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Analysis on Landscape Pattern and Dynamic Variations of Linghe Estuarine Wetland

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Abstract. This paper studied the variations of Linghe estuarine wetland wetland's landscape pattern and its fragmentation degree using classification data of in 2000 and 2005. With calculations on indicators of patch density and fragmentation indexes, it was discovered patch density of main wetland types reduced and became not obvious, and the nature reserve had an obvious trend of rapid increase in the number of residential areas. The degree of fragmentation was evident prior to 2000 and the trend continued until 2005. These variations of wetland landscape pattern are mainly caused by human activities and social-economic factors. There must be active protection and restoration measures to achieve economic, social and ecological benefit unification for Linghe estuarine wetland wetland nature reserve.

Keywords: Estuarine wetland, Fragmentation, Dynamic variations

1. Introduction

Linghe estuarine wetland is located in southern coast of Linghai city, Liaoning Province, northeast China. Composited of large areas of reed marshes, tidal flats, wet meadows, sea water area and small rivers, the wetland has great value for scientific research and economy development [1]. While in recent years, due to excessive reclamation and human activities, reed marshland area had experienced substantial contraction, intensified land erosion led to large siltation of the estuary, retreat sea shoals area kept growing and the wetland environment became increasingly fragile, which seriously destroyed local ecological environment and caused enormous economic losses and resource waste [2].

The article launched dynamic evolution research on the landscape pattern of Linghe estuarine wetland, revealed the impact of natural environment and human activities on the wetland's landscape pattern, provided a new perspective and theoretical basis for wetland landscape protection, wetland ecosystem restoration and landscape ecological planning [3], in order to achieve the ecological balance of the wetland's environment and protect the wetland scientifically and effectively.

2. Data source and dynamic analysis

2.1. Source of data

Based on the wetland's landscape data in TM [4]RS image of 2000 and 2005 and combination on text and graphic materials such as land use maps and functional zone maps in 2000, vegetation maps and field survey data, an information database of the study area is established [5]. Image interpretation is conducted in ArcView3.3 platform with combination interpretation method of direct interpretation and comprehensive analysis [6]. A classification system of Linghe estuarine wetland estuary wetland is established with consideration of image spectral characteristics and spatial features. To validate the accuracy of interpretation achievements, we conducted field GPS validation and projection conversion to ensure the data consistent with its corresponding RS image coordination.

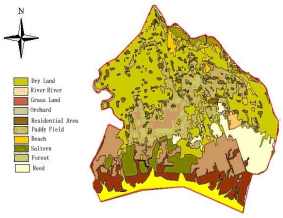

Fig.1 Classification of wetlands in 2000

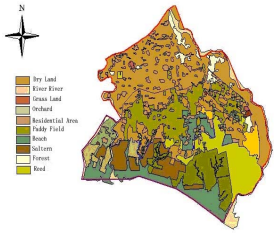

Fig.2 Classification of wetlands in 2005

2.2. Analysis on dynamic variations

Based on various types of wetland area in 2000 and 2005, we identified the dynamic variations of wetland resources, as shown in Table 1.

Tab.1 Analysis on dynamic variations of Linghe estuarine wetland

Items	Area in 2000 (km^2)	Area in 2005 (km^2)	Variations of Area (km^2)	Annual rate of Variations (%)
Dry Land	289.9	309.26	19.36	1.12
Beach	79.63	73.02	-6.61	-1.38
Paddy Field	152.8	120.37	-32.43	-3.53
Forest	21.7	21.94	0.24	0.18
Orchard	395.58	335.74	-59.84	-2.52
Reed	64.23	79.88	15.65	4.06
Grass Land	0.46	1.51	1.05	38.04
Residential Area	35.96	66.12	30.16	13.98
River	40.89	37.88	-3.01	-1.23
Saltern	44.22	53.09	8.87	3.34

As seen in Table 1, the decrease rate of paddy field area is -3.53% and increase rate of dry land is 1.12%, which dues to large-scale reclamation and expansion of rice cultivation. Residential area increased from 35.96 km^2 in 2000 to 66.12 km^2 in 2005, the annual change rate is 13.98%. Residents' grazing land reclamation also caused obvious increase of dry land area. Growing population not only occupied the area of natural wetlands, it also destroyed the habitat of animals, caused coastal erosion, soil desertification and alkalization. Quarrying and sand-digging resulted in reduction of beach area from the original 79.63 km^2 to 73.02 km^2, the annual change rate is -1.38%. All these changes led to a weakened storage capacity of the wetland, reduced biodiversity and attenuation of water purification function.

3. Analysis on Fragmentation of wetland landscape pattern

3.1. Selection of landscape indexes

By selecting multiple landscape pattern indexes to reflect the overall diversity and morphological characteristics of the wetland environment, the article studied the spatial pattern variations and the fragmentation degree of the study area.

(1) Patch area

$$A_i = \sum_{j=1}^{n} a_{ij} \tag{1}$$

The value of A_i restricts the species number, abundance and breeding of secondary species settled in this particular type of patch. In general, the amount of energy and mineral nutrients in a patch has a direct proportion of its area.

⑵Patch density index

$$F_i = \frac{N_i}{A_i} \tag{2}$$

For a particular wetland type i, F_i is patch density, N_i is number of patches, A_i is total area of the wetland. F_i indicates the number of patches per unit area, it can be used to calculate patch density of the entire landscape, it can also be used to calculate patch density of various landscape types.

⑶ Fractal dimension index

$$D_{f_i} = 2 \times \ln(P_i/4)/\ln(A_i) \tag{3}$$

For a particular wetland type i, P_i is the circumference and A_i is the total area. The main application of fractal dimension in landscape ecology is to determine the complexity of patch shape in order to describe the landscape pattern quantitatively.

⑷ Separation index

$$S = \frac{D_i}{B_i} \tag{4}$$

In which， $D_i = \frac{1}{2} \times (N_i/A)^{\frac{1}{2}}$， $B_i = \frac{A_i}{A}$

Separation index describes the discrete degree of different elements' distribution in a particular landscape type. The greater value indicates more scattered of patches for this particular landscape type, and the succession of landscape is more frequent.

3.2. Analysis on wetland Landscape Fragmentation

Four landscape pattern indexes are selected to calculate the wetland fragmentation indexes from 2000 to 2005, they are area of patch types, patch number, patch density index and proportion of particular patch type. The calculation is shown in Table2.

Tab.2 Wetland fragmentation index of Linghe estuarine wetland from 2000 to 2005

Year	Type	Patch Area(km^2)	Patch Number (N)	Patch density （N/ km^2）	Fractal dimension	Separation
2000	Dry Land	289.90	43	0.148	1.819	0.331
	Beach	79.63	7	0.088	1.884	0.487
	Paddy Field	152.8	31	0.203	1.962	0.534
	Forest	21.70	67	3.088	2.477	5.527
	Orchard	1.49	16	10.738	8.680	39.334
	Reed	64.23	14	0.218	1.651	0.854
	Grass Land	0.46	1	2.174	0.848	31.852
	Residential Areas	35.96	158	4.394	2.625	5.122
	River	40.89	6	0.147	2.777	0.878
	Saltern	44.22	8	0.181	1.618	0.937
2005	Dry Land	309.26	47	0.152	1.838	0.325
	Beach	73.02	11	0.151	2.122	0.666
	Paddy Field	120.37	34	0.282	1.829	0.709
	Forest	21.94	31	1.413	2.182	3.718

Orchard	0.62	11	17.742	4.034	78.379
Reed	79.88	26	0.325	1.649	0.935
Grass Land	1.51	2	1.325	1.144	13.723
Residential Areas	66.12	184	2.783	2.310	3.006
River	37.88	8	0.211	2.199	1.094
Saltern	53.09	16	0.301	1.664	1.104

Greater value of patch density indicates greater number of patches per unit area, which means the status of landscape fragmentation is serious. As table 2 showed, patch density of paddy field increased from 0.203/ km^2 in 2000 to 0.282/ km^2 in 2005, paddy field area decreased while the number of patches increased, indicating the diameter of paddy field patches became smaller and fragmentation became serious. Patch density of orchard has the maximum increase, from 10.738/ km^2 in 2000 to 17.742/ km^2 in 2005.

Grasslands has minimal change in fractal dimension, indicating the wetland experienced greater interference by the outside world. Human's tapping resulted in oversimplification of grass patch shape and degradation of grassland landscape . The increase of arable land and residential area is followed with continues separation and isolation of marshal reeds in large patches, the number of marshal reeds' fractal dimension is reduced, which caused the quality and ecological environment of marshes deteriorated. The index of patch density and separation for orchards is bigger than other types of wetlands. Because in condition of economy, terrain and human's activities, patches became small and dense, the degree of fragmentation increased, which indicates larger degree of landscape fragmentation by human interference.

In general, it can be seen by data comparison that fragmentation and separation of the wetland is serious before 2000, and the trend continued from 2000 to 2005.

4. Conclusions

Based on wetland classification data of Linghe estuarine wetland in 2000 and 2005, the article studied the spatial and periodical trend of the wetland landscape pattern in aspects of the annual dynamic variations rate of wetlands, fragmentation indexes and the driving forces. The results showed Linghe estuarine wetland had fragmentation trend before 2000, it continued from 2000 to 2005. Socio-economic factors caused by human activities are the main reasons which caused the wetland's current situation. Active protection and restoration measures must be taken as quickly as possible to achieve economic, social and ecological benefit unification for Linghe estuarine wetland nature reserve.

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