Identification and Optimization Strategy of Ecological Security Pattern in Zhaoyuan City

Jin Wang[1], Youzheng Sun[2(✉)], Meihuan Yang[3], and Baoqiang Chen[4]

[1] Xi'an FanYi University, Xi'an 710054, China
[2] The First Institute of Photogramemetry and Remote Sensing, Ministry of Natural Resources, Xi'an 710054, China
972581573@qq.com
[3] Xi'an University of Science and Technology, Xi'an 710054, China
[4] China Coal Xi'an Design Engineering Co., Ltd., Xi'an 710054, China

Abstract. Human activities have seriously threatened the natural ecological security at present. In order to better promote the construction of ecological civilization, how to accurately identify the ecological security pattern has become the key. Taking Zhaoyuan City, a typical resource-rich coastal city, as the research object, the ecological source was identified comprehensively based on habitat quality and ecosystem service value combined with landscape connectivity. The MCR model was used to construct the comprehensive resistance surface, and the circuit theory was used to extract the ecological corridor and ecological key points. Based on this, the ecological security pattern of the coastal resource-rich area was constructed, and the targeted restoration suggestions were put forward.

Keywords: ecological security pattern · habitat quality · ecological source · minimum cumulative resistance model · Circuit theory · ecological corridor

1 Research Status of Ecological Security Pattern

With the rapid advancement of urbanization, ecological and environmental problems such as the reduction of ecological land, degradation of habitat quality, intensification of landscape fragmentation, reduction of ecosystem service functions, and loss of biodiversity functions have emerged, which seriously threaten the sustainable development of the region [1]. In 2017, the report of the 19th National Congress proposed to "implement major projects for the protection and restoration of important ecosystems, optimize the ecological security barrier system, and build ecological corridors and biodiversity conservation networks" [2, 3] as one of the important tasks of building a beautiful China.

2 Overview of the Study Area and Data Sources

2.1 Overview of the Study Area

Zhaoyuan City (37°05′–37°33′N, 120°08′–120°38′E) is located in the western part of Yantai City, Shandong Province (Fig. 1). Total land area within the territory.

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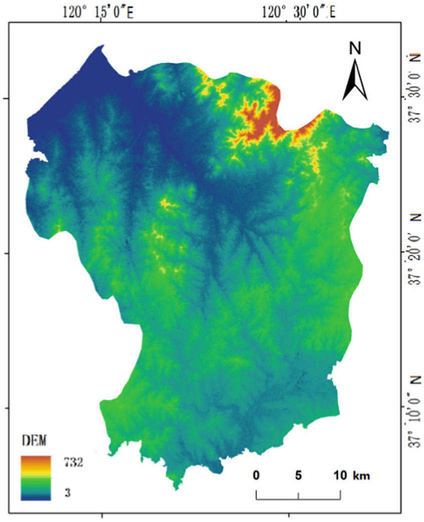

Fig. 1. Location map of Zhaoyuan City

The area is 1432.32 square kilometers, of which 471.23 square kilometers are mountainous areas, accounting for 32.9% of the total land area; 550.01 square kilometers in hilly area, accounting for 38.4%; The plain area is 328 square kilometers, accounting for 22.9%; The depression covers 83.07 square kilometers, accounting for 5.8%. The terrain is high in the northeast, central and west, as shown in Fig. 1.

2.2 Data Sources

The 2018 land use vector data came from the Land and Resources Bureau of Zhaoyuan City, which was mainly used for habitat quality analysis and ecosystem service value estimation. DEM data with a spatial resolution of 30 m × 30 m is derived from the geospatial data cloud platform (http://www.gscloud.cn). Basic vector data such as road traffic in Zhaoyuan City, from the Open Street Map data platform (http://www.openstreetmap.org); The socio-economic data comes from the 2019 Zhaoyuan Statistical Yearbook, which is used to calculate grain production and planting area.

3 Research Methods

3.1 Identification of Ecological Origins

In this paper, three indicators were selected to identify ecological sources, namely habitat quality, ecosystem service function and landscape connectivity [4], and the three outcomes were superimposed with equal weights, and the selection level was higher and the area was greater than 0.4 km^2 as an ecological source.

(1) Assessment of habitat quality. Habitat quality is an analysis of the impact of anthropogenic threat factors on land use/cover patch. This paper uses the Habitat Quality

Table 1. Attribute tables of threat factors

Threat factor	Maximum distance (km)	Weight	Spatial decay type
Cultivated land	0.5	0.4	linear
Town land	6	1.0	exponential
Rural settlements	4	0.6	exponential
Mining land	5	0.8	exponential
Transportation land	3	0.6	linear
Other land uses	2	0.3	linear

module in the InVEST model to evaluate habitat quality, explores the changes of habitat quality according to the data required by the model and the model evaluation principle, and mainly refers to the InVEST model user manual and similar phase for the setting of the parameters in the threat factor attribute and the parameters involved in sensitivity [5], as shown in Table 1.

(2) Assessment of the value of ecosystem services. In this paper, the latest revised equivalent of ecosystem service value per unit area [5] by scholars Xie Gaodi et al. in 2015 was used to estimate the value of ecosystem services in Zhaoyuan City. Based on the research of Xie Gaodi et al., 1/7 of the average grain value per unit area in that year was used as the economic value equivalent of ecological service value [6]. The grain output of Zhaoyuan City in 2018 was 5569.646kg/hm^2, and the average grain price was 2.36 yuan/kg, which was calculated as Zhaoyuan City 2018. The annual economic value of the equivalent factor of ecological service value is 1877.766 yuan/hm^2.a, From this, the value of ecosystem services in Zhaoyuan City is calculated.

(3) Landscape connectivity. The degree to which ecological landscapes affect the circulation and obstruction of species is landscape connectivity. In this paper, Guidos software is used to extract the core area of landscape type combined with morphological spatial pattern analysis method (MSPA).

3.2 Comprehensive Resistance Surface Determination

The minimum cumulative resistance model (MCR model) refers to the model of the total resistance that a species needs to overcome to overcome in its journey from source point to target location. According to the geographical characteristics of Zhaoyuan City, six impact factors (Table 2) are selected to construct the MCR model. Referring to the research results of previous scholars [7], and then the comprehensive resistance surface is calculated according to the weight corresponding to the impact factor.

3.3 Construction of Ecological Corridors

Ecological corridors refer to the passages through which matter and energy flow between various ecological sources. This paper uses circuit theory to identify the ecological corridor of Zhaoyuan City by constructing a comprehensive resistance surface, using

Table 2. Weight and coefficient of resistance factors

Impact factor	Weight	Resistance factor	Drag coefficient	Impact factor	Weight	Resistance factor	Drag coefficient
Type of land use	0.400	woodland	1	Aspect	0.100	South	1
		Meadows, waters	3			Southeast, southwest, flat land	3
		cultivated land	5			Due east, due west	5
		Other lands	7			Northeast, Northwest	7
		Construction land	9			Due north	9
Undulation	0.150	<150°	1	Distance from road	0.125	<1000	9
		150°-300°	3			1000–2000	7
		300°-450°	5			2000–3000	5
		450°-600°	7			3000–4000	3
		>600°	9			>4000	1
slope	0.100	<8°	1	Distance from a body of water	0.125	<500	9
		8°-15°	3			500–1000	7
		15°-25°	5			1000–1500	5
		25°-35°	7			1500–2000	3
		>35°	9			>2000	1

circuit theory, and using the Linkage pathway tool tool. Combined with the research results of predecessors and the current situation of the research area [8, 9], this paper constructs an ecological corridor with a width of 700 m.

4 Results and Analysis

4.1 Identify Ecological Origins

The high-value areas of habitat quality in Zhaoyuan City are widely distributed in the low hilly areas, and the land use types are mainly forest land and water areas. The low-value area is located in relatively concentrated towns and settlements, mainly distributed in the middle of the study area, and the area accounts for a relatively large area. The total value of ecosystem services in Zhaoyuan City is 4.244 billion yuan, with high service values for forest land and water ecological systems, and lower construction land and surrounding farmland. The overall distribution is characterized by lower north-south and central parts and higher east-west. Areas with high values of landscape connectivity have scattered patches and low overall levels, mainly arable land and forest land.

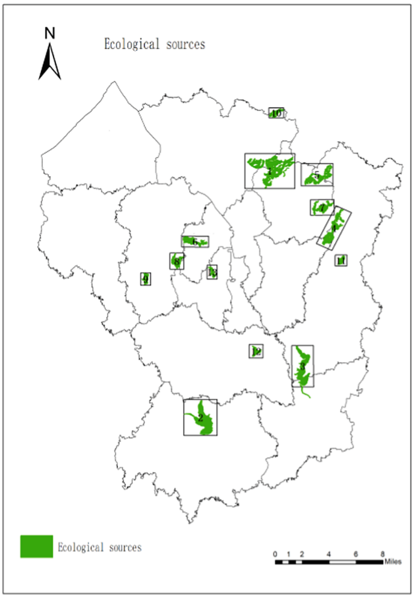

Fig. 2. Identification of ecological sources

In this paper, 13 ecological sources were identified, as shown in Fig. 2, with a total area of 23.11 km^2, accounting for 1.6% of the total area of Zhaoyuan City, mainly woodland and water. It is found in reservoirs and waters in the low hilly areas in the east and in the northwest. The northern and central parts of the study area are mainly urban areas and mining areas, and the ecological source distribution is small.

4.2 Build Comprehensive Resistance Surfaces and Ecological Corridors

The high-value area of the comprehensive resistance surface is located in the central urban area of Zhaoyuan City, and the distribution is relatively concentrated, while the distribution of other areas is scattered and fragmented, and the overall distribution of the comprehensive resistance surface is similar to the resistance surface of the land use type. The central and northern parts of Zhaoyuan City have a large resistance value compared with other regions. The areas with low ecological resistance are mainly distributed in the low hilly areas, and the land use types are mainly woodland and grassland, and there are fewer human activities, which is conducive to the connectivity of ecological source areas.

A total of 28 ecological corridors were identified in Zhaoyuan City, as shown in Fig. 3. According to the distribution of ecological sources and ecological corridors in the study area, it is recommended to protect the existing ecological source areas, strengthen the construction of the original corridors, and take corresponding measures to increase the number of ecological source areas and accelerate the construction of the ecological corridor spatial network. In view of the long distance between ecological sources in the

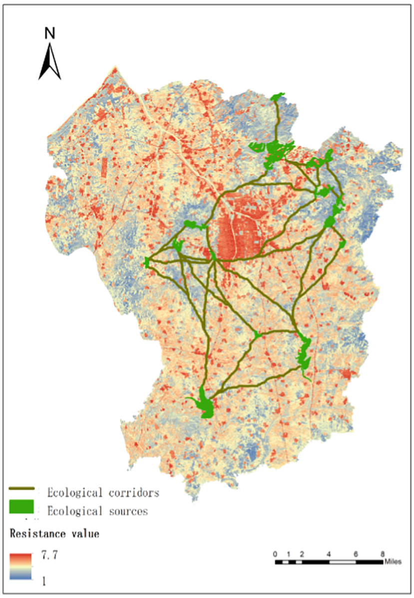

Fig. 3. Ecological corridor

west, it is necessary to focus on protecting the central position of the corridor to prevent the dilemma that the ecological corridor is broken and species are difficult to circulate.

5 Conclusion

Taking Zhaoyuan City, Shandong Province, a coastal resource-rich area as the research object, this paper comprehensively identifies ecological source areas and extracts ecological areas to be restored by constructing habitat quality models, estimating ecosystem service values and analyzing landscape connectivity. The results showed that a total of 13 ecological sources were extracted in the study area, mainly forest land and water, with a total area of 23.11 km^2, accounting for 1.6% of the total area of Zhaoyuan City Reservoirs and waters in the low hilly areas in the east and in the northwest. The northern and central parts of the study area are mainly urban areas and mining areas, and the ecological source distribution is small. Among the townships, Linglong Town accounts for the largest proportion of ecological source area and is relatively concentrated. There are 28 ecological corridors with a width of 700 m.

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