Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 10 (2011) 2472 – 2477

Procedia Environmental Sciences

2011 3rd International Conference on Environmental Science and Information Application Technology (ESIAT 2011)

Analysis of the Expanding Process of the Spartina Alterniflora Salt Marsh in Shanyutan Wetland, Minjiang River Estuary by Remote Sensing

Wenlong Zhang[1,2,3] , Congsheng Zeng[1,2,3] ,Chuan Tong[1,2,3],Zichuan Zhang[1,2,3],Jiafang Huang[1,2,3]

[1]*Institute of geography, Fujian Normal University, Fuzhou 350007, China;*
[2]*Research Center of Wetlands in Subtropical Region, Fuzhou 350007, China;*
[3]*Key Laboratory of Humid Subtropical Eco-geographical Process (Fujian Normal University), Ministry of Education, Fuzhou 350007, China*
[a] *guozhang_123@tom.com*

Abstract

Spatio-temporal dynamics of Spartina alterniflora marshes in the Shanyutan Wetland, Minjiang River estuary in 2006 and 2010 were studied by the aerial images and Google Earth stellite images and field investigations. The expansion of S. alterniflora was significant, the areas were 211.03 hm2 and 306.94 hm2, respectively in 2006 and 2010. They mainly distributed in the middle tidal flat and extended quickly from northwest to southeast. Number of Patches of S. alterniflora marsh decreased by 59.17 %, Mean Patch Size increased by 266.67 %, Patch Shape Index decreased from 23.28 to 19.50. 85.03 hm2 of mudflats changed to S. alterniflora marshes, accounting for 72.54 % of the area of increased S. alterniflora marsh, and mainly occurred in low tidal flat and surrounding areas of tidal creeks in east and central zones.

Key Words: Spartina alterniflora; expansion; 3s technology; Minjiang River estuary

Introduction

Spartina alterniflora originates in the Atlantic coast, and is introduced to different regions for promoting deposition and protecting embankment[1]. However, due to a series of favorable survival and diffusion mechanisms, it spreads quickly, makes great negative impacts on local ecological systems and brings the local economy down to some extent[2,3,4,5,6,7]. Since 1980s, remote sensing technology has become the primary information sources of land cover and composition, and has been widely applied to monitoring invasive species, landscape dynamics and so on[5]. Nowadays many scholars at home and abroad had monitored the dynamic characteristics of *S.alterniflora* in many areas based on existing TM images and the actual investigation[4,5,8,9,10,11]. But TM images' spatial resolution is only 30m×30m, which is

doi:10.1016/j.proenv.2011.09.385

relatively low for accurate area extraction, especially for small areas.

With vascular plants 72 families 175 genus 247 species, and the most abundant area both in number and species in Minjiang River watershed[12],Shanyutan wetland is the largest natural tidal wetland of Minjiang River estuary, and it has been established as a provincial natural reserve in 2007. However, *S.alterniflora* invades quickly, and has exerted a strong influence on local biodiversity and birds' habitat. At present, the studies of shanyutan wetland mainly focus on physiological aspects, and studies about dynamic characteristics and driving forces, based on remote sensing images, have not been seen. This paper, combined the use of high resolution images with the GPS field survey, studied dynamic characteristics and driving forces, and discussed the influence of natural factors, human factors and itself physiological characteristics in the expanding process, so as to provide scientific support for biodiversity protection and wetland ecosystem management.

Materials and Methods

The study area is located in shanyutan wetland, Minjiang River estuary, and most of it is estuary tidal salt marsh formed in Meihua waterway by the silt from upstream. Based on aerial images on October14, 2006, the north border takes the subtidal line as a benchmark and do 100 meters buffer for boundary, while the south border takes the artificial dam for boundary, an area about 893 hm^2. Study area is significantly affected by formal semi-diurnal tides. It belongs to transitional zone between southern subtropics and central subtropics, warm and humid in climate, abundant in precipitation, with 19.3 ℃ for mean annual temperature, 1380 mm for mean annual rainfall, 153 d for mean annual rainfall days. The soil belongs to coastal solonchak and sandy soil, pH value partial acidity[12]. Vegetation composed mainly by *Phragmite australis*, *Cyperus malaccensis*, *Scirpus triqueter* and *S.alterniflora*, among them the last is alien invasive species.

First, we use the topographic maps of study area to make geometry correction for the aerial images on October 14, 2006, and then take it for the reference, select several control points, and make rectification for the Google Earth satellite images on August 13, 2010, error control within half pixel. Combined with field survey, we located *S.alterniflora* patches with GPS. We interpreted and classified images with ArcGIS, artificial visual interpreting, finally draw the figures of spatial distribution, and establish spatial database. Two stage landscape type figures conversed for grid figure, grid size for 0.5 m×0.5 m, and obtained the integrated data needed after the space superposition analysis. Calculated the mean annual diffusion rate V, patch shape index *SI* respectively[13], specific computation formulas are as follows:

$$V = \sqrt[N]{S_j / S_i} - 1 \qquad (1)$$

$$SI = P / (2\sqrt{\pi A}) \qquad (2)$$

S_i equals the size (hm^2) of *S.alterniflora* in i year, S_j equals the size (hm^2) in j year, N equals the number of years from i year to j year; A equals the total size (hm^2), P equals the total perimeter(hm）, when patch shape index is about 1, the patch is near circular, when patch shape index is 3 to 4, the patch is near square.In addition, the comparison of two period images and relevant material collected shows that different parts have different invading time and great differences in spatial distribution. For better analysis, shanyutan wetland is divided into East, Central and West zones, taking tide ditch for natural boundary, East zone 314.33 hm^2, Central zone 371.51 hm^2, West zone 206.85 hm^2 (figure 1).

Results and Analysis

Dynamics of Spatial and temporal pattern of S.alterniflora.

S.alterniflora invaded rapidly, size increased from 211.03 hm^2 in 2006 to 306.94 hm^2 in 2010, mean annual diffusion rate is 9.82 %. It mainly distributed in mid tidal flat , and outspread from northwest to southeast .There were relatively few in low and high tidal flat, and the distribution characteristics of different zones existed significant differences (Table 1,figure 1).

East zone, the size of *S.alterniflora* increased from 113.88 hm^2 in 2006 to 165.81 hm^2 in 2010, mean annual diffusion rate is 9.85 %. There are lots of *S.alterniflora* from low tidal flat to high tidal flat, but distribution characteristics existed significant differences. The population structure in mid tidal flat is single, showing continuous big patches distribution; in high tidal flat it also shows continuous big patches distribution, but the patches size are smaller; in low tidal flat, primarily distributed by associations, the number is more but the sizes are smaller, and the vegetation coverage obviously less than mid tidal flat.

Central zone, the size of *S.alterniflora* increased from 80.39 hm^2 to 112.49 hm^2, mean annual diffusion rate was 8.76 %. It mainly distributed in mid tidal flat, then the low tidal flat. The spatial distribution in mid tidal flat also shows continuous big patches distribution, but the sizes are smaller. Distribution areas in low and high tidal flat are relatively small, except for individual patches, the rest mainly distribute scattered, and the vegetation coverage is lower than mid tidal flat.

West zone, *S.alterniflora* size is smaller than East and Central zones significantly, the size increased from 16.66 hm^2 to 29.09 hm^2, mean annual diffusion rate was 14.47 %. It mainly distributed in mid tidal flat. The spatial distribution in mid tidal flat also shows continuous big patches distribution, but the patches surround the big patches mainly distribute in associations, sizes are smaller while the number is bigger. There is almost no *S.alterniflora* in high and low tidal flats.

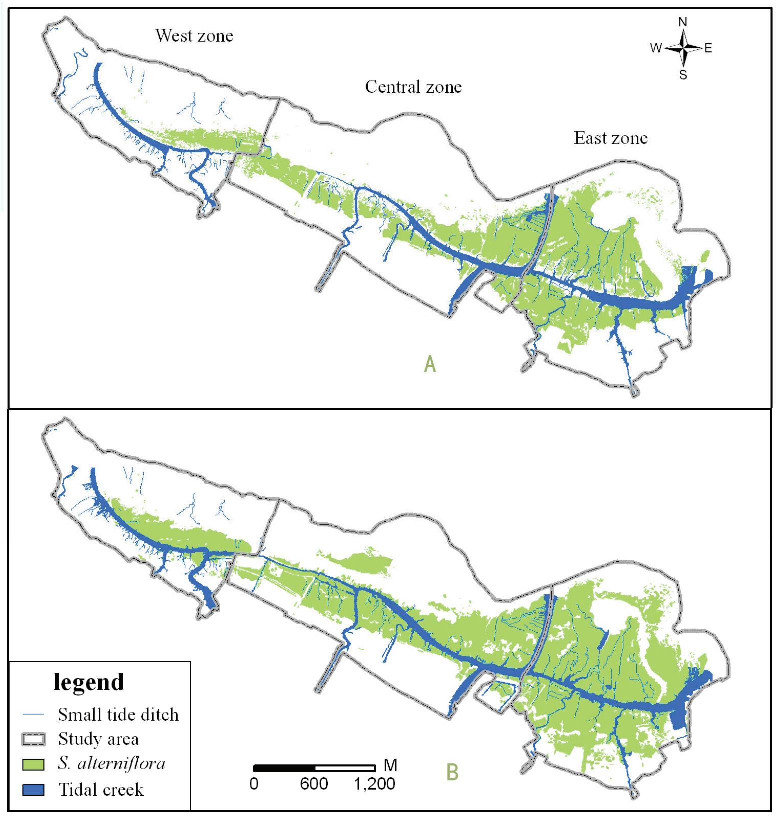

Fig.1 Spatial distribution of *S.alterniflora* marsh in the Shanyutan wetland(A:2006; B:2010)

Tab.1 Changed areas and averaged expansive rates of *S. alterniflora* marsh in the shanyutan wetland (hm^2)

	East zone	Central zone	West zone	Shanyutan wetland
2006	113.88	80.39	16.66	211.03
2010	165.81	112.49	29.09	306.94
V(%)	9.85	8.76	14.47	9.82

Patches quantity and features of shape changing of S.alterniflora.

There are great changes both in patches quantity and shapes (Table 2). Due to rapid expansion, population patches are connected together, making the patches number declined rapidly from 867 to 354, reduced by 59.17 %; mean patch size increased rapidly from 0.24 hm^2 to 0.88 hm^2, increased by 266.67 %; maximum patch size has also increased from 35.59 hm^2 to 40.10 hm^2. Patch shape index *SI* declined from 23.28 to 19.50, shows that patches tends to be regular. In addition, in 2006 patches of single patch shape index *SI* in 1~2, 2~3, 3~4, 4 above accounted for 93.85 %, 4.41 %, 0.93 % and 0.81 % respectively; in 2010 patches *SI* in 1~2, 2~3, 3~4, 4 above accounted for 85.71 %, 9.71 %, 3.17 % and 1.14 % respectively, indicate that the patches shapes are basically round or approximate circle, but the proportion of round or approximate circle decreased, single patch shapes transform to polygon gradually.

The *S.alterniflora* of East, Central and West zone have obvious differences in sizes, spatial distribution, patches quantity and shapes. The dynamic changes, patch number, mean size, max patch size and shape index in the whole study area almost have the same changing trends, showing that patch number decreased quickly, mean patch size and max patch size increased, patch shape index reduced gradually, and the changing range of every index of East and Central zone is near to the whole study area, but the invading rate in West zone is obviously higher than other zones, the changing range of patch number, mean patch size, max patch size and patch shape index in West zone are also larger than other zones. From the numerical characteristics of individual index, the patch number, mean patch size, max patch size of *S.alterniflora* in deferent zones in 2006 and 2010 showing that East zone > Central zone > West zone. In a word, the patches tends to be regular from east to west gradually, patch number and mean patch size also reduce gradually.

Tab.2 Patches characteristics of *S.alterniflora* in the shanyutan wetland

Time	2006				2010			
Characteristics	N	MPS	*SI*	MP	N	MPS	*SI*	MP
East zone	341	0.33	14.05	35.59	165	1.00	13.52	40.10
Central zone	327	0.25	15.78	24.22	117	0.96	12.70	26.90
West zone	199	0.08	11.63	13.59	72	0.4	6.62	24.73
Shanyutan wetland	867	0.24	23.28	35.59	354	0.88	19.50	40.10

N equals the number of patches; MPS equals the Mean Patch Size; *SI* equals the Patch Shape Index; MP equals the max patches size

Transformation Characteristics of S.alterniflora Patches.

The size of *S.alterniflora* expands unceasingly, mainly occupied native vegetation and bare beaches; Meanwhile, there are some areas native vegetation or bare beaches take place *S.alterniflora* due to artificial or natural factors(figure 2, figure 3).

The land types shifted to *S.alterniflora* include bare beaches, native vegetation and tidal creek, and the total area is 117.22 hm^2.The area of bare beaches shifted to *S.alterniflora* is 85.03 hm^2, accounting for

72.54 % of the increased area.

East zone, the area of bare beaches shifted to *S.alterniflora* is 39.53 hm^2, mainly distributed in low tidal flat edge, the surrounding area of tidal creek and high tidal flat; Central zone, the shifted area is 30.47 hm^2, mainly in low tidal flat and the surrounding area of tidal creeks; West zone, the shifted area is 15.06 hm^2, mainly in mid tidal flat, there are also some patches being invaded in high tidal flat.

The area of native vegetation shifted to *S.alterniflora* is 24.47 hm^2, accounted for 20.88 % of the increased area. East zone, the area of native vegetation shifted to *S.alterniflora* is 9.17 hm^2, mainly distributed in mid and high tidal flat; Central zone, the shifted area is 13.90 hm^2, mainly in high tidal flat and some parts of mid tidal flat; West zone, the shifted area is only 1.40 hm^2, mainly in mid and high tidal flat. Besides, there are some tidal creek shifted to *S.alterniflora*, about 7.72 hm^2, distributed mainly in the surrounding area of tidal creeks of East zone.

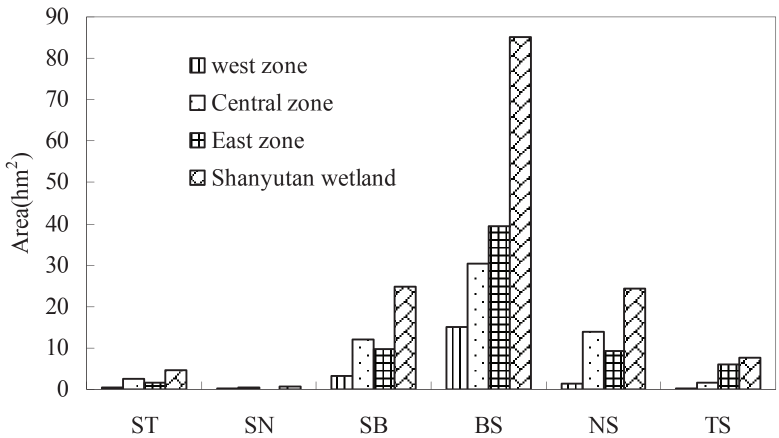

Fig.2 Plaques transformation characteristic in the shanyutan wetland

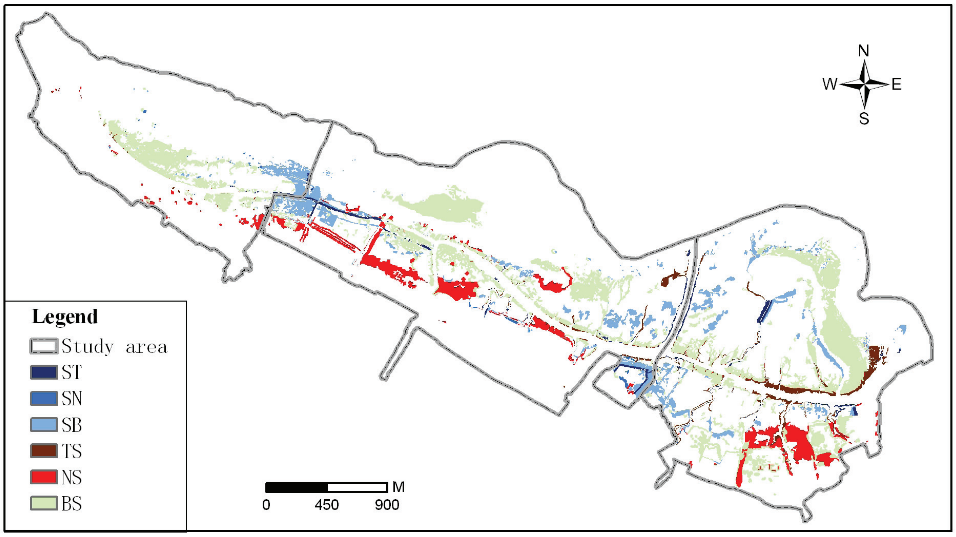

Fig.3 Spatial distribution features of Plaques transformation in the shanyutan wetland

(ST indicates *S.alterniflora* changes to tidal creek; SN: *S.alterniflora* changed to native vegetation;

SB: *S.alterniflora* shifted mutflats; conversely, indicates another direction transformation.)

The land types *S.alterniflora* shifted to include bare beaches, native vegetation and tide ditch, and the total area is 14.98 hm^2, much smaller than that shifted to it. The size shifted to bare beaches is 11.99 hm^2, accounted for 80.04 % of it shift to others. The size shifted to bare beaches is relatively large in East and Central zones, distributed mainly in the surrounding area of Continuous Station and some scattered patches in East zone. The size shifted to native vegetation and tide ditch is only 0.48 hm^2 and 2.50 hm^2 respectively.

Acknowledgements

This research was supported by key project of Fujian Provincial Department of Science and Technology(2009R10039-1). We also thank Yongxun zhang, Qinghua He, Yongyue Ma and Ping Yang for their field assistance.

References

[1] T.G.Tang and W.J.Zhang: Engineering sciencesVol. 5 (2003), p. 15

[2] J.C.Callaway and M.N.Josselyn: Estuaries Vol. 15 (1992), p. 218

[3] C.C.Daehler and D.R.Strong: Biological Conservation Vol. 78 (1996), p. 51

[4] D.R.Ayres, D.L.Smith, K.Zaremba, S.Klohr and D.R.Strong: Biological Invasions Vol. 6 (2004), p. 221

[5] H.M Huang and L.Q.Zhang: Journal of Plant Ecology Vol. 31 (2007), p. 75

[6] C.Y.Liu, S.Q.Zhang, H.X.Jiang and H.Wang: Chinese Journal of Applied Ecology Vol. 20 (2009), p. 901

[7] H.Y.Yu, W.W.Shao, M.C.Han, J.Yu and Z.Y.Hu: Environmental Monitoring In China Vol. 26 (2010), p. 70

[8] Y.M.Shen, Y.M.Liu, Q.Z.Chen: Journal of Plant Resources and Environment Vol. 11(2002), p. 33

[9] S.M.Sun: Journal of Oceanography in Taiwan Strait Vol. 24(2005), p. 223

[10] X.Yu, J.Y.Tian, J.Q.Li and J.K.Sun: Marine Environmental Science Vol. 28(2009), p. 684

[11] W.H.Pan, J.J.Chen, C.L.Li and J.Y.Wang: Chinese Agricultural Science Bulletin Vol. 25(2009), p. 216

[12] J.Q.Liu, C.S.Zeng and N.Chen, in: Research of Minjiang River Estuary wetland, edited by Chinese science press, Beijing(2006), in press.

[13] D.N.Xiao, in: Research methods and index system of landscape space structure, edited by China Forestry Publishing House, Beijing(1991), in press.