Journal of Landscape Research 2019,11(5): 35–40

Spatial Pattern Characteristics and Influencing Factors of National Forest Cities in China

HAN Jing[1], TANG Beipei[2], HOU Shaojing[1]
(1. College of Urban and Environmental Sciences, Northwest University, Xi'an, Shaanxi 710127, China; 2. Xi'an Natural Resources and Planning Bureau, Chang'an Branch, Xi'an, Shaanxi 710100, China)

Abstract In view of the deficiency of national forest cities in the exploration of spatial pattern and influencing factors, this paper adopted the methods of nearest neighbor analysis, kernel density analysis and unbalanced index calculation to analyze the spatial agglomeration pattern and spatial differentiation pattern of national forest cities. The factors affecting the selection and distribution of national forest cities were investigated by using the geographic detector and GWR model. The research results show that: ① National forest cities show a spatial aggregation pattern of "east and west sparse, gradient change", whose distribution is closely related to the climatic area; ② The number of national garden cities, forest coverage rate, urbanization rate and local general budget income are four factors that have significant influence on the selection and distribution of national forest cities; ③ The four significant influencing factors all have different degrees of spatial non-stationarity, and their two-factor and nonlinear enhancement effects can be generated after two interactions, among which the enhancement effect is the most obvious when the local general budget income interacts with other factors.

Keywords National forest cities, Distribution pattern, Influencing factors, GeoDetectors, GWR model
DOI 10.16785/j.issn1943-989x. 2019.5.010

In order to improve the urban ecological environment, promote the growth of forest resources and realize the integration of urban and rural development of ecological construction, the State Forestry Administration and the National Greening Committee initiated the selection and commendation activity of national forest cities in 2004, which together with national garden cities has become the highest honor of urban ecological construction in China[1]. After 14 years of development, the selection policies and construction goals of national forest cities have been constantly enriched and improved[18,19]. By the end of 2018, 158 cities had won this award, greatly promoting the construction of ecological civilization in China. The current related research about national forest cities is not much, there is only a small amount of researches on the basis of summarizing policy changes and selection index, the construction of key[2–3], development strategy[4–5], the index system[6] were discussed, or comparison with the national garden cities of[7-8], or with a single city as a case study of ecological landscape construction[9–10]. However, it is worth noting that the academic research on similar selection activities, such as national garden cities, national historical and cultural city, Chinese traditional village, etc., has achieved relatively fruitful results in spatial pattern analysis and exploration of relevant influencing factors[11–13], but there is almost no such research on national forest cities.

In view of this, this paper used ArcGIS nearest neighbor analysis, kernel density estimation, overlay analysis and other methods to depict the national forest cities spatial pattern, and on the basis of GeoDetector and GWR model to find out the releted factors affecting the national forest cities provincial distribution pattern of the related factors, screening and spatial effect analysis, in order to make the selection of national forest cities more scientific and reasonable, and provide ideas for the selection activities associated with the study and reference.

1 Research objects, data and methods

1.1 The research objects

The research objects of this paper are 158 national forest cities above the county level named by the end of 2018, excluding 7 cities, counties, districts and counties. xGeocouding was used to obtain the location coordinates of the 158 national forest cities, and their distribution was visualized in ArcGIS10.2 (Fig.1). National forest cities are distributed in 24 provinces in mainland China except municipalities directly under the central government and Hainan, Tibet and Gansu.

1.2 The data source

Study data were taken from website (http://www.mohurd.gov.cn) of Ministry of Housing and Urban-Rural Development PRC and Ministry of Forestry PRC (http://www.forestry.gov.cn). Administrative boundaries and other spatial data were derived from the 1:250,000 basic geographic information database established by the national center for basic geographic information (http://ngcc.sbsm.gov.cn). The city's statistical data were derived from the city's 2018 statistical yearbook and the national economic and social development statistical bulletin.

1.3 The research methods

1.3.1 Kernel density estimation. It is the most widely used in spatial analysis, and also has many applications in the study of geographical element distribution[14]. In this paper, the spatial data dimension is set to 3 to obtain the three-dimensional visualized kernel density map, which can more intuitively and stereoscopic reflect the distribution pattern of national garden cities and national forest cities than the common plane contour map. The method can be realized by means of Kernel Density tool integrated in the ArcGIS spatial analysis module. The calculation formula is as follows:

$$f_n(x) = \frac{1}{nh^3}\sum_{i=1}^{n} k\,(x-x_i/h) \quad (1),$$

In formula: $k\,(x-x_i/h)$ is the kernel density equation, h is the bandwidth, using default values; n is the total number of factors.

1.3.2 Unbalanced index. It can represent the equilibrium degree of distribution of national forest cities in different spatial scales, and the

Received: July 30, 2019 Accepted: August 25, 2019

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

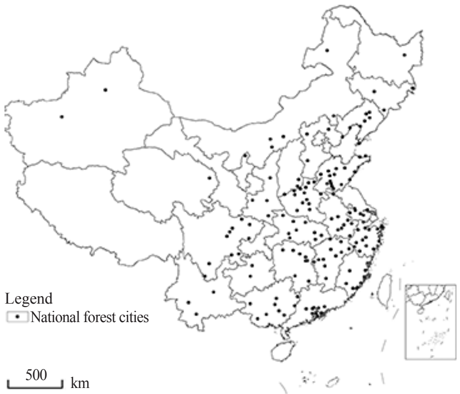

Fig.1 Spatial distribution of national forest cities

calculation formula is shown in the references[15]. The value of the index S is [0,1]. If S =0, it indicates the average distribution of the two types of cities in each region. If S =1, it indicates that both types of cities are concentrated in one area.

1.3.3 Geographic detector. Geographic detector is a spatial statistical method to reveal spatial differentiation and its driving force[16], including factor detection, ecological detection, interactive detection and risk detection. In this paper, based on the calculation of a single independent variable q value by factor detection, the interaction between independent variables is determined by interactive detection.

1.3.4 Geoweighted regression model (GWR). It can effectively estimate data with spatial autocorrelation and reflect the spatial non-stationarity of parameters in different regions. The model formula is as follows[17]:

$$y_i = \beta_0 (u_i, v_i) + \sum_{k=1}^{p} \beta_k (u_i, v_i) x_{ik} + \varepsilon_i \quad (2),$$

In formula: y_i is the value of the dependent variable of sampling point i; β_0 is the intercept, $(u_i, v_i)$is the coordinate of sampling point, and $\beta_0 (u_i, v_i)$ is the constant term of sampling point i ; $\beta_k (u_i, v_i)$ is the coefficient of the K^{th} independent variable of sampling point i, and x_{ik} is the K^{th} independent variable of sampling point i. ε_i is the random error term.

2 Results and analysis

2.1 Characteristics of spatial distribution pattern of national forest cities

2.1.1 Spatial agglomeration pattern. First, ArcGIS was used to analyze the average nearest neighbor distance of national forest cities (Fig.2), and calculated that the average observation distance was 105.393 km, the expected average distance was 139.895 km, the nearest neighbor index was 0.753, and the Z score was –5.912, and the significance level p value was < 0.01. The results show that the national forest cities present evident gathering on the space pattern. On this basis, the kernel density estimation of national forest cities was analyzed, and a three-dimensional visual expression map (Fig.3) was drawn to explore the specific areas and pattern expression of their spatial agglomeration. The results show that the spatial distribution of national forest cities presents two peaks of high density. Specifically, the high-density area on the lowest level of the topographic ladder has numerous mountains and formed an obvious "two-peak confrontation" pattern; the second level also has a certain degree of uplift; the highest level of the ladder shows a plain structure, and the national forest cities shows an obvious spatial clustering feature of "east and west sparse, gradient change".

2.1.2 Spatial differentiation pattern. The results of the nearest-neighbor index calculation and kernel density estimation above respectively reflect the spatial aggregation characteristics of national forest cities from two aspects of distance and density, namely, the imbalance of spatial distribution. On this basis, the spatial differentiation pattern of national forest cities is further explored from the two aspects of natural areas and provincial administrative regions.

(1) Natural areas. First of all, from the perspective of the seven geographical areas, the imbalance index of national forest cities was calculated to be 0.455, indicating that their distribution in the seven geographical units was relatively balanced. By region, east China is the most densely populated area of national forest cities, and central China and south China rank the second and third respectively. The number of national forest cities in the above three geographical regions accounts for more than 70% of the total number, with a strong momentum of "creating national forest cities". The number of national forest cities in northwest China is only a few and ranks the last, and its ability of "creating national forest cities" is obviously weak (Table 1).

Whether it is the increase of green quantity, the improvement of forest greening quality, or the conservation of urban forest, it will be restricted or promoted by climatic conditions such as water and temperature. The location information of national forest cities is superimposed on China's climate zoning map (Fig.4) to explore the influence of climate differentiation characteristics on spatial distribution and correlation of national forest cities. The figure shows that the distribution of the national forest cities of intensive in the warm temperate sub-humid regions, north tropical wet regions and humid tropical regions and tropical humid regions in South Asia, and further statistics show that the four regions contain respectively the number of the national forest cities 45, 34, 36, 26, a total of 141, the sum accounts for 89.24% of the total forest city number.

It can be seen that the national forest cities are obviously distributed in the warm temperate sub-humid regions and humid subtropical regions where the temperature and humidity conditions are good and suitable for plant growth. At the same time, the east China and central China is located in the both climatic regions, in addition, the Hainan Province in southern China are also located in the two regions, which therefore makes them on the number of national forest cities obvious advantages, and obviously restricted because of the climate in northwest China, and the reality foundation of "creating national forest cities" is insufficient.

(2) Provincial administrative region. The imbalance index of national forest cities at the provincial scale is calculated to be 0.53, indicating that the distribution is relatively balanced at the provincial scale. However, compared with the seven geographical regions mentioned above, the distribution of national forest cities at the provincial scale is more unbalanced. Further drawing Lorenz curve (Fig.5), it can be seen that Shandong, Zhejiang, Henan, Jiangxi, Sichuan, Hubei, Hunan, Guangdong, Guangxi and Anhui provinces are densely distributed areas of national forest cities, accounting for more than 60% of the total number. The number of national forest cities in the four municipalities

Table 1 Sub-geographical area statistics of national forest cities

Region	Number	Proportion	The cumulative proportion	Rank
Eastern China	63	39.87%	39.87%	1
Central China	32	20.25%	60.13%	2
South China	18	11.39%	71.52%	3
Southwest	15	9.49%	81.01%	4
Northeast	12	7.59%	88.61%	5
North China	10	6.33%	94.94%	6
Northwest	8	5.06%	100.00%	7

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

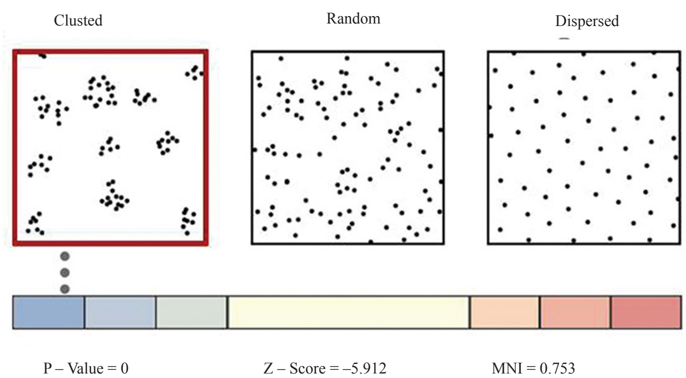

Fig.2 Nearest neighbor index

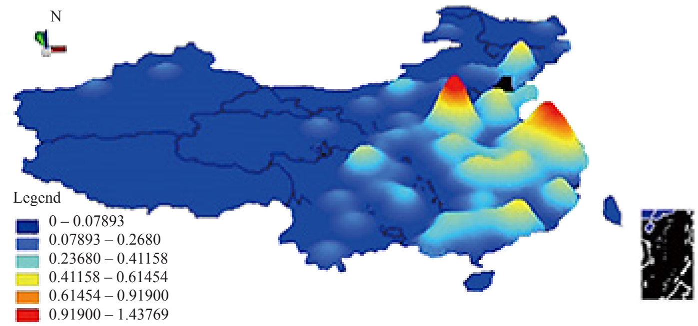

Fig.3 3D kernel density map of national forest cities

directly under the central government and the eight provinces and regions of Jilin, Heilongjiang, Hainan, Guizhou, Tibet, Gansu, Qinghai and Ningxia accounts for less than 5% of the total, which is a region with a small number of national forest cities, or even a blank area.

2.2 Factors influencing the distribution pattern of national forest cities

2.2.1 Variable selection. In the light of the national forest cities policy selection properties, on the basis of related literature[11-13], from four aspects of the selection standard, realistic foundation, capital investment and residents' demand, 12 detailed indicators are selected as independent variables, and to the national forest cities as the dependent variable, to the number of cities in the provincial scale of its spatial differentiation pattern of the influence factors are explored. The reasons, basis and meanings of each independent variable are detailed as follows (Table 2).

(1) Selection criteria. The evaluation and assessment system and standards of national forest cities have the most direct impact on the "creating national forest cities" activities of a region. Among them, forest coverage rate, urban green coverage rate of urban built-up areas and urban per capita park green area are the key quantitative indicators in the evaluation standards of national forest cities calendar edition, which reflect the construction capacity of urban green facilities. Therefore, these three indicators are taken as the selection criteria.

(2) Realistic basic factors. This factor includes the number of national garden cities, urbanization rate, forest thickness and average annual precipitation. Among them, there is a certain consistency between the evaluation criteria of national garden cities and national forest cities. Therefore, if a city has been named national garden cities, it has a good foundation in the management of greening

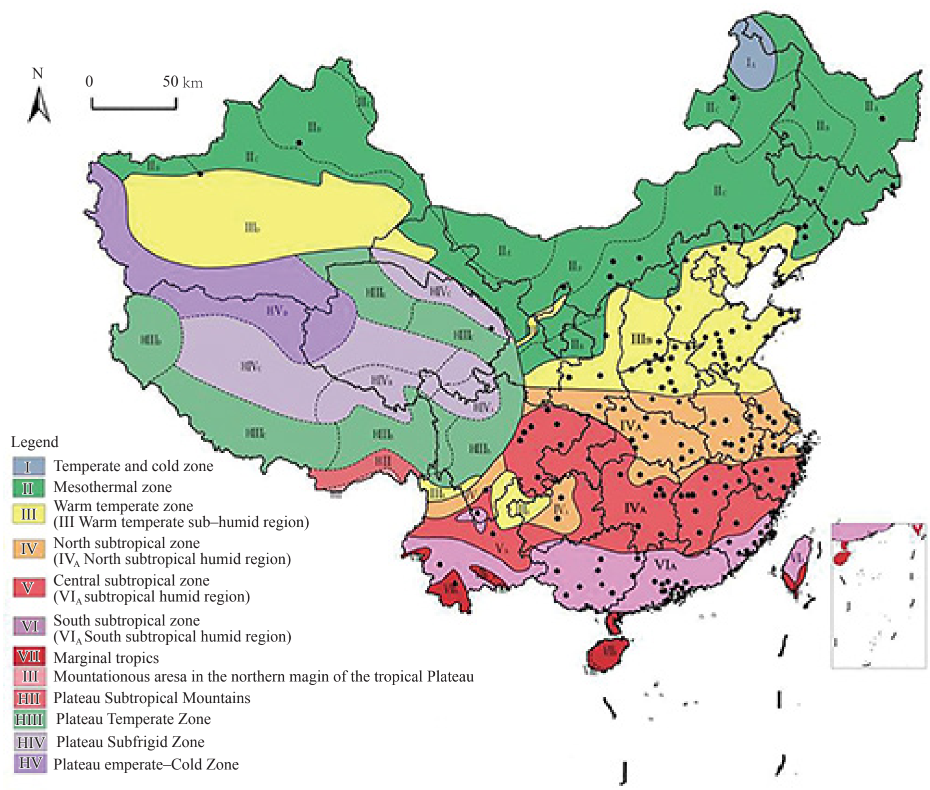

Fig.4 The superimposition of national forest cities on climate zones in China

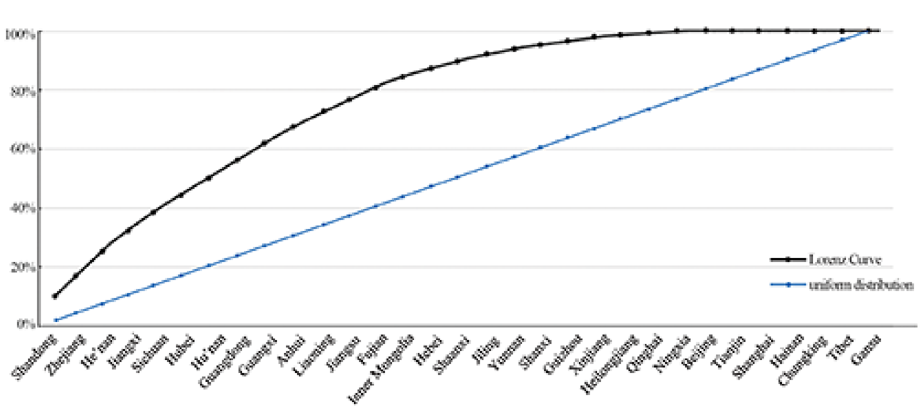

Fig.5 Lorentz Curve of national forest cities

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

construction. Therefore, it can be considered that the establishment of national garden cities affects the evaluation of national forest cities to some extent. The urbanization rate represents the development level of a region's cities, while the average annual precipitation and climatic conditions can represent the natural basic conditions of "creating national forest cities" in a region.

(3) Factors of capital investment. This factor includes per capita GDP, local general budget income and forestry investment completion amount. The first two of them can reflect the fund guarantee ability of "creating national forest cities", the latter represents the fund investment intensity of a district forestry.

(4) Residents' needs. With the increase of urban residents' income and the enrichment of material life, their demand for a good living environment will show an upward trend. Therefore, two indicators, urban residents' per capita disposable income and consumption level are used to represent the degree of urban residents' demand for environmental quality.

2.2.2 Factor analysis based on factor detection. The above 12 independent variables are screened by factor detection in GeoDetector, and the operation results are shown in Table 3. The forest coverage rate, the number of national garden cities, the urbanization rate and the local general public budget income are all less than 0.1, passing the significance test of 90%, which is the factor that has a significant impact on "creating national forest cities".

Specifically, the order of influence degree of the four explanatory variables is: National garden cities number >forest coverage rate > urbanization rate of local general budget income >urbanization rate, due to the assessment content of "creating national garden cities"shall always focus on the construction of green ecological space, which is somewhat identical with the assessment standard of "creating national forest cities", so a certain city, was named national garden city, the greening application of construction management and organization has had a good foundation, therefore, the intention and the behavior and the creation of national forest cities office will be incentives, therefore, realistic foundation and the criteria factors contained in the number of national garden cities and the influence degree of the forest coverage rate both ranked the top two. In essence, it shows that the selection of national forest cities is directly affected by "creating national garden cities " on the surface, but it is still affected by the selection standard

Table 2 Description of explanatory variables

Category	Indicator	Unit
Selection criteria	forest coverage rate	%
	Green coverage in urban built-up areas	%
	Urban per capita park green area	m^2
Realistic basic factors	Number of national garden cities	pcs
	Urbanization rate	%
	The thickness of the forest	mm
	Perennial average precipitation	mm
Capital investment	GDP per capita	Ten thousand yuan
	Local general budget revenue	Ten thousand yuan
	Forestry investment completed amount	Ten thousand yuan
Residents' needs	Per capita disposable income of urban residents	Ten thousand yuan
	The consumption level of urban residents	Ten thousand yuan

Table 3 Regression results of GeoDetector

Item	*q* statistic	*p* value
Number of national garden cities	0.782	0.000
Forest coverage	0.402	0.049
Local general budget revenue	0.372	0.048
Urbanization rate	0.334	0.068
Green coverage in urban built-up areas	0.245	0.247
Per capita park green area	0.114	0.583
GDP per capita	0.350	0.114
The consumption level of urban residents	0.119	0.603
Per capita disposable income of urban residents	0.145	0.574
Forestry investment completed amount	0.287	0.216
Perennial average precipitation	0.171	0.425
The thickness of the forest	0.226	0.285

from the root. In addition to the above two, a region's capital guarantee ability and the city's development level also play a very obvious role in "creating national garden cities ". The above results show that national forest cities are shaped by policy selection, realistic basis and capital input.

2.2.3 Analysis of influencing factors based on GWR model. Because factor detector can only by numerical to reflect the overall influence of the size of the independent variable on the dependent variable, and can't reflect the respective variable on the space difference of the influence degree of the different parts of the dependent variable and the positive and negative. Meanwhile, the Global Moran's I index of the number of provinces in national forest cities is 0.141, and Z score is 2.399, since there is space correlation, the further introduction of geographically weighted regression (GWR) model, the above four factors significantly influence the optimization analysis and equation. The "FIXED" and "ADAPTIVE" kernel types in GWR model were respectively used to analyze four influencing factors. The results show that the "FIXED" kernel type had better fitting performance, so the kernel type was selected for further analysis. The Adjusted R2 of the model was 0.693, which indicated a good fitting performance.

As can be seen from Table 4, the number of national forest cities and forest coverage rate still rank the first two, followed by the urbanization rate, showing a positive correlation, while local general budget income is negatively correlated, which may be related to the provincial analysis scale. Specifically (Fig.6):

(1) The regression coefficient of the number of national garden cities is between 7.772–7.776, and the fluctuation is not obvious, indicating that there is insignificant difference in the effect intensity of this influencing factor on "creating national forest cities" in various provinces, but compared with the northwest and northeast regions, the southeast, south China and southwest regions are slightly affected.

(2) The forest coverage rate of regression coefficient between 5.368–5.378, has the certain fluctuation change, effect from east to west, three northeast provinces of China, Zhejiang, Shanghai, the five provinces and regions affected by the largest, that is the future want to declare the five provinces and create national forest cities need to pay more attention to increase the forest coverage rate. In addition, the effect intensity of this factor in Xinjiang and Tibet is relatively weak.

(3) The urbanization rate of regression coefficient between 3.027–3.055, the fluctuation is obvious. The spatial changes of influence

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

Table 4 Summary of GWR model results

Explanatory variables	Mean value	Maximum	75% quantile	25% quantile	Minimum
Number of national garden cities	7.775	7.777	7.775	7.774	7.772
Forest coverage	5.374	5.378	5.376	5.373	5.368
Urbanization rate	3.045	3.055	3.050	3.042	3.027
Local general budget revenue	–1.685	–1.673	–1.680	–1.690	–1.700
bandwidth	36,474	–	–	–	–
AICc	160.358	–	–	–	–
R^2	0.734	–	–	–	–
Adjusted R^2	0.693	–	–	–	–

intensity are similar to the quantitative factors of national garden cities, showing the spatial differences of weak northwest and strong southeast. Xinjiang, Tibet, Qinghai, three areas affected by the youngest, and the effect of the strongest provinces in Shanghai, Zhejiang, Jiangxi, Fujian, Guangdong, Guangxi and Hainan, improve the rate of urbanization, which helps this seven areas to create national forest cities.

(4) The regression coefficient of public budget income is between –1.700 and –1.673, which is spatially manifested as a gradually decreasing step change from north to south. Its effect is more significant in northwest, northeast and north China, especially in the five regions of Xinjiang, Inner Mongolia and northeast provinces. South China is the least affected area, which is more influenced by the actual basis and urban development.

2.2.4 Interaction analysis of influencing factors. First use of ArcGIS Jenks natural fracture method for the quantity of the above four significant influence factors of stratification and translated into type, and then use the interaction in GeoDeetector to detect two interaction analysis was carried out on the factors, the results chart shown in table 5, the enhanced effect of both two factors work together will produce, including double factor enhanced for, $q(A \cap B) > q(A) + q(B)$ nonlinear enhanced to $q(A \cap B) > \mathrm{Max}(q(A), q(B)$, the enhanced

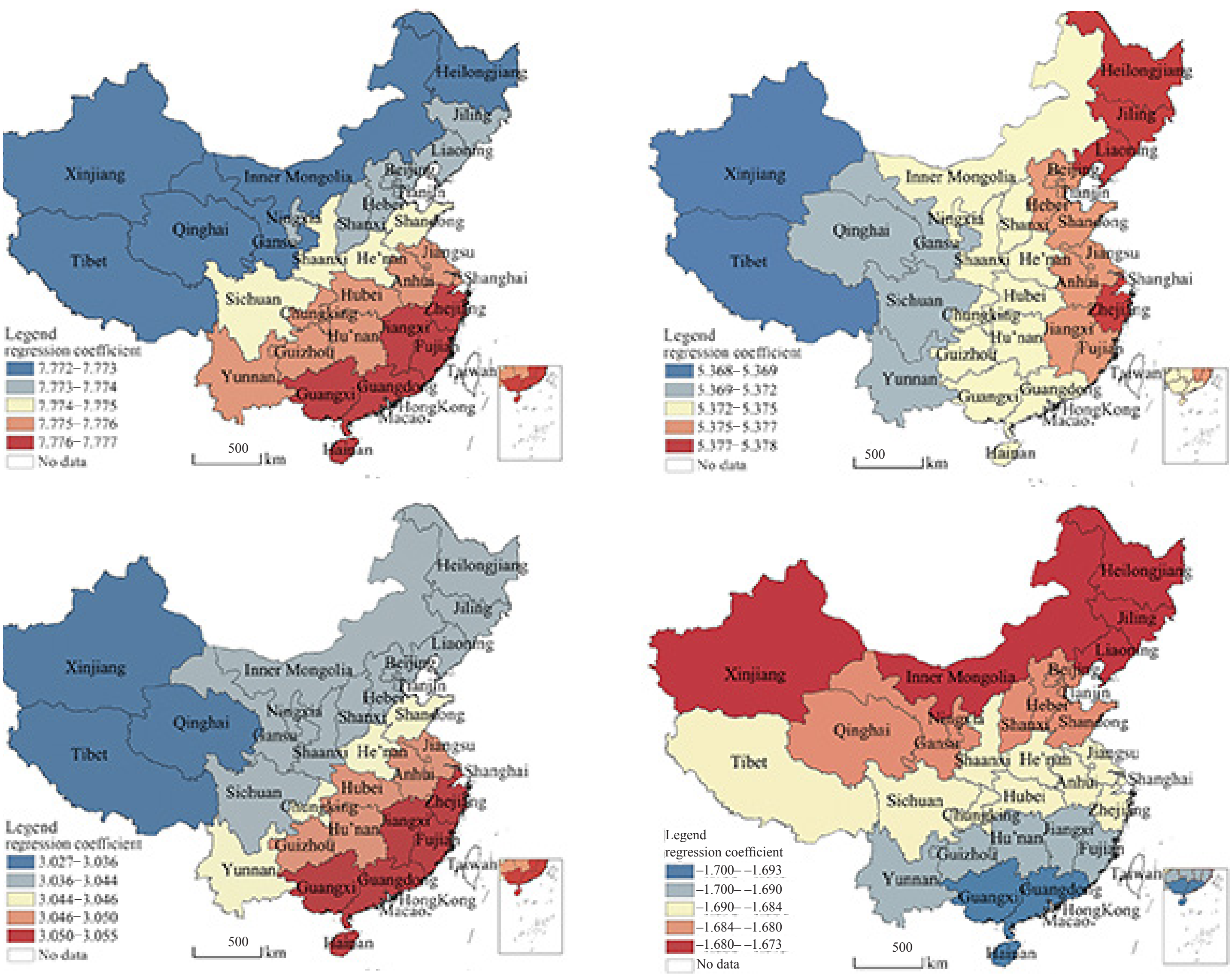

Fig.6 Spatial pattern of coefficient in GWR model

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

effect of the latter is greater than the former, so although the number of national garden cities this factor effect is strongest when alone, However, when the two factors work together, the synergistic promotion effect produced by the combination of local general budget income, forest coverage rate and urbanization rate is obviously better, and the q value of the effect intensity is also ranked in the top three. Therefore, great attention should be paid to the declaration and establishment of national forest cities. In addition, although the number of national garden cities and forest coverage have a two-factor enhancement effect when acting together, its q value still ranks the first, which is the interaction combination with the best effect.

Table 5 The results of interaction detection of influencing factors

Interactive influencing factors	q value	Types of interactions
The number of national garden cities ∩ forest coverage rate	0.853	↑
Population of national garden cities ∩ urbanization rate	0.795	↑
National garden cities population ∩ local general budget revenue	0.732	↑
Forest coverage ∩ urbanization rate	0.661	↑
Forest coverage ∩ local general budget income	0.804	↑↑

Note: ↑ is two-factor enhancement type; ↑ for nonlinear enhancement

3 Conclusion

In this research, the spatial pattern of national forest cities was characterized by nearest-neighbor index and three-dimensional kernel density analysis. Using the geographic detector and GWR model comprehensively, the paper analyzes the four categories of 12 independent variables selected, reveals the significant factors affecting the pattern of national forest cities, and describes the spatial heterogeneity of their effects, so as to further explore the interaction between the influencing factors with the help of geographic detector. The main conclusions are as follows:

(1) The national forest cities show a spatial aggregation pattern, and its distribution characteristics are mainly manifested as "east and west sparse, gradient change". The two high-density peaks coincide with the central plains urban agglomeration and Yangtze river delta urban agglomeration on the first step respectively. In addition, the distribution pattern of national forest cities is closely related to climate zones, most of which are located in east, central and south China regions located in sub-humid regions of warm temperate zone and subtropical humid regions.

(2) The number of national garden cities, forest coverage rate, urbanization rate and local general public budget income are four significant factors affecting the number of national forest cities, except the latter, all of which have positive effects, and the former has the strongest effect. The establishment of national forest cities and its spatial pattern are influenced by selection policy, realistic basis and capital investment. At the same time, the effects of the four significant factors are different in space, but their non-stationarity in space is different, and their distribution characteristics are different. Among them, the effect of urbanization rate is relatively strong in space heterogeneity, and the effect intensity of the number of national garden cities basically does not vary from province to province.

(3) The influence of the four significant factors on the spatial pattern of national forest cities is not independent of each other, and there are two interaction types, nonlinear enhancement type and two-factor enhancement type, which have greater influence than the single effect. Local general budget income has the most obvious enhancement effect on urbanization rate and forest coverage rate, and the best effect is the combination of the number of national garden cities and forest coverage rate.

References

[1] Liu, T. F., Duan, S. J. & Wang, Y. (2010). Review of the two sets of standards for urban ecological construction in China. *Chinese Landscape Architecture*, (3), 40-42.

[2] Liu, H. M. (2018). Research on priorities of building national forestry city. *Forestry Economics*, (3), 77-79.

[3] Wang, C. (2016). Some issues of forest city cluster construction in China. *Journal of Chinese Urban Forestry*, *14* (2), 1-6.

[4] Wu, H. J., Dan, X. Q. et al. (2017). Status quo, challenges and strategies of national forest cities development in China. *Forest Resources Management*, (5) ,14-19.

[5] Liu, H. M. (2017). Countermeasure analysis of urban forest city development in China. *Journal of Chinese Urban Forestry*, *15*(6), 52-54.

[6] Wang, W. B., Wu, K. L. et al. (2016). Research on the index system of the Pearl River Delta national forest cities group with Lingnan Characteristics. *Forestry Economics*, (8), 100-103.

[7] Peng, L. (2004). "Urban Forest" is against science: views of landscape architecture expert symposium should be replayed. *Landscape Architecture*, (55), 95-98.

[8] Zhang, J. P. (2015). Several ideas for founding garden cities and forest cities. *Journal of Anhui Agri*, *43*(4), 174-176.

[9] He, J. H., Yuan, Y. et al. (2019). Ecological civilization planning and the national-level forest city construction of Foshan. *Planners*, (8), 59-65.

[10] Luo, N. (2013). *Research on Linhai Forest City Construction Planning*. Zhejiang University. (Master's//thesis) Retrived from China National Knowledge Infrastructure.

[11] Rui, Y., Tang, B. P. & Wang, X. et al. (2018). The spatio-temporal evolutionary characteristics and the impact mechanism of national garden cities in China. *Geography Research*, *37*(1), 20-36.

[12] Han, J., Rui, Y. & Ma, T., et al. (2019). Evolution and influencing factors of inter provincial distribution pattern of national garden counties. *Resources and Environment in the Yangtze Basin*, *28*(4), 828-838

[13] Yu, L. L. (2010). The space evolution of the national history city regions: land use research. *Economic Geography*, *30*(1), 12-16.

[14] Gao, C., Jin, F. J. (2015). Spatial pattern and industrial characteristics of economic technological development areas in eastern coastal China. *Acta Geographica Sinica*, *70*(2), 202-213.

[15] Feng, Y. F., Yu, W. Y. & Lei, R. L. (2017). Spatial distribution features and controlling factors of traditional villages in Guangdong Province. *Scientia Geographica Sinica*, *37*(2), 236-243.

[16] Wang, J. F., Xu, C. D. (2017). Geodetector: principle and prospective. *Acta Geographica Sinica*, *72*(1), 116-134.

[17] Wu, P., Li, T. S. & Li, W. M. (2018). Spatial differentiation and influencing factors analysis of rural poverty at county scale: a case study of Shanyang county in Shaanxi province, China. *Geography Research*, *37*(3), 593-606.

[18] Wang, D. M. & Wang, C. K. (2015). Study on Urban Forest Construction Concepts and Layouts in Taizhou City. *Journal of Landscape Research*, *7*(2), 35-39.

[19] Yin, W. D. & Mu, B. & Zhang, W. X. (2016). Urban Forest Layout of Taiyuan City. *Journal of Landscape Research, 8*(1), 33-34, 40.

(C)1994-2020 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net