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Spatial and Temporal Analysis of Landscape Ecological Disturbance in Yulin

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Abstract: *Yulin is one of the important energy and chemical bases, located in ecologically fragile region in China. Landscape ecological disturbance of which affects regional ecological protection and high quality development. Remote sensing images covering Yulin in 2000, 2005, 2010, 2015 and 2018 were interpreted to process landscape thematic with the software ERDAS and ArcGIS10.2Landscape ecological disturbance model was established. Yulin is one of the important energy chemical industry area in China, located at the intersection of Loess Plateau and Mu Us Desert, and the vulnerability of ecosystem in this area is extremely prominent. This paper aimed to reveal the spatial-temporal characteristics of landscape ecological quality. The results showed that:(1)from the perspective of time change, landscape ecological disturbance fluctuates greatly, the degree of landscape disturbance decreased significantly and increased from 2010 to 2015 and reacheig its peak,(2)from the perspective of spatial change, the severe disturbance area is mainly concentrated in the areas with large population density and developed economy.*

Keywords: *Landscape ecological stability, disturbance, Landscape ecological quality, Yulin*

1. Introduction

Disturbance is an important part of the ecological process, and moderate disturbance can promote the development of ecosystems and species evolution [1-3] .However, the disturbances caused by human activities often have a negative impact on the natural environment. Picket [4] (1985) described disturbance as a relatively discrete event that destroys the structure of ecosystems, communities, or populations and changes the suitability of resources and substrates. Wei Bin [5] proposed that moderate disturbance can promote the development of the landscape, and it is also the main biological factor that enhances the composition of the landscape or the structure, function and dynamic process of the ecosystem. There are many ways for humans to interfere with the landscape, such as agricultural production, urban construction, land reclamation, road construction, etc. For humans, this is a normal social and economic activity, but for landscapes, it is a kind of disturbance [6].

Yulin is located in the junction of the Loess Plateau and the Mu Us Sandy Land, the fragility of the ecosystem is extremely prominent. As a national energy base, mining of minerals has also caused a series of ecological problems. At the same time, Yulin is one of the key areas for returning farmland to forests and grasses, and human activities are intense. Many scholars have studied the ecological fragility [7-8], ecological risk [9-10], ecological security [11] and ecosystem services [12-14] of the area, but the ecological disturbance of its landscape has not been carried out yet. The study of landscape ecological disturbance can provide a scientific basis for the adjustment of land use structure in Yulin area and the ecological restoration and reconstruction of mining areas, and is of great significance to the promotion of regional environmental improvement and sustainable use of resources.

2. Materials and Methods

2.1. Overview of the study area

Yulin is located in the north of Shaanxi Province, China, where extends over 36°49′-39°35′N,107°15′-111°15′E with a total area of 42921.1km2. This area consists of 12 counties: Yuyang, Hengshan, Shenmu, Fugu, Qingjian, Suide, Wubao, Jiaxian, Mizhi, Jingbian, Dingbian (Figure 1).Yulin located at the junction of Mu Us Desertt and Loess Plateau, which shapes unique landforms.

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The geomorphology is generally bounded by the Great Wall, the north is the sandy grass beach area, and the south is the loess hilly and gully area. The annual average temperature is 10.5℃and the annual average precipitation is about 400 mm.

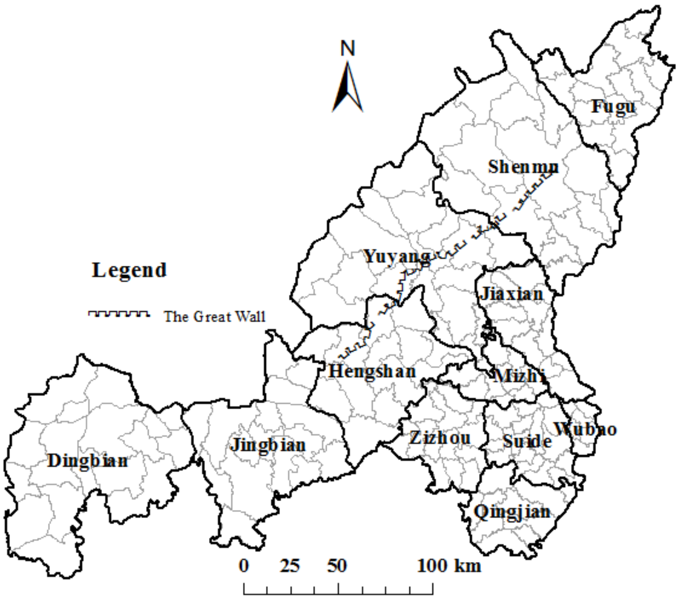

Fig 1: Administrative divisions of the study area

2.2. Data sources and processing

The remote sensing images in the same season (Landsat ETM, september 2000, 2005, 2010, 2015, 2018) were selected from the websit (http://www.gscloud.cn) the NDVI are from monthly synthetic Products MODND1M,500M,China.The statistical data mainly come from the statistical yearbook of Shaanxi Province from 2000 to 2018,the Yulin statistical yearbook,the statistical bulletin of the national economic and social development of Yulin and the official website of the relevant departments of the Yulin Municipal Government.

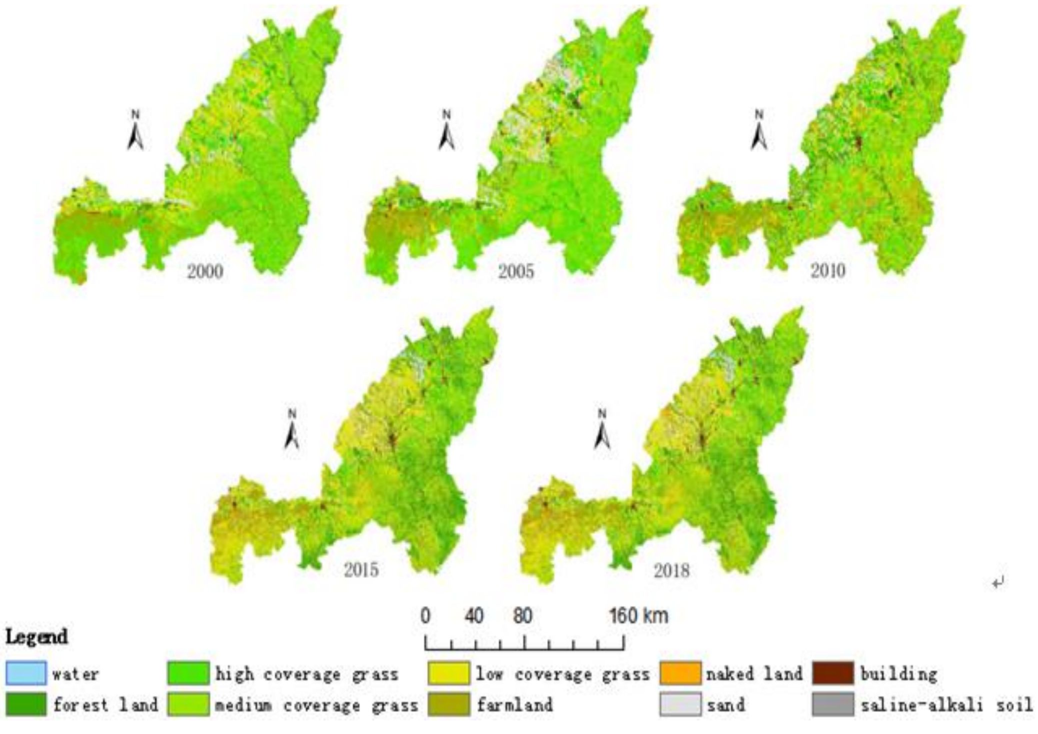

Fig 2: Landscape types of Yulin

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According to the "Current land use classification(GB/T21010-2017)",combined with the LUCC classification system established by the "China 20th Century LUCC Spatio-temporal Data Platform", the actual and remote sensing image texture characteristics of the Yulin area, the landscape types are classify into 10 categories: water, forest land, high coverage grass(coverage rate≥50%),medium coverage grass(20%≤coverage rate<50%),low coverage grass(coverage rate<20%), farmland, naked land, sand, building and saline-alkali land. After the five phases of remote sensing images acquired in 2000, 2005, 2010, 2015 and 2018 were geometric correction, the ERDAS software was used for supervision and classification, and the research landscape thematic data that met the interpretation accuracy requirements were formed (Figure 2).According to the area of Yulin, using a grid sample plot of 10×10km (Figure 3),the landscape thematic map is cut into 527 cell grids, the index of each cell is calculated, and the Kriging interpolation method is used for spatialization.

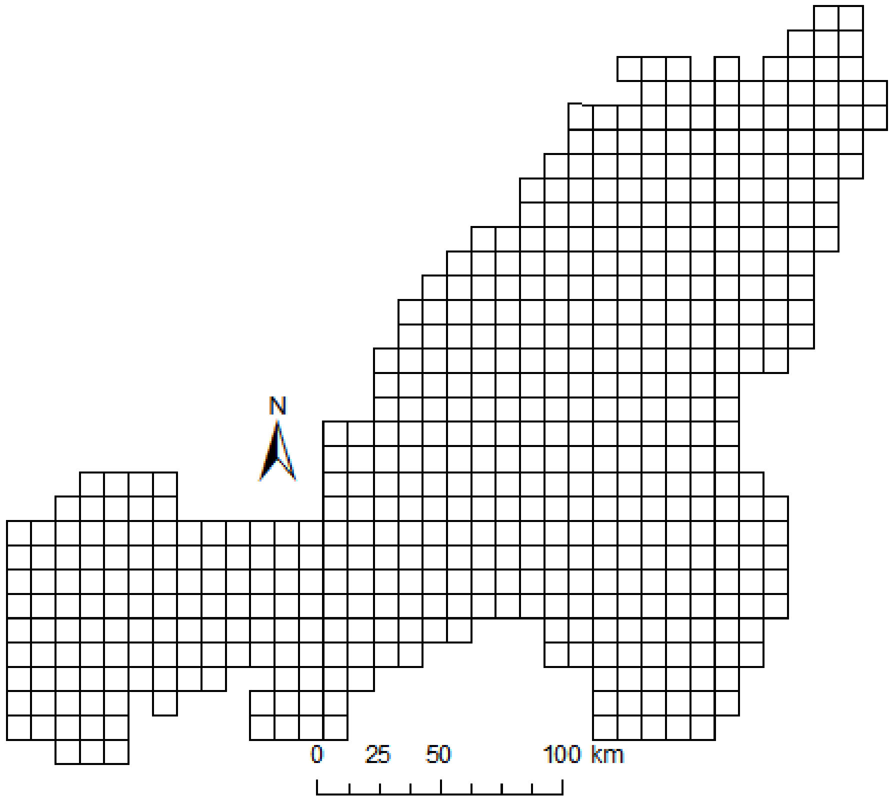

Fig 3: The map of sample area

3. Methods

3.1. Index Selection Principles

Comprehensive, scientific and reasonable index is an important prerequisite for constructing evaluation model. The selection of factors follows this principles [15]: (1) comprehensiveness: the index that can fully reflect the ecological stability of landscape; (2) independence: there are often overlap and mutual influence in landscape pattern index, so we should select the index with independent and obvious characteristics; (3) measurability: some indexes can reflect landscape characteristics theoretically, but actually their acquisition and quantification process is difficult and operational, so we should avoid selecting such index and choose simple and easy to obtain index as far as possible.The landscape disturbance model is constructed by the construction land disturbance index, the fragmentation index and the ecological sensitivity index.(table 1)

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Table 1: Valuation system of landscape ecological quality

Criterion level	Index	meaning
Disturbance	Construction disturbance index	Human construction activities are a kind of disturbance to the landscape ecosystem, blocking the migration of organisms and the circulation of material and energy, and reducing the natural purity. In terms of spatial scale, when the degree of disturbance is small, the landscape is generally stable; when the disturbance increases, the landscape stability decreases [16].
	Fragmentation index	In the process of urbanization, the landscape is divided into patches of different sizes and shapes, which increases fragmentation and hinders biological flow and affects biodiversity finally [4].
	Ecological sensitivity index	This index indicates the sensitive response of the ecosystem to external disturbances, and is an essential component of landscape disturbances. The higher the ecological sensitivity, the more easily the ecological environment will be destroyed and the greater the ecological disturbance. Ecological sensitivity reveals the difficulty and possibility of problems in the ecological environment.

3.2. Determination of index weight

Analytic hierarchy process (AHP) is a kind of quantitative and qualitative analysis decision method proposed by American operational research Saaty [17] in 1970s.It has the characteristics of system, flexibility and simplicity. The decision problem is decomposed into different hierarchies according to the order of target layer, criterion layer and scheme layer. By solving the method of judging matrix feature vector, the weight of each element of a certain layer to each element of the previous layer is determined, and the total weight of the target is determined by weighted sum. Thus the optimal scheme is obtained.

Standardization: Each index has different of character and dimension and standardization can eliminate error.

$$X^{*} = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \tag{1}$$

Where X^{*} represents the standardized value, X_i is the original index, $X_{\max}$ and $X_{\min}$ are the maximum and the minimum of the sample data, respectively.

Building a judgment matrix, the importance of each index is assigned by 1-9 scale method (Table 2), 20 experts' opinions on the degree of importance are sorted out, each factor is compared in pairs, and the judgment matrix is constructed.

Table 2: relative scale for preference

Judgment of preference	Numerical Rating
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very Strongly important
9	Extremely important
2,4,6,8	the intermediate value between the two adjacent judgments

Construction of judgment matrix A and B by SPSS;

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$$A=\begin{bmatrix}1 & \frac{3}{2} & \frac{5}{3}\\ \frac{2}{3} & 1 & \frac{3}{2}\\ \frac{3}{5} & \frac{2}{3} & 1\end{bmatrix} \quad B=\begin{bmatrix}1 & \frac{5}{4} & \frac{3}{2}\\ \frac{4}{5} & 1 & \frac{7}{5}\\ \frac{2}{3} & \frac{5}{7} & 1\end{bmatrix} \tag{2}$$

Where ω_1 =0.43, ω_2 =0.32, ω_3 =0.25, ω_4 =0.34, ω_5 =0.40, ω_6 =0.26

Consistency test

$$CR=\frac{CI}{RI}<0.1 \tag{3}$$

Where CR is consistency ratio, $CI=\frac{\lambda_{max}-n}{n-1}$ is consistency index, RI is average random index shown in table 2, λ_{max} is max eigenvalue and n is the order of matrix. According to rule of thumb, the matrix is consistent only if the value of CR is less than 0.1.In these matrixs, CR are 0.0086 and 0.00227 respectively, which meet the consistency test and obtain the weights of each index in the study area shown in table 3.

Table 3: Average random index

n	1	2	4	5	6	7	8	9	10
RI	0.00	0.00	0.90	1.12	1.24	1.32	1.42	1.45	1.49

Table 4: Formula of index

Index	Weight	Formula
Construction interference index	0.40	$CONS=Z_1/Z$,where Z is the area of construction land and Z is area of study unit
Fragmentation index	0.34	$FR=\frac{(NP\times TE)}{(TA\times 10000)}$,where, NP ,TE ,TA denote the number of patches, the total length of the interior boundary and area of landscape, respectively
Ecological sensitivity index	0.26	$SEN=\alpha L+\beta S+\gamma R$,where L , S , R represent soil erosion sensitivity, desertification sensitivity and human sensitivity [9]

$$y_{dist}=CONS\times 0.40+FR\times 0.34+SEN\times 0.26 \tag{4}$$

Where y_{dist} is landscape disturbance

4. Result and analysis

4.1. Analysis of Ecological landscape disturbance

Divide landscape ecological disturbance into 5 grades(table5),extremely slight(y_{dist} <0.488),slight(0.488≤ y_{dist} <0.696),moderate(0.696≤ y_{dist} <0.904),relatively severe(0.904≤ y_{dist} <1.112),severe(y_{dist} ≤1.112).Figure3and figure4showed that: the landscape disturbance had changed greatly in 2000-2010, but the overall trend had increased. In 2000, the mean of disturbance is 2.965 and the grade of disturbance in most regions is moderate. Disturbance in Fugu is relatively severe. In 2005 and 2010, the average value was 1.119 and 1.305 respectively. In 2015, the maximum degree of landscape disturbance was reached and the mean value was 4.6 and .most areas were relatively severe

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disturbance. In 2018, the average was 4.257, with a slight improvement. The degree of disturbance in Mizhi, Zizhou, Suide, Wubao and Qingjian changed from severe disturbance to moderate and mild grade. The severe disturbance area is mainly concentrated in the areas with high population density and developed economy in central Yulin, especially Shenmu and Yuyang, in which the long-term coal mining seriously destroies the land and ecological environment and the ecological vulnerability further leads to soil erosion and desertification.

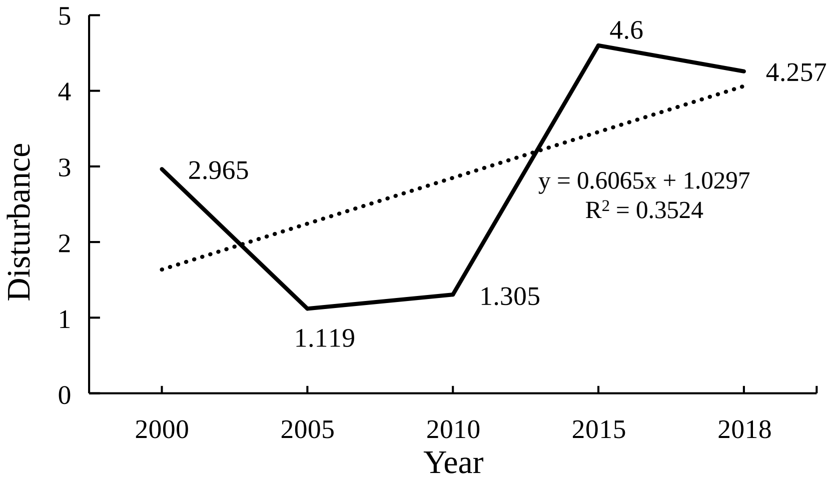

Fig 3: Average of landscape disturbance

Table 5: Area and Percentage of landscape ecological grades

Grade of Disturbance	Level	2000	2005	2010	2015	2018
		Percentage/%	Percentage/%	Percentage/%	Percentage/%	Percentage/%
Extremely slight	1	0	89.4	74.9	0	0
Slight	2	25.2	9.4	21.3	0	3.1
Moderate	3	59.8	1.0	2.7	.6.3	17.8
Relatively severe	4	8.4	0.1	0.50	27.49	29.5
Severe	5	6.6	0	0.57	66.3	49.7

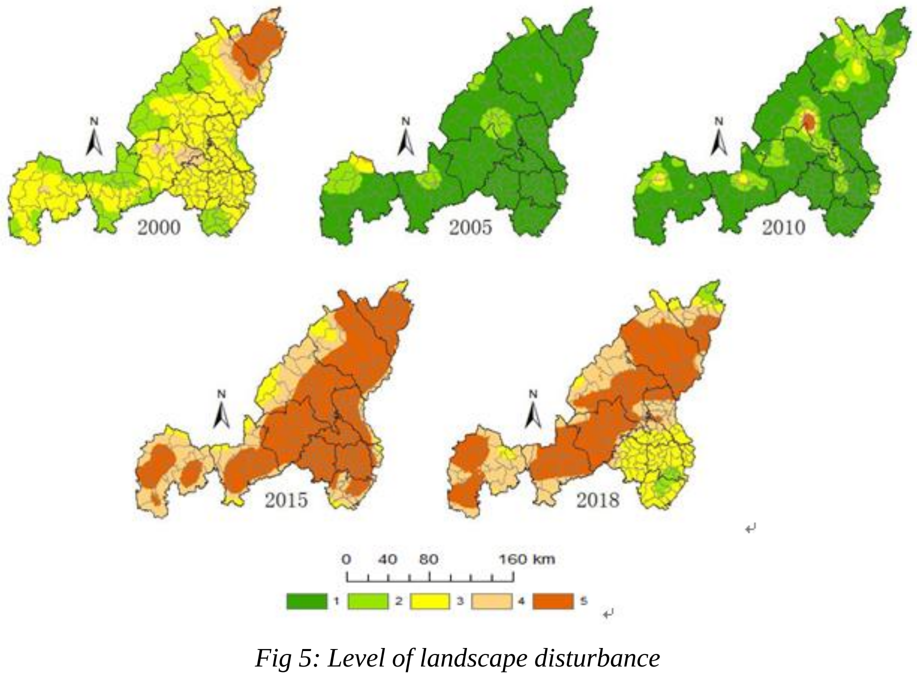

Fig 5: Level of landscape disturbance

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5. Discussion

5.1. The impact factors of Landscape Ecological disturbance

Fugu is an important part of the national energy and chemical base in northern Shaanxi. Driven by economic benefits, mining leads to land subsidence, thus increasing soil erosion and causing landslides to make the ecological environment more fragile. In addition, Fugu is located in the Yellow River "Golden Triangle" area where is the junction of Shanxi, Shaanxi and Nei Monggol and many highways are under construction, which will also have a certain impact on the landscape ecological disturbance [18].Moreover,the severer landscape ecological disturbance in Yuyang and Hengshan is mainly affected by Yuheng Industrial Park. According to the relevant research, the lack of water resources in the park restricts the development of the industry. In order to ensure economic benefits, the over-exploitation of groundwater in the park has led to problems such as mining subsidence, water resources destruction, soil erosion and damage to surface vegetation, coupled with drainage and drainage into nearby deserts and ditches, resulting in waste of water resources, while some enterprises in the park have illegally discharged sewage, resulting in pollution of water sources in surrounding villages and people's health damage [19].The landscape ecological quality in Dingbian was always poor .The natural conditions of Dingbian are relatively fragile, the geological hazards and natural disasters are frequent. There are large saline-alkali land, where is the only lake salt production area in Shaanxi. Thus, in the process of controlling saline-alkali land, we should pay attention to change the distribution of soil and water and take measures such as improving drainage and water storage system, leveling land, improving sand and constructing farmland forest network, which can effectively improve the local ecological environment [20].

5.2. Recommendations for improving ecological disturbance

For areas with high disturbance, Yuyang and Hengshan should optimize the spatial pattern of the land, finely delineate and control urban development boundaries, rationally develop and utilize urban land, and control population density; Fugu and Shenmu should pay attention to combining ecological and economic benefits, implement sustainable exploitation of resources and establish environmental monitoring demonstration areas.

Regarding the low level of landscape ecological disturbance, Suide, Fugu, Qingjian, Wubao and Jiaxian have relatively good ecological environment at present. It is still necessary to actively carry out rural comprehensive quality improvement and rural revitalization projects, promote the construction of high-standard farmland, increase land productivity, optimize agricultural structure, promote the overall development of ecological agriculture and economic agriculture.

Finally, it is aimed at Jingbian and Dingbian. we must pay attention to increase the intensity of saline-alkali land management, take effective measures such as improving drainage and water storage systems, leveling the land, improving sand coverage, and building farmland forest nets to improve the productivity of local cultivated land, and at the same time solve the problem of oil In the area of pollution, enterprises with unsound qualifications will be rectified.

5.3. Uncertainty of landscape ecological disturbance assessment

Due to the many and complex factors affecting the ecological environment, there are certain limitations in the study. The impact on its social, economic, and humanistic driving forces needs to be further integrated and analyzed; year-by-year data is used, a long-term series study on the disturbance will result in more accurate results; however, the current results can provide scientific reference for the area’s territorial and spatial planning, comprehensive renovation and restoration.

6. Conclusion

From the perspective of time change, landscape ecological disturbance fluctuates greatly. The average values of landscape ecological disturbance in 2000, 2005, 2010, 2015, 2018 were 2.965, 1.119, 1.305, 4.6 and 4.257 respectively. In 2005 and 2010, the degree of landscape disturbance decreased significantly and increased from 2010 to 2015 and reacheig its peak. Then the grade decreased slightly from 2015 to 2018.However, from the slope of the trend line, landscape ecological disturbance is still intensifying.

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From the perspective of spatial change, the severe disturbance area is mainly concentrated in the areas with large population density and developed economy. In 2018, the ecological disturbance of the northwest mining area decreased significantly.

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