A Comparison Study on Species Diversity of Woody Plants in Mountain Parks and Riverside Parks of Fuzhou City

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Abstract. In order to know the situation of plant diversity of mountain parks and riverside parks in Fuzhou city, the woody plants of different mountain parks and riverside parks in Fuzhou city were studied in this paper. The typical sampling method was used in this survey. Then the composition of plant community, the origination of plants and the species diversity index were analyzed to explore the differences of plant diversity between different types of parks. The research was aimed to provide basic data for the biodiversity conservation in Fuzhou city. The results showed that the species of woody plants of mountain parks and riverside parks was abundant, the similarity of the composition of plant community is extremely high, the number of woody plant species and the application proportion of native tree species of mountain parks was higher than that of riverside parks. The abundance index and the Shannon-Wiener index of tree layer of mountain parks was higher than that of riverside parks. The abundance index and the Shannon-Wiener index of shrub layer of mountain parks was lower than that of riverside parks.

Keywords: Mountain park, riverside park, plant community, woody plant, species diversity.

1. Introduction
With the continuous improvement of China's economic level and urbanization level, the environmental problems faced by cities are becoming more and more serious since the reform and opening up, and it also has a significant impact on the plant diversity of urban green space [1]. Urban greening is an important measure to strengthen the diversity of urban green plants, however, the stereotyped urban greening tends to homogenize the plants between different types of green space and reduce the plant diversity [2]. As an important part of urban green space system, park landscape greening and plant diversity are the most typical [3]. Plant diversity not only enriches the landscape of the park, but is also a key factor in maintaining ecological stability [4]. Due to the different types of parks, there will be obvious differences in plant diversity [5]. Therefore, the comparative study of plant diversity...
among different types of parks is of great significance for urban park construction and sustainable development.

At present, many cities at home and abroad, such as Coimbra [6], Xi’an [7], Huaihua [8] and Chongqing [9], have carried out surveys on the plant diversity among different types of urban green space. Fuzhou city, the capital of Fujian Province, as the Wulong River and Minjiang River traverse the urban area of Fuzhou, and there are many mountains inside and outside the urban area, mountain park and riverside park green space become an important part of the urban green space of Fuzhou, with cooling and humidifying, carbon sequestration, oxygen release, protection and attract biological and other important roles [10]. Chen Yi [11, 12], Li Hui [13, 14] and others have made an investigation and analysis of Fuzhou National Forest Park, Riverside Park and other parks. However, there are few comparative studies on the plant diversity of different types of parks at home and abroad. Based on the characteristics of the study area, this paper selects mountain parks and riverside parks, and understands the landscape homogeneity of different regions under the background of artificial urban landscapes, to provide an effective theoretical basis for the construction and protection of plant diversity in Fuzhou parks.

2. Overview of research Area

As the capital of Fujian Province, Fuzhou is located in the Minjiang Estuary area in the eastern part of Fujian Province, the geographical coordinates are N25°15’-26°29’, E118°08’-120°31’. The landform of Fuzhou is a typical estuary basin, and its altitude is mostly between 600-1000 m. The average annual precipitation in Fuzhou is 900-2100 mm. There are 84 parks in the city, with a park green area of 3054 hm², and a per capita park green area of 12.9 m².

3. Research Method

3.1. Survey location

Fuzhou belongs to the mountainous and hilly zone, and more large-scale parks are mostly built on mountains and along the river. Therefore, mountain parks and riverside parks are selected as the survey sites of the article. Through the survey of all mountain parks and riverside parks in Fuzhou, we mainly select parks with artificial configuration or severe human interference. Since Qishan is less subject to human interference, 4 mountain parks are selected, namely Yushan Park, Pingshan Park, Wushan Park and Forest Park, 4 riverside parks: Minjiang Park, Beach Park, Guoguang Park, and East Riverside Park. Mountain parks are generally located in the city or suburban mountainous landscape zone. Riverside parks are mainly close to the river, the specific location is shown in Figure 1.

![Figure 1. The location of riverside parks and mountain parks](image-url)
3.2. Investigation method
In the preliminary study of the plant survey of Fuzhou mountain parks and riverside parks, the "species-area curve accumulation method" was used for the research, and 20m×20m and 5m×5m were used as the sampling standards for the survey of trees and shrubs. In this paper, the typical sampling method is used to conduct a comprehensive survey of 8 selected parks, and 10 sample plots of 20m×20m are selected from each park, a total of 80 arbors are sampled. The trees in each tree plot were investigated for each tree, and four 5m×5m shrub plots were set on the diagonal of the plot, a total of 320 shrub plots.

3.3. Data analysis method
In this paper, the coefficient of similarity of flora is used as a quantitative indicator to measure the similarity of plant composition between two different types of park green spaces [15]; the importance value is used as a comprehensive quantitative index to evaluate the status of a certain tree species in the community [7, 16], while the frequency is used as a reference index to measure the frequency of the species, and the relative significance is calculated by the cross-sectional area of breast height. Margalef richness index and Shannon-Wiener diversity index are used as indicators to reflect the abundance of greening tree species in the park. Comparing the tree species with the query results on Flora of China, getting the type of plant source.

(1) Important value
Important value of arbor = (relative density + relative frequency + relative significance)/3
Important value of shrub = (relative density + relative frequency + relative coverage)/3

(2) Relative frequency
Frequency (%) = (number of plots of a certain plant/total number of plots) ×100%
Relative frequency (%) = (the frequency of a certain plant/the sum of the frequencies of all plants) × 100%.

(3) Margalef richness index
Margalef richness index $R = (S - 1)/\ln N$ In the formula, $S$ is the number of species, and $N$ is the total number of individuals in all species.

(4) Diversity index
Shannon-Wiener Diversity Index $H = -\sum_{i=1}^{S} P_i \ln P_i$

$P_i$ represents the proportion of the $i$-th species in the total, then $p_i=N_i/N$, $N_i$ is the number of individuals in the $i$-th species, and $N$ is the sum of the number of individuals in all species.

(5) Fauna similarity coefficient
Exploring the similarity of flora between different regions is generally calculated using the similarity coefficient formula proposed by Czechanowski in 1913 [12]:

$$SC = \frac{2C}{A+B} \times 100\%$$

In the formula, $Sc$ is the similarity coefficient, $A$ is the number of plant species (family, genus) in A, $B$ is the number of plant species (family, genus) in B, and $C$ is the number of plant species (family, genus) shared by both places number of.

4. Results and analysis

4.1. Woody plant composition comparison

4.1.1. Woody plant species. Based on the data in references [12] [14], field surveys were used to make corrections. According to survey statistics, there are 94 species of trees and 54 species of shrubs in the
4 selected typical mountain park green spaces in Fuzhou, belonging to 110 genera and 49 families. Among them, angiosperms have 42 families, 98 genera, and 131 species, gymnosperms have 7 families, 12 genera, and 17 species. There are 60 and 49 species of evergreen trees and shrubs, and 34 and 5 species of deciduous trees and shrubs. There are 53 species of trees and 52 species of shrubs in 4 typical riverside park green spaces, belonging to 46 families and 77 genera, including angiosperms, 43 families, 74 genera and 102 species, gymnosperms, 3 families, 3 genera and 3 species, there are respectively 34 and 44 species of evergreen trees and shrubs, 22 and 5 species of deciduous trees and shrubs, respectively. In general, the number of woody plants in mountain parks is significantly more than that in riverside park. The ratio of trees to irrigation in mountain parks is 1.74, and the ratio of trees to irrigation in riverside park is 1.02, but the ratio of the number of evergreen tree species to the number of deciduous trees is both close to 3:1. The tree species composition of each park is shown in Table 1.

| Park          | family | genus | species | tree | shrub | evergreen | deciduous | aggregate |
|---------------|--------|-------|---------|------|-------|-----------|-----------|-----------|
| Yushan Park   | 36     | 52    | 61      | 33   | 28    | 47        | 14        | 61        |
| Wushan Park   | 30     | 42    | 45      | 25   | 20    | 30        | 15        | 45        |
| Pingshan Park | 25     | 38    | 44      | 24   | 20    | 36        | 8         | 44        |
| Forest Park   | 38     | 73    | 93      | 63   | 30    | 71        | 22        | 93        |
| Minjiang Park | 25     | 35    | 41      | 23   | 18    | 30        | 11        | 41        |
| Beach park    | 26     | 35    | 43      | 16   | 27    | 33        | 10        | 43        |
| Guoguang Park | 30     | 43    | 51      | 22   | 29    | 40        | 11        | 51        |
| East Riverside Park | 24 | 29 | 32 | 19 | 13 | 23 | 9 | 32 |

In mountain parks, the top 10 tree species with important value is *Acacia confusa* (13.04%), *Ficus concinna* (7.21%), *Cinnamomum camphora* (5.56%), *Amygdalus persica f. duplex* (4.88%), *Osmanthus fragrans ‘Siji Gui’* (3.18%), *Mangifera indica* (3.06%), *Bombax malabaricum* (2.79%), *Schima superba* (2.61%), *Melaleuca leucadendron* (2.57%), *Broussonetia papyrifera* (2.56%). The top 10 shrub species in important value is *Schefflera octophylla* (18.10%), *Rhododendron pulchrum* (9.34%), *Loropetalum chinense* (7.42%), *Rhapis excels* (7.07%), *Excoecaria cochinchnensis* (5.08%), *Cordyline fruticosa* (4.75%), *Duranta repens* (4.74%), *Murraya exotica* (3.99%), *Bougainvillea glabra* (2.98%), *Ficus microcarpa* (2.67%). In riversdie park, the top 10 tree species in important value is *Bischofia javanica* (6.15%), *Celtis sinensis* (5.64%), *Ficus concinna* (5.49%), *Ceiba speciosa* (5.46%), *Cinnamomum camphora* (4.92%), *Osmanthus fragrans* (4.76%), *Mangifera indica* (4.60%), *Bauhinia purpurea* (4.60%), *Erythrina variegate* (3.85 %), *Amygdalus persica* (3.52%). The top 10 shrub species in important value is *Loropetalum chinense* (6.70%), *Rhododendron pulchrum* (6.07%), *Cordyline fruticosa* (4.66%), *Photinia serrulata* (3.97%), *Ixora chinensis* (3.23%), *Duranta repens* (2.52%), *Calliandra haematocephala* (2.29%), *Fagraea ceilanica* (2.21%), *Hibiscus rosa-sinensis* (2.01%), *Ficus benjamina* (1.98%).

4.1.2. Frequency analysis. The frequency value of different tree types used in mountain park green space in Fuzhou is between 2.50%-40.00%. Among them, there are 4 types of trees with application frequency value greater than 25%, namely *Cinnamomum camphora* (40.00%) and *Acacia confusa* (37.50%), *Ficus concinna* (30.00%), *Osmanthus fragrans* (27.50%); The frequency values between different shrub species ranged from 0.63%-27.50%, of which only *Schefflera octophylla* (27.50%) had an application frequency value greater than 25%.The frequency value of different tree species used in the green space of riverside Park in Fuzhou is between 2.50%-25.00%, of which only *Bischofia javanica* (27.50%) has a frequency value of more than 25%; among different shrub species the frequency value is between 0.63%-17.50%. It can be seen from Table 2 that there are 123 species of woody plants with a frequency of less than 10% in mountain parks, accounting for 83.11% of the
total number of woody plant species. This shows that although the application of plant species in Fuzhou mountain parks and riverside parks is relatively rich and the plant landscapes are more diverse, there is also the phenomenon of repeated application of certain woody plants.

Table 2. Frequency of Woody Plants in mountain parks and riverside parks of Fuzhou city.

| Frequency% | Mountain park | Riverside park |
|------------|---------------|----------------|
|            | tree | shrub | tree | shrub |
| 0≤X<5      | 44   | 40    | 25   | 41    |
| 5≤X<10     | 30   | 9     | 14   | 8     |
| 10≤X<15    | 8    | 2     | 6    | 2     |
| 15≤X<20    | 4    | 2     | 5    | 1     |
| 20≤X<25    | 4    | —     | 2    | —     |
| ≥25        | 4    | 1     | 1    | —     |
| aggregate  | 94   | 54    | 53   | 52    |

4.2. Comparative analysis of flora similarity

The mountain park and the riverside park share 35 families, 56 genera, and 62 species (Table 3). The highest degree of similarity between the flora of mountain parks and riverside parks is family (73.68%), followed by genera (59.59%), and finally species (49.01%). The similarity of families, genera and species between mountain parks and riverside parks has decreased with the expansion of the family of species, but the similarity of species is still close to 50%, while the similarity of family reaches 70%. Above, which shows that the two different types of parks have great similarities in flora, which may be caused by the patterning of greening or the similarity of climate.

Table 3. Comparison of similarity coefficients at the families, genera, species level in mountain parks and riverside parks.

| Flora    | Mountain Park | Riverside Park | Total | Aggregate | Similarity Coefficient |
|----------|---------------|----------------|-------|-----------|------------------------|
| families | 49            | 46             | 35    | 60        | 73.68%                 |
| genera   | 110           | 77             | 56    | 130       | 59.59%                 |
| Species  | 148           | 105            | 62    | 191       | 49.01%                 |

4.3. Comparative analysis of plant sources

In Fuzhou Mountain Park, 47 native species accounted for 31.75% of the total, 56 species introduced domestically, accounting for 37.84% of the total, and 45 species introduced from abroad, accounting for 30.41% of the total. In riverside park, there are 23 local species, accounting for 21.90% of the total, 47 domestic species, accounting for 44.76% of the total, and 35 foreign species, accounting for 33.34% of the total.

It can be seen from Table 4 that in Fuzhou, with the exception of Forest Park, which is mainly native species (37.63%), and Beach Park, which is mainly introduced from abroad (46.51%), other mountain parks and riverside park greenbelt plants are mainly domestic introduced species, supplemented by local and foreign introduced species, among them, Wushan Park (46.67%) and East Riverside Park (46.88%) have the highest proportion of domestic introduced species. Although the proportion of native species used in mountain parks is higher than that of riverside park, in general, Fuzhou native species have not been widely used in mountain parks and riverside parks.
Table 4. The origination of Woody Plants in mountain parks and riverside parks of Fuzhou city.

| Park type  | Native species | Proportion% | Domestically introduced species | Proportion | Imported species | Proportion% | Total |
|------------|----------------|-------------|---------------------------------|------------|-----------------|-------------|-------|
| Yushan Park| 20             | 32.79       | 27                              | 44.26      | 14              | 22.95       | 61    |
| Wushan Park| 13             | 28.89       | 21                              | 46.67      | 11              | 24.44       | 45    |
| Pingshan Park| 15             | 34.09       | 18                              | 40.91      | 11              | 25.00       | 44    |
| Forest Park| 35             | 37.63       | 28                              | 30.11      | 30              | 32.26       | 93    |
| Minjiang Park| 14             | 34.15       | 19                              | 46.34      | 8               | 19.51       | 41    |
| Beach Park | 7              | 16.28       | 16                              | 37.21      | 20              | 46.51       | 43    |
| Guoguang Park| 13             | 25.49       | 22                              | 43.14      | 16              | 31.37       | 51    |
| East Riverside Park| 5              | 15.63       | 15                              | 46.88      | 12              | 37.49       | 32    |

4.4. Comparative analysis of species diversity

4.4.1. Species richness. As shown in Figure 2, the species richness of trees in most of the mountain parks and riverside parks of Fuzhou is greater than that of shrubs. In different types of park green spaces, the species richness of the arbor layer shows mountain parks (13.244)> riverside Park (7.610), the species richness of shrubs shows riverside Park (5.551)> mountain parks (4.975). Mountain parks have more natural communities with arbor and grass as the main structure than riverside parks, while riverside parks are mostly artificially arranged plant communities with arbor, shrub and grass structures, resulting in the shrub layer species richness of mountain parks being lower than that of riverside parks.

In the mountain parks survey, the species richness of the arbor layer is shown as Forest Park (10.297)> Yushan Park (5.630)> Wushan Park (4.117)> Pingshan Park (3.908), the species richness of the shrub layer is shown as Forest Park (3.148)> Yushan Park (2.916)> Pingshan Park (2.273)> Wushan Park (1.815). In the survey of riverside parks, the species richness of the arbor layer is shown as Minjiang Park (4.092)> Guoguang Park (3.956)> East Riverside Park (2.989)> Beach Park (2.758), the species richness of the shrub layer is shown as Guoguang Park (3.673)> Beach Park (3.505)> Minjiang Park (2.035)> East Riverside Park (1.480). Based on this, among mountain parks, Forest Park has the highest species richness of trees and shrubs, Pingshan Park has the lowest species richness of trees, and Wushan Park has the lowest species richness of shrubs.
4.4.2. Species Diversity Index. As shown in Figure 3, the Shannon-Wiener diversity index values of trees and shrubs in mountain parks and riverside parks are relatively high, which indicates that woody plants in mountain parks and riverside parks have high diversity, and the diversity of the tree layer is higher than that of the shrub layer. In different types of parks and green spaces, the diversity index of the arbor layer is mountain park (3.837) > riverside park (3.435); the diversity index of the shrub layer is riverside park (2.899) > mountain park (2.791). This may be because mountain parks have more large upper trees than riverside parks, which makes the undergrowth lack of light, and some shrubs cannot grow normally or even die, making the diversity of shrubs in mountain parks less than that of riverside parks.

In mountain parks, the Shannon-Wiener diversity index of the arbor layer is Forest Park (3.567) > Yushan Park (3.085) > Wushan Park (2.334) > Pingshan Park (2.251); Shannon-Wiener diversity of the shrub layer is Forest Park (2.356) > Wushan Park (2.354) > Yushan Park (2.307) > Pingshan Park (2.218). In riverside Park, the Shannon-Wiener diversity index of the arbor layer is Minjiang Park (2.607) > East Riverside Park (2.531) > Guoguang Park (2.393) > Beach Park (2.322); The Shannon-Wiener diversity index of the shrub layer is as follows: Beach Park (2.889) > Guoguang Park (2.213) > East Riverside Park (2.096) > Minjiang Park (2.023). It is worth noting that although Minjiang Park in riverside Park has the highest diversity of arbor layers, the diversity of shrubs is the worst.

Figure 2. The comparison of Margalef index of plants in mountain parks and riverside parks of Fuzhou city

Figure 3. The comparison of Shannon-Wiener index of plants in mountain parks and riverside parks of Fuzhou city
5. Conclusion and discussion

The article is aimed at the 4 mountain parks of Fuzhou City, Yushan Park, Wushan Park, Pingshan Park, and Forest Park and the 4 riverside parks of Minjiang Park, Beach Park, Guoguang Park, and East Riverside Park, a total of 80 trees in 8 parks Survey of plots and 320 shrub plots. Compared with previous studies, the sample size of articles is relatively large. Compared with the tree species of riverside Park by Chen Yi [11], the tree species of riverside Park is not much different. At the same time, new mountain parks are added. The data provides more basic data for studying the diversity of plants in Fuzhou and the homogeneity of plant regions.

The common characteristics of woody plants in Fuzhou mountain park and riverside Park are that there are many species and the similarity of flora is great. The application ratio of evergreen tree species to deciduous tree species is both 2.8, and the application of deciduous shrubs is very few, with only 5 species. The dominant species in the arbor and shrub layer shared by the two types of parks are Ficus microcarpa, Cinnamomum camphora, Mango, Bi peach, Rhododendron sylvestris, Loropetalum chinensis, mainly artificial greening tree species. The difference between the woody plants in mountain parks and riverside parks is that the number of species in mountain parks is more abundant than that of riverside parks, mainly in that the number of arbor species is 1.8 times that of riverside parks. The native tree species of Fuzhou, Ficus microphylla and Acacia confusa have become dominant species in mountain parks. The proportion of local species used in mountain parks in Fuzhou is higher than that of riverside parks, and the proportion of domestic and foreign introduced species used in riverside parks is higher than that of mountain parks, the species richness index and diversity index of the tree layer of mountain parks are higher than those of riverside parks, while the index of the shrub layer is lower than that of riverside Park. In the 4 mountain parks, the species richness index and diversity index of arbor and shrub layer are quite different. In response to the above situation, the following suggestions are made:

1) Adapt trees to the site, eliminate blind and modular park greening methods, and enrich plant planting methods to improve the heterogeneity of plant landscapes between different types of parks. Blindly and modeled greening methods will make the flora of different types of parks with geographical and environmental differences too similar, and thus reduce the urban biodiversity. In mountain parks, there are some natural plant communities with arbor and grass as the main structure. According to the principle of ecology, a certain proportion of the natural community structure should be maintained in the park, but the dense trees in some natural communities make the underforest canopy density higher. In order to increase the hierarchical structure of the community and improve the diversity index, it is possible to consider adding negative-tolerant shrubs, and use a variety of plant combinations to reasonably match trees, shrubs and grass [17]. Relevant studies have shown that the construction of near-natural plant communities should be based on native dominant plants in local natural vegetation, supplemented by exotic plants that have been domesticated for many years, in order to increase the stability of the green space ecosystem and also reflect the heterogeneity of plant landscape between different regions [18, 19].

2) Develop and utilize native tree species with high garden ornamental value in Fuzhou to build a distinctive urban biodiversity pattern. Native plants not only can adapt to the local climate, geography and other environmental conditions, are easy to survive and manage, but also have relatively low prices. They should become the first choice for urban greening [20, 21].According to research, the following plants can be widely used in Fuzhou mountain park and riverside park [22, 23]:Toona sinensis, Tapiscia sinensis, Michelia foveolata, Dendrobenhamia angustata, Parakmeria lotungensis, Platycarya strobilacea, Ailanthus altissima, Nyssa sinensis, Sapium discolor, Chorospondias axillaris, Pistacia chinensis, Melissaia pinnata, Tsoongia axillariflora, Emmenopterys henryi, Alchornea treviroides, Phyllagathis fordii, Ardisia crenata, Michelia figo, Euscaphis japonica, Glochidion eriocarpum, Eurya saxicola, Weigela japonica, Clerodendrum kaichianum, Lindera erythrocarpa, Camellia trichoelada, Hypericum patulum, Daphne kiusiana, Pieris japonica, Chionanthus retusus.
(3) Increase the types and number of deciduous shrubs, and create a plant landscape with distinct seasons and rich community levels. The plants of deciduous shrubs are generally low and short, most of them are full-bodied, and some species have a large number of flowers and have high ornamental value [24]. However, deciduous shrubs are rarely used in the green areas of Fuzhou mountain park and riverside Park. Gardeners should make full use of Fuzhou’s native tree species and introduce some deciduous shrubs suitable for growth in Fuzhou, such as Hibiscus syriacus, Deutzia discolor, Flueggea virosa, Cotinus coggygria, Callicarpa bodinieri, Poncirus trifoliata, Ficus carica, Zanthoxylum bungeanum, Swida alba, Tamarix chinensis, Sambucus williamsii, Euonymus alatus, Rubus corchorifolius, Swida paucinervis, Exochorda racemosa, Lespedeza formosa, Caragana sinica, etc.

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