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Features of Plant Community and Driving Forces of Plant Community Succession in the Typical Desert Wetlands

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Abstract: Desert wetlands play a significant role in flood regulation, water purification, biodiversity maintenance, and regional ecological environment improvement. Vegetation is a key factor affecting wetland function and it is important to study the features of plant community and the driving forces of plant community succession. The Ningxia Habahu National Nature Reserve, a typical desert wetland ecosystem, was selected to study the features of wetland plant communities including plant density, biomass and frequency, and vegetation coverage, as well as the habitats, structural characteristics, species composition, dominant population structure, and other characteristics of different ecosystems. Data was collected using long-term fixed-point observation, sampling monitoring, and other methods. The results showed that the total plant density, total biomass, Magalef index and Shannon–Wiener index of the different desert wetlands in the reserve area were all relatively low, which was caused by the poor habitat and salinization of the arid environment. There was no significant difference between the root–shoot ratio of the wetland plants in the reserve area and that of the construct species of other ecosystems. The specific leaf area of the wetland plants was also not significantly different from that of the construct species of other ecosystems. Vegetation nitrogen-to-phosphorus (N/P) ratios were found to be the key driving force for the succession of plant community in the desert wetlands. These results not only provide underlying insights for the improvement of species diversity and ecological environment, but also provide a scientific basis for the sustainable protection and restoration of typical desert wetlands.

Keywords: desert wetlands; plant community; morphological features; driving forces; N/P ratio

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1. Introduction

Wetlands, one of the most important natural ecosystems, are closely related to human survival, reproduction, and sustainable development [1]. The role of wetlands is irreplaceable by other ecosystems in resisting floods, regulating runoff, preventing droughts, degrading pollution [2], regulating climate [3,4], preventing soil erosion, and beautifying the environment [5]. At present, most studies about wetlands focus on biogeochemical cycles, eco-hydrology and water resources [6], wetland biodiversity [7], ecosystem services [8], ecological restoration and reconstruction [9], wetlands monitoring [10], and other aspects. Specially, the research on wetland eco-hydrology reveals the interaction relationships between wetland ecology and hydrological processes, as well as the response mechanism and evolution trend of wetland eco-hydrology under changing environments [11,12], which greatly promotes the protection of wetland ecosystems. Vegetation is a key factor affecting the hydrological function of wetlands, and reasonable selection and configuration of plant species can maintain the stability of ecological structures and functions [13–15].

As is well-known, vegetation construction is one of the most important links in ecological restoration and reconstruction [16]. Reasonable vegetation construction must not only take into account the status quo of local natural, social, and economic development, but more importantly, it must combine the unique characteristics of local natural habitats, and especially, the water balance of the vegetation-soil system is particularly important [17]. Research on the evapotranspiration process and the quantitative assessment of soil moisture balance in the artificial–natural vegetation area in deserts can help to improve the ability of artificial protective vegetation construction and the human ability to protect the environment [18,19].

In recent years, wetland plant individuals and plant community composition, spatial distribution of plants, and their succession have been greatly affected by extreme climate and high-intensity anthropogenic regulation. The extreme climate and high-intensity anthropogenic regulation change the water level, frequency, and duration of flooding to maintain wetland stability through the connections among river flow, biological community, and ecosystem [20–22]. In turn, the growth, transpiration, and retention of plants also affect the balance of soil water. The significant coupling effects between wetland hydrology and plants leads to important feedback between the two [23]. The structure and function of wetlands are changed by the strong interactions between hydrological and ecological processes [24]. The process of wetland ecological hydrology is currently one of the most important research contents of ecological hydrology [25]. In the restoration design of the Tarim River wetland, the species and number of plants have increased significantly through the ecological management of the upper and middle reaches, and then the vegetation coverage has also significantly increased [26].

It has been reported that sewage resources and nutrients such as N and P can be removed or reused through the biological, chemical, and physical adsorption and fixation of the soil–plant system, as well as the capillary-siphon actions of soil, and organic pollutants in sewage can be degraded at the same time [27]. For example, Wang et al. and Hu et al. achieved good results in ecologically controlling and restoring desertification, and finally proposed a sustainable wetland utilization model [28,29]. Niu stated that wetland landscape ecological restoration should be closely integrated with wetland ecological restoration to restore the natural attributes and to highlight the differences of wetland landscapes [30]. From the perspective of biodiversity conservation, Mauchamp et al. and Apajalahti et al. evaluated the impacts of wetland connectivity restoration on plant communities, and believed that aquatic vegetation restoration projects should be simultaneously implemented to enhance the biodiversity in the environment [31,32].

As far as wetlands in arid and semi-arid regions in China are concerned, literature has also reported the characteristics of plant communities and their effects on ecological functions in different wetlands [33–35]. The Ningxia Habahu National Nature Reserve locates in a typical transition zone. The landform transitions from the Loess Plateau to the Ordos Platform, the climate transitions from semi-arid area to arid area, the soil transitions from lime calcite to brown calcite, and the vegetation changes from grassland to desert. In the transition, the agricultural structure gradually changes from agricultural areas to pastoral areas [36]. Wetlands in the Ningxia Habahu National Nature Reserve are important midway stops for bird migration, and they are typical desert wetlands. This study investigated the features of plant communities in the wetlands of Ningxia Habahu National Nature Reserve and its driving mechanism of different forces, aiming to promote the conservation of wetland biodiversity and the protection of wetlands in arid and semi-arid regions. Therefore, the objectives of the present work are (1) to study the features of plant community and the morphological characteristics of typical desert wetland plants, and (2) to explore the driving forces of plant community succession of the typical desert wetland plants.

2. Materials and Methods

2.1. Study Area

The Ningxia Habahu National Nature Reserve belongs to a typical desert wetland ecosystem and is located in the north-central part of Yanchi County, in Wuzhong City of Ningxia Hui Autonomous Region (106°53′–107°40′ E and 37°37′–38°03′ N; Figure 1). The average altitude is 1461 m, and the area belongs to the temperate continental semi-arid climate. The total area of the reserve area is 84,000 hm^2, of which the core area, buffer area, and experimental area are, respectively, 36.55%, 26.55%, and 36.90%. The territory of the reserve area is all inland gullies without large rivers, and the surface water is dominated by atmospheric precipitation and spring water. The gullies all originate from the north–south watershed and both sides of the east–west watershed in the central and northern parts of Yanchi County. Most of the rivers on the east side of the north–south watershed are seasonal rivers, which are generally longer, wider, and larger in flow. There are few ditches toward the watershed, which are shorter and narrower and have less flow. Generally, the ditch is 5–18 km long and flows into lakes, swamps, or depressions to form large lakes, swamps, and wetlands. The wetland area in the reserve area is 9353.41 hm^2 (10.54% of the total area), including 1.17% of river wetland, 4.99% of lake wetland, 92.46% of swamp wetland, and 1.38% of artificial wetland.

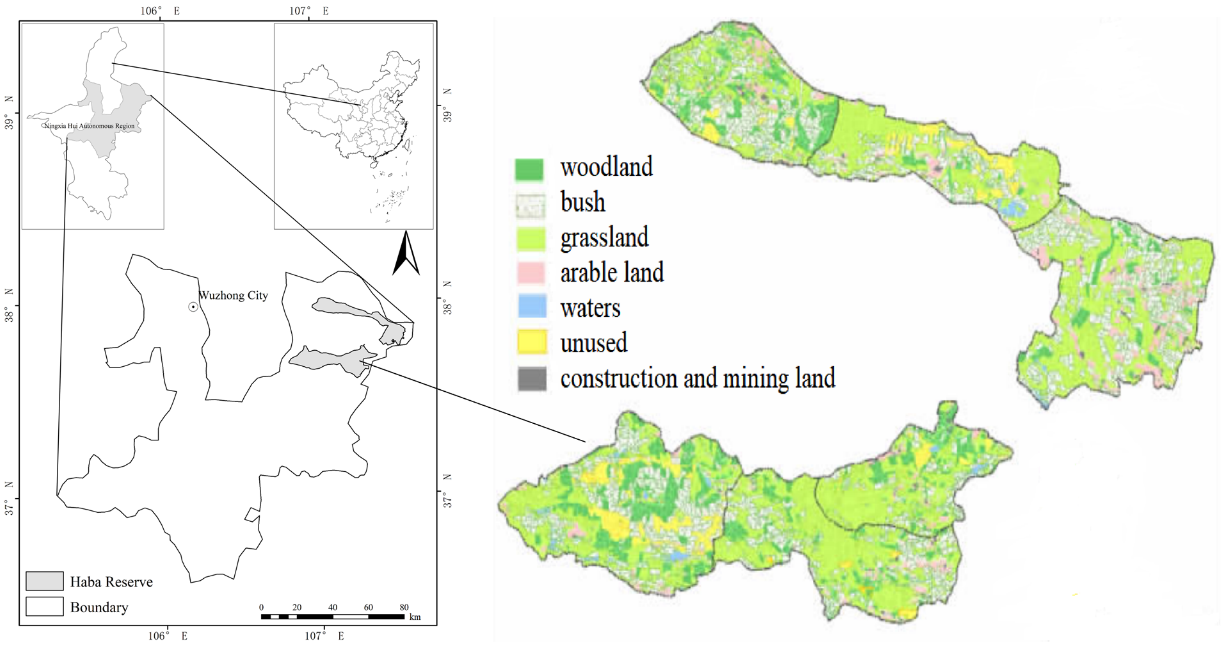

Figure 1. Schematic diagram of the study area.

In the semi-arid grassland area, the limited wetland resources are even more precious, mainly including the Huamahu wetland and the Habahu wetland (Table 1). The abundant groundwater and special geological structure in the reserve area are the main reasons for the formation of wetlands. Wetlands in the reserve area are mostly located in the catchment area, and are supplied by numerous rivers, ditches, and springs. Additionally, desert condensed water on the slopes around the depressions and the overflow of underground confined water in depressions are also important water sources for wetlands. The above water sources supply more than 10 million m^3 of water to the Habahu wetland annually, thus ensuring the further formation and sustainable development of the Habahu wetland.

Table 1. Typical desert wetlands in the Ningxia Habahu National Nature Reserve.

Name	Location	Altitude (m)	Wetland Type	Composition	Soil Type
Habahu wetland	107°7′ E 37°42′ N	1385–1510	Seasonal lagoon	Lakes, swamps, dunes, and wetland meadows	Sandy soil, saline soil, and fluvo-aquic soil
Huamahu wetland	107°23′ E 37°44′ N	1345–1350	Reservoir	Surface water, swamp, and wetland meadow	Sandy soil, saline soil, and fluvo-aquic soil

2.2. Experimental Design

According to the status quo of wetlands in the Ningxia Habahu National Nature Reserve and the existing monitoring conditions, wetland ecological monitoring points were set up in the Habahu and Huamahu wetlands. Long-term fixed-point and fixed-position observation and sampling monitoring were conducted to provide basic information of wetland water resources as well as the habitat and living conditions of wild plants. Wetland ecological monitoring includes wetland hydrology and water quality monitoring, wild plant monitoring, meteorological and climatic characteristics monitoring, and wetland threatened status monitoring. Two fixed sampling plots were set up at each location around the Habahu and Huamahu wetlands, and the four sampling plots were year-round monitored. The main monitoring contents include the density, biomass, and frequency of plant individuals, the vegetation coverage, the habitat, structural characteristics, species composition, dominant population structure, and other characteristics of different ecosystem types. At the same time, the vegetation restoration, soil water content, dynamic changes of organic matter, and nutrient content in the sampling plots were regularly measured and recorded in detail. The species, number of plant individuals, and biomass of the wetland plant community were investigated. The *Achnatherum splendens* community used a quadrat of 4 m × 4 m, other herbs used a quadrat of 1 m × 1 m, and the area of shrub flat and stubble rejuvenation used a quadrat of 50 m × 50 m.

2.3. Data Processing and Calculation

Species abundance, species diversity, and community productivity were calculated basing on the data obtained from the detection according to ecological methods [36]. The formula for calculating the Margalef index (D), which characterizes species abundances, is as follows:

$$D = (S - 1)/\ln N \tag{1}$$

where S is the total number of species in the community, and N is the total number of observed individuals (increasing or decreasing with the sampling size). The Simpson index (Ds) and Shannon-Weiner index (H'), that characterize species diversity, are calculated as follows:

$$D_S = 1 - \sum_{i=1}^{n} \frac{N_i(N_i - 1)}{N(N - 1)} \tag{2}$$

$$H' = 3.3219\left(\mathrm{lg}N - \frac{1}{N}\sum_{i=1}^{n} N_i \mathrm{lg} N_i\right) \tag{3}$$

where Ni is the number of individuals of the ith species; N is the total number of all individuals; n is the number of species; and 3.3219 is the coefficient of transformation from $\log_2$ to $\log_{10}$. In addition, the root–shoot ratio (α) and the specific leaf area (β) of the plant were also monitored in the plant monitoring. The calculation formulas are as follows:

$$\alpha = \frac{W_1}{W_2} \times 100\% \tag{4}$$

$$\beta = \frac{A}{W} \tag{5}$$

where W_1 is the root weight, g; W_2 is the shoot weight, g; A is the sampling area of a certain plant leaf, cm^2; W is the corresponding dry weight of the sampling leaf, g.

3. Results

3.1. Features of Plant Community in the Typical Desert Wetlands

In the Huamahu wetland, the niche width of *Scirpus triqueter* was 3.83 and that of *Phragmites communis* was 2.99 in the sampling plot of 0 m away from the lake (Table 2), indicating that these two species still maintained the ability to further expand living space. All the niche widths of *Aneurolepidium angustus*, *Phragmites communis*, *Artemisia scoparia,* and *Sonchus brachyotus* were found to be greater than 3, excepting that of *Setaria viridis,* which itself was an r-strategist and typical opportunist less than 3 in the sampling plot of 10 m away from the lake. The niche width of each species was between 2 and 3 in the sampling plot of 20 m away from the lake, indicating that their ecological adaptability and competitiveness were roughly the same.

Table 2. Characteristics of plant community in the Huamahu wetland.

Distance from the Lake	Species	Density (ind/m^2)	Biomass (g)	Height (cm)	Important Value	Niche Breadth
0 m	*Phragmites communis*	415	568.5	76	224.1	2.988
	Scirpus triqueter	47	42.1	27	32.5	3.829
	Aneurolepidium angustus	7	2.6	53	32.7	2.309
	SmallAcorus calamus	3	5.1	16	10.8	2.987
10 m	*Aneurolepidium angustus*	277	418.3	78	201.3	3.184
	Phragmites communis	19	27.4	66	40.6	3.29
	Artemisia scoparia	23	11.9	39	26.6	3.484
	Sonchus brachyotus	16	34.7	13	17.6	3.408
	Setaria viridis	3	2.4	28	13.9	2.255
20 m	*Heteropappus altaicus*	5	12.2	16	31.3	2.953
	Aneurolepidium angustus	16	15.5	45	65.5	2.96
	Artemisia scoparia	23	13.6	35	70.1	2.93
	Phragmites communis	7	3.2	27	26.8	2.719
	Setaria viridis	4	2.8	24	20.2	2.581
	Lactuca tatarica	2	4.1	11	13.4	2.897
	Pennisetum centrasiaticum	3	1.2	19	14.4	2.442
	Leonurus japonicus	1	2.9	38	21.3	2.095
	Astragalus laxmannii Jacquin	1	18.2	26	37.1	2.84

However, in the Habahu wetland, the niche width of *Phragmites communis,* which was the dominant species, was only 2.85 in the sampling plot of 0 m away from the lake, though the important value of *Phragmites communis* was 147.5. Although the important values of *Leymus secalinus* and *Artemisia scoparia* were only around 50, the niche widths of the two were all greater than 3.3 (Table 3), indicating that they would gradually dominate in this area. In the sampling plot of 10 m away from the lake, although the important value of *Leymus secalinus*—which was the dominant species—was 140.8, the niche width of *Leymus secalinus* was 3.36 while that of *Artemisia scoparia* was 3.81, indicating that *Artemisia scoparia* presented a stronger competitiveness. The niche widths of all species were between 2 and 3 in the sampling plot of 20 m away from the lake, indicating that their competitiveness was roughly the same.

Table 3. Characteristics of plant community in the Habahu wetland.

Distance from the Lake	Species	Total Density (ind/m^2)	Total Biomass (g)	Height (cm)	Important Value	Niche Breadth
0 m	*Phragmites communis*	58	224.7	39	147.5	2.854
	Leymus secalinus	44	16.8	25	56.3	3.358
	Artemisia scoparia	27	38.4	17	45.3	3.588
	Artemisia argyi	4	7.5	35	30.7	2.661
	Chenopodium glaucum	2	6.3	23	20.2	2.705
10 m	*Leymus secalinus*	121	145.9	28	140.8	3.358
	Artemisia scoparia	29	39.1	26	45.3	3.812
	Sophora alopecuroides	7	31.7	39	36.2	3.339
	Phragmites communis	5	4.6	31	20.8	2.619
	Corispermum hyssopifolium	3	11.4	7	9.6	3.43
	Swainsonia salsula	1	11.4	28	19.4	2.769
	Astragalus melilotoides	1	27.2	33	27.8	3.043
20 m	*Leymus secalinus*	15	18.3	38	46.7	3.328
	Sophora alopecuroides	7	18.9	32	35.1	3.249
	Artemisia scoparia	37	45.2	34	89.5	3.364
	Phragmites communis	7	8.3	42	32	2.744
	Astragalus laxmannii Jacquin	3	18.3	29	28.7	3.107
	Pennisetum centrasiaticum	6	1.3	7	11	3.085
	Corispermum hyssopifolium	4	10.1	13	17.3	3.362
	Chenopodium glaucum	2	7.4	18	15.2	2.956
	Heteropappus altaicus	3	10.9	14	17.1	3.286
	Clematis urophylla	1	5.3	6	7.4	3.236

As for the species of the lakeside plant communities at the monitoring points of the Huamahu wetland and Habahu wetland, they were found to be relatively single according to the monitoring results of lakeside plant diversity (Table 4). However, in general, the farther away the distance was, the more the lakeside species richness index, Magalef index, and the species diversity index, and the Shannon-Weiner index and Simpson index increased relatively. This is because the plants closer to the waterside needed to endure the stress of hypoxia caused by water immersion and the stress of soil salinity, and then the bit widths became narrower to accommodate specialized habitats. It was much better when it was far away from the lakes.

Table 4. Characteristics of plant communities around lakes in the typical desert wetlands.

Site	Distance away from the Lake	Total Density (ind/m^2)	Total Biomass (g)	Magalef Index	Shannon–Wiener Index	Simpson Index	Pielou Evenness Index
Huamahu	0 m	472	618.3	0.487	0.631	0.217	1.048
	10 m	338	494.7	0.687	1.001	0.319	1.433
	20 m	62	73.7	1.938	2.502	0.781	2.622
Habahu	0 m	135	293.7	0.815	1.756	0.673	2.512
	10 m	167	271.3	1.172	1.311	0.444	1.552
	20 m	85	144	2.026	2.578	0.764	2.578

Furthermore, root–shoot ratio was one of the features for characterizing plant drought tolerance, and specific leaf area reflects the ability of plants to utilize light in the community [37]. Both the root–shoot ratio and specific leaf area of the major plants in the wetland ecosystems in the reserve area were measured. The results showed that the plant root–shoot ratio of the wetland ecosystem in the reserve area was not significantly different from that of the grassland ecosystem and sandy land ecosystem (Figure 2), which indicated that most of the plants distributed in the wetlands of the reserve area were wet mesophytes, and there was no significant difference in drought tolerance from grassland plants. The results in Figure 3 showed that the plant specific leaf area of the wetland ecosystem in the reserve area was roughly the same as that of the grassland ecosystem, and there was no significant difference between different ecosystems in the reserve area.

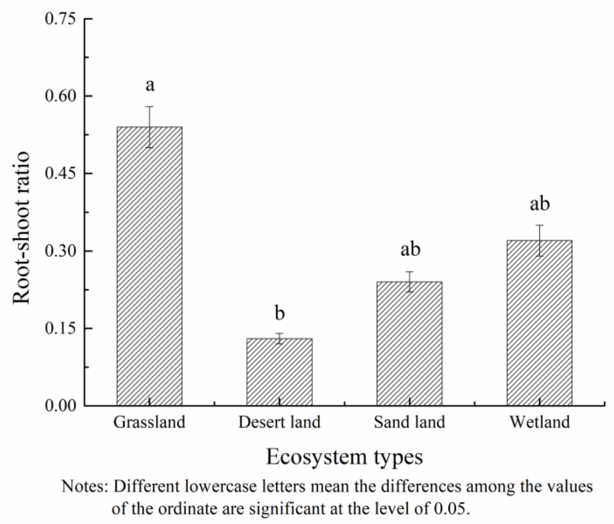

Figure 2. Root–shoot ratio of each ecosystem in the Ningxia Habahu National Nature Reserve.

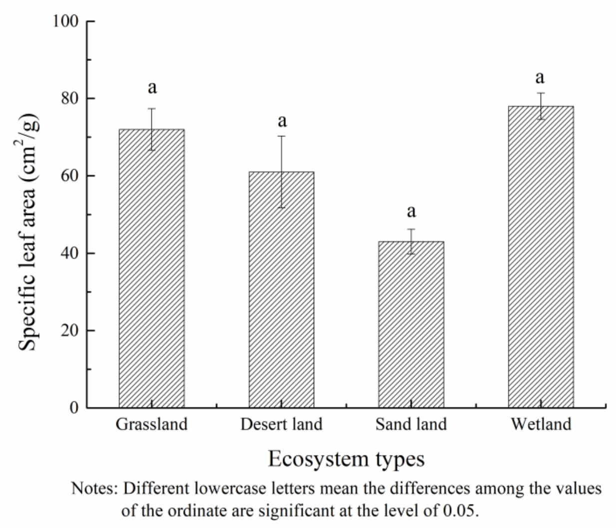

Figure 3. The specific leaf area of plants in each ecosystem of the Ningxia Habahu National Nature Reserve.

3.2. Driving Force of Plant Community Succession in the Typical Desert Wetlands

In the reserve area, the plant communities in the early, middle, and late stages of a succession series were selected as *Artemisia ordosica*, *Sophora alopecuroides*, and *Stipa bungeana*, respectively. The soil of the *Artemisia ordosica* community area belonged to a semi-fixed aeolian sandy soil and fixed aeolian sandy soil. The soil of the *Sophora alopecuroides* community area belonged to fixed aeolian sandy soil, and the soil of the *Stipa bungeana* community area belonged to light ash calcium soil and ash calcium soil. According to ecological norms, the number of individuals and biomass of *Artemisia ordosica*, *Sophora alopecuroides*, and *Stipa bungeana* communities were investigated, and the nitrogen (N) and phosphorus (P) contents of each plant in each quadrature were determined. The vegetation nitrogen-to-phosphorus (N/P) ratio of each plot was calculated by using biomass as a weighting factor according to statistical processing methods. The results showed that the vegetation N/P ratio of *Artemisia ordosica*, *Sophora alopecuroides*, and *Stipa bungeana* communities were respectively 11.27 ± 0.97, 17.08 ± 0.86, and 20.84 ± 1.01 (Table 5). It was found that there would be a larger vegetation N/P ratio in the *Sophora alopecuroides* community when *Sophora alopecuroides* was dominant, though it was a leguminous plant and had a strong N fixation ability. Conversely, there would be a smaller vegetation N/P ratio when *Sophora alopecuroides* was not dominant. The minimum value of the vegetation N/P ratio in the *Sophora alopecuroides* community was 7.56, while the maximum value was 23.88.

Table 5. Vegetation N/P ratios in plant communities in different succession stages in the semi-arid regions.

Plant	Observations	Mean	Min	Max	Extreme	Standard Error	Standard Deviation	Kurtosis	Skewness
Artemisia ordosica	25	11.27	4.93	25.02	20.09	0.97	4.87	2.16	1.34
Sophora alopecuroides	25	17.08	7.56	23.88	16.32	0.86	4.32	−0.66	−0.35
Stipa bungeana	25	20.84	13.34	38.78	25.45	1.01	5.04	5.84	1.71

At the early succession stage of plant community, there was a significant linear positive relationship between the total plant density of the *Artemisia ordosica* community and the vegetation N/P ratio (p < 0.01); namely, the total plant density increased with the increment of vegetation N/P ratio (Figure 4). At this time, the aboveground biomass of the *Artemisia ordosica* community increased with the increment of the total plant density, but the regression relationship was not significant. In the middle succession stage of the plant community, there is no obvious consistency between the total plant density of the *Sophora alopecuroides* community and the vegetation N/P ratio (Figure 5). However, the above-ground biomass of the *Sophora alopecuroides* community was positively linearly correlated to the total plant density (p < 0.01); namely, the above-ground biomass regularly increased with the increment of the total plant density (Figure 6).

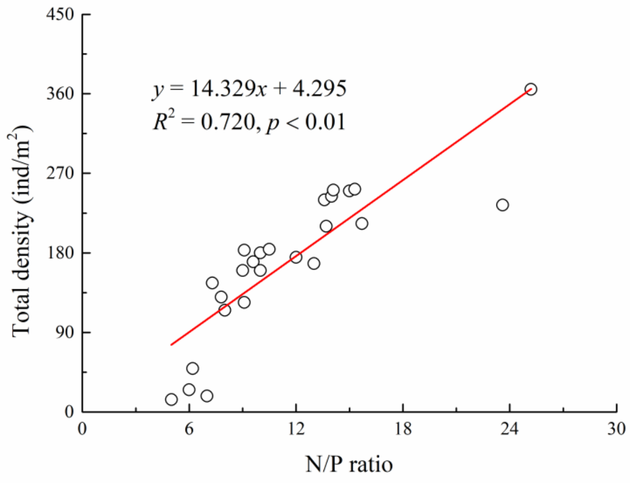

Figure 4. Relationship between the total plant density and N/P ratio in the *Artemisia ordosica* community.

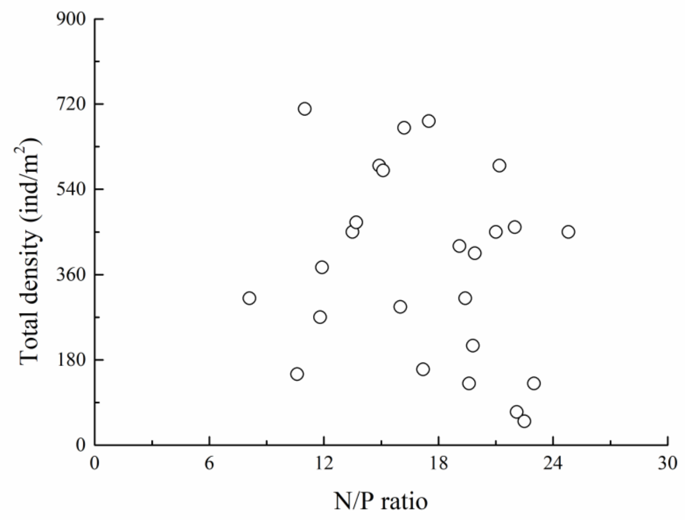

Figure 5. Relationship between the total plant density and N/P ratio in the *Sophora alopecuroides* community.

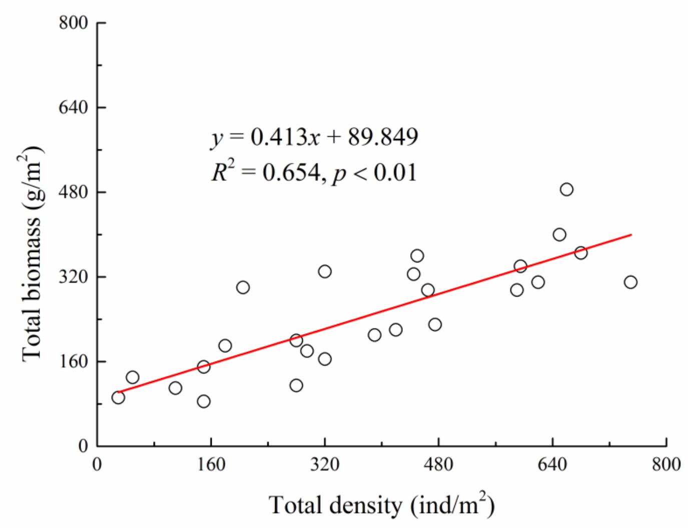

Figure 6. Relationship between above-ground biomass and total density in the *Sophora alopecuroides* community.

Moreover, the vegetation N/P ratio and total density of the *Artemisia ordosica* community and *Sophora alopecuroides* community were combined and then regressed. It could be seen from Figure 7 that the total density of the plant community and the vegetation N/P ratio showed a significant quadratic function relationship in the early and middle succession stages of the plant community, with vertex coordinates of (14.2, 382.5). At the late succession stage of plant community, the relationship between total plant density and N/P ratio of *Stipa bungeana* showed a negatively linear correlation regression relationship ($p < 0.01$); namely, the total plant density gradually decreased with the increase of vegetation N/P ratio (Figure 8). At this time, the community biomass of *Stipa bungeana* also decreased with the increase of total plant density but the regression relationship was not significant.

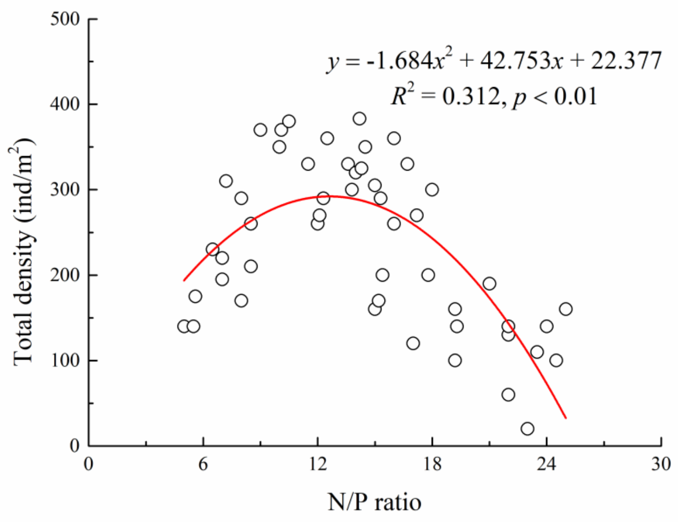

Figure 7. Relationship between total plant density and N/P ratio in early-*Artemisia ordosica* and mid-*Sophora alopecuroides* community successions.

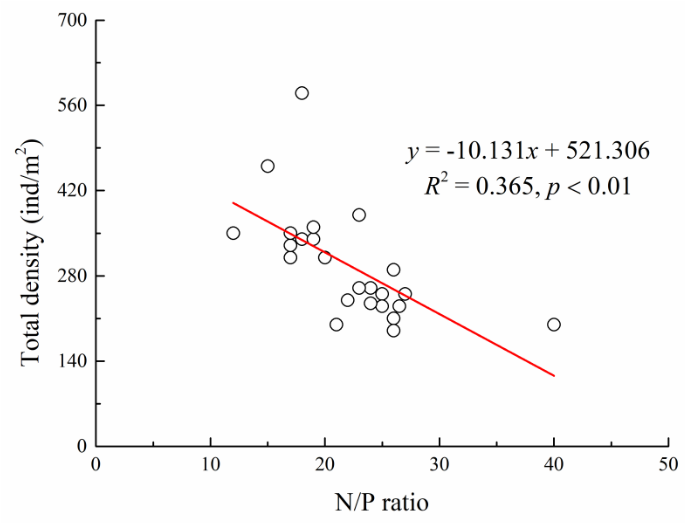

Figure 8. Relationship between total plant density and N/P ratio in the *Stipa bungeana* community.

4. Discussion

It could be seen from the previous results that the above-ground plant biomass, density and vegetation coverage decreased with the decrement of soil moisture content with the drying of wetlands while the vegetation richness index and Shannon–Wiener diversity index showed a trend of firstly increasing and then decreasing. Soil moisture affected vegetation coverage and plant biomass by firstly changing vegetation density, that was, the reduction of soil moisture first reduced vegetation density, which in turn reduced vegetation coverage and plant biomass [38]. Soil moisture mainly affected vegetation density by affecting soil clay content, which in turn affected vegetation biomass and coverage [39]. The decrease of soil clay content and the increase of sand content were not conducive to the maintenance of soil moisture and nutrients as well as the growth of vegetation roots, thus affecting the growth of vegetation [40,41]. The decrease of soil moisture content drove the decrease of soil organic carbon (C) and total N content, which led to the decrease of vegetation density and biomass [42]. Soil moisture promoted the growth of plants by increasing the content of soil C, N, bacteria, and fungal PLFA, and fungi had the most important role in promoting vegetation biomass. The increase of soil microbial biomass C and N, bacterial, and fungal contents also promoted the increase of vegetation diversity [43]. By analyzing the influence of soil moisture on vegetation features by driving clay particles, nutrient composition, and microbial community structure, it was found that bacteria and fungi had a significant role in promoting vegetation diversity relative to soil particle composition and nutrient composition. It showed that in the process of wetland drought, the changes of soil moisture and soil nutrients mainly affected the vegetation diversity by affecting soil microorganisms [44,45].

The results of this study showed that the plant succession in the reserve area were derived from sand dunes. In the early succession stage of plant community, the total density of the *Artemisia ordosica* community increased in a linear, positive correlation with the increase of vegetation N/P ratio. However, at the same time, the biomass of *Artemisia ordosica* tended to increase with the increase of the vegetation N/P ratio, though the correlation was not significant. The change of soil N was more significant while the change of soil P was not obvious for the early plant community in the reserve area derived from sand dunes. Soil N increased rapidly due to atmospheric N deposition and organic matter transformation after litter decomposition [46]. Then, there was a corresponding increase in N, which resulted in a larger N/P ratio in the plants. However, due to the very poor soil N content in the early plant community in the reserve area derived from sand dunes, the absolute value of the N content in the plants was not too high, which resulted in the increase of the total density of the *Artemisia ordosica* community with the increase of the vegetation N/P ratio [47]. At the middle succession stage for the *Sophora alopecuroides* community, soil N continued to accumulate and soil P also began to accumulate. There was no obvious statistical relationship between the total density of *Sophora alopecuroides* and the vegetation N/P ratio, but the biomass of the *Sophora alopecuroides* community increased significantly with the increase of the total density. At the late succession stage, the plant community was inhibited by P due to the large consumption of P, due to its physiological and biochemical effects on plant drought resistance [48]. The results of this study showed that, at the late succession stage for *Stipa bungeana*, the total density of *Stipa bungeana* was significantly negatively correlated with the increase of the vegetation N/P ratio, that was, negative density restriction occurred significantly. The biomass of the plant community decreased with the total density of the plant community, but it was not significant, which reflected the P restriction [49].

It was pointed out that plant growth at the community level was mainly restricted by N when the vegetation N:P ratio <14, co-limited by N and P when N/P was 14–16, and mainly limited by P when N/P >16 [50,51]. The vegetation N/P ratio of *Artemisia ordosica*, *Sophora alopecuroides,* and *Stipa bungeana* communities indicated that *Artemisia ordosica* community was N-limited while *Sophora alopecuroides* and *Stipa bungeana* communities were P-limited (Table 5). Interestingly, in the early and middle succession stages, the total density of the plant community was significantly related to the vegetation N/P ratio by a quadratic function, indicating that when the vegetation N/P ratio was close to 14.2, the community would experience negative density constraints. In other words, in the middle and late succession stages of plant community, plant growth was mainly limited by P, which led to negative density constraints. The negative density constraint was a very common phenomenon in nature, and factors that affected negative density constraints include water, nutrients, and salinity [52]. As far as nutrients were concerned, it was not so much limited by N or P as by the N/P ratio. The results of this study suggested that the vegetation N/P ratio in the reserve area was the driving factor for the negative density constraints.

5. Conclusions

This paper systematically studied the features of plant community and the driving forces of plant community succession of the typical desert wetland plants. It was found that the total plant density, total biomass, Magalef index, and Shannon–Wiener index of the wetland plants in the reserve area were all low due to the poor habitat and saline-alkali. Both the root–shoot ratio and specific leaf area of the wetland plants in the reserve area were not significantly different from those of the construct species of other ecosystems. Negative plant density constraints were the result of interactions between plants as well as interactions between plants and the environment. A series of early, middle, and late succession stages of plant community in the reserve area were respectively selected. The total plant density of the *Artemisia ordosica* community increased with the increase of the vegetation N/P ratio, while that of the *Stipa bungeana* community decreased, and negative density constraints were exhibited in the late succession stage. The vegetation N/P ratio was greater than 14.2 and exhibited a negative density constraint in the early and middle succession stages of the plant community. Analysis showed that this negative density constraint was due to P confinement. Therefore, the vegetation N/P ratio in the reserve area was the driving force for negative density constraints, while the vegetation N/P ratio was the driving force for plant community succession. Relevant results could not only provide a reference for the improvement of species diversity and ecological environment, but they also provide a scientific basis for the sustainable protection and restoration of typical desert wetlands.

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