Choice-experiment-method-based research into the future improvement of Beijing's urban forest

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Abstract

Purpose – The purpose of this paper is to measure the influence factors of their preferences for urban forest, marginal values of various properties and relative values of different scheme portfolios, thus arriving indirectly at the city residents' demand for urban forest improvement.
Design/methodology/approach – This paper, based on the data from the 2015–2017 field survey questionnaire of city residents over the radius of Beijing's 5th Ring Road, uses the choice experiment method (CEM) to conduct a study of its residents' demand for urban forest.
Findings – Beijing's city residents are generally inclined to accept a relatively low payment of urban forest while hoping to access a relatively high urban afforestation coverage with the construction of relatively many city parks, especially focusing on the specialized park management; the marginal values of biodiversity and greenery coverage are far higher than those of greenbelts in quantity and the maximum marginal value of biodiversity remains as high as RMB29.42, indicating that the city residents do not favor much the number of greenbelts over other aspects but they generally hope to achieve a higher greenery coverage and a richer biodiversity.
Research limitations/implications – Generally speaking, what Beijing City needs most is not continuing the increase in the number of greenbelts, but engaging in the rational retrofit of its existing greenbelts and optimizing its urban forest structure.
Originality/value – This paper may provide reference for determining the city residents' payment criteria for urban forest and will be of equally great significance to developing cities and their urban forest.

Keywords Urban forest, Beijing city, Choice experiment method (CEM)

Paper type Research paper

1. Introduction

Since the reform and opening-up, China has constantly deepened its urbanization process along with the rapid increase in its urban population, thus posing severe challenges to its urban eco-environment, which in turn created in its city dwellers an expectation of better quality in their living environment. Over the past years, China has, to some extent, boosted its urban forest development through its urban development programs and eco-civilization construction, such as, "Landscape Garden City" and "Eco-City". By the end of 2015, the greening rate in China's urban built-up areas had reached 36.34 percent, and the number of parks in its urban areas amounting to 13,662 with a total area of approximately 606,000 hectares. Nevertheless, China still faces a series of problems in terms of its overall national situation, such as, overall slow development, unbalanced regional development, poor level of

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technology and insufficient social participation and cognitions. With its rapid urbanization development and continuous surge of urban eco-environment concerns, China's city residents have raised constant requirements for urban environment. And urban forest as the principal part of urban ecosystem is also a crucial support for safeguarding urban ecological security, and therefore, it plays an important and fundamental role in urban eco-civilization construction. With the constant economic and social development, the Chinese government has also given strong emphasis on enhancing the level of its urban forest construction. As of October 2017, there had been 137 cities honored with the title of "National Forest City" in this country and urban forest construction had become one of its major goals for urban development. For instance, the municipal government of Beijing, China's capital city and also one of the international metropolises with the fastest development in the world in recent years, has also paid high attention to its urban eco-environmental protection. Importantly, against the backdrop of eco-civilization construction, the pivot role of urban forest in promoting the harmony between man and nature has become more prominent than ever, which not only raised new requirements for urban forest construction but also injected fresh impetus to the development and perfection of urban forest.

The domestic and overseas research hotspots of urban forest are currently focused on the roles of landscaping and afforestation in providing practical values and public services that involves multiple aspects, such as, enhancing environmental quality (Irga *et al.*, 2015), improving urban landscapes (Fetene and Worku, 2013), improving city residents health and living quality (Clark and Nicholas, 2013), meeting their needs for recreation and entertainment (Majumdar *et al.*, 2011) and providing the habitat for urban wildlife (Monroe *et al.*, 2012). Obviously, urban forest provides city dwellers with materials and services in multiple areas, thus meeting the needs for city residents living and urban development in various aspects; in addition, research also found that urban forest construction is inseparable from the recognition and support of urban residents, whose feedback on urban forest plays an active part in boosting and improving urban forest construction (Dwyer *et al.*, 2002). In other words, facilitating the internalization of external benefits of urban forest will be an effective means of addressing a series of issues facing urban forest. As a redistribution of economic interests under the given economic development level and eco-environmental awareness, urban forest payment by city residents will involve interests adjustments of a multitude of social entities.

This paper believes, with the constant deepening of the current perception and usage behavior of urban forest of city residents, it would be possible on this basis to delve into the specific willingness and preferences for making the improvement of their future urban forest; in other words, dissimilar to their "consciousness expression" (city residents' multidimensional awareness) and "activeness expression" (city residents' usage behavior), the preferences and demand of city residents for future urban forest will be the embodiment of their "creativity expression." According to the existing research, the city resident based analysis will be one of the major contents of research relating to future urban forest (Junquera *et al.*, 2001). However, in terms of current research progress, there is less research conducted proceeding from the level of city residents on future urban forest improvement. With this notion in mind, this paper further discusses city residents' future preferences and needs for urban forest, the analysis mainly proceeding from their willingness for making urban forest improvement.

The role played by city residents in improving urban forest may be manifested in their willingness to pay (WTP) for short. Currently, WTP has generally been used as one of the important criteria for gauging public preferences and demand in the world; it represents the amount of money that consumers are willing to pay for a certain number of consumer goods or services. Namely, city residents as the beneficiaries and consumers of ecological services should make certain payments for the external benefits of urban forest that they are

entitled to. Existing studies have made the measuring analysis of WTP for city residents safeguarding and improving the urban forest environment, taking small and large cities respectively for example (Saz-Salazar and Garcia-Menendez, 2001; Lorenzo *et al.*, 2000); other research has also been conducted into the supporting degree and needs of city residents for urban forest, proceeding from their WTP (Zhu and Zhang, 2008; Zhang and Zheng, 2011).

To sum up, this paper plans to conduct research from three levels, which are proceeding from the theory of personal utility to analyze the factors influencing city residents willingness to improve urban forest and determine their preferences for and the degree of their improvement of urban forest; calculating the marginal values of the states and levels of various properties to determine city residents' WTP of different properties; and calculating the compensative surpluses of portfolio schemes of various properties to determine the WTP of city residents willing to pay for making the improvement of various properties. This research may provide reference for determining the city residents' payment criteria for urban forest and will be of equally great significance to developing cities and their urban forest.

2. Studied areas and data sources

According to both domestic and foreign existing studies, there are currently different discussions about the scope of urban forest, but the fundamental viewpoints are consistent; i.e. forest, trees and other plant growth areas within the urban range as well as wildlife within this range and necessary related facilities, all of which fall into the category of urban forest. This research take the six urban districts of the Beijing Municipality as the studied areas, their representativeness and typicality reflecting the below aspects. First, the six urban districts of the Beijing Municipality account approximately for 8.44 percent of the total area of its entire urban areas; however, around 60 percent of the urban permanent population live within these districts; second, their regional GDP accounts for over 70 percent of the total all the year round, being the integral part of the economic growth as a whole; lastly, the quantity and structure of urban forest resources the six districts have in recent years shown a gradually rational growth momentum, but problems remained outstanding in the aspects of urban population, social economy and resources. Combined with the existing research output and related norms, this research determines the specific survey locations to be the typical urban greening areas of Beijing City, including parks, public green space and community greenbelts (Hansmann *et al.*, 2007; Arnberger and Eder, 2012; Wendi and Yifan, 2015; Hailong, 2017). In light of this, field questionnaire surveys with city residents as the respondents were conducted on many occasions from December 2015 to November 2017, with 650 questionnaires distributed for each survey and a total of 3,250 completed questionnaires; unfinished samples with severe losses or uncompleted of information were removed to ultimately arrive at a total of 2,975 valid city residents' questionnaires, the total effective rate reaching 91.53 percent. According to relevant standards for valid response rate in foreign countries, the valid response rate of this research survey was satisfying indeed (Babbie, 2010). The specific locations for implementing the questionnaire surveys are shown through Figure 1.

In terms of overall situation of sampled city residents, the female proportion is slightly higher than the male proportion, with over 60 percent of the surveyed city residents aged below 40, over 80 percent being high school and or two-year college graduates or above, a relatively large proportion of married people, a generally good health condition and an average of monthly income of below RMB6,000; the number of people in the family of surveyed city residents is mostly 3 or above, of whom the number of senior citizens is averagely at below 2 and the number of children is mostly 1; the number of people among the city residents surveyed with Beijing household registration is slightly higher than that with no Beijing household registration, the number of years of their living in Beijing is mostly 1 to 5 and over 15, the number of months of their living in Beijing is generally over 9 and their residential areas are mainly located between the 2nd and 5th Ring Roads.

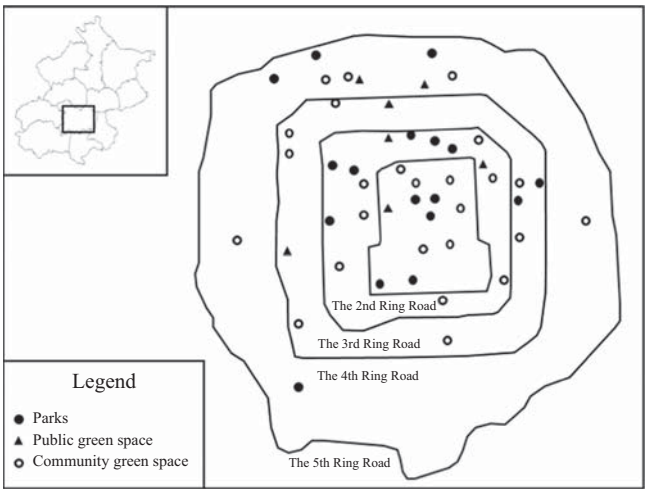

Figure 1.
Survey locations

2.1 CEM model design

A relatively advanced WTP assessment methodology, the Choice Experiment Method (CEM) was put forward based on the factor value theory proposed by Lancaster (1966) and the random utility theory advanced by Luce (1959) and Mcfadden (1974), which was raised and put into use in the marketing field at the earliest by Louviere and Woodworth (1983) and later extended gradually into the fields like, transportation economics, public health and resource environmental economics (Adamowicz *et al.*, 1992; Hanley *et al.*, 1998). To be specific, the utility of goods is dependent upon and existent in various property characteristics of this goods and changes in the level of a certain property may result in the changes in the consumer's preference for or choice of it. CEM is designed to build several selection sets through setting up portfolios of different property states, and the interviewee will select the portfolio scheme under different property states that is the most favorable to him from each different selection set, based on the size of personal utility brought to him from the corresponding scheme, thus indirectly making tradeoffs between various property states (Zhongmin *et al.*, 2003; Xiaohong, 2012).

This research builds CEM models based on the existing research output (Hanley *et al.*, 1998). And random utility models are used for the concrete analysis, i.e. under the assumption of utility maximization; city residents may receive a certain utility from each selection (Mcfadden, 1974). If V_{ij} is used to represent the direct total utility of selected scheme j by city resident i, V_i represents the observable utility of selected scheme j by city resident i, ε_{ij} represents the unobservable utility (i.e. random utility), x_j represents the property character of selected scheme j by city resident i, T_j represents the WTP of city resident i for scheme j, then the calculation formula of city resident utility is:

$$V_{ij} = V_i(x_j, T_j) + \varepsilon_{ij}.$$

This research takes the level of property state and individual characteristics of city residents as the variable of the utility function, using the multinomial logit (MNL) model for computation. The formula is as below:

$$V_{ij} = \mathrm{ASC} + \sum_{m=1}^{4} (\beta_m Z_m)_{ij} + \sum_{n=1}^{6} (\alpha_n P_n)_{ij}.$$

In the above formula, ASC is the constant term, Z_m is the variable of various properties, P_n is the individual characteristic variable of various city residents, β_m and α_n are the corresponding estimated parameters ($m = 4$, $n = 7$). In light of these, the computation formula of value, MWTP of various properties of urban forest is as below:

$$\mathrm{MWTP} = -\beta_P/\beta_T.$$

In the above formula, β_p and β_T represent the estimated coefficients of property variable and price term, respectively. In light of these, the calculation can be done to arrive at the compensating surplus or CS of urban forest, i.e. the WTP amount of city residents. If V_0 is served as the initial utility and V_1 as the final utility, then the computation CS formula is as below:

$$\mathrm{CS} = -\frac{1}{\beta_T}\left[\ln\left(\sum_i \exp V_0\right) - \ln\left(\sum_i \exp V_1\right)\right].$$

The key link of CEM is determining various property variables and the level of their states. The present research gauges city residents' willingness to improve urban forest in terms of four aspects of properties on the basis of literatures review, expert consultation and pre-surveys, i.e. number of greenbelts (Z_1), greenery coverage ratio (Z_2), biodiversity (Z_3) and payment amount (Z_4) (Valck *et al.*, 2014; Jingmei *et al.*, 2015; Zheng *et al.*, 2017); in the meantime, seven city resident individual characteristic variables were also incorporated into this research in consideration of policy cognitional and feedback differences resulted from city resident individual characteristic differences (Zhu *et al.*, 2013; Erda *et al.*, 2015). Apart from these, this research uses environmental awareness (Q_1) as the concomitant variable to gauge the cross effect of model estimation (Shijiu *et al.*, 2015; Yazhen *et al.*, 2016). The setups of specific variables and their state levels are shown in Table I.

It must be pointed out however that measures were especially taken to avoid the hierarchical quantitative effect when the state levels of property variables were set up for this research; namely, consideration is given to the diversity of interviewed city residents' selections on the one hand, while the number of state levels is controlled on the other hand, thus ensuring the smooth implementation of choice experiments (Van Loo *et al.*, 2011).

It can be noticed therefore that the property and level of urban forest improvement are Property 4 and Level 4, respectively. Based on total factor combination design method, a total of $4\times4\times4\times4 = 256$ portfolios of different property states can be arrived at. Through partial factor test design method, portfolios of 16 types of property states are screened out for this research, as shown in Table II.

Based on the information above, this research makes the random pairwise coupling of the portfolios of 16 types of property states to form eight selection sets, each of which contains two improvement plans and one status quo plan (Table III). In addition, the improvement plans indicate that various properties for urban forest improvement must reach the necessary state levels, for which city residents must make the corresponding payment; the status quo plans will not make any improvement of various properties, nor will city residents need to make corresponding payment, i.e. various properties of urban forest will all keep their current state levels. In consideration of the time and receptivity of the interviewed city residents, excessively asked questions will not be conducive to garnering valid survey results. Hence, based on the defined property portfolio plans of urban forest improvement willingness and by reference to relevant handling methods in the existing research, this research divides the CEM-based questionnaire into four versions, each of which includes two selection sets. The interviewed city residents need to choose the

Variables			Value-taking method (state levels)
Dependent variables	Y	Scheme selection	1 = city residents select improvement plans; 0 = city residents select status quo plans
Property variables	Z_1	No. of greenbelts	1 = unchanged; 2 = increased by 2 per annum; 3 = increased by 4 per annum; 4 = increased by more than 4 per annum
	Z_2	Greenery coverage ratio	1 = keep 20%; 2 = reach 30%; 3 = reach 40%; 4 = reach over 40%
	Z_3	Biodiversity	1 = unchanged; 2 = increase in common species; 3 = increase in protected species; 4 = increase in both common and protected species
	Z_4	Payment amount	1 = RMB0; 2 = RMB50; 3 = RMB100; 4 = over RMB100
Characteristic variables	P_1	Gender	1 = male; 0 = female
	P_2	Age	(Years old)
	P_3	Education	(Year)
	P_4	Monthly income	(RMB)
	P_5	No. of people in a family	(Person)
	P_6	Years of living in Beijing	(Year)
	P_7	Months of living in Beijing	(Month/Year)
Concomitant variables	Q_1	Environmental awareness	"5→1" represents "strong awareness → weak awareness"
Constant term	ASC	Constant term	1 = participate in at least 1 improvement plan; 0 = not participate in any improvement plan

Table I.
Properties of urban forest improvement and their state levels

Notes: Option 1 in property plans indicates the state level that various properties are currently in (i.e. floor level). In addition, the greenery coverage ratio, 20 percent is Beijing's urban afforestation coverage ratio in 2015, the data for which are sourced form www.bjyl.gov.cn

	Property state			
Plan Nos.	No. of greenbelts	Greenery coverage ratio	Biodiversity	Payment amount
1	1	1	1	1
2	2	1	2	2
3	3	1	3	3
4	4	1	4	4
5	1	2	2	3
6	2	2	1	4
7	3	2	4	1
8	4	2	3	2
9	1	3	3	4
10	2	3	4	3
11	3	3	1	2
12	4	3	2	1
13	1	4	4	2
14	2	4	3	1
15	3	4	2	4
16	4	4	1	3

Table II.
Properties and portfolios on willingness for urban forest improvement

most preferential one from among the three plans in each selection set, i.e. all the city resident has to do is put two ticks on each questionnaire (Zhu *et al.*, 2013; Zheng *et al.*, 2017).

2.2 Urban forest single-property demand analysis

This research makes the econometrics analysis through two MNL models of city residents' willingness for urban forest improvement, proceeding from city residents' willingness.

The dependent variables of the models are all the interviewed city residents' selective probabilities in the selection sets of different urban forest improvement plans; the dependent variables in Model 1 include property variables only and in the independent variables in Model 2 are added the city residents individual characteristic variable and the property variable's cross term, in addition to the included property variable. The computation results are shown in Table IV. In general terms, the coefficient calculated symbols are all conformant to their actual conditions and the significance level of Model 2 is in general higher than that of Model 1; the constant term ASC is a positive number, indicating that most interviewed city residents are inclined to select improvement plans; the city residents' environmental awareness is generally high, which enhances their WTP amount. Take the results of Model 2 for example, the city residents' education background, monthly income, years and or months of living in Beijing have significant impacts on their willingness for urban forest improvement; gender, age and number of people in the family have insignificant impacts, on the other hand. This shows that the higher their household income, the stronger their willingness and capacity for participating in urban forest improvement; in addition, the longer their years and months of living in Beijing, the deeper their perception of Beijing's environmental conditions, and hence, these city residents would focus more on

Properties	Plan 1	Plan 2	Plan 3
No. of greenbelts	Unchanged	Increase by 2 per annum	Increase by 4 per annum
Greenery coverage ratio	Keep 20%	Keep 20%	Keep 20%
Biodiversity	Unchanged	Increase in common species	Increase in protected species
Payment amount	RMB0	RMB50	RMB100
Your choice	☐	☐	☐

Table III.
Examples of plans for surveying city residents' willingness for urban forest improvement

Variables		Model 1 Estimated values	Model 1 SE	Model 1 *t*-value	Model 2 Estimated values	Model 2 SE	Model 2 *t*-value
	ASC	0.0114	0.0335	0.3403	0.0543	0.0135	4.0222
No. of greenbelts	Z_1	0.0456	0.0253	1.8024	0.0498**	0.0224	2.2232
Greenery coverage ratio	Z_2	0.1421***	0.0334	4.2545	0.1457***	0.0243	5.9959
Biodiversity	Z_3	0.2324***	0.0342	6.7953	0.3354***	0.0246	13.6341
Payment amount	Z_4	−0.0117	0.0265	−0.4415	−0.0114	0.0217	−0.5253
Environmental awareness × no. of greenbelts	$Q_1 \times Z_1$	–	–	–	0.0749***	0.0106	7.0660
Environmental awareness × greenery coverage ratio	$Q_1 \times Z_2$	–	–	–	0.2324***	0.0221	10.5158
Environmental awareness ×biodiversity	$Q_1 \times Z_3$	–	–	–	0.4122***	0.0239	17.2469
Environmental awareness ×payment amount	$Q_1 \times Z_4$	–	–	–	−0.0079	0.0187	−0.4225
Gender	P_1	–	–	–	−0.0994	0.1250	−0.7952
Age	P_2	–	–	–	0.0227	0.0156	1.4551
Education background	P_3	–	–	–	0.0917***	0.0122	7.5164
Monthly income	P_4	–	–	–	0.3485***	0.0596	5.8473
No. of people in the family	P_5	–	–	–	0.1118	0.0897	1.2464
Years of living in Beijing	P_6	–	–	–	0.8441***	0.0549	15.3752
Months of living in Beijing	P_7	–	–	–	0.7901***	0.0507	15.5838
Log likelihood		−1,356.1236***			−1,255.7682***		

Notes: *,**,***Indicates a significant level of 10, 5 and 1 percent

Table IV.
Results of MNL model regression estimation for Beijing's urban forest improvement

urban forest, thus more favoring the improvement in the development and construction of urban forest through a number of conducive measures.

Based on the results of model regression estimation, this research calculates the marginal monetary cost, i.e. the marginal value of various properties that must be paid for changing a certain property of urban forest (Table V). It can be seen from the table that the marginal values of biodiversity and greenery coverage ratio are far higher than those of number of greenbelts. Besides, the marginal values of various variables in Model 2 are all higher than those in Model 1, and the marginal value of biodiversity remains the highest, reaching RMB29.42.

The above results show that the interviewed city residents' preference for the number of greenbelts is by no means high, but they generally hope to attain a higher greenery coverage ratio and a richer biodiversity, indicating that what Beijing Municipality needs the most at present is not continuing to increase the number of greenbelts, but making the rational improvement of the existing greenbelts and further optimizing the urban forest structure.

2.3 Demand analysis of urban forest property portfolios

This research believes that there exist differences in the WTP of the utility brought from the a certain type of city residents' improved property state, i.e. various types of plans for selections are of different CS. Based on this, the information on property state improvement and corresponding value changes can be arrived at through calculations (Table VI).

It can be noticed from Table VI that Plan 13 is the city residents' optimal plan among all the property portfolio plans, i.e. the best choice for urban forest improvement implemented in the future. In addition, the interviewed city residents' preference for the number of greenbelts is by no means high, but they generally hope to attain a higher greenery

Table V.
Marginal values of properties of Beijing's urban forest

Property variables	Expressions	Model 1 (RMB)	Model 2 (RMB)
No. of greenbelts	$MWTP_{Z1} = -\beta_1/\beta_4$	3.90	4.37
Greenery coverage ratio	$MWTP_{Z2} = -\beta_2/\beta_4$	12.15	12.78
Biodiversity	$MWTP_{Z3} = -\beta_3/\beta_4$	19.86	29.42

Table VI.
Value accounting results for different portfolios of plans of Beijing's urban forest

	Improvement of property state levels			Improved willingness values	
Plan	No. of greenbelts	Greenery coverage ratio	Biodiversity	Model 1	Model 2
1	1	1	1	36.88	51.33
2	2	1	2	60.64	85.12
3	3	1	3	84.40	118.91
4	4	1	4	108.16	152.70
5	1	2	2	68.89	93.54
6	2	2	1	52.92	68.48
7	3	2	4	116.41	161.11
8	4	2	3	100.44	136.06
9	1	3	3	100.90	135.74
10	2	3	4	124.66	169.53
11	3	3	1	68.97	85.63
12	4	3	2	92.73	119.42
13	1	4	4	132.91	177.94
14	2	4	3	116.94	152.89
15	3	4	2	100.97	127.83
16	4	4	1	85.01	102.78

coverage ratio and a richer biodiversity, indicating that what Beijing Municipality needs most at present is not continuing to increase the number of greenbelts, but making the rational improvement of the existing greenbelts for them to be brought into fuller play, thus further optimizing the urban forest structure. To attain Plan 13, the improvement willingness value of city residents in Model 1 reaches 132.91 and this value in Model 2 reaches 177.94. The initial state of various plans and properties is the situation where city residents do not participate in the urban forest improvement; it can be thought therefore that city residents would choose Plan 13 as their best choice for the future implementation of forest improvement.

3. Conclusions and discussions

This research, proceeding from the demand of city residents for urban forest, analyzes the improving direction for and specific contents of urban forest improvement, with discussions about in what ways that urban forest needs for replenishment and improvement in the future. Specifically, this section, using the CEM, mainly discusses the property preferences and demand for urban forest improvement from three levels: define city residents' preferences for and degrees of urban forest improvement, proceeding from the personal utility theory; calculate the marginal values of property states and levels of urban forest to determine city residents' WTP of different properties, thus reflecting the key areas for urban forest improvement; and calculate CP for property portfolio plans of urban forest to determine the optimal property portfolio plans for urban forest improvement. This research analysis will be of great significance to the further development and improvement of urban forest.

The results of analysis of city residents' urban forest preferences and demand show: Beijing's city residents are generally inclined to accept a relatively low urban forest payment while hoping to access a relatively high urban afforestation coverage, build relatively many city parks and focus on making the specialized park management; the marginal values of biodiversity and greenery coverage ratio are far higher those of number of greenbelts and the marginal value of biodiversity remains as high as RMB29.42, indicating that the city residents' preference for the number of greenbelts is by no means high, but they generally hope to attain a higher greenery coverage ratio and a richer biodiversity. Generally speaking, what Beijing Municipality needs the most at present is not continuing to increase the number of greenbelts, but making the rational improvement of the existing greenbelts and optimizing the urban forest structure.

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