Multivariate Statistical Analysis on Main Factors of Grassland Degradation in Ewenki Grassland in China*

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Abstract: Grassland resources are not only an important part of regional economic development, but also play an important role in regional ecosystems. It is an important means of production for animal husbandry as well as an important ecological barrier for the natural environment. Based on the relevant data of grassland resources in the Ewenki grassland from 2005 to 2016, this paper applies the factor analysis method and the grey relational analysis method to analyze the main influencing factors of grassland degradation in the Ewenki grassland. The analysis results show that the vegetation coverage of the Ewenki grasslands has shown a steady upward trend on the whole in past ten years, while the proportion of fine forages has decreased year by year and the unreasonable human activities have led to the decline of grassland biomass. The analysis results of influencing factors showed that economic factors reflecting human activities were the main factors affecting grassland degradation in the Ewenki grassland, and their contribution rate was much higher than that of other factors.

Key words: Ewenki grassland; grassland degradation; influencing factors; statistical analysis

БНХАУ-ын Эвэнки тал дахь бэлчээрийн доройтлын үндсэн хүчин зүйлсийн олон талт статистикийн шинжилгээ

Хураангуй: Бэлчээрийн нөөц нь бүс нутгийн эдийн засгийн хөгжлийн чухал хэсэг төдийгүй бүс нутгийн экосистемд чухал үүрэг гүйцэтгэдэг. Энэ нь мал аж ахуйн үйлдвэрлэлийн чухал хэрэгсэл төдийгүй байгаль орчны экологийн чухал саад бэрхшээл юм. Эвенки бэлчээрийн 2005-2016 оны бэлчээрийн нөөцийн холбогдох мэдээлэлд үндэслэн энэхүү бүтээлд Эвенки бэлчээрийн бэлчээрийн доройтолд нөлөөлж буй гол хүчин зүйлсийг шинжлэхэд хүчин зүйлийн шинжилгээний арга болон саарал хамаарлын шинжилгээний аргыг ашигласан болно. Шинжилгээний дүнгээс харахад Эвенки бэлчээрийн ургамлын бүрхэвч сүүлийн 10 жилд бүхэлдээ тогтвортой өсөх хандлагатай байгаа бөгөөд сайн бэлчээрийн эзлэх хувь, бэлчээрийн биомасс ч хүний зүй бус үйл ажиллагааны улмаас жилээс жилд буурч байна. Нөлөөлөх хүчин зүйлсийн шинжилгээний үр дүнгээс үзэхэд Эвенки бэлчээрийн доройтолд хүний үйл ажиллагааг тусгасан эдийн засгийн хүчин зүйлс нөлөөлсөн гол хүчин зүйл бөгөөд тэдгээрийн хувь нэмэр бусад хүчин зүйлсээс хамаагүй өндөр байна.

Түлхүүр үгс: Эвенки бэлчээр; бэлчээрийн доройтол; нөлөөлөх хүчин зүйлүүд; Статистикийн дүн шинжилгээ

Introduction

Grassland degradation refers to the phenomenon or process in which the biological resources, land resources, water resources and ecological environment of grassland are degraded under the influence of natural conditions and human activities, resulting in the decline of productivity. Activities of grassland degradation include: grassland desertification, salinization and grassland pollution. Grassland resources not only provide a large amount of economic development basis for human production and life, but also an important ecological barrier for human survival. With the development of social economy, the phenomenon of unreasonable land reclamation and exploitation by human beings has made the degradation of grassland resources more and more serious.

As one of the important pastoral areas in the Inner Mongolia Autonomous Region, Ewenki Autonomous Banner is rich in grassland resources and is also one of the important ecological barrier protection in northern China. In 2002, China promulgated the first "Opinions on Strengthening Grassland Protection and Construction", which clearly stated that "resources should be utilized in a way of focusing on protection and supplemented by construction, so as to improve the utilization rate and production capacity of grasslands. "[1].

With the development of social economy, people's demand for grassland resources is increasing, and grassland resources are facing a serious trend of degradation. Natural conditions and unreasonable human activities are important factors for grassland resource degradation[2]. The research of H S Thind & M S Dhillon (1994) showed that the main influencing factor of grassland degradation is the problem of land[3]; Snyman. (2005) conducted a systematic study of grassland in South Africa, and believed that the degree of closeness between temperature and land is the main factor of degradation affecting grassland[4]; Yang Rurong believes that the continuous intervention of human factors is the main factor of grassland degradation in western China[5]; Zhu Jinzhong's research on grassland degradation in Xinjiang in 2003 showed that the unreasonable utilization of human influence on grassland resources is the main cause of grassland ecological destruction in Xinjiang[6]; Li Huixia (2005) used factor analysis to quantitatively analyze the degradation of grasslands in the northern part of the Tibet Autonomous Region. The research results showed that the change of natural environment is the root cause of grassland degradation in the region.[7]. Although relevant scholars have carried out targeted studies in different regions, there are few studies on grassland ecology in the Ewenki grassland, especially the statistical analysis of grassland degradation factors.

The reasonable protection and effective utilization of grassland resources play

a vital role in promoting the economic development of pastoral areas. At the same time, it can protect the natural ecological environment and alleviate the trend of grassland degradation. However, in recent decades of social development, human beings lack the awareness of grassland protection, and a large number of land reclamation, indiscriminate mining, etc. have left a large number of grassland ground exposed, and soil and water degradation has become more and more common. This not only goes against the ecological balance of nature, but also directly affects the regional economic development and the sustainable production of animal husbandry. In recent years, the phenomenon of land degradation in the Ewenki area has been increasing year by year, which has seriously affected the production and life of local herdsmen.The purpose of this research is to systematically analyze the main influencing factors of grassland degradation in Ewenki grassland, and explore the dominant restrictive factors of grassland degradation, so as to promote the advantages of the region and avoid the disadvantages, so as to provide a reference basis for the rational protection and utilization of grassland resources and the sustainable development of grassland ecology.

Overview of the study area and data sources

(1) Physical and geographical features

The Ewenki Autonomous Banner is located in the southeastern part of the Hulunbuir Grassalnd and in the northeastern part of Inner Mongolia Autonomous Region. Its climate belongs to temperate continental climate, and the sunshine duration in summer can reach up to 16 hours, which is very beneficial to the development of animal husbandry. There are many rivers and lakes in the Ewenki Autonomous Banner, with more than 200 rivers of varying lengths and thousands of large and small lakes, with abundant surface water capacity. The storage capacity of groundwater in the Ewenki area is relatively rich. The total land area of the whole Banner is 27.985 million mu. Among them, the grassland area is 11.894 million mu, occupying nearly half of the land area of the whole Banner. The territory of the Ewenki Autonomous Banner is relatively rich in mineral resources, especially coal resources, which have reached millions of tons.

(2) Social and economic situation

There are 25 ethnic groups in the Ewenki Autonomous Banner. From 2005 to 2016, the total GDP output value of the region increased from 2.727 billion yuan to 11.569 billion yuan, with an average annual increase of 737 million yuan; the output value of the primary industry increased year by year, from 393 million yuan

to 833 million yuan, and during the period from 2014 to 2016, the output value of the primary industry was decreasing year by year, showing a trend of gradually shrinking the primary industry; the per capita net income of farmers and herdsmen increased from 4781 yuan to 18969 yuan, showing a kind of steady upward trend of per capita income.

(3) State of grassland degradation

Grassland degradation is the deterioration of the structural characteristics and functional processes of grassland ecosystem in the process of its evolution and under the joint action of human activities and natural conditions, that is, the overall deterioration of plant, animal and microbial communities and their living environment. The main manifestations of grassland degradation are the decline of grassland vegetation coverage, height, and above ground biomass quality, the deterioration of soil habitat production capacity and the decline of ecological functions. The forage grasses in the Ewenki grassland are mainly Leymus chinensis and Stipa, all of which belong to the grass family, and can reach a height of 30-80 cm.

The interannual variation of grassland vegetation cover in Ewenki from 2005 to 2016 was analyzed. It can be seen from Figure 1 that the grassland vegetation coverage in the Ewenki area has changed between 48.76 and 62.58 in the past decade, with an average value of 55.67, and the inter-annual variation in vegetation coverage is small. Judging from the interannual variation trend of grassland vegetation coverage, the slope of the linear regression equation slope > 0, the overall grassland vegetation coverage showed a steady increase trend, and increased at a rate of 4.895 every 10 years, and the overall growth of grassland vegetation was improving. However, from 2005 to 2016, the proportion of fine forages in the Ewenki grassland decreased at a rate of 33.741 per 10 years, and the goodness of fit of the linear regression variance was above medium. It shows that the proportion of fine forage in the Ewenki grassland is decreasing year by year, which directly affects the quality and above ground biomass of the grassland.

Fig. 1 The interannual variation trend of grassland vegetation coverage and the percentage of good forage in Ewenki from 2005 to 2016
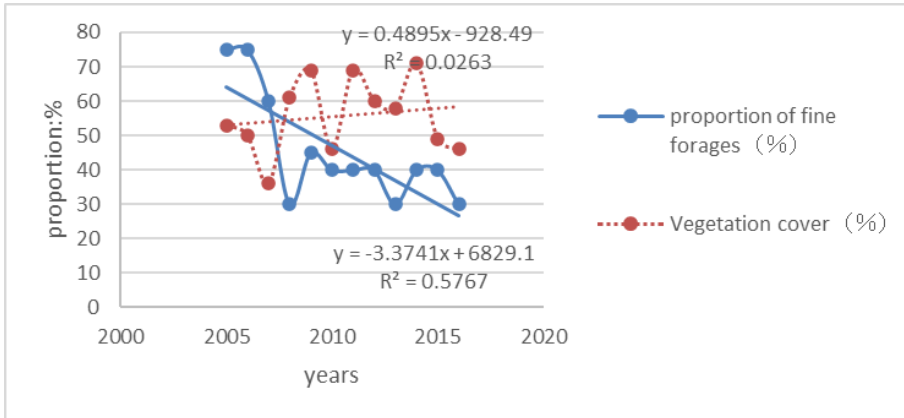
The interannual variation of above ground biomass in the Ewenki grassland from 2005 to 2016 was analyzed. It can be seen from Figure 2 that the above-ground biomass of the Ewenki grassland has changed between 3108.25 and 4835.91 (kg/m2) in the past decade, with an average value of 3972.08, and the inter-annual variation of the above-ground biomass is small. Judging from the interannual variation trend of above ground biomass, the slope of the linear regression equation slope < 0, the above ground biomass showed a steady decrease trend, and decreased at a rate of 453.67 per 10 years, and the above ground biomass of the Ewenki grassland was generally decreasing.

Fig. 2 Interannual variation trend of aboveground biomass in Ewenki grassland from 2005 to 2016
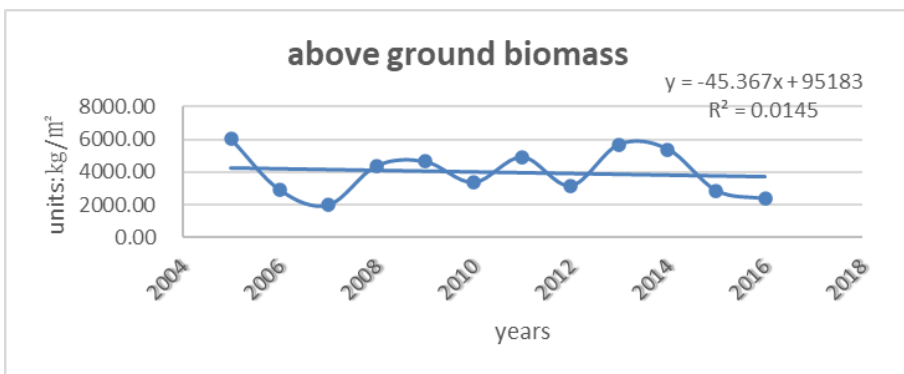
(4) Data sources and research methods

The main source of data in this paper is the Statistical Yearbook of Hulunbuir City from 2005 to 2016. The relevant indicators of grassland degradation in Ewenki come from the continuous and effective monitoring data of "Ewenki Autonomous Banner Meteorological Station" and "Ewenki Grassland Station" including, the average annual temperature, the average annual precipitation, the population, the number of livestock at the end of the year, the total GDP output value, the output value of the primary industry, the per capita net income of farmers and herdsmen, grassland coverage, biomass and other indicators. In terms of specific statistical analysis methods, IBM SPSS Statistics 21.0 is used for data entry, descriptive statistical analysis, factor analysis, and grey correlation analysis.

Empirical study on the influencing factors of grassland degradation in Ewenki

(1) Eco-climate characteristics

1. Temperature

The monthly average temperature changes in the Ewenki grassland are shown in Figure 3. The highest monthly average temperature is July, the lowest month is January, and the annual average temperature is -0.57°C (2005-2016). From 2005 to 2016, the annual average temperature showed a "concave" trend, as shown in Figure 4. The annual average temperature fluctuates between -2°C and 1.5°C. It can be seen that the temperature in the Ewenki grassland area is relatively stable and rising slightly throughout the year. 2007 has become the warmest year in the past ten years, and 2012 has become the coldest year. Since 2012, the phenomenon of "global warming" in the Ewenki grassland area has gradually become obvious, mainly because the "warm winter" phenomenon has become the norm in the Ewenki area.
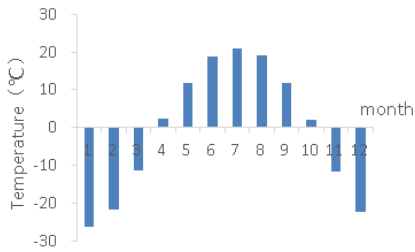
Figure 3 Monthly average temperature
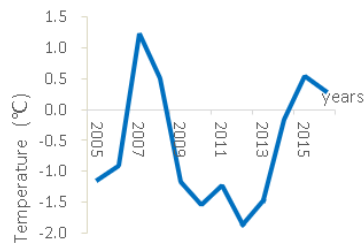in Ewenki from 2005 to 2016

Figure 4 The annual average temperature
in Ewenki from 2005 to 2016

2. Precipitation

From 2005 to 2016, the average annual precipitation of the Ewenki grassland was 9.46mm, and the change rule was in a relatively stable state for a long time (as shown in Figure 5), which played an irreplaceable auxiliary role for the vegetation growth of the grassland.

Figure 5 Average precipitation from 2005 to 2016
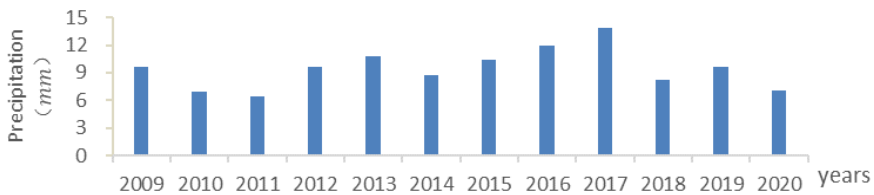
(2) Socioeconomic characteristics

1. Population

The rapid expansion of the population has led to a huge consumption of resources, the per capita resource demand has increased, and the pressure on grasslands has increased year by year. According to the data released by the Statistical Yearbook of the Inner Mongolia Autonomous Region from 2005 to 2016, the population of the Ewenki area showed a trend of first increasing, then stabilizing, and then gradually decreasing. As can be seen from Figure 6, from 2005 to 2010, the population increased by 1566; from 2012 to 2014, the population was relatively stable; from 2014 to 2016, the population gradually decreased. Because of the

changing population, pastoral pressures are also changing. In order to improve the quality of life and increase the per capita income, farmers and herdsmen vigorously develop aquaculture, which greatly shortens the recuperation time of grassland in the Ewenki grassland, gradually weakens the recovery ability of the grassland, and accelerates the degradation rate of the grassland.

Figure 6 Population and annual growth rate from 2005 to 2016
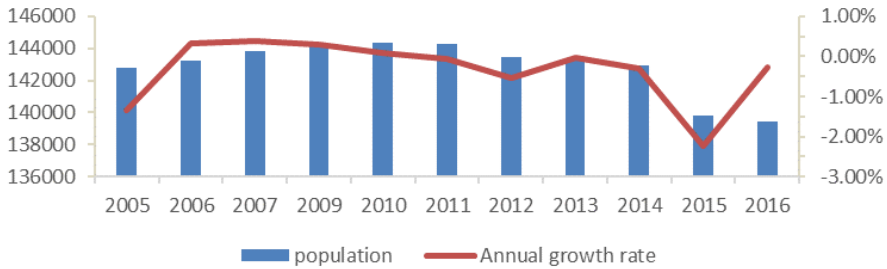
2. Economic factors

Today, with the rapid development of social economy, the economy of Ewenki Banner is also rising rapidly, especially the development of animal husbandry, which has become an important part of the economic development of this area, occupying a certain economic position in the total GDP output value, as shown in Figure 7 shown. It can be seen from this that the GDP output value of the Ewenki Banner increased steadily from 2005 to 2016.

Figure 7 GDP and Growth Rate
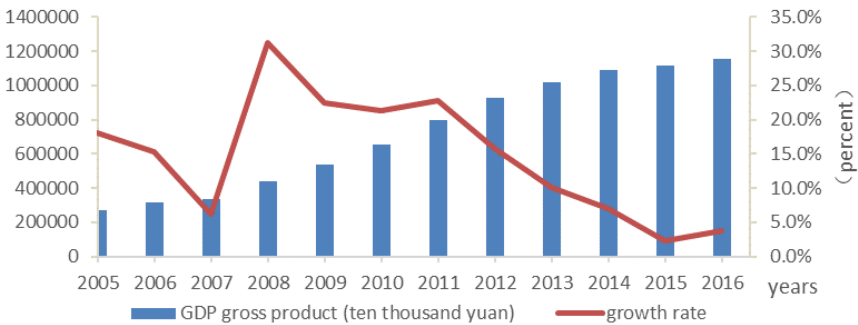
With the development of social economy, the living standards of the people in this area have been improved year by year. As shown in Figure 8, the per capita income of farmers and herdsmen in the Ewenki area showed a steady upward trend from 2005 to 2016.

Figure 8 Per capita net income of farmers and herdsmen
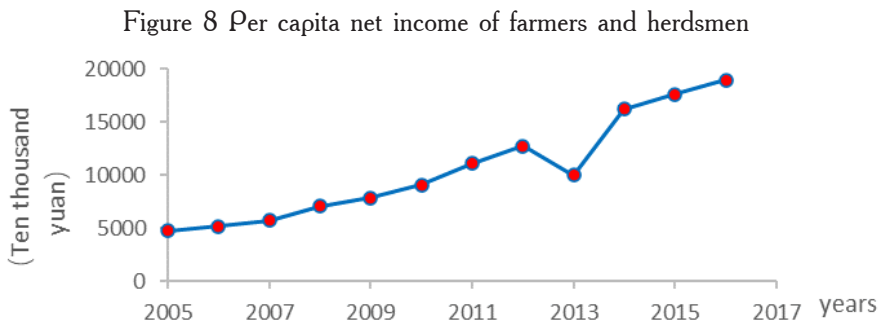
In the primary industry, animal husbandry occupies a certain position in the local area. From the analysis results in Figure 9, it can be seen that the total output value of the primary industry has a certain correlation with the number of livestock on hand at the end of the year. The two complement each other.

Figure 9 The relationship between the total value of the primary industry and the number of livestock heads at the end of the year
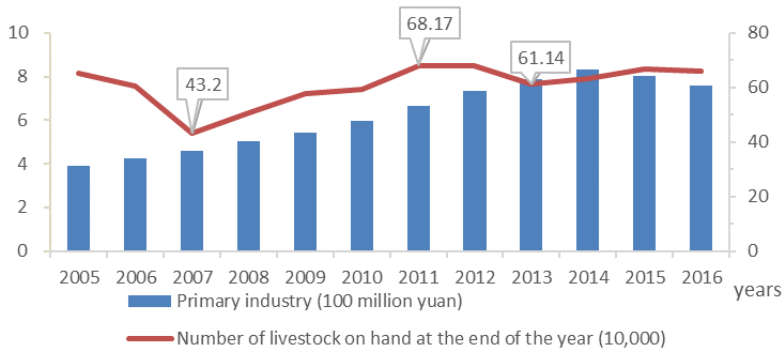
(3) Statistical analysis of the leading factors of grassland degradation in Ewenki

Factor analysis is the extension and development of principal component analysis.

Its purpose is to synthesize variables with intricate relationships into a small number of factors to reproduce the relationship between the original variables and factors. A multivariate statistical analysis method for classifying variables. Combining the availability of factors related to grassland degradation in Ewenki, this study selected the population, GDP total output value, primary industry output value, number of livestock at the end of the year, average annual temperature, average annual precipitation, per capita net income of farmers and herdsmen, grassland vegetation in the Ewenki area. Nine indicators, such as coverage and above-ground biomass, are recorded as x_1 to x_9 in turn. First, the correlation analysis of all indicators yields the following results in Table 1:

Table 1 Correlation coefficient matrix

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
x_1	1	0.570	0.455	0.427	0.403	0.252	0.724	0.400	0.287
x_2	0.570	1	0.985	0.574	0.015	0.292	0.937	0.049	0.076
x_3	0.455	0.985	1	0.518	0.040	0.358	0.889	0.003	0.111
x_4	0.427	0.574	0.518	1	0.534	0.352	0.551	0.324	0.373
x_5	0.403	0.015	0.040	0.534	1	0.615	0.190	0.684	0.645
x_6	0.252	0.292	0.358	0.352	0.615	1	0.016	0.470	0.453
x_7	0.724	0.937	0.889	0.551	0.190	0.016	1	0.176	0.066
x_8	0.400	0.049	0.003	0.324	0.684	0.470	0.176	1	0.875
x_9	0.287	0.076	0.111	0.373	0.645	0.453	0.066	0.875	1

From the analysis results in Table 1, it can be seen that most of the variables selected in this study have certain correlations and overlapping information. The most direct way to solve these problems is to perform factor analysis on the original variables. While factor analysis can effectively reduce the number of variables, it can also reflect most of the information of the original variables.

Table 2 Common factor variance

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
initial	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
extract	0.717	0.944	0.872	0.684	0.800	0.664	0.955	0.803	0.750

From the results in Table 2, it can be seen that the value of the amount of information extracted by each index selected is greater than 0.5, indicating that the amount of information lost in this factor analysis is less, and the result of the factor analysis is ideal.

The initial eigenvalues, variance contribution rate, and variance cumulative contribution rate of the data correlation matrix were obtained through factor analysis of the relevant indicators affecting grassland degradation (as shown in Table 3). According to the principle that the eigenvalue is greater than 1, three main factors are extracted, and the cumulative contribution rate of variance reaches 87.544%, indicating that the three factors explain 87% of the information of all nine influencing factors, and the loss of the original index is relatively small.

Table 3 Variance and cumulative value

Element	total	Variance contribution rate %	Variance cumulative contribution rate %
1	3.781	42.009	42.009
2	3.308	36.755	78.764
3	0.790	8.780	87.544

Table 4 Rotation component matrix

variable	Element		
	1	2	3
x_1	-0.711	0.230	0.553
x_2	0.975	-0.019	0.159
x_3	0.935	-0.025	0.280
x_4	0.652	0.609	-0.180
x_5	-0.040	-0.837	-0.317
x_6	0.218	0.455	0.770
x_7	0.965	-0.095	-0.125
x_8	-0.119	0.895	0.172
x_9	0.002	0.887	0.132

It can be seen from Table 4 that the original variable x_1 can be represented by each factor as:

$x_1 = -0.711F_1 + 0.230F_2 + 0.553F_3$,

The original variable x_2 can be expressed as: $x_2 = 0.975 F_1 - 0.019 F_2 + 0.159 F_3$, and so on for other variables.

It can be seen from the above table that only a few indicators for each factor have large factor loads. Therefore, the factors affecting grassland degradation in the Ewenki grassland can be classified according to the above table, and the 9 indicators are divided into three categories according to high load, which are listed in Table 5 below.

Table 5 Factor Loading Index

Factor	High Load Index	Meaning
F_1	x_1: area population x_2: Regional GDP x_3: Gross value of primary industry x_4: Number of livestock heads at the end of the year x_5: per capita net income of farmers and herdsmen	Economic factors
F_2	x_6: annual mean temperature x_7: Average annual vegetation coverage x_8: aboveground biomass	natural factor
F_3	x_6: Average annual precipitation	Precipitation factor

First factor F_1 in the study area, the population, GDP, total value of primary industry, number of livestock at the end of the year, per capita income of farmers and herdsmen and other indicators have a large load. Therefore, F_1 named as the economic factor reflecting grassland degradation; Second factor F_2 the factor load values of annual average temperature, annual average vegetation coverage and aboveground biomass are large, so they are named as natural factors; Third factor F_3 only the annual average precipitation has a large load value, so it is named as precipitation factor. Therefore, we can use these three factors to evaluate the main influencing factors of grassland degradation in Ewenki grassland, and their cumulative contribution rate is 87.544%, which basically reflects the original information of all influencing factors in this study on the premise of less information loss. Among them, the contribution rate of social factors reflecting human activities is much higher than that of other factors.

Grey incidence analysis has a wide range of applications in ecosystems, social systems, agricultural systems and many other fields. The basic idea of grey incidence analysis is to judge whether the relation is close according to the similarity of the geometric shapes of the sequence curves. The closer the curves are, the greater the correlation between the corresponding sequences, and vice versa. The grey incidence analysis on the factors of grassland degradation in this area yields the following results, as shown in Table 6:

Table 6 Grey correlation degree and ranking

Factor	Value	Association sort
The number of livestock at the end of the year	0.7269	1
temperature	0.6677	2
Precipitation	0.6446	3
Per capita net income of farmers and herdsmen	0.6272	4
population	0.6159	5
Aboveground biomass	0.6011	6
grassland vegetation cover	0.5776	7
GDP	0.5771	8
Output value of primary industry	0.5549	9

From the calculation results of the degree of grey incidence analysis, it can be seen that the correlation degree between the number of livestock at the end of the year and the grassland degradation is the largest, and the correlation degree is 0.726, indicating that the number of livestock at the end of the year has the greatest impact on the grassland degradation of the Ewenki grassland. The correlation degrees of the remaining indicators are annual average temperature (0.6677), precipitation (0.6446), per capita net income of farmers (0.6272), population (0.6159), aboveground biomass (0.6011), grassland vegetation coverage (0.5776), GDP (0.5771) and the output value of the primary industry (0.5549), and the correlation degree is greater than 0.5, indicating that the importance of the above indicators for grassland ecological protection in this region cannot be ignored.

Conclusion

Based on the dynamic change data of grassland degradation factors in the Ewenki grassland from 2005 to 2016, this study combined factor analysis and grey incidence analysis to conduct specific research.

According to the analysis results, the grassland vegetation coverage of the Ewenki grassland showed a steady increase as a whole, and at the same time, due to the influence of the annual decline in the proportion of fine forages, the overall above ground biomass showed a slow decreasing trend.

The influencing factors of grassland degradation in Ewenki can be reduced by three common factors including economic factors, natural factors and precipitation. Economic factors reflecting human activities are the main factors affecting the study of grassland resources , and their contribution rate is much higher than that of other factors. It shows that nature's own regulating function has been destroyed by human's unreasonable and unscientific activities; human over-exploitation and

grassland industrialization have become one of the main concerns for the sustainable development of grassland resources as well as the core problem affecting the sustainable development of grassland ecology.

The grey incidence analysis method was used to analyze the correlation degree of grassland degradation factors in descending order: the number of livestock at the end of the year (0.7269), temperature (0.6677), precipitation (0.6446), per capita net income of farmers (0.6272), population (0.6159)), biomass (0.6011), grassland vegetation coverage (0.5776), GDP (0.5771), primary industry output value (0.5549), the correlation degree is greater than 0.5, indicating that the importance of the above indicators in the study of grassland ecology in this region cannot be ignored .

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