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Construction of Ecological Security Pattern in Shandong Province Based on Ecological Red Line

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Abstract: *Constructing regional ecological security pattern and solving environmental problems are the key to realize regional sustainable development. Taking Shandong Province as the study area, this paper establishes the ecological source and establishes the ecological security pattern by using the least resistance model. Identifying ecological source and building ecological security pattern according to ecological red line area can not only improve the scientificity of practice, but also provide technical support for delimiting regional ecological red line and building ecological security pattern. Constructing regional ecological security pattern and solving environmental problems are the key to realize regional sustainable development. Taking Shandong Province as the study area, this paper establishes the ecological source and establishes the ecological security pattern by using the least resistance model. Identifying ecological source and building ecological security pattern according to ecological red line area can not only improve the scientificity of practice, but also provide technical support for delimiting regional ecological red line and building ecological security pattern.*

Keywords: *Ecological security pattern, Ecological red line, Minimum resistance model, Shandong Province*

1. Introduction

The degeneration of ecosystems, the loss of biodiversity, the desertification of land, the erosion of soil and water, the pollution of water, air and soil and other problems caused by the unreasonable use of human beings have resulted in great changes in the ecosystems of our country [1]. By connecting ecological red line with ecological security pattern, establishing regional ecological security pattern can effectively promote regional ecological protection and maintain the stability of ecological system. The research mode of "ascertaining source-tectonic resistance surface-extracting corridor" has been widely used in ecological security, and the minimum cumulative resistance model (MCR) is mainly used to discuss the selection of resistance factors, the structure of resistance surface and the interpretation of safety pattern, while the identification method of source is relatively lacking [2-3]. By delineating the ecological red line to determine the source, build the ecological security pattern of the region, thus establishing a more comprehensive and systematic ecological security pattern [4-8].

In this paper, Arcgis 10.2 and the corresponding technology are used to study the ecological security pattern of Shandong Province. Taking the importance of ecosystem service function and environmental sensitivity of Shandong Province as evaluation indicators, the ecological protection red line is delineated and analyzed, and included in the framework of ecological security pattern [9-10].

2. Research areas and methods

2.1. Survey of study area

Shandong Province is located on the east coast of China and the lower Yellow River, 34°25N~38°23N ,114°36E~122°43E. The province covers an area of 158,000 square kilometers and has 16 prefecture-level cities. Shandong Province is located at the middle end of the three ladders which are descending from west to east in China. The general topographic features are high in the middle, low in

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the surrounding areas and various types of topography. The climate of Shandong Province belongs to the warm temperate monsoon climate type, with mild climate, concentrated rainfall, uneven distribution of rainfall season and rich mineral resources.

2.2. Data source and data processing

Based on the GIS platform, this paper evaluates the provincial eco-environmental quality and delimits the ecological space by using the comprehensive assessment technology of ecological importance and degradation. Based on the latest remote sensing images and land survey data, the ecological factors such as river, forest, lake and grassland are determined by remote sensing interpretation. Overlay important ecological functional areas, various types of protection areas and other land, water and sea areas that need to be protected for comprehensive analysis to ensure the integrity and stability of ecological systems and preliminarily determine ecological space.

3. Ecosystem identification method

According to the main ecological functions and eco-environmental sensitivity characteristics of the major ecological function areas in Shandong Province, the ecological service importance and eco-environmental sensitivity assessment method are adopted to determine the ecological red line area in Shandong Province. Secondly, on the basis of determining the ecological red line and referring to the construction mode of urban landscape ecological security pattern, the ecological source land and urban land are selected. ArcGIS 10.2 was used, based on the model of minimum cumulative resistance, through the minimum cumulative resistance and difference between ecological source land and urban land. Through further study, the spatial layout of buffer zones, ecological corridors, radiation channels, strategic nodes and other areas is obtained, thus establishing the overall ecosystem of the ecosystem [5].

3.1. Ecological red line delineation method

In this paper, the ecological red line in Shandong Province has been delineated by the use of water resources conservation, biodiversity protection, soil conservation, windbreak and sand-fixation, desertification, geological disaster of land desertification and other indicators on the importance of ecosystem services function and ecological sensitivity assessment results [7-9], and its comprehensive analysis has been made to obtain the value of ecosystem services. Through the method of grading natural discontinuity, the importance is divided into five grades, which are unimportant, generally important, moderately important, highly important and extremely important. Detailed assessment methods are shown in Table 1. The sensitivity evaluation results of soil and water loss and geological hazards were classified by the same analysis method, including insensitivity, sensitivity, medium sensitivity, high sensitivity and extreme sensitivity. Finally, the ecological red line of Shandong Province was determined by adding the extremely sensitive and highly sensitive grades of the extremely important ecosystem resources.

Table 1: Methodology for assessment of the importance and ecological sensitivity

Type of evaluation	Formula	Parameter
Water conservation	$NPP_{mean} \times F_{sic} \times F_{pre} \times (1-F_{slo})$	F_{sic} is soil seepage, F_{pre} is precipitation., F_{slo} is a slope
Biodiversity conservation	$NPP_{mean} \times F_{pre} \times F_{tem} \times (1-F_{alt})$	Temperature for F_{tem} and altitude for F_{alt}
Soil conservation	$NPP_{mean} \times (1-K) \times (1-F_{slo})$	K is soil erodibility and F_{slo} is slope.
Soil erosion	$SS_i=4\sqrt{R_i \times K_i \times LS_i \times C_i}$	SS_i is i space unit sensitivity index of soil and water loss, R i is rainfall erosivity,K_i is soil erodibility,LS_i is long slope,C_i is vegetation cover.
Geological hazard	$GS_i=\sqrt{\prod_{i=1}^{2} G_i}$	GS_i is i space unit geological hazard sensitivity index,G_i is the sensitivity rating of the i factor

3.2. Construction of Ecological Security Pattern

In this study, the minimum cumulative resistance model is used to establish the minimum cumulative resistance surface of ecological source land and urban land in Shandong Province. The MCR model was initially applied to the biological protection safety regime, which reflects the minimum resistance from any point in a spatial plane to each source [8]. MCR difference = MCR ecological source - MCR urban

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land. If the difference is negative, it indicates that the ecological source of the area is relatively less resistant to expansion, and is more suitable for the expansion of ecological source. If the difference is positive, it indicates that the area is more suitable for the expansion of urban area. If the difference is 0, this is the boundary between the expansion of ecological source of the area and the expansion of urban land.

3.2.1. Determination of source

Source areas are natural habitats of existing biodiversity, and their internal consistency and capacity to expand or absorb play an important role in maintaining landscape ecosystems and should be protected. The ecological red line area is the basic guarantee area for the protection of regional ecological security. In the construction of ecological security system in Shandong Province, the land ecological security pattern is constructed. Debris and tiny patches were removed in accordance with the integrity and sustainability of the ecological environment [10-12].

3.2.2. Determination of resistance surface

Land use, vegetation cover, geological disaster conditions and other factors on the ecological protection of land development and utilization of different degrees. Combined with the actual situation of Shandong Province, the region influence factor with high relevance is selected to construct resistance surface. After normalizing or classifying the initial data of a single factor, the resistance is assigned. According to the influence degree of each index, the weight of each index is calculated by AHP method in Table 2.

Table 2: Grading and Weights of Resistance Factors of Ecological Source Area Expansion

Evaluation factor	Weight		Resistance value		Resistance value		Resistance value
		Woodland	0	Wetland	5	Shrub woodland	10
Land use	0.260	Sparse woodland	15	Grassland	20	Cultivated land	30
		Garden	50	Other Land	70	Artificial land	100
Distance from town settlements	0.136	<0.25km	90	0.5-1km	50	>2km	10
		0.25-0.5km	70	1-2km	30		
Distance from mining site	0.114	<1km	90	2-5km	50	10-15km	10
		1-2km	70	5-10km	30	>15km	0
Distance from river	0.087	<1km	10	3-5km	50	>10km	90
		1-3km	30	5-10km	70		
Distance from railway	0.071	<1km	90	2-5km	50	10-15km	10
		1-2km	70	5-10km	30	>15km	0
Distance from road	0.053	<0.5km	90	1-2km	50	5-10km	10
		0.5-1km	70	2-5km	30	>10km	0
Sensitivity of soil erosion	0.053	Extremely sensitive	90	Sensitivity	50	Insensitive	10
Sensitivity of land desertification	0.053	Extremely sensitive	90	Sensitivity	50	Insensitive	10
Slope index	0.110						
Topographic potential index	0.056						

Resistance values are normalized by range method 0~100

3.2.3. Construct Ecological Security Pattern

In the construction of ecological security pattern in Shandong Province, it generally includes the selection of ecological source, ecological resistance surface, buffer zone, ecological corridor and strategic node. After determining the ecological source and the resistance surface, the minimum cumulative resistance difference and the maximum cumulative resistance difference were obtained by using the minimum cumulative resistance model. Using the result of the minimum accumulated difference, the distribution of the ecological security pattern in this area was obtained.

The buffer zone is a potential area for natural restoration and expansion of a natural habitat. In the pattern of ecological security, the buffer range and boundary of different safety levels are determined according to the mutation interval of the minimum resistance isoline[15][16].

Ecological corridor, as a low cumulative resistance area of ecosystem, can combine two similar ecosystems, which is similar to an ecological corridor with low resistance[17][18].

Radiation pathway refers to the low resistance valley line of plant population in the ecological environment. It is a way of low resistance and possible expansion of biological activities. Using the hydrological calculation technique of ArcGIS 10.2, the plane valley range of minimum cumulative resistance was extracted and used as radiation channel.

The node of ecological strategy is the intersection of ecological corridor and least resistance corridor, and the weak point of ecological corridor.

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4. Results and discussion

Ecological source is an important part of establishing ecological security pattern, and its accuracy and scientific nature will have a significant impact on the construction of the entire ecosystem [19]. Ecological protection red line delineation is the key link of regional ecological protection, its ecological system is very sensitive and fragile, its geographical boundaries are clear, to some extent, there is no cross. Therefore, taking the red line of ecological protection as the ecological source of regional ecological security pattern provides a new idea for the construction and optimization of ecological security pattern.

4.1. Ecological red line delineation

Based on the method of delineating the ecological red line in Shandong Province, the study area is analyzed from four aspects: water conservation, soil and water conservation, windbreak and sand-fixation, and biodiversity maintenance.

Based on the ecological sensitivity assessment of soil erosion and land desertification, the eco-sensitive areas in Shandong Province include the hilly area in the middle and south of Shandong Province, the hilly area in the Jiaodong Peninsula and the coastal area in the southeast of Shandong Province, covering an area of 47,900 square kilometers, accounting for 30.00% of the whole province.

The ecological red line distribution in Shandong Province was determined by superimposing the sensitive and sensitive areas of soil and water loss and geological hazards in the study area.

4.2. Ecological security pattern of Shandong Province

The MCR model is used to determine the minimum cumulative resistance surface. The minimum cumulative resistance surface refers to the continuous surface of population migration in time and space. Its resistance surface is similar to the surface. By using ArcGIS's Cost Range Finding Model, the minimum cumulative resistance surface of the source region is calculated and simulated. The difference between the minimum cumulative resistance is the largest in the southwest and northwest plains of Shandong Province, where the terrain is relatively flat and human activities are frequent, while the central areas of Shandong Province (Tai'an and Laiwu) and the northeastern areas of Shandong Province (Yantai and Weihai) are relatively steep and are restricted by human factors to form low-lying areas.

Based on the relationship curve between the minimum cumulative resistance value and the grid area, reclassify in ArcGIS 10.2 is used to reclassify, and Jenks breakpoint method is used to divide the resistance surface into 3 grades according to the mutation point. High-level buffer zones shall be prohibited development zones to strengthen ecological protection, and all forms of development and construction activities shall be strictly prohibited; intermediate-level ecological buffer zones shall be restricted development zones in the course of economic development in Shandong Province, focus on protection of ecological environment, prohibit development and construction activities which harm ecological system functions, and maintain ecological system stability. Low-level ecological buffer zones shall strengthen development of ecological infrastructure, carry out ecological restoration for areas with serious ecological environment damage, and ensure ecological system stability.

According to the path model of minimum cumulative resistance and minimum consumption, ArcGis 10.2 is used as the spatial analysis software platform to optimize the objective function. There are 284 ecological corridors with a total length of 102,000 km in Shandong Province. Radiant pathway is the possible direction for species during migration. For species, the path should not only consider one ecological corridor, but also establish several paths. Therefore, the valley line in the surface of minimum cumulative resistance, as a low resistance route except ecological corridor, is the potential route of species movement, which can provide supplement for ecological corridor. There are 300 nodes in Shandong Province, among which there are 260 intersections between ecological corridor and ecological corridor and 40 intersections between ecological corridor and maximum resistance path. Ecological strategy node is the most vulnerable area of ecological corridor. Ecological protection and construction should be strengthened in this area, which plays an important role in the integrity of regional ecosystem.

Many factors need to be considered in the construction of ecological security pattern, and the identification of ecological source will have a great impact on the construction of ecological security pattern in the whole region.

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References

[1] Ye Xin, Zou Changxin, Liu Guohua, Lin Naifeng, Xu Mengjia. Main Contents and Progress of Ecological Security Pattern Research. Journal of Ecology, 2018, 38 (10): 3382-3392.
[2] Yue Deipeng, Yu Qiang, Zhang Qibin et al. Progress in Research on Optimization of Regional Ecological Security Pattern [J]. Journal of Agricultural Machinery, 2017, 48 (2): 1-10.
[3] Yu Kongjian. Landscape Ecological Security Pattern of Biological Protection [J]. Journal of Ecology, 1999, 19 (1): 8-15.
[4] Lv Yinchao. Construction of Urban Ecological Security Pattern Based on Ecosystem Service Value [D]. Suzhou University of Science and Technology, 2019.
[5] Mengjijun, Wang Ya, Wang Xiaodong, et al. Construction of Landscape Ecological Security Pattern of Guiyang City Based on Minimum Cumulative Resistance Model [J]. Resources and Environment of the Yangtze River Basin, 2016, 25 (7): 1052-1061.
[6] Peng Xichen. Delineation of Ecological Protection Red Line in Anhua County, Hunan Province Based on Minimum Resistance Model. Shenyang Agricultural University, 2018.
[7] Hu Fei, Yu Yiqi, Zheng Yue, Yang Xie. Study on the Method of Delineation of Ecological Protection Red Line [J], Planner, 2018, 34 (05): 108-114.
[8] Shanshan Yang, Changxin Zou, Weishou Shen, et al. Construction of Ecological Security Pattern Based on Ecological Red Line Division: Taking Jiangxi Province as an Example [J]. Journal of Ecology, 2016, (01): 250-258.
[9] Yuan Pengqi. Study on Ecological Red Line Delineation of Ruyang County Based on Ecological Security Pattern. Huazhong University of Science and Technology, 2019.
[10] Knaapen JP, Scheffer M, Harms B. Estimating habitat isolationin landscape planning [J]. Landscape Urban Planning, 1992, 23 (1): 1-16.
[11] Zhaodianhong. Ecological Security Pattern Evaluation and Ecological Red Line Delineation: Based on Fragmentation Analysis [J]. Fujian Architecture, 2017 (11): 15-21.
[12] Du Shixun, Rong Yuejing. Spatial Recognition of Ecological Security Patterns in Shanxi Province [J]. Soil and Water Conservation Study, 2017, 24 (06): 147-153 2. DOI: 10.13869/j.cn. rswc. 20170925.001.
[13] Li Guoyu, Lin Lichun, Luo Dongshen, Wang Qiang. Ways to Optimize the Pattern of Ecological Land Protection in Fuzhou [J]. Notification on Water and Soil Conservation, 2019, 39 (02): 234 - 241.
[14] Li Weijia, Ma Lin, Zang Zhenhua, Gao Jian, Li Junqing. Construction of ecological security pattern of Erhai Basin based on ecological red line [J]. Journal of Beijing Forestry University, 2018, 40 (07): 85-95. DOI: 10.13332/j. 1000-1522.20170074.
[15] Wu K. Delineation of the Red Line of Ecological Protection and Discussion on the Measures of Management and Control under the Territorial Space Planning: Taking Shandong Province as an Example [J]. East China Forest Manager, 2020, 34 (01): 4-7.
[16] Wu Bing, Wu Yuanxiang, Wang Hanyu, Liu Qing, Ma Fang. Research on Ecological Environment Spatial Hierarchical Management and Control Strategy [J]. Environmental Protection Science, 2017, 43 (01): 1-5. DOI: 10.16803/j.cnki.isn. 1004-6216. 2010.
[17] Li Guoyu. Optimization of Ecological Land Protection Layout in Fuzhou Based on Landscape Safety Pattern Approach [D]. Fujian Normal University, 2018.
[18] Chen Xiaoliang, Chen Guosheng, Xiang Xiaowen. Construction of Ecological Security Pattern Based on Ecological Red Line Division: Taking Hunan Province as an Example [J]. Journal of Wuhan Polytechnic, 2017, 16 (05): 55-58.
[19] Han Qiyao. Red Line Planning for Ecological Protection of Acheng District, Harbin City [D]. Harbin Institute of Technology, 2016.