysis of tree scores for various influencing factors under biodiversity conservation (B6).

In terms of ornamental effects, among factors such as leaves (C14), flowers (C15), fruits (C16), branches (C17), and fragrances (C18), although evergreen tree species have relatively limited performance in these aspects, *Pittosporum brevicalyx* performs outstandingly in floral fragrance, while *Grevillea robusta* has high ornamental value in fruit and branch morphology.

Analyze the single landscape factor scores of 10 deciduous fruit and leaf trees in Scheme Layer 2, as shown in Figure 7.

Celtis tetrandra (D1) received the highest stress resistance (C1) score, enabling it to survive and thrive in harsh urban environments. *Sapindus delavayi* (D4) scored highest for air purification (C3). *Liquidambar formosana* (D5) scored highest for seasonal variation (C7), with its bright red autumn foliage adding striking seasonal color. Viewing effect: In terms of leaves (C14), flowers (C15), and fruits (C16), *Koeleruteria bipinnata* (D3) has a unique fruit shape, bright colors, and high ornamental value; The leaf morphology of *Liriodendron chinense* (D6) is beautiful, with a yellow color in autumn and excellent ornamental effect.

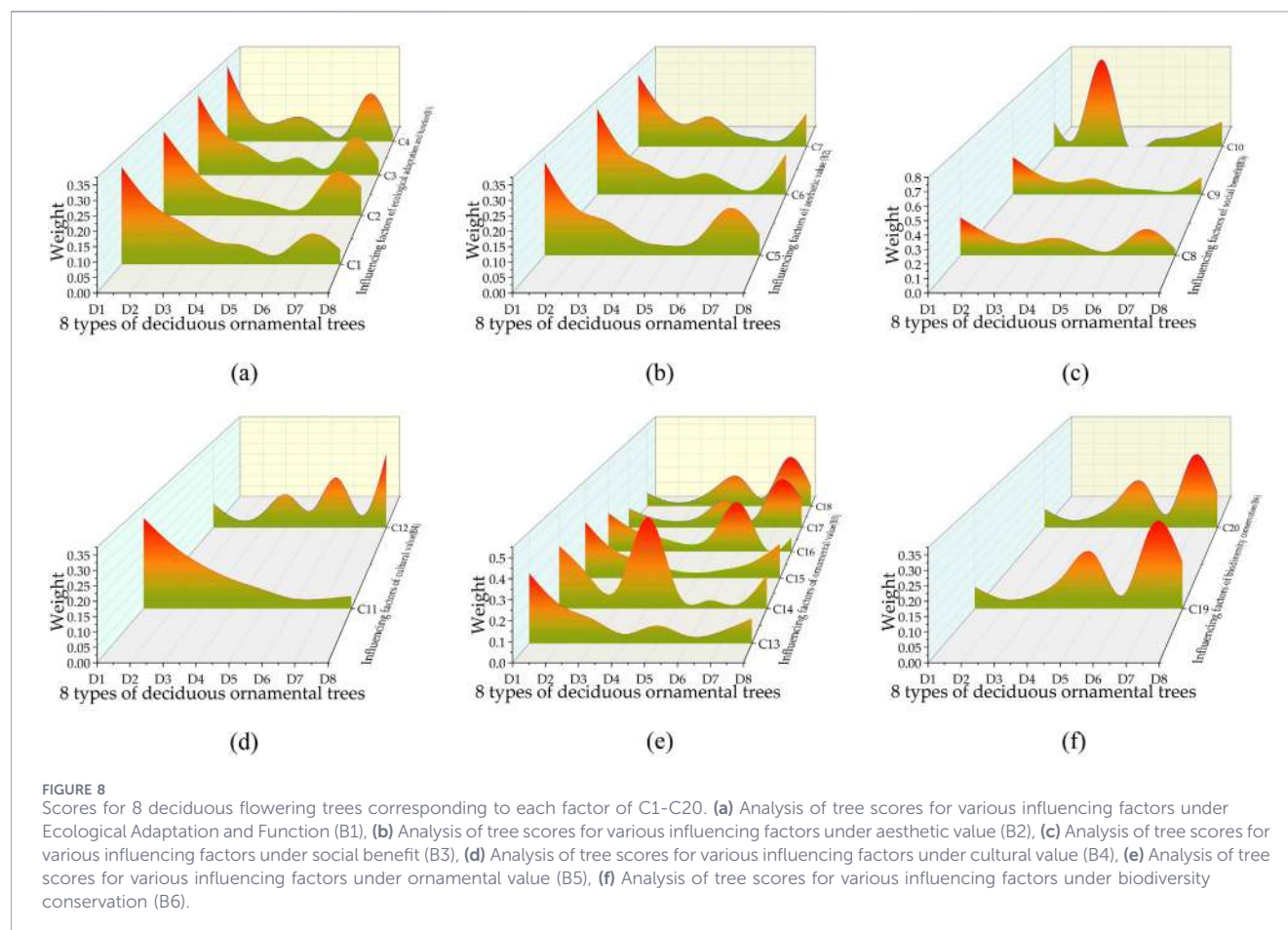
Analyze the single landscape factor scores of 8 deciduous ornamental trees in Plan Layer 3, as shown in Figure 8.

In terms of color richness (C5) and obvious seasonal changes (C7), *Albizia kalkora* (D1)'s flowers are brightly colored and have a long flowering period, significantly enhancing the aesthetic value of urban green spaces. In terms of flowers (C15) and fragrance (C18), the flowers of *Albizia kalkora* (D1) are not only beautiful in color, but also have fragrance, greatly enhancing the ornamental and

sensory experience of urban green spaces. Although ornamental tree species are mainly used for viewing flowers, *Jacaranda mimosifolia* (D4) and other tree species have dense inflorescences, providing a brief habitat and foraging place for small wild animals such as birds.

In terms of dominant tree species, *Grevillea robusta* has the highest comprehensive score in the evergreen group, mainly attributed to its high stress resistance (C1), strong spatial organization ability (C4), and significant ornamental characteristics. This tree species has a broad canopy and grows rapidly, forming a spatial skeleton in a short period of time while providing a habitat for birds, reflecting the synergy between ecological functions and landscape benefits. *Pistachia chinensis* stands out in the leaf and fruit observation group, with obvious seasonal changes (C7) and wide soil adaptability (C2). It is a native tree species with both ecological adaptability and cultural value. *Albizia kalkora* scored the highest in the flowering group, with bright colors, long flowering period, and fragrant aroma. It not only attracts pollinators but also significantly enhances the recreational experience. The above-mentioned tree species exhibit excellent performance in IGS environments, which may be related to their wide ecological range and tolerance to environmental disturbances, making them particularly suitable as backbone tree species for mixed configuration of urban informal green spaces.

In summary, different tree species exhibit varying performances on individual factors, reflecting the diversity and complexity of plant



configuration. In the plant configuration of urban linear informal green spaces, tree species with higher scores should be selected based on the specific functions and ecological environment conditions of the green spaces to achieve the best ecological, aesthetic, and social benefits. These analysis results not only provide scientific basis for urban greening in Kunming, but also provide valuable references for green space construction in other cities.

3.4 Analysis of plant configuration in linear informal green space landscape plants

Based on the above evaluation results, combined with the ecological characteristics and functional requirements of each space, the following plant configuration principles are proposed.

The green spaces along the Panlong River are classified as waterfront informal green spaces (IGS), where configuration should emphasize the coordinated enhancement of ecological functions and landscape benefits. For this purpose, evergreen tree species with strong stress resistance and good soil adaptability, such as *Lindera communis*, *Machilus yunnanensis*, and *Camphora officinarum*, together with deciduous ornamental species for foliage and fruit, including *Celtis tetrandra* subsp. *Sinensis* and *Koelreuteria bipinnata*, should be selected to form a stable ecological foundation. These should be complemented by flowering species such as *Prunus yunnanensis* and *Jacaranda mimosifolia*, as well as autumn-colored species like *Liquidambar formosana*, to enrich

seasonal dynamics. Native species including *Sladenia celsaifolia* and *Albizia kalkora* should be utilized to provide habitats for biodiversity. Additionally, species such as *Magnolia grandiflora* and *Metasequoia glyptostroboides* may be integrated to create distinctive spatial features (Figure 9).

The green spaces along the Yunnan-Vietnam Railway are classified as transportation corridor-type informal green spaces (IGS), where plant configuration should balance historical and native values. Tree species of historical significance, such as *Firmiana simplex*, along with native characteristic species including *Celtis tetrandra* subsp. *Sinensis* and *Sapindus delavayi*, should be selected to reflect the railway's historical heritage and regional identity. Meanwhile, flowering species such as *Prunus yunnanensis* (spring-flowering), *Jacaranda mimosifolia* (summer-flowering), and autumn-colored species like *Liquidambar formosana* should be configured to create a landscape with year-round visual appeal (Figure 10).

The green spaces along the Changchong Mountain Trail are classified as mountain trail-type informal green spaces (IGS), where plant configuration should prioritize ecological adaptability, landscape ornamental value, and visitor safety. Tree species with strong stress resistance and soil and water conservation functions, such as *Camphora officinarum* (large-leaved form) and *Grevillea robusta*, should be selected to establish ecological security barriers. These should be paired with flowering ornamental species such as *Magnolia denudata* and *Paulownia fortunei*, as well as aromatic

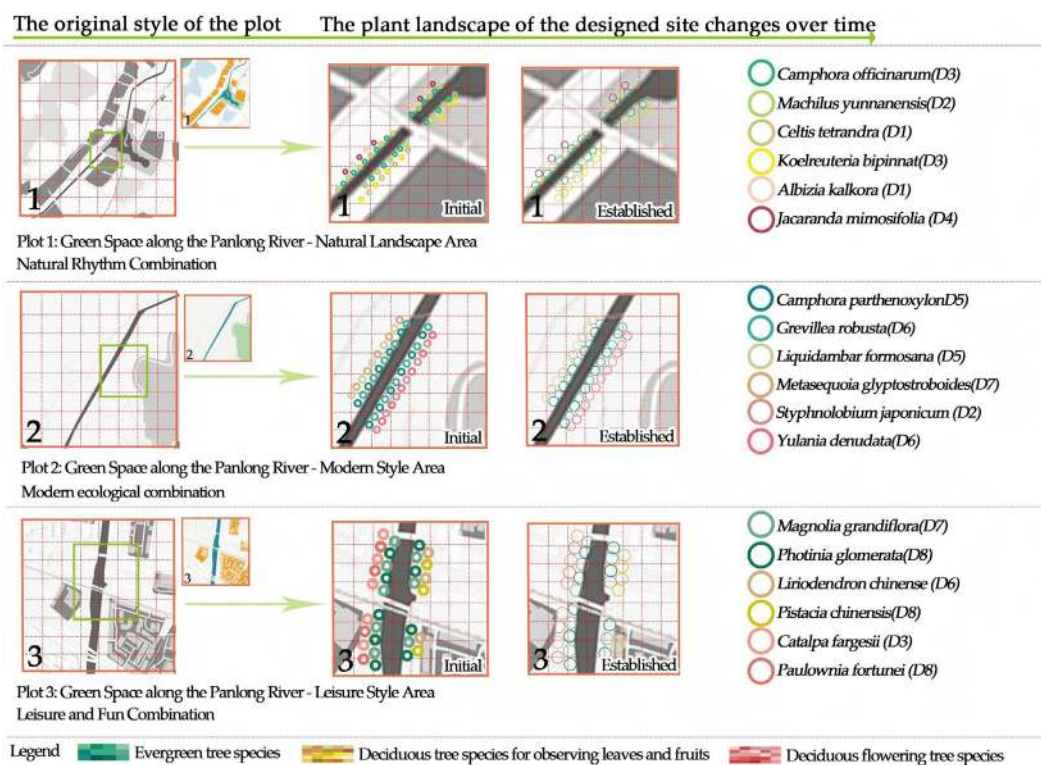


FIGURE 9
Plant configuration patterns of three typical green spaces along the Panlong River.

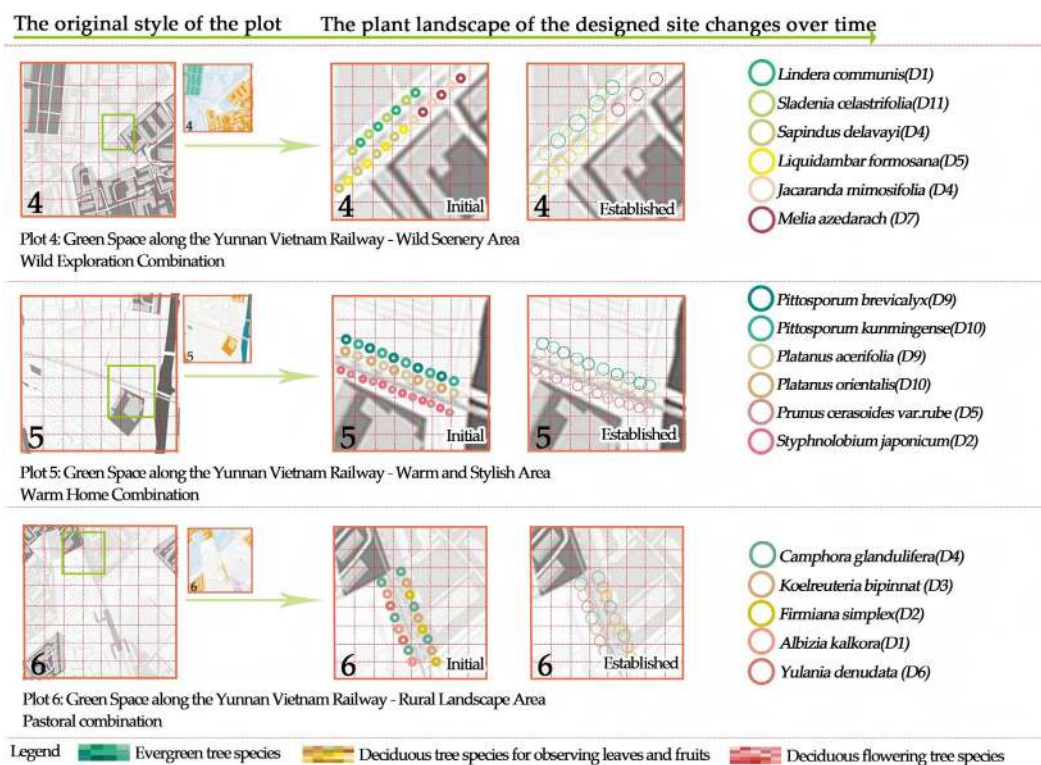
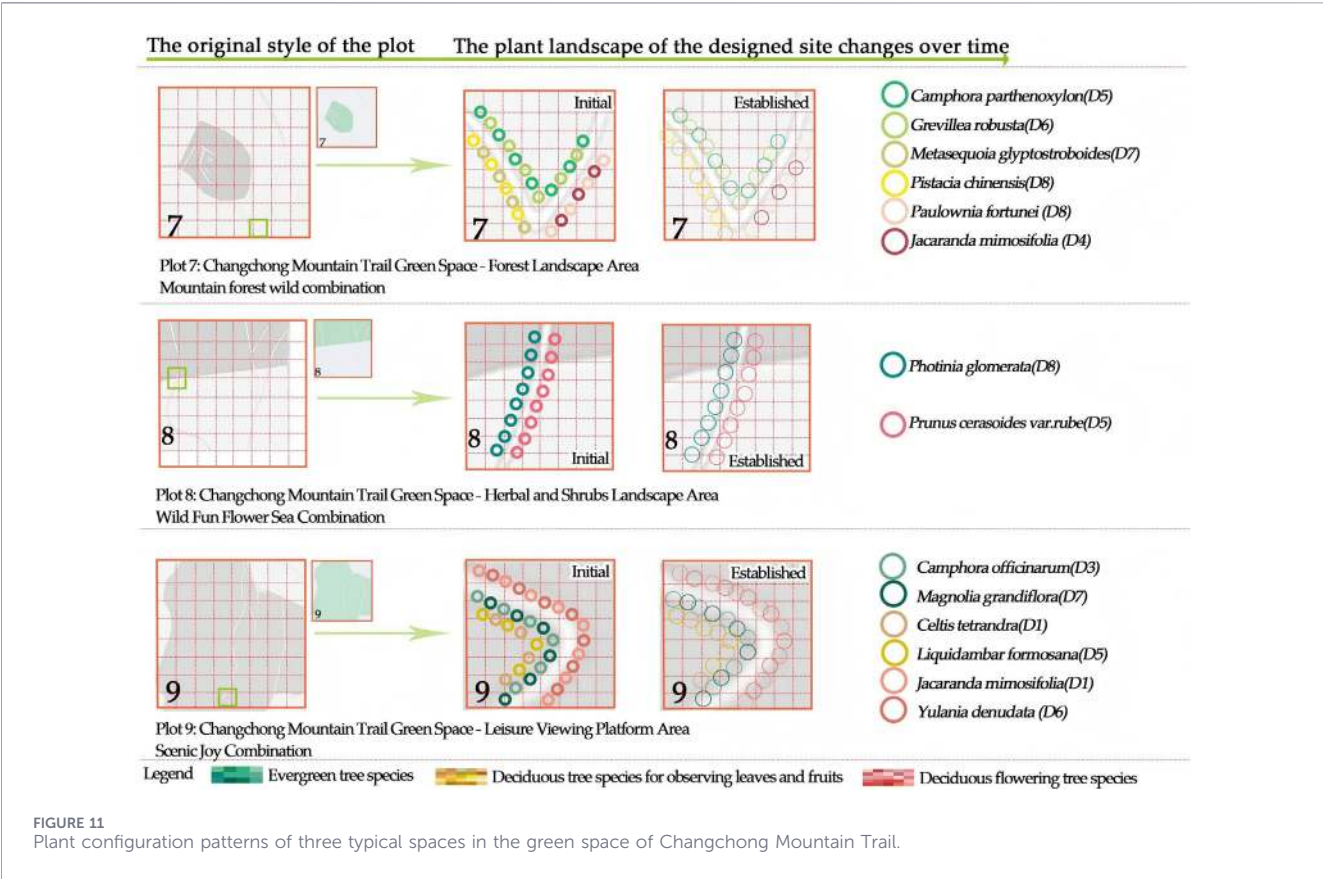


FIGURE 10
Plant configuration patterns of three typical green spaces along the Yunnan Vietnam Railway.



species like *Melia azedarach*, to enhance the trail's scenic quality and recreational experience. Species including *Koelreuteria bipinnata* and *Pistacia chinensis* should be utilized to provide food sources and habitats for wildlife (Figure 11).

During the initial phase of succession, the site primarily supports native herbs and small shrubs, thereby creating fundamental ecological conditions for the introduction of new seedlings. After 10 years of growth, the seedlings develop into trees and form a stable plant community together with the native vegetation. Twenty years later, the site gradually evolved into urban linear informal green spaces with complete ecological functions and excellent landscape quality, becoming an important link between urban environment and natural ecology (Figure 12).

4 Conclusion

4.1 Main findings and work contributions

This study focuses on the plant configuration patterns of linear informal green spaces in cities. Taking the green spaces along the Panlong River in Kunming, the Yunnan Vietnam Railway, and the Changchong Mountain Trail as examples, it deeply explores plant configuration strategies based on plant diversity characteristics. We conducted a comprehensive evaluation of 29 garden plants using the Analytic Hierarchy Process (AHP) evaluation model and identified the following main findings:

In terms of plant diversity and ecological adaptability, spontaneous plants dominate in the linear informal green spaces studied. Through the Analytic Hierarchy Process evaluation, we found that ecological adaptation and functional factors such as stress resistance, soil adaptability, and air purification capacity occupy a high weight in plant selection, indicating that these factors are crucial for maintaining the ecological balance of urban linear informal green spaces. Especially some key and backbone tree species, such as *Lindera communis*, *Machilus yunnanensis*, *Camphora officinarum*, etc., have shown strong ecological adaptability and functional value.

In terms of aesthetic value and social benefits, research results show that aesthetic value factors such as color richness, morphological diversity, and seasonal changes play an important role in enhancing the overall landscape effect of urban linear informal green spaces. For example, ornamental tree species such as *Celtis tetrandra*, *Firmiana simplex*, *Koelreuteria bipinnata*, as well as flowering tree species such as *Albizia kalkora* and *Jacaranda mimosifolia*, have played a positive role in beautifying the environment and attracting tourists. In terms of cultural value and ecological diversity protection, although historical value and local value factors have relatively low weights in plant selection, it cannot be ignored that some tree species with local characteristics, such as *Sladenia celastriifolia*, *Celtis tetrandra*, *Albizia kalkora*, *Camphora glandulifera*, have important significance for inheriting and promoting local culture. In addition, these linear informal green spaces provide valuable habitats for urban biodiversity and promote the development of species diversity.

In terms of plant configuration patterns, we have drawn plant configuration pattern diagrams for three research areas based on the characteristics and requirements of different spaces. At the level of

social benefits, reasonable plant arrangement effectively promotes residents' leisure, socialization, and spontaneous activities by providing shade, defining activity boundaries, enhancing spatial security and place identity. Wutong and other historical symbolic trees are arranged along the Yunnan Vietnam Railway, strengthening the emotional connection of cultural heritage; The Changchong Mountain Trail is equipped with flower viewing and aromatic tree species, which enhances the attractiveness and frequency of use of the trail. These models fully consider ecological adaptability, aesthetic value, social benefits, cultural value, and ecological diversity protection, providing scientific basis and practical reference for the plant configuration of urban linear informal green spaces.

4.2 Research significance and future prospects

The significance of this study lies in revealing the important value of plant diversity in urban linear informal spaces and exploring plant configuration strategies based on plant diversity characteristics. The study systematically incorporates IGS plant configuration into the framework of urban biodiversity conservation and ecological network construction, emphasizing that the mixed planting of self grown plants and garden plants is not only for landscape purposes, but directly contributes to the stability and resilience of the overall urban ecosystem through providing habitat resources, maintaining population communication, and enhancing habitat connectivity. The study provides a scientific basis for optimizing urban green space layout and enhancing green space ecological service efficiency by evaluating the functions of different plants in air purification, spatial organization, and other aspects. By evaluating the aesthetic value of plants, a reference for plant configuration patterns is provided for urban greening and beautification, which helps to create urban landscapes with regional characteristics, enhance urban image and residents' quality of life. For the improvement of IGS in urban planning, a classified plant configuration strategy should be established; The urban management department can formulate the "Technical Guidelines for Plant Configuration of Urban Linear Informal Green Spaces", clarify the plant selection list, configuration ratio, and maintenance standards for different types of IGS, and promote the transformation of IGS from a "spontaneous state" to a "standardized guidance". In high-altitude or subtropical cities with climate conditions similar to Kunming, the indicator system and weight structure of this study can be directly referenced; When applying, special attention should be paid to the localization adjustment of the "ecological adaptation and functionality" dimension.

Looking ahead, we will further explore the node and corridor functions of different types of IGS in regional ecological networks, focusing on the differences and commonalities of plant configuration patterns in different climate zones and urban scales, in order to construct a more comprehensive and systematic theoretical system of plant configuration. Meanwhile, we fully recognize that Kunming, as a biodiversity hotspot, boasts plant resources that extend far beyond the scope covered by the current recommended list of landscape plants. Subsequent research will further expand the selection of plants, incorporating more

native protected tree species and ancient tree resources not included in the list, in order to more comprehensively reflect the plant diversity characteristics of Kunming and enhance the ecological representativeness and regional applicability of the research results.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#), further inquiries can be directed to the corresponding authors.

Author contributions

XZ: Formal Analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review and editing. ZX: Formal Analysis, Funding acquisition, Investigation, Methodology, Software, Supervision, Writing – original draft, Writing – review and editing. XC: Writing – original draft, Writing – review and editing. JW: Methodology, Software, Writing – original draft, Writing – review and editing. XY: Formal Analysis, Writing – original draft. LY: Methodology, Writing – original draft. LW: Methodology, Supervision, Writing – original draft, Writing – review and editing. RL: Software, Writing – original draft. YW: Writing – original draft, Writing – review and editing.

Funding

The author(s) declared that financial support was received for this work and/or its publication. This study was supported by the Yunnan Fundamental Research Projects (grant number 202401AU070071), the Youth Fund of Yunnan Forestry Technological College (grant number KY(QN)202219), the Fund of Yunnan Forestry Technological College (grant number KY(YB)202207), the Scientific Research Fund of the Yunnan Provincial

Department of Education (grant number 2024J1456, 2024J0337), the Xingdian Talent Support Program of Yunnan Province of China (grant number XDYC-QNRC-2024-185), and the Yunnan health training project of high level talents (grant number H-2025002).

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenvs.2026.1796169/full#supplementary-material>

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