THE IMPACT OF THE *SPARTINA ALTERNIFLORA* CONTROL ON THE LANDSCAPE PATTERN IN YANCHENG COASTAL WETLAND OF CHINA

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Abstract. The paper selected a typical area of Yancheng coastal wetland as a case, and utilized remote sensing images from 1983, 1997, 2000, 2021, and 2023 as data sources. The landscape ecology, GIS technology, and R-Vector Coefficient methods were used to analyze the impact of *Spartina alterniflora* control on landscape patterns. The results were as follows: The development of *Spartina alterniflora* communities in the study area underwent a progression of "scattered points → patches → belts → elimination", with developmental trend transitioning from "point blasting" to "spread diffusion" and finally "collapse". The area of *Spartina alterniflora* had been reduced from a peak of 4 124.361 hm² to 162 hm² after the control. The centroid of the standard deviational ellipse of *Spartina alterniflora* communities had shifted from the south to the northeast in the region, with the lengths of major and minor axes decreasing from 6 771.415 m and 727.669 m during peak expansion to 1350.543 m and 208.396 m post-control. The orientation angle had abruptly changed from approximately 160° to 124.252°. Before and after the treatment, *Spartina alterniflora* and mudflats had the greatest impact on regional landscape pattern and landscape diversity. The Pearson Correlation Coefficient between *Spartina alterniflora* and regional landscape patterns decreased from 0.955 pre-control to 0.562 post-control, while its correlation with landscape diversity increased from 0.280 to 0.452. The Pearson Correlation Coefficient for mudflats with regional landscape patterns declined from 0.345 to 0.122, and its correlation with landscape diversity dropped from 0.292 to 0.050. Finally, scientific recommendations for *Spartina alterniflora* control were proposed. These results could provide actionable references for regional ecological restoration and high-quality sustainable development.
Keywords: *landscape pattern, Spartina alterniflora control, standard deviational ellipse, R-vector coefficient, Yancheng coastal wetland*

Introduction

Spartina alterniflora, a perennial salt marsh plant native to North America, has significantly influenced the ecological stability and balance of Chinese coastal regions (Zhang et al., 2005). Research on the spatiotemporal dynamics of *S. alterniflora* expansion and its impact on landscape patterns yielded substantial findings. These studies encompass large-scale analyses, comparisons across diverse coastal types, and detailed small-scale investigations. Utilizing remote sensing imagery, researchers employed various methodologies to accurately extract *S. alterniflora* community data, achieving

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high precision (Luo et al., 2024). These efforts have elucidated key aspects of *S. alterniflora* communities, including their scale, spatial distribution, expansion rates, trends, and effects on landscape patterns.

S. alterniflora community in Yancheng National Nature Reserve has the largest area. *S. alterniflora* has replaced *Suaeda salsa* as a pioneer community in coastal wetlands and developed into the thousands of meters wide *S. alterniflora* belt (Liu et al., 2004, 2009; Han et al., 2024; Xu and Zhang, 2025). *S. alterniflora* marsh had undergone a transformation from seaward to landward expansion, with the expansion of *S. alterniflora*, the landscape structure of Yancheng National Nature Reserve may change from 4 landscape belts to 3 landscape belts in the future (Zhang et al., 2014). By the end of 2019, *S. alterniflora* marsh had been connected to *Phragmites australis* (*P. australis*) marsh, and the interspecies competition in the core area had also changed from *S. alterniflora* and *S. salsa* to competition between *S. alterniflora* and *P. australis*, and *S. salsa* was facing the risk of disappearance.

The impact of *S. alterniflora* community on the ecological processes of coastal wetlands including the ecological processes such as the hydrogeographical landforms and soil physical and chemical properties of coastal wetlands. The introduction of *S. alterniflora* successfully accelerated the deposition rate of tidal flat, which increased the slope of the coastal wetlands (Li and Zhang, 2003; Zhang et al., 2006), changed the topography pattern of the coastal wetland in the sea-land direction, transformed the original decreasing terrain from land to sea to “U” shape (Hou et al., 2013), caused changes in the hydrogeographic pattern of tidal flat (Wang, Gao and Jia, 2006), promoted the accumulation of heavy soil metals (Chen and Ma, 2017), changed the physical and chemical properties of soil pH, moisture content, organic carbon and total phosphorus (Zhang et al., 2014), promoted methane emissions, enhanced soil carbon sink strength and carbon sequestration capacity, and changed the structure and function of soil microbial populations and communities invaded areas (Ruan et al., 2019). *S. alterniflora* gradually formed a single plant community, which reduced the biodiversity of bird habitats and the number of suitable habitats continues to decline (Wang et al., 2019), was not attractive to most birds (Liu et al., 2013), and also had adverse effects on birds such as *Grus japonensis* that rely on the reproduction of *S. salsa* community (Liu et al., 2009, 2020; Zhang et al., 2018; Xie et al., 2018; Wang et al., 2019, 2020, 2022). It is pointed out that controlling the invasion of *S. alterniflora* and maintaining the wetland habitat types such as *P. australis* and *S. salsa* marsh was conducive to improving the suitable habitat range of rare species such as *Grus japonensis* (Cao et al., 2016).

In 2003, *S. alterniflora* was included in Chinese first batch of invasive alien species list. The government department issued the “Special Action Plan for Prevention and Control of the *S. alterniflora* (2022-2025)”, proposing to strive to effectively control the *S. alterniflora* by 2025. Jiangsu Province had also formulated the “Implementation Plan for the Special Action on the Control of *Spartina alterniflora* in Jiangsu Province (2023-2025)”, which clearly proposed to complete the control tasks of the *S. alterniflora* in three years. Yancheng had formulated the “Implementation Plan for the Special Action on the Control of the *Spartina alterniflora* in Yancheng City (2023-2025)”, the control of *S. alterniflora* had achieved significant results. However, there were still few reports on the impact of the control of *S. alterniflora* on the regional landscape pattern and ecological benefits. Therefore, the article took Yancheng National Rare Bird Nature Reserve as an example, and took the remote sensing images in 1983, 1997, 2000, 2021 and 2023 as the data source. The landscape pattern analysis method combined with R-Vector Coefficient

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was used to analyze the impact of the control of *S. alterniflora* on the regional landscape pattern, so as to improve the effectiveness of *S. alterniflora* control, and provide theoretical reference for the scientific control of *S. alterniflora* in the coastal area.

Materials and methods

Study area

Jiangsu Yancheng National Rare Bird Nature Reserve is located between 32°48′47″N~34°29′28″N, 119°53′45″E~121°18′12″E. It is located in the central coastal area of Jiangsu Province. It is adjacent to the Yellow Sea in the east. The coastline is about 582 km long and has an area of 2.47×105 hm^2. It is the largest silty coastal wetland on the west coast of the Pacific Ocean and an important node on the migratory route from Northeast Asia to Australia. Nearly 3 million migratory birds come here to stop every year. There are important protected animals such as *Grus japonensis*, *Ciconia boyciana*, *Ciconia nigra*, *Grus leucogeranus*. It is the largest *Grus japonensis* wintering site in China and one of the largest and most concentrated areas for *S. alterniflora* area in China. The core area of the National Rare Bird Nature Reserve in Yancheng of Jiangsu Province (*Fig. 1*), extending to Xinyanggang River in the north and Doulonggang River in the south, is a typical silt coastal wetland. The landscape types are mainly *P. australis* marsh and *S. salsa* marsh, *S. alterniflora* marsh, and mudflats. *S. alterniflora* development was the most typical in Yancheng coastal wetland, so Yancheng was also a pioneer and demonstration area for the control of *S. alterniflora*.

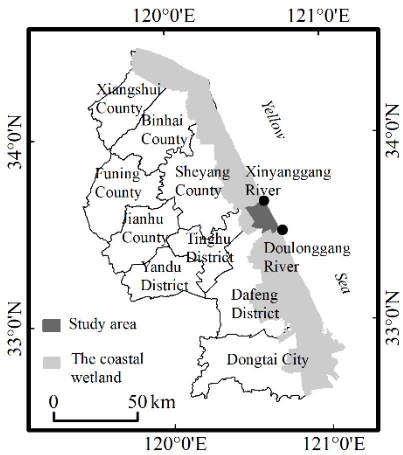

Figure 1. *The location of the study area. (The Yancheng National Nature Reserve (YNNR) is located in the central part of the east coast of China)*

Data source and processing

The data sources are Multispectral Scanner System (MSS) image in 1983, Thematic Mapper (TM) images in 1997, 2000 and 2022, and Enhanced Thematic Mapper Plus (ETM+) in 2023 (*Table 1*).

In ENVI, FLAASH atmospheric correction module was used to perform atmospheric correction on images, in order to eliminate the interference of atmospheric and lighting factors on ground reflection. Then, select landmark locations with obvious features on the

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map and obtain coordinates through GPS positioning. Geometric correction was performed using nearest neighbor pixel resampling and quadratic polynomial calculation methods to ensure the Root Mean Square (RMS) was less than 0.5 pixels. In order to unify the area of the research area, based on 2000 remote sensing images, Basic Tools Subset Data Via ROIs was used for uniform cropping.

Table 1. *The information of TM remote sensing images*

Time	Strip No.	Row No.	Cloud amount
1983.11.30	119	37	10%
1997.10.18	120	37	0.02%
2000.05.20	119	37	0.03%
2022.02.26	120	37	2%
2023.12.06	120	37	1.54%

Then, Using the Principal Components module for principal component analysis, the cumulative contribution rate of the first three principal components exceeded 95%, and then Red-Green-Blue (RGB) synthesis was performed to highlight the contrast of the terrain. Further applied High Pass Filter (HPF) transform (3×3 transform kernel) to enhance the panchromatic band. Using Transform RGB to Hue-Saturation-Value (HSV) to perform spatial transformation on multispectral colors. Further perform HSV to RGB to achieve image fusion between multispectral and panchromatic bands. The image classification was performed using the Classification-Unsupervised-Isodata module, with the coastal wetland features categorized into six classes: roads, water surfaces, *P. australis*, *S. Salsa*, *S. alterniflora*, and mudflats. While the water bodies maintain fixed spatial positions and the roads exhibit distinct linear characteristics that allow for manual interpretation, the spectral confusion between *S. alterniflora* and *P. australis* was known as the “different objects with similar spectrum phenomenon” required refinement using a decision tree classifier on the initial results. Through the Region of Interest (ROI) in Basic Tools, representative areas were selected for each feature type. Spectral characteristics were statistically analyzed from original spectral bands, principal components and Normalized Difference Vegetation Index (NDVI). This analysis enabled the extraction of optimal thresholds for effective feature discrimination. The classified raster images were converted to vector format and imported into ArcGIS. Based on historical data and field survey results, the classification outcomes were then refined.

Finally, the confusion matrix was constructed using Ground Truth ROIs for accuracy validation in ENVI. The results showed an overall accuracy exceeding 90%, with the Kappa Coefficient greater than 0.9. The production of landscape type maps for the study area were completed in ArcGIS (*Fig. 2*).

Landscape pattern index selection

The landscape pattern index can highly condense landscape pattern information, reflecting landscape structure and spatial configuration information (Wu, 2007). In the study, Percentage of Landscape Type (PLAND), Largest Patch Index (LPI), Total Edge (TE), Edge Density (ED), Mean Patch Area (AREA_MN), Landscape Shape Index (LSI), Mean Shape Index (SHAPE_MN), Mean Fractal Dimension (FRAC_MN), Mean Core Area (CORE_MN), Interspersion and Juxtaposition Index (IJI), Aggregation Index (AI),

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Shannon's landscape Diversity Index (SHDI) and Shannon's Evenness Index (SHEI) were selected to describe the landscape spatial structure and pattern characteristics. The landscape pattern index is calculated from the two scales of type and landscape respectively. The calculation of landscape pattern index were completed in Fragstats 4.2.

Landscape spatial distribution was characterized by changes in the direction and length and short axis of the standard deviation ellipse in ArcGIS.

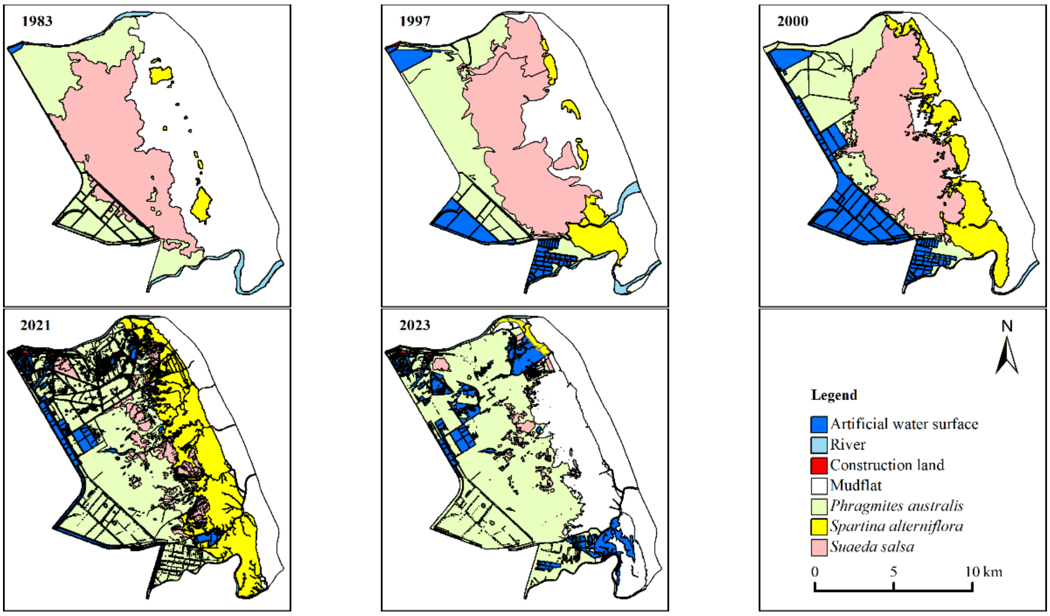

***Figure 2.** The landscape types in the study area from 1983 to 2023*

Matrix similarity

The measurement of matrix similarity can be expressed by coefficients (R-Vector Coefficient, RV). The coefficient is a multivariate generalization of the square of the Pearson Correlation Coefficient, and is a vector version of the Pearson Correlation Coefficient. The matrix is not a linear transformation, but is just a manifestation of high-dimensional data, deduced from the perspective of norms. The RV is between 0 and 1, and is used to characterize the proximity of two or more sets of data. It is often calculated by correlation with biological data, the closer it is to 1, the stronger the explanatory power between the two sets of data. The RV is generally calculated by traces of the covariance matrix. The specific announcement is as follows (*Eqs.1–3*):

$$RV=\frac{tr(S_{XY}S_{YY}^{-1}S_{YX}S_{XX}^{-1})}{\sqrt{tr(S_{XX}^{-1}S_{XX})tr(S_{YY}^{-1}S_{YY})}} \quad \text{(Eq.1)}$$

$$X=(X_1,X_2,X_3,\cdots,X_p) \quad \text{(Eq.2)}$$

$$Y=(Y_1,Y_2,Y_3,\cdots,Y_p) \quad \text{(Eq.3)}$$

In these equations, X is the landscape pattern index matrix of type scale; Y is the landscape pattern index of region scale (Johansen,1995; Juselius, 2006).

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Results

Changes in the area of S. alterniflora

The introduction of *S. alterniflora* in Yancheng coastal wetland in the early 1980s and experienced the expansion process of “scattered points → patches → belts → elimination”. From the perspective of spatial morphology changes, the expansion of *S. alterniflora* in Yancheng coastal wetland could be divided into the following four stages (*Fig. 2*). From 1983 to 1997, it could be called “point explosion” expansion. *S. alterniflora* started from several points expanding its distribution range to the surrounding space in a rapid and large-scale diffusion similar to explosion in a relatively short time. The community spatial morphology developed from point to surface patch, and *S. alterniflora* community area increased from 329.461 hm^2 to 1042.316 hm^2, and the percentage of the community area in the study area increased from 1.849% to 5.862%. From 1997 to 2000, it could be called the conversion mode of “point blasting →spread diffusion”. *S. alterniflora* community increased its distribution range in a gradually extending and continuous manner in space, and the spatial morphology of the community had developed from patches to strip like distributions that were connected from north to south and several kilometers wide from east to west, *S. alterniflora* community area increased to 2297.529 hm^2, with an area percentage reaching 12.948%. From 2000 to 2022, it could be called “spread diffusion”. *S. alterniflora* community expanded continuously in a plane-like manner, spreading continuously in both sea and land directions, continuously increasing the community distribution range, and the community area reached 4124.361 hm^2, with an area percentage reaching 23.117%. After 2022, it could be called a “collapse mode”. On December 5, 2022, the government departments issued the “Special Action Plan for the Prevention and Control of the *S. alterniflora* (2022-2025)”. Local governments had issued corresponding plans. Under human interference, *S. alterniflora* community quickly disappeared in the region in a very short period of time, directly causing *S. alterniflora* ecosystem to become extinct. Only 500 m wide on the south side of Xinyanggang estuary was retained in the study area, with an area of about 162 hm^2, accounting for only 0.909% of the study area. This sudden change would have a series of chain reactions to the coastal wetland, and the structure and function of the ecosystem would have undergone significant changes.

Changes in spatial distribution of S. alterniflora

Standard deviation ellipse can reflect the degree of dispersion, central trend and directional trend of spatial distribution of geographical elements. The degree of dispersion of data in the primary and secondary distribution directions is represented by the major and minor distribution axis of the ellipse. The larger the difference between the long and short axes, the stronger the directionality of the data points. From 1983 to 2021, the centers of the standard deviation ellipse of *S. alterniflora* community basically swinged in the south of the study area. After the initial completion of the *S. alterniflora* control in 2023, the center of *S. alterniflora* community had shifted to the northeast corner of the region. Judging from the major axis and short axis of the standard deviation ellipse. Due to the relatively scattered distribution of the *S. alterniflora*, the lengths of the long axis and short axis were slightly higher in the study area in 1983. The lengths of the long axis and short axis had developed to 6771.415 m and 727.669 m respectively before the control of *S. alterniflora* in 2021. After the initial completion of the control of *S. alterniflora* in 2023, the lengths of the long axis and shot axis of the standard deviation

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ellipse decreased sharply, to 1350.543 m and 208.396 m, decreased by 80.055% and 71.361% respectively. Judging from the direction changes of the standard ellipse, before the control of *S. alterniflora*, the directions of the standard deviation ellipse were relatively stable, basically maintaining at around 160°, after the initial completion of the control of *S. alterniflora* in 2023, the direction of the standard deviation ellipse suddenly changed to 124.252° (*Fig. 3; Table 2*).

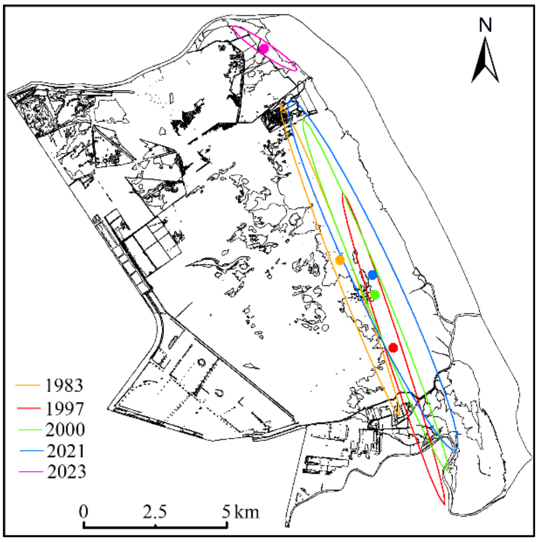

Figure 3. *The changes in standard deviation ellipse of S. alterniflora community*

Table 2. *The changes of standard deviation of S. alterniflora community*

Year	Cent X /m	Cent Y /m	XstdDisst /m	YstdDisst /m	Rotation/°
1983	20835833.800	3720671.250	5819.420	306.677	159.094
1997	20837692.100	3717602.150	5752.367	278.121	161.862
2000	20837057.700	3719467.810	6640.318	374.840	160.973
2021	20836972.400	3720156.370	6771.415	727.669	154.622
2023	20833190.400	3728079.570	1350.543	208.396	124.252

The impact of the control of S. alterniflora on regional landscape pattern

In terms of landscape type scale, the landscape pattern index of *S. alterniflora* changed significantly, and there were two trends before and after governance. The first type, such as AREA_MN and CORE_MN indexes, showed a continuous upward characteristic. The second type of *S. alterniflora* show opposite characteristics after the control, which could be divided into two situations, LPI, TE, ED, LSI, IJI and AI indexes show significant declines, SHAPE_MN and FRAC_MN indexes show significant rises.

The control of *S. alterniflora* had a significant impact on the regional landscape pattern. Judging from the changes in the regional landscape pattern index, it was also divided into two types (*Fig. 4*). The first type was to maintain the original change trend, which could be divided into two situations, the LPI index continued to decline, the IJI, SHDI and SHEI indexes maintained the original characteristics of rising first and then falling. The second type was the control of *S. alterniflora*, which caused a sudden change

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in the regional landscape pattern, which could be divided into two situations. TE, ED and LSI indexes showed an upward trend before the control of *S. alterniflora*, and fell rapidly after the control. AREA_MN, SHAPE_MN, FRAC_MN, CORE_MN and AI indexes showed a downward trend before the control of the *S. alterniflora*, and rose rapidly after the control.

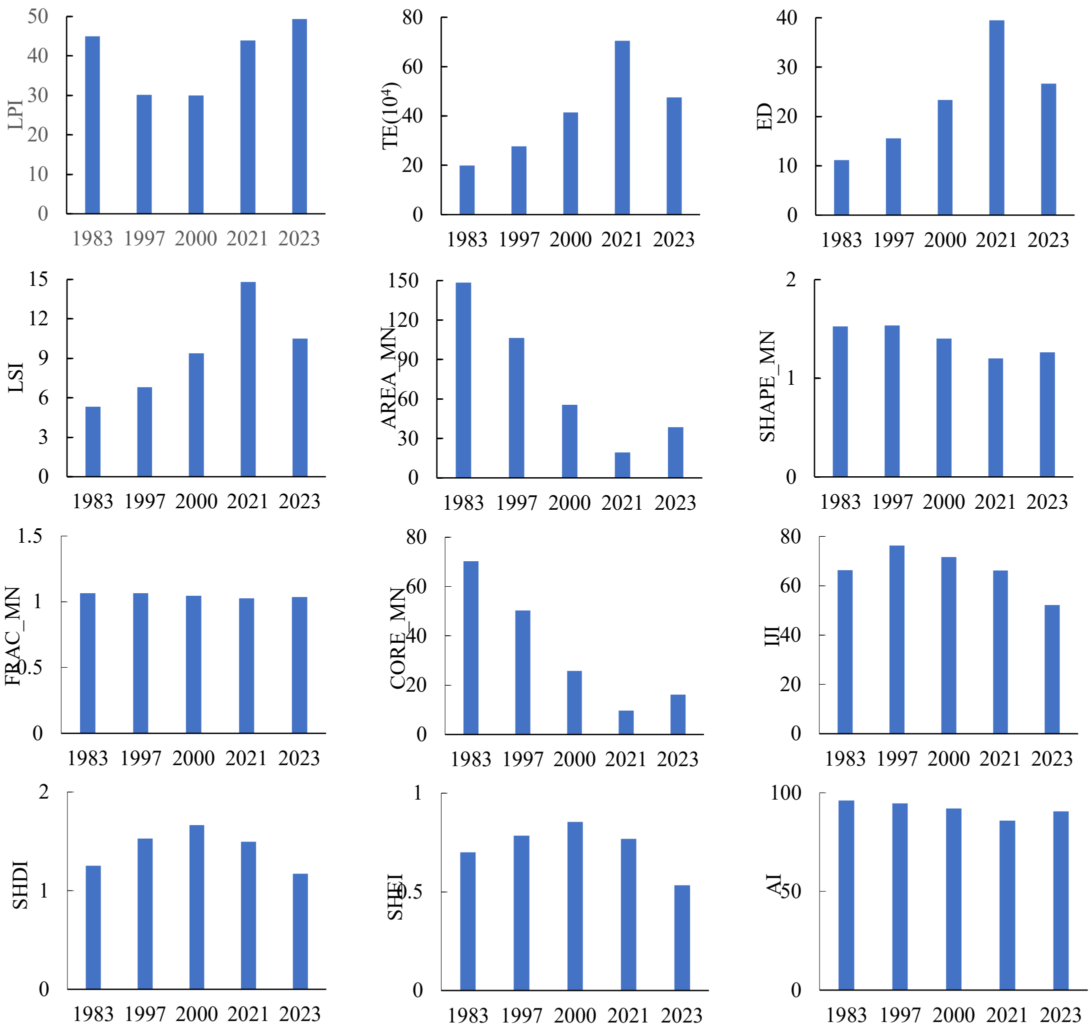

Figure 4. *The changes of landscape pattern in the study area*

Based on the landscape pattern analysis, the matrixes were constructed based on type-scale landscape pattern index, regional landscape pattern index and regional landscape diversity. The R-Vector Coefficient (RV) between type-scale landscape pattern and regional landscape pattern was comparative analyzed before and after the control of *S. alterniflora*. In *Table 3*, it could be observed that *S. alterniflora* and mudflats had the greatest impact on regional landscape pattern and landscape diversity from the RV. The RV of *S. alterniflora* type and the regional landscape pattern was 0.955 before the control, and fell to 0.562 after the control. The RV of *S. alterniflora* type and the landscape diversity increased from 0.280 to 0.452. The RV of the mudflats type and the regional landscape pattern decreased from 0.345 before the control, and decreased to 0.122 after

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the control. The RV of the mudflats type and the landscape diversity decreased from 0.292 to 0.050. On the one hand, the area of *S. alterniflora* community has dropped sharply after the control. On the other hand, *S. alterniflora* control area had not carried out vegetation restoration, and the default state was mudflats, which had led to a rapid increase in the area of mudflats.

Table 3. *Changes in the RV of landscape types and regional landscape patterns before and after the control of S. alterniflora*

Landscape type	Landscape pattern		Landscape diversity	
	Before the control	After the control	Before the control	After the control
S. alterniflora	0.955	0.562	0.280	0.452
P. australis	0.885	0.827	0.007	0.090
S. salsa	0.988	0.806	0.093	0.151
Mudflats	0.345	0.122	0.292	0.050

Conclusion and discussion

This article used remote sensing images as the data source and applied geography, landscape ecology and mathematical methods to analyze the impact of the control of *S. alterniflora* on the landscape pattern in the typical area in Yancheng coastal wetland of China. It pointed out that the development of *S. alterniflora* community in the study area had gone through a process of “point → surface → belt → elimination”, and the development mode has changed from “point blasting” to “spread diffusion” and finally “collapse”. The area of *S. alterniflora* had increased from a peak of 4124.361 hm^2 to 162 hm^2 after the control. The control of *S. alterniflora* had a profound impact on its community standard deviation ellipse center, major and minor axes, and direction. The center shifted from the south to the northeast of the study area, and the length of the long and short axes decreased by 80.055% and 71.361% respectively after the control of *S. alterniflora*, with a sudden change in direction from around 160 ° to 124.252°. The control of *S. alterniflora* had a profound impact on the regional landscape pattern and landscape diversity. In terms of landscape types, the RV between the landscape type scale and the regional landscape scale, and the landscape diversity showed the greatest changes in *S. alterniflora* and mudflats. Based on the author’s previous research on the continuous expansion of *S. alterniflora* in Yancheng coastal wetland, the study analyzed the abrupt impact of *S. alterniflora* rapid control under human activities on the landscape structure and pattern, providing reference for subsequent habitat restoration and evaluation (Zhang et al., 2020; Xu and Zhang, 2005).

Pay attention to the invasion and expansion of S. alterniflora and its negative effects

The distribution area of *S. alterniflora* in Jiangsu Province accounted for about 1/3 of the national total, with the largest distribution area in Yancheng. *S. alterniflora* had become the most serious invasive plant in the global coastal wetland ecosystem and had been included in the “List of the First Batch of Invasive Species in China”, causing harm to regional ecosystem stability and ecological security, and had become a focus of attention in coastal areas. First, the rapid expansion and spreading characteristics allow it to quickly invade the ecological niche of local salt marsh species in coastal areas, resulting in significant changes in the plant species and vegetation structure of indigenous

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ecosystems, and causing the plant species in coastal wetland ecosystems to tend to be single. Second, the height of *S. alterniflora* is usually above 1.5 m, and the coverage can reach 100%. It was not attractive to most birds and was no longer suitable for bird habitat and reproduction, which reduced the biodiversity of bird habitats, and the number of suitable habitats continued to decline, so that the bird community structure would tend to simplify. The strong blocking effect of *S. alterniflora* on the tide was affected, and the natural spread of the tide was affected. The terrain on the sea side of *S. alterniflora* marsh continues to silt, resulting in *S. salsa c*ommunity becoming weaker and weaker by seawater, and *S. salsa* community was constantly shrinking. It also had an adverse impact on birds that rely on *S. salsa* community to reproduce. Third, previous studies had shown that the silt-promoting function of *S. alterniflora* caused changes in the hydrogeographic pattern in coastal areas, it had an important impact on the ecosystem process of important elements such as carbon, nitrogen, and phosphorus in the coastal wetland.

The control of S. alterniflora does not mean "clearing"

In view of the actual needs of biodiversity protection, the negative effects of *S. alterniflora* invasion had attracted great attention, and the effective control of *S. alterniflora* was urgently needed. The government departments promulgated "Special Action Plan for the Prevention and Control of the *Spartina alterniflora* (2022-2025)", requiring strengthening the control of *S. alterniflora* invasion areas, proposing "strengthen follow-up monitoring and prevention and control after governance, scientifically carry out ecological restoration of the control region in combination with actual conditions, and the coastal ecological environment has been initially improved." However, from the current "the control" basically equaled "the clearance". In this case, we need to consider what will happen after the complete clearance? How to understand "the control", how to control, and what would be happen the ecological system after "the control" or "the clearance"?

The positive role of S. alterniflora in coastal protection cannot be ignored

We could objectively view the pros and cons of *S. alterniflora*. Completely eliminating *S. alterniflora* may not be conducive to the stability of the coastal ecosystems and the construction of ecological security patterns. Therefore, the positive function of *S. alterniflora* must be viewed objectively. First, *S. alterniflora* had played an active role in wind protection, silting and land production, effectively delayed the coastal erosion towards land in the direction of sea and land, and the coastal erosion towards the south in the vertical direction, protecting the tidal flat surfaces in the coastal area, protecting the coastal wetland ecosystems, and maintaining the conditions for birds to rely on for their habitat. According to on-site monitoring of the study area, the height of silt-promoting *S. alterniflora* in the study area exceeded 1.5 m. Second, the researches had shown that the extract of *S. alterniflora* was related to human health in many aspects, and its correlation index were constantly improving with the deepening of research and development. *S. alterniflora* health food can fully make a difference in the implementation of Chinese health management for the prevention and treatment of chronic diseases (Qin, 2019).

The control of S. alterniflora need scientific and technological support

At present, the control methods of *S. alterniflora* in the coastal area are mainly physical removal, including deep turning technology, mowing-flooding and flooding technology,

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crushing-diffusion technology, and crushing-film technology. Simply clearing *S. alterniflora* without finding effective alternative species is clearly not in line with regional reality. We need to adhere to the systematic engineering concept of *S. alterniflora* control. On the one hand, we need to scientifically understand the mechanism of *S. alterniflora* in the coastal area, clarify the diffusion and spread mechanism of *S. alterniflora* to provide theoretical support for *S. alterniflora* control. On the other hand, for the specific functional area, we need to scientifically define the spatial boundaries of *S. alterniflora* control from the multifunctional perspective, and promote moderate-scale *S. alterniflora* control, that is, to protect the tidal flat and protect the coast, we need to retain a certain width of *S. alterniflora*, and at the same time prevent the further spread of *S. alterniflora* in the land direction. Further, we need to innovate technologies, strive to achieve the rational use of *S. alterniflora*, and explore efficient comprehensive governance paths for *S. alterniflora* suitable for the coastal area.

The control of S. alterniflora need to be adapted to local conditions

First, Jiangsu coast is the typical silt coast. Unlike the rocky coast and mangrove coast, the positive effect of *S. alterniflora* on Jiangsu coast is more obvious. Second, Jiangsu coast has both erosion and silt characteristics, and the response characteristics of different types of the coasts to *S. alterniflora* are obvious. Third, Jiangsu coast has Chinese first coastal wetland type world natural heritage site and two national nature reserves. The stability and diversity of the ecosystem also show significant differences in response to *S. alterniflora*. Therefore, the control of *S. alterniflora* need to be tailored to local conditions. The suggestions are as follows. First, *S. alterniflora* outside the embankment of the erosion-type coast and non-important production area and ecological functional area can be retained to maintain the stability of the coast and the tidal flat to slow down the process of coastal erosion towards land. Second, *S. alterniflora* in the typical silted coastline, the important production areas and the ports can be removed. Third, it is recommended to retain a certain width and scale of *S. alterniflora* on the erosion coastline and the important ecological functional area to maintain the stability of the coast and tidal flat through artificial interference to strictly control expansion to the land to protect the diversity of the ecosystem. Fourth, it need strengthen the research and development of alternative species of *S. alterniflora.* Therefore, the control of *S. alterniflora* in the coastal area is not a simple answer to “whether to be *S. alterniflora* ”, but to answer the questions of “where to be needed and where not to be not”, “if it want, how much to be needed, how to be needed”, and the social benefits, ecological benefits and economic benefits should be considered from the comprehensive functions of *S. alterniflora*.

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