Research Article
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Investigation and analysis of road greening in Jingzhou city

Abstract

Jingzhou city is well-knowing for its ancient historical, massive cultural, and river system ramified. To understand the actual status of road greenery in Old Town, three typical roads, Quyuan South Road, Wude Road, and Jiang Jin Road, were sifted and divided into nine plots (Quyuan South Road, Wude Road a, Wude Road b, Wude Road c, Wude Road d, Jiang Jin Xi Road). Indexes of species abundance, Shannon-Weiner, Simpson, and Pielou were employed to dissect the road belt community. Results showed that the community diversity was higher in plant structure complicated than only shrubs arrangement. The ideal road plots were Jiangjin West Road, sections a and b of Wude Road based on the evaluation results of the above indexes and actual effects of sunshade, seasonal changes, and ecological function. The shortcomings of the investigational road uncovered the existing problems. Too much attention has been paid to the ornamental effects to lower the importance of ecological function and the utilizing comfort of citizens. Therefore, the urban road greenery should combine the environmental function and aesthetic needs, and regular maintenance management should be timely and scientific.

Keywords: Jingzhou, road greening, plant configuration, investigation

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Research Background

Urban roads, as a carrier that connects different areas in a modern city, not only influence the city's overall road aesthetics and landscape ecology but also shoulder the function of migration channels for biological migration. As Jane Jacobs said: "When we think of a city, the first thing that comes to mind is the road. A vibrant city is dependent on its better road landscape. Conversely, the city is dull when the road scenery is full of monotonous and uniform trees and shrubs".[1-3] The city road's overall appearance directly affects the city's picturesque or dullness. Although the city's rapid development has changed the quality and speed of automobile traffic, the problem that a thousand roads share a similar road greening mode is still seen in some cities, especially on old town roads. It lags behind the pace of road ecological civilization to a certain extent. Therefore, based on the urban road development needs and the current situation, fully considering the energy flow, material flow, and information flow, these bonds to the ecosystem. According to a special time and concrete places, tailoring the vision of the road landscape ecological corridor is very critical.[4-5]

Jing zhou (JZ) inherits and possesses the long and profound Culture of the Chu Dynasty. Its district covers 14 099km^2, with high topography in the west and low topography in the east and a well-developed river system. The building of the National Garden City has led to a substantial improvement in the greening quality urban areas of Jingzhou. In JZ City, the planting of trees along urban roads has been increasing, focusing on the selection of tree species and color matching according to local natural and humanistic features. Meanwhile, road greening[6-9] concentrates on applying native plants for over 50%. The Municipal Garden Bureau has been trying to upgrade the urban landscape by paying more attention to seasonal changes and considering pedestrians' comfort and visual feeling. However, the construction and development of JZ still face the contradiction of protection and development. Thus, there is a long way to go to make the task of scientific planning and implementation of urban road landscape and improving and enhancing the urban ecological corridor come true.

To find out the main problems of road greening in Jingzhou, our team selected three representative roads in Jingzhou city. Our aim is to provide a basis for definite road upgrading in the future based on quantifying the problems of road greening through a series of models such as the Shannon index, Pielou evenness index, and so on.

Survey site and research methods

Survey Locations

The survey area and investigation plots in this study are illustrated in Figure 1. the three traffic arteries in Jingzhou city, namely, Quyuan South Road, Wude Road, and Jiangjin West Road.

The dark blue line indicated Wude Road, the red line was Quyuan South Road, and Jiangjin West Road was outlined by yellow in Figure 1b.

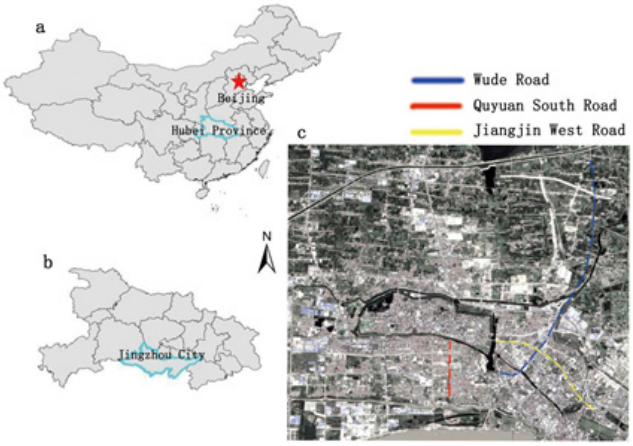

Figure 1 The location of Jingzhou in Hubei province and the distribution of investigated roads.

Survey and calculation methods

Three representative roads were selected, and a series of community sample plots, 200m^2, was set up. The tree and shrub layers were investigated by phytocoenology, including plant species, crown width, breast height diameter, and number. Furthermore, ten small sample squares (4m×5m) were arranged in the sample plot, and

each small sample square was investigated one by one for all existing plant species. If the species appeared in the small sample square, it was recorded in the table, and then the frequency of each plant was counted separately. The species diversity index not only represents the community structure, functional complexity, and organization level but also shows some ecological habits of each community more systematically and clearly.

The indices of plant diversity include species richness index (S), Shannon-Weiner index (H'), Simpson index (D), which demonstrates the level of community diversity, and Pielou evenness index (J),which reflects the uniformity of distribution of different species in a community. Plant diversity[10,11] was calculated by the composite indicators of the importance values of each species at each level.

Species importance value（N%）=Relative abundance+ relative frequency + relative coverage)/3:

Species richness:

S =Number of species occurring in the sample plots

Shannon-Weiner Index:

$$H' = -\sum_{i=1}^{n} P_i \ln(P_i)$$

Simpson Index:

$$D = 1 - \sum_{i=1}^{n} P_i^2$$

Pielou Index:

$$J_{sw} = H'/\ln S$$

N_i is the importance value of the species i, and N is the sum of the essential values of all species in the community at each level. $P_i = N_i/N$ is the relative importance value of the species i; and S is the total number of species in the layer.[12-16]

Results and Analysis

Community status of the plots

There were 30 and 23 plant species in the nine survey sample plots (1800m^2 in total), including 33 genera and 35 species in 25 families. Among which with 3 families and 4 genera and 4 species of gymnosperms, and 31 species of angiosperms in 22 families. Rosaceae and Hamamelidaceae contain 4 species (4 genera) and 3 species (3 genera), respectively, more than other plant families. The average number of species is 3.4 and 2.6 in the layers of trees and shrubs in each sample site, and less diverse. The survey results of canopy density and bare land rate were obtained by counting and statistic of the plant species and crown diameter of each road, as shown in Table 1.

Table 1 Community characteristics of the investigated plots

No.	Plots	Community Type	Canopy density%	Bare land ratio %
1	Qu Yuan South Road	*Citrus maxima +Ligustrum lucidum + Platanus acerifolia + Gardenia jasminoides+Rhododendron simsii*	70	12
2	Wude Road a	*Cinnamomum camphora + Ligustrum lucidum+Trachycarpusfortunei + Elaeocarpus decipiens+Buxus megistophylla+Distyliumracemosum*	90	10
3	Wude Road b	*Amygdalus persica + Koelreuteriapaniculata+ Cycas revoluta + Gardenia jasminoide s+ Loropetalumchinensevar.rubrum. + Euonymus japonicus*	80	5
4	Wude Road c	*Osmanthus fragrans + Livistona chinensis + Cycas revoluta + Platycladusorientalis + Loropetalumchinensevar.rubrum+ Pittosporum tobira*	80	7
5	Wude Road d	*Loropetalumchinense+ Pittosporum tobira + Cinnamomum camphora+ Buxus megistophylla+ Euonymus japonicus*	70	4
6	Jiang Jin West Road	*C.camphora + Prunus cerasifera+ Distylium chinense+ Euonymus japonicus + Gardenia jasminoides+ Buxus megistophylla*	90	4

As illustrated in Table 2, trees with high frequency in these plots were Platanus acerifolia, Cinnamomum camphora, Koelreuteriapaniculata, Livistona chinensis, Prunus serrulatavar. lannesiana, Prunus persica. C. camphora and Prunus serrulata were commonly planted in several sample plots. The critical values of C. camphorareached 65.3%, 14.1%, and 12% in the three sample plots.

Table 2 shows the highest frequency of trees from different investigated plots

Species Name	Frequency%	Species Name	Frequency%
Platanus acerifolia	55	*Livistona chinensis*	20
Cinnamomum camphora	40,20,40	*Prunus serrulatavar.lannesiana*	35
Koelreuteriapaniculata	40	*Prunus persica*	40

Note: Data of frequency having more than a single indicates that the species occurs more frequently in different sample sites. In contrast, single data suggests that the species occurs more regularly only in a particular area.

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Regarding shrubs in the above plots, shrubs with higher frequency were Gardenia jasminoides, Buxus megistophylla, Platycladusorientalis, Pittosporum tobira, Distyliumchinense, and Sabina procumbens (Table 3). Which gardenia was a widespread species in the road landscape of Jingzhou. The critical values also reached 79.4%, 42.1%, and 21.1%, respectively. However, the inharmonious distribution of trees and shrubs has been a crucial problem in Old Town. For example, the greenery part d of Wude Road was dominated by shrubs and only one kind of tree, the Cinnamomum camphora.

Table 3 Shrubs with the highest frequency of occurrence in the shrub layer in each sample site

Speciesname	Frequency	Speciesname	Frequency
Gardenia jasminoides	65,40	*Distyliumchinense*	40
Buxus megistophylla	25	*Platycladusorientalis*	40
Pittosporum tobira	50	*Sabina procumbens*	20

Comparative analysis of plant diversity index

As a comprehensive index, the Shannon-wiener index(H') is better than othersin showing the community structure and reflects the connections and interactions between community structure and the ecological environment. It can visually present the degree of uniformity and richness of plant species in specific landscape communities. As for the plant diversity index, part b of Wude Road has been listed the highest one, reaching 12 species, in which the tree layer accounts for 7 species. The Shannon-wiener index of Wude Road b reached 1.1814 and 1.0626, higher than other Roads and other parts of Wude Road. Although H' was the highest in Wude Road b, the Pielou uniformity index (J) was only 0.6071 and 0.6602. The table shows that the Pielou uniform index of the shrub layer is mostly higher than the tree layer. The possible reason is shrubs have higher planting densities and relatively unique planting. Firstly, the arrangement of trees has more choices in planting mode than shrubs; both regular and irregular have more concrete methods. Secondly, the design and layout of trees[17] must comply with the planning and design rules, such as planting rhythm, the inherited characters of trees, the conventional notion of flowering through three seasons, and having landscape scenery the whole year.

Comparing the index of Species abundance, Simpson and Shannon-wiener of the three roads, the best one was in Wude Road b, and the second was Jiangjin West Road, which was all higher than the others (Table 4). The Pielou uniform index of the tree layer in Jiangjin West Road was the highest. As for the shrub layer, the highest Pielou uniform index was Wude Roada (0.9982), and the lowest was part b of Wude Road.From the above analysis, the preliminary conclusion was drawn that the data of the Pielou uniform index didn't agree with the index of Species abundance, Simpson and Shannon-wiener. Different indexes should be applied comprehensively to objectively evaluate the structure and ecological values of the plant landscape.

Table 4 Shows the diversity of trees and shrubs in different plots

Place	Plot	S		D		H'		J	
		Tree	Shrub	Tree	Shrub	Tree	Shrub	Tree	Shrub
Quyuan South Road	1	3	2	0.8838	0.8062	0.8045	0.6077	0.7323	0.8768
Wude Road a	2	4	2	0.8692	0.8744	0.9838	0.6919	0.7097	0.9982
b	3	7	5	0.9381	0.9309	1.1814	1.0626	0.6071	0.6602
c	4	3	3	0.8968	0.9078	0.8354	0.8692	0.7604	0.7912
d	5	1	3	0.0000	0.9081	0.0000	0.9550	0.0000	0.6889
Mean		3.8	3.2	0.6760	0.9053	0.7502	0.8948	0.5193	0.7846
Jiangjin West Road	6	2	4	0.9155	0.9211	0.8932	0.9689	0.8130	0.6989

The top three best roads were Jiangjin West Road, Wude Road b, and Wude Road a, based on the above index analysis and the practical greenery effects of sunshade, dividing space, seasonal variation, and so on.

Survey results of different roads

South of Quyuan Road

The total length of South of Quyuan Road is 1,800m. The greenery mode was a special One Plate Two Belt Type. Just as illustrated in Figure 2, on the left side of the road is lining some private built houses and stores, and on the opposite side is only one type of tree as a diversion belt to separate pedestrians and vehicles, and a green belt composed of lawn, shrubs, and trees was adjacent to the sideway. The advantage of this model lies in taking action to get with the unique road circumstance. Meanwhile, the disadvantage was lacking enough lanes to routes different vehicles, so the actual traffic status was jamming.[18]

Figure 2 The planting status of Quyuan South Road.

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Wude Road

Wude Road of Old Town consists of four sections; its total length is 2 350 m. The planting mode of Section a (long 750m) was Three Panels and Four Belts. The greenery structure was made up of three lanes and four green belts. The two green belts separated the lanes of cars and bicycles in the middle. Adjacent to it, two rows of Cinnamomum camphora are planted between the bicycle lanes and pedestrian space (Figure 3). The total length of Wude Road b (800m) has Two Panels And Three Belts. A single green belt is in the middle of the road to divide the opposite cars and bicycles. On two sides of this Section a line planting of Koelreuteria paniculate. (Figure 4). The mode of Section c was similar to sections b and d, but the plant composition differed. The plant structure of the dividing belt is Livistona chinensis, Cycas revoluta, Loropetalumchinense, Platycladusorientalis, and Pittosporum tobira (Figure 5). Section d is 550m long. The structure of the middle belt[19] was composed of Loropetalumchinense, Pittosporum tobira, and Euonymus japonicus, in which Buxus megistophylla was planted per10 meters (Figure 6). The motorlane and sidewalk were divided by row Koelreuteriapaniculata.

Figure 3 Section a of Wude Road.

Figure 4 Section b of Wude Road.

Figure 5 Section c of Wude Road.

Figure 6 Section d of Wude Road.

Jiangjin West Road

The total length of Jiangjin West Road is 3300m, with Three Panels and Four Belts. The survey sample size was set as 1000m long. The green belt of C.camphora lined along the sidewalks, which are neatly planted, keeping pedestrians cool in summer. The Distyliumchinense (1.5m×1.0m) was buried in the interspaces between trees, which grew well and was free from diseases and pests. The green belt in the middle of the road comprises small trees plus shrubs. In which the small trees are the colorful leaf species, Prunus Cerasifera. Distyliumchinense, Euonymus japonicus, and Gardenia jasminoides are pruned as a hedge evenly and distributed among them. Reineckiacarnea has been planted on both sides against the motorway also.

The main advantages of the Jiangjin Road traffic separation mode include: (1) the car lanes and bicycle lanes are reasonably separated. The latter was hardly interfered by the passage of cars. (2) The color change of the green belt is noticeable. C. camphora has been an excellent tree in the Yangtze river basin in the light of its dark green leaves, tender green new leaves, old red leaves inset into the green crown, and fragrant flowers in late spring. When it comes to Prunus Cerasifera, there have been keeping colorful season features, that as purple-red leaves and pink flowers covering the crown in the spring season, which and those lower shrubs together play good roles in safeguarding traffic safety (Figure 7). The disadvantage of this road greenery is that the central traffic belt has two-way lanes in each direction, and in the middle, the double yellow line has been used as a separation sign; the most prominent defect is the sight of the drivers has been easily obstructed at night frow car glare of opposite direction (Figure 8). Therefore, there need one green belt to separate[20] the opposite running cars, considering to keep the traffic safety and lower vehicle glare.[21]

Figure 7 Jiangjin West Road.

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Figure 8 Jiangjin West Road.

Conclusion

The survey of road greening in the Old Town of Jingzhou uncovered the main problems of the green belts of the urban street. Firstly, road greening has been lacking integrity, and the overall situation,[22,23] the possible reason was seldom collaborations of administrative units and even different departments. The whole distance of Wude Road was 2350meters in this investigation, but the greenery style was diverse from each other for all the four sections. Secondly, Some roads in the main urban area only focused on the ornamental effects of greening sites and ignored the amount of green and total environmental benefits.[24] For example, the traffic green belt of Wude Road d only applied shrubs, landscape-level single. Thirdly, the maintenance management has not met the practical needs after landscape, which did result in the planting project hardly implementing the original design notions. Therefore, the relevant departments should fully consider the forward-looking effect of road greening in the future design of the scheme

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Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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