Dynamic Change and Influence Factor Analysis of Vegetation Community of West Liaohe River Plain

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Abstract. With intensive mining of groundwater and expansion of irrigation area, reversion has happened to the grassland and arable area of West Liaohe River Plain, and the natural property of ecological system has declined sharply. Through historical literature research and plant sampling survey, comparison was made for the status dynamic change of grassland vegetation community on the West Liaohe River Plain before (1980) and after interference (2016). According to the result, it showed that the grassland vegetation species diversity of West Liaohe River Plain dropped from 917 to 258. Besides, the influence factors affecting vegetation community change were also analyzed, 1) the grassland was occupied by arable land, thus resulting in a shrink in grassland area from 48,900 km2 in 1980 to 22,400 km2 in 2016. Due to the locality in species distribution, therefore, the shrinking process of grassland also represented the process of species disappearance; 2) large-scale well irrigation resulted in the overall decrease of underground water level and the vegetation ecological degradation; 3) overgrazing and other problems brought by rapid development of animal husbandry.

1. Introduction
The agricultural structure imbalance in the agriculture and pasturage interlaced zone of semi-arid region, over-development of water resource and the unsustainable development have become more and more outstanding for a long time. The water resource development intensity in partial area has been close to the limit, and land desertification, grassland degradation and the weakening of ecological function have become increasingly serious. Many scholars have carried out researches on grassland vegetation community succession, and their researches mainly focus on the following directions: feature description of vegetation succession stage [1], vegetation restoration succession [2] and vegetation degradation succession [3]. In recent years, the impact of groundwater on vegetation has gradually become a hot spot in the research field of ecology and environmental sciences, researches mainly focus on studying the relations among groundwater and vegetation distribution, biomass characteristics, vegetation physiological ecology etc., as well as quantitative analysis of the ecological water level that is suitable for vegetation growth [4-5]. Besides, ecological de-farming and the vegetation succession spatial-temporal pattern distribution after de-farming have become hot issues in the research of landscape ecology and phytoecology.

West Liaohe River Plain is a typical semi-arid region. with intensive mining of groundwater and expansion of irrigation area, reversion has happened to its grassland and arable area, and the natural property of ecological system has declined sharply. The natural resources of this region, especially the depletion of water and soil resources and decline of renewable ability, have resulted in weakening of ecological basis, which is a major hidden danger for the economic society and ecological safety of the entire region. For this purpose, many scholars have carried out related researches on West Liaohe...
River Plain. Chen conducted an analysis on the response relationship between groundwater depth and vegetation ecology on West Liaohe River Plain, he believed that when the groundwater depth was less than 4m, it had a significant impact on vegetation coverage, and it was suitable for grassland vegetation growth when the groundwater level depth was between 0.5m and 2.7m. In addition, he also performed a prediction analysis for the vegetation evolution trend on the West Liaohe River Plain [6]. Jin analyzed the influence of groundwater level and climate factor on grassland growth of West Liaohe River Plain [7]. Yan analyzed the grassland ecological pattern of West Liaohe River Plain based on support of groundwater conditions [8]. However, most researches focus on the existing grassland, while few are aiming at analyzing how the natural grassland vegetation community free of man-made interference is evolved into the existing degraded grassland. In this paper, through historical literature research and plant sampling survey, comparison was made for the status dynamic change of grassland vegetation community on the West Liaohe River Plain before and after interference, and analysis was made for the influence factors affecting the vegetation community change.

2. Materials and Methods

2.1. Study areas

The West Liaohe River Plain is located in the east of the West Liaohe River Basin which main section is in Tongliao City, with a land area of about 65,000 km² (Fig. 1). The West Liaohe River Plain is a typical area of the farming pastoral ecotone in the semi-arid region of China. The average annual precipitation in the region is less than 400mm, and the average annual evaporation is more than 1000mm. Rainfall does not directly generate surface runoff, and the vertical infiltration of precipitation is significant, and the groundwater is rich and the vertical recharge is stable. The natural ecology in semi-arid area is the grassland vegetation supported by groundwater. The spatial pattern and landscape change of ecosystem reflect the spatial distribution pattern evolution of groundwater. Grassland ecology greatly affects the ecological quality and stability of the whole region.

![Figure 1. study areas](image)

2.2. Field Data Collection

To understand the current situation of grassland vegetation in West Liaohe River Plain, three vegetation surveys were carried out from 2016 to 2017, and a total of 306 sampling sites were selected (Fig. 2), which could basically reflect the vegetation distribution of grassland in West Liaohe River Plain and was well representative. In order to accurately describe the composition of vegetation species in West Liaohe River Plain in the 1980s, this paper systematically screened and sorted out the plants recorded in every banner county of the region in the Flora of Inner Mongolia [9]; focused on the composition of wild plants, therefore, the artificial cultivation vegetation (including Chinese cabbage, radish and other economic cultivation crops) can be eliminated during the statistics. Vegetation Map
of the People's Republic of China [10] generally reflects the vegetation distribution in China from the 1980s to the mid-1990s, and records the regional differentiation characteristics of vegetation in China in detail.

![Figure 2. sampling points of grassland vegetation investigation in West Liaohe River Plain](image)

3. Result

3.1. Natural background of vegetation community in grassland

In the early 1980s, the grassland area of West Liaohe River Plain area was 48,930.07 km$^2$, with a total of 917 species of wild plants, belonging to 108 families and 412 genera. Among them, 10 families of plants, including the compositae, the gramineae, the sedge, the legume, the ranunculaceae, the rosaceae, the caryophyllaceae, the liliaceae, the chenopodiaceae and the labiaceae, accounted for 57.25% of the wild plant species in West Liaohe River Plain.

Vegetation Map of the People's Republic of China generally reflects the vegetation distribution in China from the 1980s to the mid-1990s. In this paper, the vegetation distribution in the West Liaohe River Plain was processed by GIS and the vegetation community distribution in the 1980s was obtained. In the 1980s, the grassland area of West Liaohe River Plain was 48,930.07 km$^2$, accounting for 74.58% of the total area of the West Liaohe River Plain, and the farmland area is 16,275.43 km$^2$, accounting for 24.81% of the total area of the West Liaohe River Plain. The farming and grazing area ratio is 1:3.

3.2. Analysis of investigation results of natural grassland vegetation

From 2016 to 2017, three grassland vegetation surveys were conducted in the grassland of West Liaohe River Plain, and a total of 258 species of wild plants, belonging to 52 families and 169 genera, were found. The natural grassland of Jarud Banner covered an area of 3,932.43 km$^2$, and 242 effective sampling sites were obtained. A total of 176 plant species were found, belonging to 36 families and 121 genera. The natural grassland of Horqin Left Rear Banner covered an area of 2,770.46 km$^2$, and 55 effective sampling sites were obtained. A total of 203 plant species, belonging to 48 families and 140 genera, were found. Among them, 4 families including the compositae, the gramineae, the leguminosae and the chenopodiaceae collected a total of 133 plants, accounting for 51.55% of the plant species in this research.

3.3. Dynamic change of vegetation community of West Liaohe River Plain

Since the 1980s, with the development of irrigation area, the grassland area of West Liaohe River Plain has shrunken from 48,900 km$^2$ to 22,400 km$^2$ in 2016, including a large amount of artificial grassland and degradation succession grassland, only remaining 8,404 km$^2$ of original natural
grassland, and the species diversity has decreased from 917 to 258. As grasslands shrink, species become extinct in large numbers, and the diversity is declining faster than grassland area.

Comparing to 1980s, the natural grassland community of Jarud Banner and Inner Mongolia Kerqinzuoyihou Banner has degraded, which is specifically reflected in that the trichophorum persoon+sedge community, stipa grandis community and leymus chinensis community having high requirement for moisture have changed from centralized and continuous distribution into scattered and fragmented distribution; and the redtop community with a narrow distribution range has disappeared in 2017. Meanwhile, cleistogenes squarrosa community, artemisia frigid community, artemisia scoparia community, ephedra community and other degraded communities are widely distributed.

4. Discussion

Due to the development of irrigated agriculture, the farming-pastoral ecotone with planting industry grass-animal industry stagger distributed in West Liaohe River Plain was formed. With the rapid development of irrigated agriculture, a large number of natural grasslands have been changed to farmland, and the distribution of grassland species in West Liaohe River Plain is local, so the process of grassland decrease is also the process of species disappearance. Secondly, the large-scale well irrigation leads to the overall decrease of underground water level, which weakens the supporting capacity of grassland ecosystem, leading to the deterioration of growth trend, the decrease of grassland vegetation species, and the vegetation succession in the areas adjacent to the grassland at the edge of the irrigated area. Meanwhile, the West Liaohe River Plain is also confronted with the problem of overgrazing caused by the rapid development of animal husbandry, which leads to the degradation of grassland ecosystem in West Liaohe River Plain.

4.1. Influence of land use change

The land use changes of West Liaohe River Plain from 1990 to 2016 are shown in the Figure 3. The southwest, northeast and central areas are generally covered by cultivated land, and the grassland is mainly distributed in the Jarud Banner in the northwest and the Horqin Left Rear Banner in the south. Comparing the area of grassland and cultivated land in different periods, the grassland area in West Liaohe River Plain decreased from 29,092k㎡ in 1990 to 22,439k㎡ in 2016. The change of cultivated land area showed an opposite trend, increasing from 18,251k㎡ in 1990 to 23,372k㎡ in 2016. It can be found that the ratio of farming and grazing in West Liaohe River Plain has been reversed. However, the vegetation community distribution in West Liaohe River Plain is extremely regional. With the decrease of grassland area, many species suitable for local habitats disappear, and the species diversity of vegetation also decreases almost synchronously. At the same time, irrigated areas in Horqin area and Kailu County are widely distributed, and the grassland is greatly scattered. As the underground water is extracted from the irrigation, the groundwater level around the irrigated areas drops, which leads to the failure of plant roots in the irrigated areas to absorb groundwater, results in
degradation succession and extremely single vegetation species. Therefore, the process of grassland decrease is also the process of species disappearance.

4.2. Influence of changes in groundwater dept
The natural vegetation absorbs soil water through roots. In semi-arid areas, the soil water mainly comes from the evaporation from phreatic water of groundwater, which rises to form soil water through capillary water formed by soil pores and is absorbed by vegetation roots. The distribution of vegetation community is closely related to groundwater conditions. Chen analyzed that the critical buried depth of groundwater recharge vegetation in West Liaohe River Plain ranged from 1.5m to 3m. However, as the irrigated area constantly expands, the underground water extracted from irrigation continues to increase, and the groundwater level in the research area continues to decline, resulting in the failure of groundwater to form a stable supply of vegetation roots. Especially in the surrounding areas of irrigated areas, therefore, the grassland degradation is serious, and vegetation species is extremely single. This paper collected and sorted out the groundwater depth data of 74 groundwater monitoring wells in West Liaohe River Plain since 1980. Figure 4 shows the change of groundwater depth in each county of Tongliao City from 1980 to 2014 in West Liaohe River Plain. As a whole, the groundwater depth shows a declining trend. With the continuous expansion of the irrigated area, the increase in the number of irrigation wells, and the over-exploitation of groundwater, there showed most obvious decrease of groundwater burial depth in Horqin area and Kailu County, two counties with the largest distribution of irrigated areas. The groundwater depth in Horqin area showed the maximum changes, falling from 3.2m in 1980 to 9.02m in 2014. The sharp decline of the groundwater level makes it impossible for groundwater to reach the root layer through the rising action of capillary to replenish vegetation, which leads to the degradation and fragmentation of grassland in Horqin area and Kailu County, and the serious degradation of grassland community. However, compared with those counties dominated by agriculture, the groundwater depth decrease of Jarud Banner, Horqin Left Rear Banner and other counties dominated by animal husbandry was significantly slight, and their groundwater depths was kept within 3.5m. The groundwater depth of Jarud Banner decreased from 2.19m in 1980 to 3.02m in 2014. The groundwater depth in Horqin Left Rear Banner dropped from 1.65m to 3.35m. The existing grassland which is less disturbed by human is mainly distributed in Jarud Banner and Horqin Left Rear Banner.

4.3. Influence of animal husbandry development
overgrazing was identified as one of the key drivers of declining grassland biodiversity. Overgrazing will affect the reproduction of plants. The genital stolon of plants are almost eaten up by animals, therefore, the seeds are unable to form the plant, or the ability of seed reproduction is weakened or lost. Grassland vegetation biomass decreased, and its coverage, height and density decreased. Besides, the overgrazing resulted in the decrease or decline of fine forage in grassland. Increasing grazing intensity reduced rangeland productivity and Heavy grazing resulted in annual grass dominance. long-term-
grazed soil had significantly lower water-retaining capacity compared with ungrazed soil. The combined effects of overgrazing and climate warming on soil water evaporation will accelerate soil water loss in grassland regions. This paper made statistics analysis on the animal husbandry development of Tongliao City from 1982 to 2016 (Figure 5). Before 2000, the cattle and sheep breeding in Tongliao was basically stable in 3 million to 3.5 million. Cattle and sheep breeding increased rapidly after 2000, reaching 16.04 million in 2016, 5.1 times that of 1982. On the one hand, the number of cattle and sheep breeding increased dramatically; on the other hand, the grassland area was largely cultivated for farmland. Meanwhile, it was accompanied by a dry period of more than a decade, which resulted in a decrease in the amount of pasture available on the grassland. Eventually, overgrazing resulted in the degradation of large areas of natural grassland and the great destruction of vegetation biodiversity.

![Figure 5. animal husbandry development of Tongliao City](image)

5. Conclusions

With the increase development of water and soil resources, human beings have played an increasingly significant role in the hydrological cycle, which has led to the change of the situation of runoff yield and confluence and a series of ecological effects. The West Liaohe River Plain is a typical semi-arid area. The exploitation and utilization of water and soil resources has a significant influence on the hydrological cycle of the basin, which is mainly reflected in the evolution of the pattern of farming and grazing areas.

Especially since the 1980s, with the development of irrigation area, the grassland area of West Liaohe River Plain has shrunk from 48,900 k m$^2$ to 22,400 k m$^2$ in 2016, including a large amount of artificial grassland and degradation succession grassland, only remaining 8,404 k m$^2$ of original natural grassland, and the species diversity has decreased from 917 to 258. In addition, by comparing the historical and current vegetation community composition, it was found that the species composition of the same community in the 1980s also changed greatly compared with that of current situation, mainly reflected in the decrease of plant species in the community; the appearance of artemisia frigid, euphorbia, etc., indicating that the sign of degradation has occurred to part of the natural grassland community.

West Liaohe River Plain is of obvious locality in grassland species distribution, many vegetation communities distributed in local areas have become extinct with the grassland reclaimed into arable land, and thus, the shrinking process of grassland also indicates the process of species loss. Secondly, the large-scale well irrigation leads to the overall decrease of underground water level, which weakens the supporting capacity of grassland ecosystem, leading to the grassland ecological degradation. Secondly, the groundwater depth in Horqin area showed the maximum changes, falling from 3.2m in 1980 to 9.02m in 2014. The sharp decline of the groundwater level makes it impossible for groundwater to reach the root layer through the rising action of capillary to replenish vegetation, which leads to the degradation and fragmentation of grassland in Horqin area, and the serious degradation of grassland community. Meanwhile, the West Liaohe River Plain is also confronted with
the problem of overgrazing caused by the rapid development of animal husbandry, which leads to the degradation of grassland ecosystem in West Liaohe River Plain. Before 2000, the cattle and sheep breeding in Tongliao was basically stable between 3 million to 3.5 million; cattle and sheep breeding increased rapidly after 2000, reaching 16.04 million in 2016. The grassland area shrinkage and continuous drought period lead to serious short supply of pasture, while overgrazing results in grazing of natural grassland in large area, as a result, the vegetation biological diversity is greatly destroyed.

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