Study on The Relationship between Vegetation Index And Bird Diversity in Beidagang Wetland

DAI Zi-ling¹, HE Meng-xuan¹*, LV Dan-ran¹, LIU Jia-rui¹, Xu Ling-xuan¹, Wan Peng-cheng¹, Mo Xun-qiang¹

¹School of Geographic and Environmental Sciences, Tianjin Normal University, Tianjin 300387, China

Corresponding author’s e-mail: hemengxuan1989@126.com

Abstract. Birds are an important part of wetland ecosystem. With the development of urbanization, bird vegetation is destroyed seriously, threatening bird diversity. In view of this, this paper studied the dynamic changes of NDVI (Normalized Difference Vegetation Index) and three bird diversity indexes (Shannon-Wiener index, Simpson index, Pielou index), and explored the relationship between the two, based on the wetland bird survey data and Landsat 8 remote sensing images from 2015 to 2019 in Beidagang Wetland. The results showed that: Although the growth condition of wetland plants changed from poor to better due to the ecological water rehydration measures adopted in the later period, the three indexes leveled off except in 2018. Spearman correlation analysis showed that Shannon-Wiener index was highly negatively correlated with NDVI, and slightly negatively correlated with Simpson index and Pielou index, indicating that NDVI in Beidagang Wetland had much less impact on bird diversity than other habitat factors, and could not play a leading role.

1. Introduction

In the process of ecological civilization construction in China, biodiversity protection has always been the core of work [1]. Wetland is one of the areas with the most abundant biodiversity in the world and its biodiversity protection is particularly important. This is not only the essence of sustainable development, but also China’s obligation to fulfill Convention on Wetlands of International Importation Particularly as Habitat for Waterfowl [2-3], Among them, birds are an indispensable part of wetland ecosystem, with unique ecosystem engineering effects such as species protection and ecological restoration [4]. They even are the focus and hotspot of wetland research at present.

However, with the development of urbanization, coastal wetland vegetation deteriorates seriously and cannot provide sufficient primary productivity, resulting in the loss of suitable habitat and sufficient food resources for birds [5]. In recent years, in response to the ecological restoration policy, some wetlands have been implemented in succession, and the gradually improved vegetation has made the bird diversity recover [6-7]. T.S. Ding et al [8] studied the relationship between the bird population richness and the vegetation growth in East Asia. He found that there was a significant positive correlation between the two, but the effect was weaker in the island region than in the mainland. Studies in a small area in northern Taiwan also showed such a positive linear correlation [9].

In the study of wetland birds, there are few reports on the impact of vegetation growth changes on bird diversity in Tianjin Beidagang Wetland in recent years. The bird protection work cannot be scientifically managed, which restricts the construction of ecological civilization.

As a permanent ecological protection red line area in Tianjin, Beidagang Wetland is a key resting
place for migratory birds along the East Asia-Australasia migration road. At present, there are 279 species of birds in the wetland, which has been listed as an internationally important wetland in 2020, and has been nominated as a World Natural Heritage Site of China's Yellow Sea Migratory Bird Habitat (Phase II) \(^{[10]}\). Therefore, it is of great practical significance to study the wetland birds and their habitat vegetation growth in Beidagang Wetland. In view of this, by using the survey data of wetland birds in Beidagang and Landsat 8 remote sensing images from 2015 to 2019, the paper selects NDVI (Normalized Difference Vegetation Index) as the vegetation index, Shannon-Wiener index, Simpson index and Pielou index as bird diversity indexes, to study their dynamic changes and the correlation. The results of this study can reveal the impact of vegetation change caused by human activities on birds in recent years. It could provide scientific suggestions for wetland bird diversity protection and ecological restoration, and help Beidagang wetland become the green name card of Tianjin.

2. Materials and Methods

2.1. Overview of the study area

Beidagang Wetland is located in the Binhai New District of Tianjin, 117°11'E-117°37'E, 38°36'N-38°57'N, adjacent to the Bohai Sea in the east. It is on the migratory route of birds in East Asia and the only place for migratory birds from East Asia to Australia. In 2019, the total number of migratory birds passing through the Beidagang Wetland reached 1 million. At present, the number of migratory birds in Beidagang Wetland Reserve in spring and autumn each year can reach hundreds of thousands of birds, more than 140 species of birds, including 6 species of national II class protected birds, 17 species of national class protected birds, all the species account for one third of the national bird resources.

2.2. NDVI remote sensing image analysis

2.2.1. Data source and pretreatment

The time range of remote sensing image data selected in this study is 2015-2019. Landsat 8 OLI image was selected as the data source, with high accuracy and able to cover the research time range. The seasons of the images are concentrated in summer and autumn, with relatively lush plant growth and less cloud cover, which is convenient for remote sensing processing.

2.2.2. NDVI calculation

Among all Vegetation indexes, NDVI (Normalized Different Vegetation Index) is sensitive to green plants, which can accurately reflect the Vegetation coverage and plant growth vitality. Therefore, NDVI was adopted as the vegetation index.

The NDVI calculation formula is as follows:

\[
\text{NDVI} = \frac{\text{NIR}-\text{R}}{\text{NIR}+\text{R}} \tag{1}
\]

In the formula, NIR is the reflectance of the near-infrared band, and R is the reflectance of the red band. For Landsat 8 OLI images, NIR is band 5 and R is band 4. NDVI values range from -1 to 1, NDVI>0.05 indicates vegetation cover, and the higher the NDVI value, the better the plant growth, NDVI>0.60 indicates high plant growth.

2.3. Bird data acquisition

In this study, the sampling method was adopted to conduct bird survey. In sunny and still windy weather, vehicles were used to travel. During the survey, the "sampling spot-absolute number statistics method" was adopted to record the bird species within the discernible range of a single telescope in the shortest possible time. When the flock is small, the counter is used for direct counting, and when the flock is large, group counting is adopted. At the same time, survey the ecological environment, recording the date of observation, the weather and the location of birds.
2.4. Data analysis

Based on the bird data, the Shannon-Wiener index, Simpson diversity index and Pielou evenness index were used as the bird diversity measurement factors, and the calculation formula was as follows:

1. Shannon-Wiener Index

\[ H = - \sum_{i=1}^{S} p_i \ln p_i \]  

In the formula, \( S \) is the number of species, \( p_i \) is the proportion of individuals belonging to species \( I \) in the total individuals, and \( H \) is the diversity index of species.

2. Simpson diversity index

\[ D = 1 - \sum_{i=1}^{S} (p_i)^2 \]  

In the formula, \( S \) is the number of species; \( p_i \) is the proportion of the number of individuals of species \( I \) to the total number of individuals in the community.

3. Pielou uniformity index

\[ E = \frac{H}{\ln S} \]  

In the formula, \( H \) is the Shannon-Weiner index, and \( S \) is the total number of species in the community.

In this study, the R Programming Language was used to perform Spearman correlation analysis between NDVI and the three diversity indexes in order to study whether there is a relationship and the degree of the relationship.

3. Results and Discussion

3.1. NDVI dynamic change

According to the results of vegetation index calculation in Beidagang Wetland, NDVI was divided into seven levels. NDVI>0.05 means there is vegetation cover. The higher the NDVI value, the better the plant growth. NDVI>0.60 means the plant growth is lush. The area proportions of different levels of NDVI were calculated (Table 1). The results showed that the area with NDVI between 0.05 and 0.20 doubled in 2015-2016, and the area with NDVI between 0.20 and 0.40 significantly decreased, and even the vegetation with NDVI>0.40 no longer existed. The overall average value dropped to 0.05, indicating serious vegetation degradation. Based on the actual habitat, the area with NDVI<0.05 can be judged as open water. In conclusion, the water area gradually decreased from 2016 to 2018, providing a broader living space for vegetation growth. So vegetation growth got improved. The area of NDVI>0.30 expanded, and the average value reached the peak (0.15) in 2018.

Although Beidagang Wetland nature reserve took ecological hydrating measures at the end of 2018, most vegetation have went into terminal decline, leading to low NDVI. This is due to the selected remote sensing image imaging time in 2019 is September 27.

| Year | Mean Area Proportion (%) | NDVI Mean | Mean Area Proportion (%) |
|------|--------------------------|-----------|--------------------------|
|      | 0.05 0.05-0.20 0.20-0.30 0.30-0.40 0.40-0.50 0.50-0.60 >0.60 | <0.05 | 0.05-0.20 | 0.20-0.30 | 0.30-0.40 | 0.40-0.50 | 0.50-0.60 | >0.60 |
| 2015 | 0.09 | 59.96 | 16.72 | 11.24 | 6.02 | 3.87 | 2.02 | 0.18 |
| 2016 | 0.05 | 60.60 | 32.64 | 6.36 | 0.40 | 0 | 0 | 0 |
| 2017 | 0.09 | 55.24 | 20.74 | 16.43 | 6.22 | 1.29 | 0.09 | 0 |
| 2018 | 0.15 | 53.43 | 4.83 | 7.61 | 17.45 | 13.01 | 3.45 | 0.21 |
| 2019 | 0.03 | 68.78 | 13.84 | 16.90 | 0.48 | 0 | 0 | 0 |

3.2. Bird diversity dynamic change

A total of 200 species of wild birds, 51 families and 20 orders have been recorded. There are some internationally protected species among them, such as Ixobrychus eurhythmus, Anser cygnoides, Anas formosa etc. 33 species of national protected birds were recorded, of which 6 species are national class I protected species, and 27 species are national class II protected species.
According to the ecological groups of birds, they were divided into waterfowl, songbirds, wading birds, raptors, scansores and terrestrial birds. The species dynamic changes of each ecological group were calculated (Fig. 1). As can be seen from Fig. 1, waterfowl and songbirds are the main ecological groups of wetland birds. Raptors, scansores and landfowl have fewer species because wetland habitat is not in line with their habitat preferences. The total number of bird species reached 156 in 2015, then decreased by about 20% from 2016 to 2017, and then dropped to 130 species after a slight rebound in 2018, showing an overall downward trend.

In order to quantitatively analyze the diversity of wetland birds, the Shannon-Wiener index, Simpson index and Pielou index of birds from 2015 to 2019 were calculated and used as the bird diversity measurement factors. As can be seen from Fig. 2, Shannon-Wiener index, Simpson index and Pielou index fluctuated around 2.8, 0.8 and 0.5 respectively. Except for the obvious decline of the three indexes in 2018, the changes of indexes in the other four years tend to be stable. It may be due to the large-scale expansion of construction land around the Beidagang Wetland in 2018, and the environmental pollution and ecological destruction brought by urbanization have a certain impact on the birds.

Spearman correlation analysis was performed with SPSS to obtain the relationship between NDVI and the three bird diversity indexes (Shannon-Wiener index, Simpson index and Pielou index). The results
showed that Shannon-Wiener index was highly negatively correlated with NDVI (-0.80), and slightly negatively correlated with Simpson index (-0.30) and Pielou index (-0.30). This is mainly because bird diversity is also affected by other habitat factors, such as habitat type and climate, indicating that NDVI has a much smaller effect on bird diversity than other habitat factors.

4. Conclusion
From the perspective of NDVI dynamic changes, the growth of wetland plants turned from poor to good. During 2015-2016, the average NDVI dropped to 0.05, indicating serious vegetation degradation. During 2016-2018, NDVI increased significantly. In 2019, the plant growth continued to improve due to ecological water replenishment measures. From the perspective of bird diversity dynamic changes, the Shannon-Winner index, Simpson index and Pielou index decreased significantly in 2018, but the other four years tended to be stable. From the perspective of Spearman correlation analysis, Shannon-Wiener index is highly negatively correlated with NDVI, while it is slightly negatively correlated with Simpson index and Pielou index, indicating that NDVI had much less impact on bird diversity than other habitat factors, and could not play a leading role.

There are many factors affecting bird diversity, but due to limited data access and other reasons, only NDVI was selected for analysis. In the future, more comprehensive and targeted variables will be introduced for exploration, and data volume with a longer time span will be selected to provide more accurate scientific basis for wetland ecological restoration.

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