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Temporal and Spatial Changes of NDVI and Soil Erosion in Ningxia Grassland Before and After Grazing Ban

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Abstract: Grassland is an important part of the ecosystem, which plays a good role in soil and water conservation. The degradation of grassland is easy to cause soil erosion in related areas. The reason is that overgrazing makes the grassland degrade rapidly. Ningxia has introduced a policy to ban grazing on natural grasslands, which can effectively safeguard grassland ecology, improve the condition of grasslands in Ningxia, and reduce the risk of grassland loss. This paper mainly analyzed the vegetation dynamics and soil erosion of grassland in Ningxia, and explored the changes before and after the grazing ban, to accumulate experience for ecological management.

Keywords: Grazing ban; Grassland vegetation dynamics; Soil erosion

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1. Introduction

Soil erosion can be divided into two main types: hydraulic and wind. Wind erosion and desertification are easy to cause soil nutrient loss, and eventually evolve into land degradation. Among all ecosystems, compared with other systems, the grassland ecosystem has obvious wind erosion resistance, which can play the wind and sand fixation value of grassland vegetation. Grassland vegetation has the value of intercepting sand grains, optimizing soil material composition, effectively inhibiting the erosion caused by wind and sand, and has a good effect on wind and sand prevention. At the same time, grassland also has the function of soil and water conservation, which can effectively protect soil and water resources. Grassland vegetation can cover the ground and grow close to the ground, which can block precipitation, effectively reduce surface runoff, and reduce water evaporation. On the other hand, grassland vegetation has a relatively developed root system with vertical and horizontal roots, which can effectively improve soil permeability.

2. Overview of nature in Ningxia

There are 12 types of grassland in Ningxia Province, which can be divided into 3 heat levels: cold temperature, mild warm, and mild warm; There are 5 wetness levels: slightly dry, arid, humid, and so on. The grassland type in the region is mainly semi-desert grassland, which is divided according to Ningxia region. The north of Ningxia is warm and wet grassland. In the middle of Ningxia, the grassland is mild and dry. The actual vegetation coverage was insufficient and the grass layer was sparse [1]. The temperate humid grassland and typical grassland are mainly found in the south of Ningnan.

In addition, there are roughly 24 soil types in Ningxia, and yellow soil is relatively large, accounting for about 28.33% of Ningxia's land area. The second soil type is lime-calcic soil, accounting for 26.79% of Ningxia's land area. The other soil types in Ningxia include aeolian sand, gray-brown soil, holloessian soil, and red clay, accounting for 3% to 11%. From the regional level, the Liupan Mountain and Helan Mountain are mainly distributed in Ningxia [2]. The aeolian sand is mainly distributed in the Lingyan Platform near the Mu Us region and northwest Zhongwei near the Tengger Desert. Irrigated silt is mainly distributed in Ningxia and Zhongning plains. Lingyan Plateau has been affected by the activities of clearing land and overgrazing for a long time, which has accelerated the pace of soil desertification. Because of the high wind power and relatively dry climate in this area all year round, it is the most widely distributed area of wind-blown sand in Ningxia [3]. In the northern arid region of Ningxia, the main soil types are lime-calcium soil, aeolian sand soil, and red clay, while the central region is salt soil, yellow spongy soil, and so on.

3. Spatial-temporal changes and driving forces of NDVI in Ningxia grassland before and after grazing ban

3.1. Changes in NDVI spatial pattern of grassland

According to **Figure 1**, it is not difficult to find that from the perspective of grassland cover types in Ningxia, combined with the conversion of grassland cover types at the same level, the proportion of grassland cover types decreased by 12.54% after the grazing ban. Among them, from 1988 to 2018, 44.23% of the areas with unchanged grassland cover were in Ningxia. Combined with the advanced conversion of grassland cover types, the proportion of Ningxia after the grazing ban increased by 10.56% compared with before. From 1988 to 2018, the proportion of advanced conversion of grassland cover was 54.54%, which developed into a positive evolution [4]. Before the grazing ban, the conversion of grassland type to advanced grassland type was mainly located in northwest Ningxia, and the path was from low cover to low cover grassland, accounting for 12.65%. The development of low-cover grassland was medium-cover grassland, and its path accounted for 9.59% [5]. After the actual grazing ban, the advanced grassland type conversion was mainly located in the southern, central, and eastern regions of Ningxia, and the main path was the development from low-cover to medium-cover grassland, accounting for 29.94%, which significantly optimized the ecological environment [6]. Combined with the low-level conversion of grassland cover type, the proportion after the grazing ban increased by 2% compared with that before the grazing ban. The low-level conversion after the grazing ban was mainly in the range of medium-cover to low-cover grassland, accounting for 2.73%.

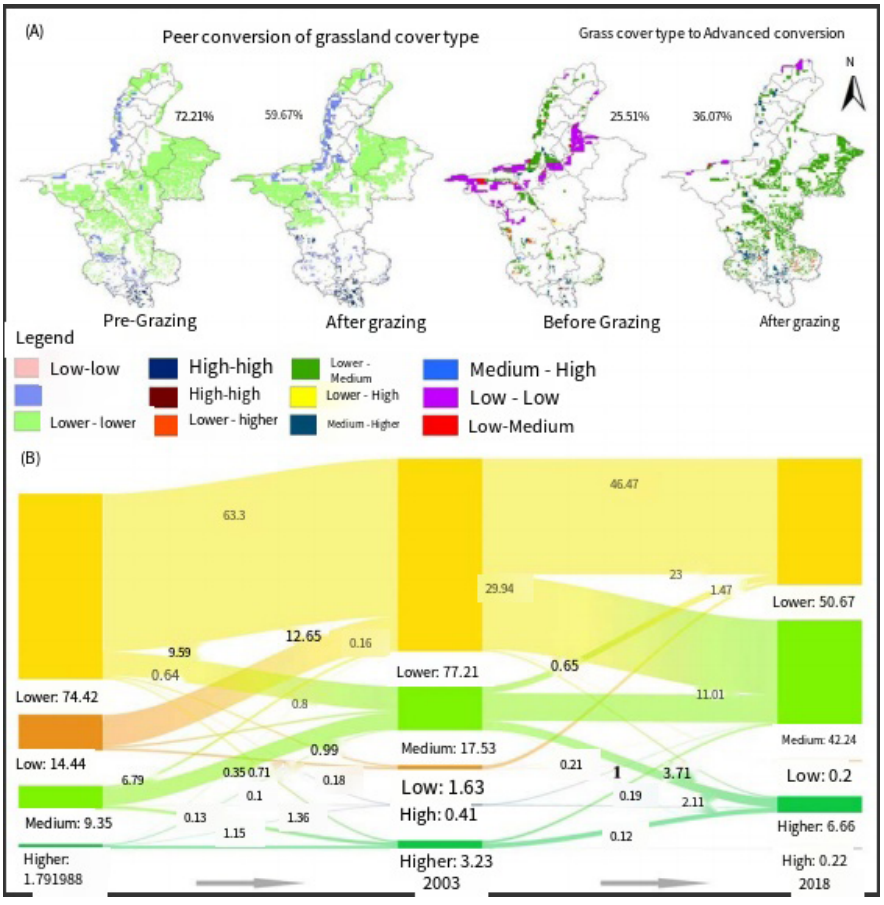

Figure 1. Spatial distribution of grassland cover transfer in Ningxia

3.2. NDVI driving forces of grassland in Ningxia before and after grazing ban

3.2.1. Effects of human activities on grassland NDVI

Human activities affect NDVI and carry out analysis activities by supporting the trend of residual difference. Before the grazing ban in Ningxia, the residual value increased rapidly from 1988 to 1994 and decreased from 1994 to 2002. In the above stages, most of the effects of human activities on NDVI were negative [7]. After that, the negative effects of human activities decreased significantly and gradually changed into positive effects. There was little change in the residual value before and after the ban on grazing in Ningxia. After the grazing ban, the influence of human activities fluctuated, and most of the residual values in this period were positive, indicating that human activities in this period had effectively improved the grassland cover [8]. Specifically, human activities had an improvement effect on NDVI, which showed an increasing trend during 1988–1994, and the fluctuation of residual value gradually increased during 2002–2018. According to the actual situation of Ningxia, the proportion of NDVI increase promoted by human activities before the grazing ban reached 66.25%, and the main distribution area was the central region. After the grazing ban, the area of NDVI decreased due to human activities increased by 21.51% compared with that before the grazing ban, mainly in the central region [9]. In conclusion, during 1988–2018, human activities contributed to the increase of NDVI, which accounted for 88.41%, and distributed in most areas of Ningxia.

3.2.2. Relative contribution of driving force to NDVI of grassland

The relative contribution of driving force to grassland NDVI was based on multiple linear regression and residual analysis. It can be combined with NDVI changes to distinguish them, including improvement area and degradation area, which effectively shows the contribution of climate change and human activities to grassland. In the NDVI improvement area of grassland, the proportion of areas affected by climate change and human activities from 1988 to 2018 was 49.98% and 56.17%. After the grazing ban, the contribution of climate change increased by 8.84%, while the contribution of human activities decreased by 18.85% [10]. Based on the decreased area of NDVI, the main influencing factor of NDVI from 1988 to 2018 was human activities, which accounted for 73.68% of the total area, and 85.39% and 93.04% of the total area before and after the grazing ban in the process.

4. Analysis of water erosion of grassland in Ningxia before and after the grazing ban

4.1. Increasing soil erosion of grassland

Soil erosion is the result of the joint action of surface, climate, and soil [11]. The spatial distribution of soil erosion is often affected by terrain, soil, and other factors, and the different terrain characteristics are mainly regional characteristics of local climate, soil, and vegetation.

The change in climate is mainly combined with the change in precipitation and temperature, which directly affects the effect of soil erosion. Due to the emergence of global warming, the global climate is constantly changing, in which hydraulic erosion increased by 2.3%, with the most obvious impact in semi-arid areas [12]. On the one hand, global warming has an impact on the water cycle [13]. On the other hand, as global warming increases land runoff, rising temperatures and decreasing precipitation promote the increase of river sediment transport and discharge. According to the factor detection, it is found that the explanatory power of temperature is third place after slope and elevation in different periods except Liupanshan area. After the grazing ban was implemented in Ningxia, the interaction between the ecological security barrier and the temperature and slope of the extension area in the Luoshan and Helan Mountains was improved. The main cause of soil erosion is high-intensity rainfall, in which a 20% increase in precipitation will increase water erosion by 37%. In the display of interaction, temperature and precipitation played a good interaction in the Liupan Mountain area [14]. According to the study of Ningxia, the erosion reached its maximum value when the annual precipitation increased to 200–400mm. When the average precipitation reaches about 300mm, the grassland erosion in Ningxia shows strong characteristics.

The relationship between soil erosivity and soil chemical and physical structure is close. The permeability of silt particles is weak, and it is easy to cause water erosion. The clay particles have the characteristics of anti-stripping, and the permeability of sand particles is stronger, which can effectively reduce the function of raindrops. The development of unreasonable human activities will lead to the destruction of soil structure the reduction of soil organic matter, and the lack of stability of aggregates. In the ecological security barrier and extension area of the Luoshan area, the content of soil organic matter is insufficient, and the content of sand is high, with the highest value of 90%. In the Liupanshan area, the soil erodibility is high, the sand content is low, and the silt content is high, accounting for 54%. Based on these soil conditions, this region has become an area of frequent water erosion in Ningxia.

4.2. “Banning grazing” effectively reduces the risk of net erosion

Proper grazing can help reduce soil erosion in grasslands. In grassland areas with proper grazing activities, animal hooves have a trampling effect on the soil, which is not enough to destroy the soil structure of the grassland.

Compared with degraded cultivated land, proper grazing can increase the soil bulk density [15]. The increase in soil volume can also reduce soil erosion to a certain extent. Overgrazing, however, will reduce the vegetation cover and permeability of grassland, and increase the probability of soil erosion. In addition, overgrazing reduces the roots of grassland vegetation which stabilizes the soil structure, thus intensifying soil erosion.

In the context of the current era, Ningxia has introduced a series of grassland ecological protection policies, focusing on the practice of banning grazing and confining breeding and implementing ecological projects to return grazing to grassland. In 2011, Ningxia officially promulgated the regulations on banning grazing and flocking, after which the level of change trend in Ningxia increased slowly as the main body. The proportion of grassland vegetation with medium coverage increased by 16.15%, distributed in the mountainous area of southern Ningxia and the west side of Ningxia Plain, among which Wuzhong City, Tongxin County, and other eastern areas of Ningxia effectively adjusted the ecological environment. The contribution of precipitation to the reduction of net erosion risk was negative. Although the precipitation increased in this stage, the net erosion risk was theoretically increased, but the impact of human activities, such as the grazing ban, resulted in the net erosion risk being reduced. When the NDVI value exceeds 0.6, no matter what the slope level is, the net erosion rate is subject to slight and mild erosion. In the above situation, banning grazing and restricting natural grassland can restore grassland vegetation, effectively reduce soil erosion caused by slope and other factors, and effectively maintain soil and water. Through the study of the temporal and spatial changes of grasslands before and after the grazing ban, soil erosion of grasslands in Ningxia can be accurately estimated. The factors can be clarified to provide academic and scientific support for the subsequent grassland management practice.

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