Postprint: Variation Characteristics of Plant Diversity in Lake Taitema Before and After Ecological Water Conveyance

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Abstract

Through comprehensive analysis of continuous vegetation data from 2000 to 2017 in Taitema Lake, field investigations and data collection were conducted on vegetation changes in inundation plots and non-inundation plots (i.e., control plots) at each monitoring cross-section. The study revealed: With the progression of ecological water transfer, the ecological benefits of vegetation in Taitema Lake gradually manifested, with biodiversity showing significant increases. In the inundation zone, the mean values of species number per unit area, vegetation coverage, and vegetation density were 6.8 species · $(100m^2)^{-1}$, 30%, and 1,350 individuals · $(100m^2)^{-1}$, respectively, which represented increases of 3-fold, 3.29-fold, and 49-fold compared to the groundwater rise zone. Furthermore, prior to water transfer (in 2000), the lake area contained plants belonging to 2 families, 3 genera, and 7 species, which increased to 10 families, 21 genera, and 26 species after water transfer, representing additions of 8 families, 18 genera, and 19 species. During the ecological water transfer process over the past decade, vegetation in Taitema Lake has evolved toward a salinized lowland meadow dominated by Phragmites australis, exhibiting a trend toward simplification. The evolutionary characteristics were primarily as follows: In the initial stage of water transfer (2000–2005), surface vegetation was dominated by newly germinated annual herbs (importance value 0.50), followed by perennial herbs (importance value 0.20), and finally shrubs (importance value 0.10). As water transfer progressed, annual herbaceous plants decreased in 2009 and were subsequently replaced by shrubs and perennial herbs: the shrubs consisted of native halophytes such as Halostachys caspica and Halocnemum strobilaceum, with newly germinated seedlings appearing, while the perennial herb was Phragmites australis. From 2012 to 2016, under the abundant water resource conditions following water transfer, the composition of dominant species tended toward simplification, and vegetation developed in the direction of a salinized lowland meadow dominated by Phragmites australis.

Full Text

Changes in Plant Diversity of the Taitema Lake Area Before and After Implementing Ecological Water Conveyance

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Abstract:
Studying the changes in plant diversity in the Taitema Lake area before and after implementing ecological water conveyance is of great significance for regenerating the ecological environment in the lower reaches of the Tarim River. Through comprehensive research on continuous vegetation data in the Taitema Lake area during 2000–2017, this study conducted field investigations and data collection, and compared the differences in vegetation variation between overflow plots and non-flood plots (i.e., controlled plots). The results were as follows: With the implementation of ecological water conveyance, the ecological benefits of vegetation in the Taitema Lake area have gradually emerged, and biodiversity has been significantly increased. In the flooded area, the average number of plant species per unit area, vegetation coverage, and vegetation density were 6.8 number $\cdot$ $(100m^2)^{-1}$, 30%, and 1350 number $\cdot$ $(100m^2)^{-1}$, respectively, which were increased by 3, 3.29, and 49 times those in the regions where the groundwater level was risen only. Before implementing the ecological water conveyance, there were 7 plant species in 3 genera and 2 families in the lake area. After that, they were increased to 26 species in 21 genera and 10 families; After implementing the ecological water conveyance for 10 years, the vegetation in the Taitema Lake area developed towards the salinized lowland meadow dominated by reeds and tended to be simplified. The vegetation evolution was characterized by that the newly germinating vegetation was dominated by annual herbs with an important value of 0.50 at the early stage of the ecological water conveyance (2000–2006), followed by perennial herbs with an important value of 0.20 and by shrubs with an important value of 0.10. With the continuous ecological water conveyance, the annual herbs decreased in 2009 and were gradually replaced by shrubs and perennial herbs. The shrubs were the native halophytes including *Halostachys caspica* and *Halocnemum strobilaceum*, and some newly germinated seedlings appeared. Under the environment with abundant water resources during the period from 2012 to 2016, the dominant species composition tended to be simple, and the vegetation developed towards the salinized lowland meadow dominated by reeds.

Keywords: ecological water conveyance; plant diversity; plant community; Taitema Lake

1 Introduction

The Taitema Lake area is located in the lower reaches of the Tarim River, where the ecological environment is extremely fragile. Since 2000, the Tarim River Basin has implemented ecological water conveyance projects, with a total water volume of 3.50×10 m^3 delivered to the Taitema Lake area by 2017. This has led to significant changes in the lake' s ecological environment and vegetation restoration. Previous studies have shown that water conveyance projects have important effects on vegetation restoration and community succession in arid regions.

Before water conveyance, the Taitema Lake area had extremely sparse vegetation, with only 7 plant species belonging to 3 genera and 2 families. The vegetation composition was simple, dominated by extremely drought-tolerant and salt-tolerant species. After water conveyance, the groundwater level rose and soil moisture conditions improved, providing favorable conditions for vegetation restoration. Studies have shown that the vegetation in the lower reaches of the Tarim River showed a significant response to water conveyance, with community diversity and biomass increasing significantly.

The implementation of ecological water conveyance has not only changed the hydrological conditions of the Taitema Lake area but also profoundly affected the structure and function of plant communities. Through continuous monitoring and research, it has been found that vegetation restoration shows obvious temporal and spatial heterogeneity, with different water conveyance methods and intensities leading to different vegetation restoration effects. Understanding the response patterns of plant diversity to water conveyance is of great significance for optimizing water resource management and promoting ecological restoration.

2 Methods

2.1 Study Area and Sample Plot Setup

The Taitema Lake area is located in the lower reaches of the Tarim River in Xinjiang. The study area is characterized by a typical temperate continental arid climate, with scarce precipitation and strong evaporation. The soil is mainly saline-alkali soil, and the natural vegetation is dominated by halophytes and drought-tolerant species.

In 2001, we established 39 sample plots of 50 m × 50 m in the Taitema Lake area. Each plot was divided into 2 subplots for vegetation survey (5 subplots + 7 subplots + 1 subplot). Within each plot, 3 quadrats of 1 m × 1 m were

set up for herbaceous plant surveys, and 2 quadrats of 23 m were set up for shrub surveys. The survey recorded species composition, number of individuals, height, coverage, and other indicators of vegetation.

2.2 Data Collection and Analysis

The vegetation survey was conducted in the Taitema Lake area in 2000 (before water conveyance) and after water conveyance (2002-2017). The survey included species composition, vegetation coverage, density, and community characteristics of different plant communities. The plant communities mainly included *Halostachys caspica*, *Halocnemum strobilaceum*, and other halophytes, as well as some newly germinated herbaceous plants.

We calculated four diversity indices: Margalef index (D = (S-1)/lnN), Simpson index (D = 1- (P ^{2})), Shannon-Wiener index (H = - (P lnP)), and Pielou evenness index. The importance value (IV) was calculated as: IV = (relative density + relative coverage + relative frequency)/3.

The vegetation data from flooded areas and non-flooded areas (control plots) were compared to analyze the effects of water conveyance on vegetation restoration. The temporal variation characteristics of vegetation diversity were analyzed using data from different years.

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3 Results

3.1 Changes in Vegetation Diversity Characteristics

After implementing ecological water conveyance, the vegetation in the Taitema Lake area showed significant restoration trends. In the flooded area, the average number of plant species per unit area was 6.8 number $\cdot$ (100m^{2}) ^{1}, vegetation coverage was 30%, and vegetation density was 1350 number $\cdot$ (100m^{2}) ^{1}. These values were 3, 3.29, and 49 times higher than those in areas with only groundwater level rise, respectively.

The Simpson diversity index showed significant differences between flooded and non-flooded areas [FIGURE 2]. The diversity index in flooded areas was significantly higher than in non-flooded areas, indicating that water conveyance significantly increased vegetation diversity. The Margalef richness index, Simpson diversity index, Shannon-Wiener diversity index, and Pielou evenness index all showed increasing trends after water conveyance [TABLE 3].

3.2 Temporal Variation of Vegetation Composition

Before water conveyance (2000), there were only 7 plant species in the Taitema Lake area, belonging to 3 genera and 2 families. After water conveyance, the number of plant species increased to 26, belonging to 21 genera and 10 families. The vegetation composition also changed significantly.

In the early stage of water conveyance (2000–2006), the vegetation was dominated by annual herbs, with an importance value of 0.50. Subsequently, perennial herbs and shrubs gradually increased, with importance values of 0.20 and 0.10, respectively. The main shrub species were native halophytes such as *Halostachys caspica* and *Halocnemum strobilaceum* [FIGURE 3].

With continuous water conveyance, annual herbs decreased in 2009 and were gradually replaced by shrubs and perennial herbs. During 2012–2016, under conditions of abundant water resources, the vegetation developed towards simplified salinized lowland meadows dominated by reeds. The Simpson diversity index showed a decreasing trend during this period, from 0.78 in 2009 to 0.70 in 2012, indicating that community structure tended to be simplified [FIGURE 4].

3.3 Community Succession Characteristics

The vegetation succession in the Taitema Lake area showed obvious stage characteristics. In the first 3–5 years after water conveyance, vegetation diversity increased rapidly, and community structure became more complex. After 10 years of water conveyance, the vegetation gradually stabilized and developed towards specific community types.

The groundwater level rise was the key factor driving vegetation restoration. In areas with groundwater depth of 2–3 m, vegetation restoration was most significant, with vegetation coverage reaching 30% and density reaching 1350 number $\cdot$ $(100m^2)^{-1}$. In areas with groundwater depth less than 1 m, vegetation was dominated by reeds and other hydrophytes, while in areas with groundwater depth greater than 5 m, vegetation restoration was limited.

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Note: Figure translations are in progress. See original paper for figures.