Vegetation Dynamic Changes of Lake Nansi Wetland in Shandong of China

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Abstract

The paper researched the Lake Nansi wetlands phytoplankton species of aquatic vascular plants, distribution and biomass from 1983 to 2006. The methods were field investigation, laboratory analysis, remote sensing and geographic information system technology. The results showed that, wetland vegetation biomass continued to decrease in Lake Nansi from 1983 to 2006. Biomass of emergent plants decreased the fastest, followed by floating-leaved plants and submerged plants. The result reflects the human reclamation, aquaculture and other activities caused reduction in primary productivity. This effect decreased gradually from the periphery to the center of the Lake.

Keywords: Lake nansi; wetland; vegetation; biomass; dynamic

1. Introduction

Lake Nansi wetland is located in Jining City, Shandong Province. The water comes from 32 counties of Jiangsu, Shandong, Henan and Anhui provinces. The catchment area is three million square kilometers [1, 2]. Lake Nansi is one of hinges for the Eastern Route Project of South-to-North Water Diversion (ERPSNW). It plays a part in local economic takeoff and ecosystem balance [3]. The basin shape of Lake Nansi is shallow dish. Its average depth is 1.46 meters for many years [4]. By the lakefront, emergent plants, floating leaved plants and submerged plants are distributed by water depth and they are showing parallel zonal distribution. Phytoplankton and floating plants are Located in surface water layers. Lake Nansi wetland plants are producers of the wetland ecosystem.

2. Research process and methods

The research selected three Thematic Mapper (TM) images in June 15, 1987, June 10, 1997, September 1, 2004, and a SPOT image in 15 June 2006 as a data source. The monthly average water level in
September was same with the monthly average water level in June. Using ERDAS9.0, ArcGIS9.0 as the main working platform, extracted remote sensing information of Lake Nansi wetland and got the area of different wetland types. Science and Technology Committee of Jining City did a project (Investigation and exploitation of natural resources research in Lake Nansi) in 1983. By the field sampling data in 1983 and interpretation of remote sensing, wetland vegetation biomass was calculated.

Thematic information collected including: topographic map of Lake Nansi which 1:5 million scale, basic geographic data of Jining City which 1:25 million scale, hydrological, meteorological and soil data of Lake Nansi, land survey data and related natural change and socio-economic survey data. They were basis to extract images information and calculate wetland plant biomass.

### 3. Landscape changes in spatial structure

Extracted Lake Nansi wetland information from TM images in 1987, 1997, 2004 and SPOT image in 2006 (Table 1). The overall classification accuracy of all images were no less than 83.5 %. It was better classification results. In addition, the scope of the study area had a slight change each year to reflect the area changes of the rice fields.

| Year | 1987 | 1997 | 2004 | 2006 |
|------|------|------|------|------|
| **Lake and Nature Water** | 580.89 | 520.3 | 477.9 | 503.32 |
| **Rivers** | 60.41 | 52.49 | 48.57 | 45.16 |
| **Reeds Field** | 325.09 | 269.61 | 131.65 | 87 |
| **Netherlands Field** | 209.92 | 128.14 | 87.85 | 57.86 |
| **Total** | 1176.3 | 970.54 | 745.97 | 693.34 |
| **Artificial Wetland** | 1106.6 | 1075.5 | 934.08 | 933.41 |
| **Rice Field** | 22.03 | 142.4 | 370 | 413.2 |
| **Water Aquaculture** | 13.31 | 21.51 | 37.11 | 38.42 |
| **Artificial Drains** | 27.41 | 31.36 | 37.72 | 42.11 |
| **Total** | 1169.3 | 1270.7 | 1378.9 | 1427.14 |
| **Non-wetland** | 126.68 | 164 | 184.4 | 186.32 |
| **Residential and Construction Sites** | 126.68 | 164 | 184.4 | 186.32 |
| **Other Agricultural Land** | 183.15 | 168.66 | 146.69 | 135.5 |
| **Other Sites** | 41.37 | 54.33 | 77.14 | 74.45 |
| **Total** | 351.2 | 386.99 | 408.23 | 396.27 |
| **Total** | 2696.8 | 2628.3 | 2533.1 | 2516.8 |

The reeds and Netherlands fields were significantly reduced and were replaced by large tracts of farming water (TABLE.1). The landscape composition of Lake Nansi wetland had more significant changes from 1987 to 2006. Natural wetlands (lake and natural water, rivers, reeds, Netherlands) area continued to decline from 1176.31km2 to 693.34km2. The lake and natural water area changed following the fluctuations of rainfall. The river, reeds and Netherlands field area were declining. The artificial wetland and non-wetland was increasing from 1987 to 2006.
4. Phytoplankton changes of Lake Nansi

4.1 Phytoplankton species and distribution

According to the results of four samples in 1983, Lake Nansi phytoplankton had 116 geniuses, belonging to eight phylum, and 46 families. Chlorophyta was most, followed by Bacillariophyta. The annual average number of phytoplankton was $218.2 \times 10^4$ per liter of water and changes in the range of $78.5 \times 10^4$ to $610.1 \times 10^4$. The annual average biomass was $1.7094\text{mg} / \text{L}$ and it changes between $0.3982\text{mg} / \text{L}$ and $2.9803\text{mg} / \text{L}$ [5].

Lake Nansi is so shallow that natural factors and human activities affect the lake largely. Phytoplankton distributes everywhere, but their number and biomass are different due to the geographical location of the sampling sites and environmental conditions. The number of Cryptophyta was most, followed by diatoms. They can be accounted for 58.3% of the total number. Diatoms biomass is most, followed by Cryptophyta. They can be accounted for 49.5% of the total biomass. So, Diatoms and Cryptophyta are the main doors in quantity or biomass in Lake Nansi. It is Cryptophyta-Diatoms type.

Phytoplankton in the distribution of the categories is different. Cryptophyta was distribution in the whole lake and appeared at anytime. Cryptophyta distribution was greater at the lake center and the main channel. Bacillariophyta distribution was distribution in the whole lake also. Chlorophyta genera distribution was throughout the lake, but the lake center was most and affected by the contaminated area was least. Euglenophyta concentrated in the main channel. Chrysophyta concentrated in the main channel, Lake Zhaoyang and Lake Dushan showed no distribution.

Lake Nansi Phytoplankton species composition, quantity, biomass and dominant species change with the seasons significantly [6]. Phytoplankton biomass was the highest in Spring (early May) and it was $2.3694\text{mg} / \text{L}$; summer followed and it was $2.1988\text{mg} / \text{L}$; The third was autumn and it was $1.4381\text{mg} / \text{L}$; Phytoplankton biomass was the least in winter and it was $0.8312\text{mg} / \text{L}$ [5]. The biomass trend which formed a descending order of seasons appeared the spring was single peak. Phytoplankton numbers and biomass trends of seasonal variation were consistent, but the number was slightly higher in winter than in autumn. So the Phytoplankton number changes was spring "single peak” also.

4.2 Phytoplankton biomass

In 1983, annual average biomass of Phytoplankton was $1.7094\text{mg} / \text{L}$, and the average water depth of sampling was 1.74m, and the lake area was1180km2. Calculated the amount of resources of Phytoplankton was 3509.74t. Images interpretation of the lakes and rivers, reeds, Netherlands fields were classified as water surface area. In1987, 1997, 2004, 2006, the water surface area were: 1176.29 km2, 970.54 km2, and 693.34km2, 745.97 km2. Phytoplankton biomass average was $1.7094\text{mg} / \text{L}$ in Lake Nansi, and annual average water depth was 1.46m. So, Phytoplankton biomass = average water depth × water surface area × average biomass unit of water. Therefore, Phytoplankton biomass of Lake Nansi wetland could be conclusion (Table II).

5. Changes of aquatic vascular plants

5.1 Aquatic vascular plants species and distribution

According to investigation on Lake Nansi in May and September1983, the lake existed 74 species of aquatic vascular plants which belonging to 28 families, 45 generals [5]. Hydrilla, Potamogeton and C.
demersum distributed the most widely. They were throughout the lake. But in different locations, there were differences in the coverage of plants. Generally, it was maximum density where the water depth within 1~2m. Distribution breadth of Potamogeton micro teeth, Malaianus, Nymphoides, reed and mushroom was second. They distributed in many parts of the whole lake. Distribution breadth of Netherlands, Gorgon, and water chestnut was third. They located in the old embankments on both sides of the Lake Superior, Lu Qiao Town west of the water, Lake of the southern part of lake.

According to various types of distribution of aquatic vascular plants of the size and plant density, Hydrilla, Potamogeton, Ceratophyllum demersum, Nymphoides, reed, mushroom, Netherlands, Gorgon, and water chestnut were constructive species of Lake Nansi. With the water depth changes from the shore to the lake center, it formed four distinct series with the ring of plants: emergent plants zone, floating-leaved plants zone, submerged plants zone and floating plants zone. With different series, there were different kinds of constructive species and the associated species. The distribution of submerged plants was the largest.

5.2 Aquatic vascular plants biomass

Aquatic vascular plant biomass changes largely with season. In spring, aquatic vascular plant has just begun growth and development. In autumn, by accumulation of organic matter, aquatic vascular plant biomass achieved maximum. Therefore, vegetation biomass of the lake wetland was biomass of vegetation in September (Figure 1).

Hydrocharitaceae, small branches and grass jelly two plants Potamogeton biomass were account for about 98% of the total submerged plants biomass. In the September peak of growth, measured biomass was 2248.9g/m2 and the distribution area was 930km2. so, the total biomass of submerged plants was about 210 × 104t (wet weight). The main types of floating-leaved plants were Nymphoides, Lotus, followed by the Gorgon and the water chestnut. In September, the average measured biomass was 247.68 g/m2 and the distribution area was 930km2. So, the floating-leaved plants total biomass was about 23.13 × 104t. Emergent plants mainly were reed, followed by mushroom. Their distribution was about 250km2, accounting for 20.5% of the lake area. By the sampling of measured data in 1983, the average biomass was 2900 g/m2, calculated the total biomass was 71.5 × 104t. Floating plants species scattered distribution and quantity was little. Therefore, the paper did not calculate their biomass. Calculation the biomass of the whole lake in autumn 1983, the total aquatic vascular plant biomass was 304.63 × 104t. The whole lake surface was 1180km2 and the average biomass was 2580g/m2. Biomass of submerged plants was the largest, accounting for 69% of the total biomass; followed by emergent plants, accounting for 23.4%, floating-leaves plants accounted for only 7.6%.
Using observed the biomass per unit area of Lake Nansi in 1983, the lake natural water and river water in the area as distribution area of submerged plants and floating plants, reed fields and charge distribution area as the distribution area of aquatic plant, aquatic vascular plant biomass can be calculated in 1987, 1997, 2004 and 2006 (Table II). Biomass of aquatic vascular plants average for many years was $250.46 \times 10^4$ t, which submerged plants, floating leaf plants and aquatic plants respectively was: $144.96 \times 10^4$ t, $15.96 \times 10^4$ t, $89.53 \times 10^4$ t.

Table 2 vegetation biomass of lake nansi wetland during 1983~2006

| Biomass (Wet Weight:10^4 t) | 1983  | 1987  | 1997  | 2004  | 2006  | Average |
|-----------------------------|-------|-------|-------|-------|-------|---------|
| Phytoplankton               | 0.35  | 0.29  | 0.24  | 0.17  | 0.18  | 0.25    |
| Aquatic vascular plants     |       |       |       |       |       |         |
| Submerged Plants            | 210   | 144.2 | 128.8 | 118.4 | 123.4 | 145.0   |
| Floating-leaved Plants      | 23.13 | 15.88 | 14.19 | 13.04 | 13.58 | 15.96   |
| Aquatic Plants              | 71.5  | 155.2 | 115.4 | 63.66 | 42    | 89.53   |
| Total                       | 304.6 | 315.3 | 258.4 | 195.1 | 178.9 | 250.5   |
| Total                       | 305.0 | 315.6 | 258.6 | 195.3 | 179.1 | 250.7   |

6. Conclusion

From 1983 to 2006, Vegetation biomass decreased continually in the Lake Nansi Wetland. Biomass of emergent plants decreased the fastest, followed by floating-leaved plants and submerged plants (Table II, Figure 2). Floating-leaved plants and submerged plant biomass from 1983 to 2004 declined continually and it increased in 2006, but it was still below the biomass of 1997, 1987, 1983 (Figure 2). Biomass of phytoplankton in Lake Nansi was declining from 1983 to 2004. Phytoplankton biomass in 2004 was less than 50% in 1983 and a slight increase in 2006 than 2004 (Table II). Relative to other ecological type of plant biomass, phytoplankton biomass was so small that its trend was not obvious in Figure 2.

Figure 2 Vegetation’s biomass of Lake Nansi wetland during 1983~2006

The result reflects the human reclamation, aquaculture and other activities caused reduction in primary productivity. This effect decreased gradually from the periphery to the center of the Lake. Nature Reserve of Lake Nansi was established in 2003 and the implementation of ERPSNW made management and protection increasing to Lake Nansi [7]. From then on, wetland ecological environment is improving and began to recover from the water depth large where distributed floating leaves plants and submerged plants. This showing that the greatest impact on the wetland factor is human activity. Therefore, under the premise
of social and economic development, controlling human activities on the Lake Nansi Wetlands more effectively become an urgent solved the problem.

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