ASSESSMENT OF GRASSLAND HEALTH BASED ON SPATIAL INFORATION TECHNOLOGY IN CHANGJI AUTONOMOUS PREFECTURE, XINJIANG

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ABSTRACT:

Based on the “pressure-state-response”(PSR) model, comprehensively applied GIS and RS techniques, 20 evaluation indicators were selected based on pressure, state and response, the entropy weight method was used to determine the weight of each index and build a grassland health evaluation system in Changji Prefecture, Xinjiang. Based on this, evaluation and dynamic analysis of grassland health in Changji Prefecture from 2000 to 2016, using GIS/RS technology, the trend of grassland health status in Changji is analyzed and studied. The results show that: 1)Grassland with low health leveld, lower health level, sub-health level, health level and high health level accounts for 1.46%,27.67%,38.35%,29.21% and 3.31% of the total area of Changji. Qitai County, Hutubi County, and Manas County are lower health levels, Jimsar County, Changji City, and Mulei County are at a relatively high level, and Fukang City has a healthy level of health. 2) The level of grassland health in Changji County decreased slightly during the 17 years, accounting for 38.42% of the total area. The area of 23,87% showed a stable trend, and the improved area accounted for 37.31% of the vertical surface area..

1. INTRODUCTION

Grassland is the largest ecosystem in China (Fu ZZ., 1996), the status of grassland is of great significance to the development of animal husbandry, biodiversity conservation, soil and water co nservation, and the maintenance of local ecological balance (Xi e GD., 2001). In addition, the grassland also has a variety of soc ial functions, the most common of which are economic and ecol ogical service functions (Min QW., 2004).

With the advancement of science and technology and people’s increasing emphasis on grassland resources (Ren JZ., 2004), Scholars elaborated on the scientific definition of grassland and emphasized the relevance of grassland and other factors, to some extent overcome the limitations and bottlenecks in the study (Zhao YL., 2008; Zhao XL., 2008; Shan GL., 2008). Human activities have become the largest disturbance factor in grassland ecosystems (Cai XM., 2000). Grassland is an important carbon stock in ecosystems, quantitative qualitative monitoring of them helps to properly manage grassland resources and to take appropriate remedial measures in case of sudden disasters. Therefore, the study of grassland ecosystem health emerged.

Grassland health assessment is a relatively late start research are a. Since James Hutton and the British ecologist Arthur Tansley proposed the concept of “natural health” and “ecosystem” in 17 88 and 1935, respectively (Xiao FJ., 2002), more research based on this theory, the authors conducted a study on the structure a nd function of the ecosystem. The American scholar Dyksterhui s first proposed the concept of the “Range condition” in 1948, a nd further proposed the theory of the “Range Site” in 1949 (Dy ksterhuis E.J.,1949). In the 1960s, evaluation methods such as g razing use, grassland management, and wild animals were adde d to the original evaluation, and the breadth of evaluation was f urther sublimated (Usa N.C., 1969). The “Man and Biosphere P roject”(MAB) that ended in the 1970s took the impact of distur bance factors on ecosystem effects as the main research content. On this basis, disturbance factors were also considered into the evaluation system (Concepts T., 1995). Until the 1980s, the UN Environment Committee put forward the concept of sustainable development in the texts such as “Protection of the Earth” and “Our Common Future” and introduced this concept into the gra ssland health assessment system. This period grassland health th e concept began to emerge. In the subsequent 1990s, an evaluati on system consisting of a combination of threshold and early wa rning indicators was highly praised by the National Advisory Ce nter and the Grassland Management Working Group (West N.E., 1994; Walker J., 1996; Pakeman R.J., 2010; Costanza R., 1997; Pellant M., 2005). Compared with the research progress abroad, domestic and grassland health related research started late, mos tly introducing and improving foreign exiting research and relat ed evaluation model construction forms. Li Bo proposed China based on grassland type succession built northern grassland deg radation grading index system (Li B., 1997). Since then, Hao D unyuan and Liu Zhongling have carried out more than 10 years of research on the degradation and diagnosis of grassland vegeta tion in 1997 and 1998 respectively, and in this basis, they have achieved certain research results (Liu ZL., 1997; Liu ZL., 1998). In 2000, Ren Jizhou established the threshold of health evaluati on based on the interface theory (Ren JZ., 2000). In 2005, Gao Anshe analysed the grassland health factors under different graz ing intensities and classified the evaluation results. The results were in good agreement with the actual conditions (Liu ZL., 19 97). Due to the differences in the research objects and the chara cteristics of the study area, the evaluation factors cannot be com pletely copied. Therefore, in the current stage of the evaluation

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process, more methods and models are used for reference and selection of indicators.

In view of the fact that animal husbandry is still the main economic model of Changji Grassland and lacks a certain degree of scientific management, the awareness of ecological protection of residents in pastoral areas needs to be strengthened and the implementation of policies has not yet been evaluated in the future. Therefore, the ecological health status of Changji Grassland needs to be implemented. According to the evaluation, this study selected and evaluated the indicators in the existing literature, and formed an evaluation index system to evaluate the health status of grassland in Changji Prefecture in June 2000-2016.

2. RESEARCH AREA

Xinjiang Changji Hui Autonomous Prefecture (herein referred to as Changji Prefecture) (Li TS., 2005; Chen XJ., 2004; Mu Nire Ḣui Hemu, 2017) is located in the north of the Tianshan Mountains, the south-eastern edge of the Junggar Basin, and its north-eastern is adjacent to Mongolia. It is a core city on the world-famous ancient Silk Road, the new 5th North Road. Its geographical position occupies a strategic position in the development of the western region and is one of the first areas in the development of the economic belt on the northern slope of the Tianshan Mountains in Xinjiang. It is an important window opening to the west of Xinjiang and Urumqi. The mountainous area of the area accounts for 22.7% of the whole area, and the desert gobi accounts for 52% of the whole area. Therefore, the area can be divided into three major landscape units: mountainous, plain and desert (Mu Nire Ḣui Hemu, 2017). It belongs to the middle temperate zone and has prominent continental features.

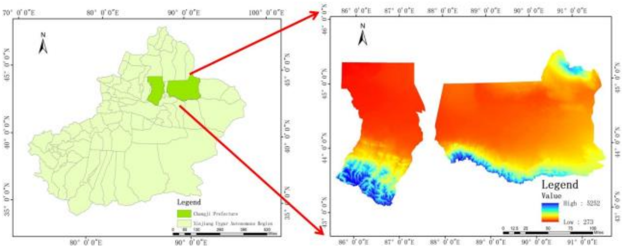


Figure 1.Location of Changji Prefecture

3. DATA AND METHODS

3.1 Data Sources

Remote Sensing Data: Remote Sensing data are sourced from the Geospatial Data Cloud (http://www.gscloud.cn/). The remote sensing data used for research in Changji Prefecture is formed by 10 image mosaics to meet the continuous June-July 2000-2016 period. In the analysis and study, a total of 114 remote sensing images were used. The year of missing data was filled by years that were adjacent and naturally consistent. The normalized vegetation index (NDVI) was produced from mosaic remote sensing images. According to Mu Shaojie (Mu SJ., 2013),Yang Hongfei (Yang HF., 2014) and Yang Huijin (Yang HJ., 2016), the application resolution was 30m. The result of NDVI data participation calculation is 5% higher than that of 990m NDVI data calculation. Therefore, this study uses higher resolution data to improve the accuracy of this study.

Other map data: administrative division map of Changji Prefecture, elevation data of Changji Prefecture, grassland type map of Changji Prefecture.

Meteorological and radiation data: average monthly temperature, monthly average precipitation and monthly average radiation.

Social economic data: Originated from Xinjiang Statistical Yearbook 2001-2017.

3.2 Evaluation Model

Grassland health assessment can characterize the status quo of grassland for sustainable and rational development. In order to achieve a scientific evaluation of grassland health status, it must comply with scientific, systematic, dominant, quantifiable and operability criteria when selecting evaluation indicators. Standards, to ensure that indicators can be deleted at the beginning of the selection are simple and have sufficient scientific value, to achieve the evaluation index system, the evaluation results are reasonable (Zhao CH., 2009; Chen MT., 2015; Xie XZ., 2013).

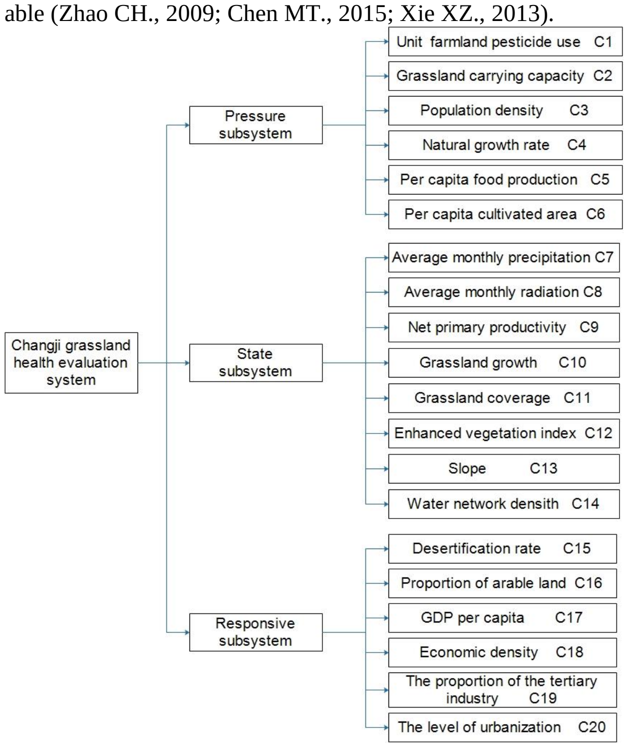


Figure 2.Assessment index system of grassland health in Changji prefecture

The PSR model has relatively few scientific applications to grassland health (Zhao YT., 2016). In general, the evaluation using the PSR model is based on a weighted sun of evaluation indicators to obtain a health assessment index, but based on the accumulation of previous studies. The simple weighted summation cannot achieve the result of a true scientific evaluation. Therefore, the previous improved PSR health index calculation model was introduced in order to make a more reasonable and scientific evaluation (Zhao YT., 2016). The calculation formula is as follows:

$$HI = \sqrt[3]{(1-P)\times S \times R} \quad (1)$$

$$P = W_1C_1 + W_2C_2 + W_3C_3 + \ldots + W_6C_6 \quad (2)$$

$$S = W_7C_7 + W_8C_8 + W_9C_9 + \ldots + W_{14}C_{14} \quad (3)$$

$$R = W_{15}C_{15} + W_{16}C_{16} + W_{17}C_{17} + \ldots + W_{20}C_{20} \quad (4)$$

where HI = grassland health
P, S, R = pressure, status, response subsystem score
W = evaluation index weight
C = evaluation index standard value

3.3 Determine The Weight

Determining the weight is an important part of grassland health assessment. The weight of the index will directly affect the healt h evaluation results. The methods for determining weights can b e roughly divided into subjectively determined weights and obje ctively determined weights. There are obvious different between the two methods. Compared to objectively determining the wei ghts can make a true and professional description of the actual s ituation in the study area from the perspective of experts. Howe ver, the cognitive differences among experts will cause the actu al situation to be subjective, although objectively determining th e method of weighting without expert cognition as a reference c annot reflect the actual situation in the region; it also fundament ally eliminates the subjective impact and can objectively obtain the results of grassland health assessment.

This paper chooses the weight of entropy method to calculate th e weight, entropy method is an objective method to determine th e right, according to the degree of variation of each index, the u se of information entropy to calculate the entropy weight of the index through the entropy weight, thus obtain objective weights (Yu J., 2012), at the same time, calculate the weight of indicato rs on the basis of data standardization.

$$W_i = \frac{1-e_i}{k-\sum e_i} \quad (5)$$

where k = number of indicators
e_i= information entropy

3.4 Trend Analysis

Trend analysis is a function that take times as an independent va riable, which also known as trend forecasting. This study selecte d a linear regression analysis to analyse the trend of grassland h ealth in Changji Prefecture from 2000 to 2016 (Lu ML., 2010; Rapport D.J., 1996; Yang Y., 2009).

$$S = \frac{n\times\sum_{i=1}^{n} i\times HI_i - \sum_{i=1}^{n} i \times \sum_{i=1}^{n} HI_i}{n\times\sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2} \quad (6)$$

where s = slope value
HI_i = grassland health index
i = corresponding year
n= years

If the slope value is greater than 0, the grassland health status of the area is improved. The larger the value, the more obvious th e improvement of the grassland health condition; if the slope val ue is less than 0, the meaning is opposite. According to the tren d analysis calculation and data statistics, the corresponding relat ionship between the value range of slope and the change of gras sland health status is clear.

4. GRASSLAND HEALTH ASSESSMENT RESULTS

4.1 Index Weight Calculation Results

Table 1. Standard and weight of grassland health assessment index system in Changji prefecture

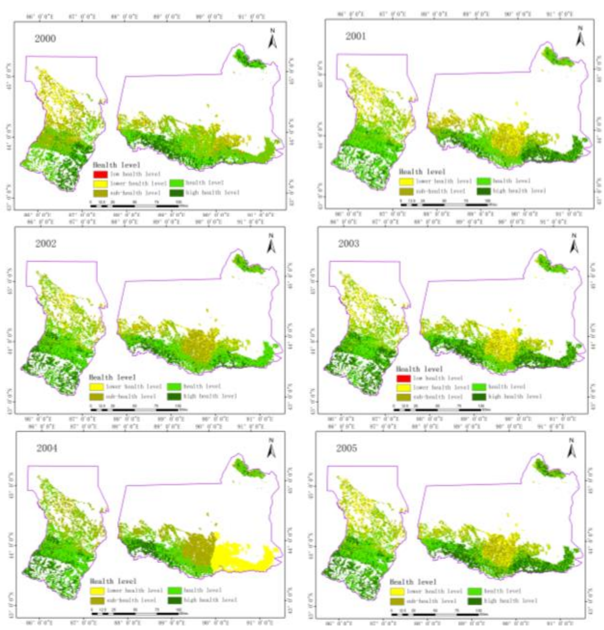
Target level	Criteria layer	Indicator layer	Weight
		Unit farmland pesticide use	0. 02
		Grassland carrying capacity	0. 008
	Pressure subsystem	Population density	0. 06
		Natural growth rate	0. 009
		Per capita food production	0. 008
		Per capita cultivated area	0. 01
Changji grassland health evaluatio n system		Average monthly precipitation	0. 01
		Average monthly radiation	0. 03
		Net primary productivity	0. 03
		Grassland growth	0. 06
	Statue subsystem	Grassland coverage	0. 06
		Enhanced vegetation index	0. 03
		Slope	0. 3
		Water network density	0. 3
		Desertification rate	0. 01
		Proportion of arable land	0. 014
	Responsiv e subsystem	GDP per capita	0. 005
		Economic density	0. 03
		The proportion of the tertiary industry	0. 004
		The level of urbanization	0. 002

4.2 Analysis of Chang of Grassland Health Time in Changji Prefecture

According to the establishment of the evaluation criteria, the co mprehensive index of grassland health in Changji prefecture wa s graded using ArcGIS reclassification tools.

Table 2. Grade standard of grassland health assessment in Changji prefecture

Health level	Grassland health index
High health level	HI＞0.75
Health level	0.55＜H I≤0.75
Sub-health level	0.25＜H I≤0.55
Lower health level	0.15＜H I≤0.25
Low health level	H I≤0.15



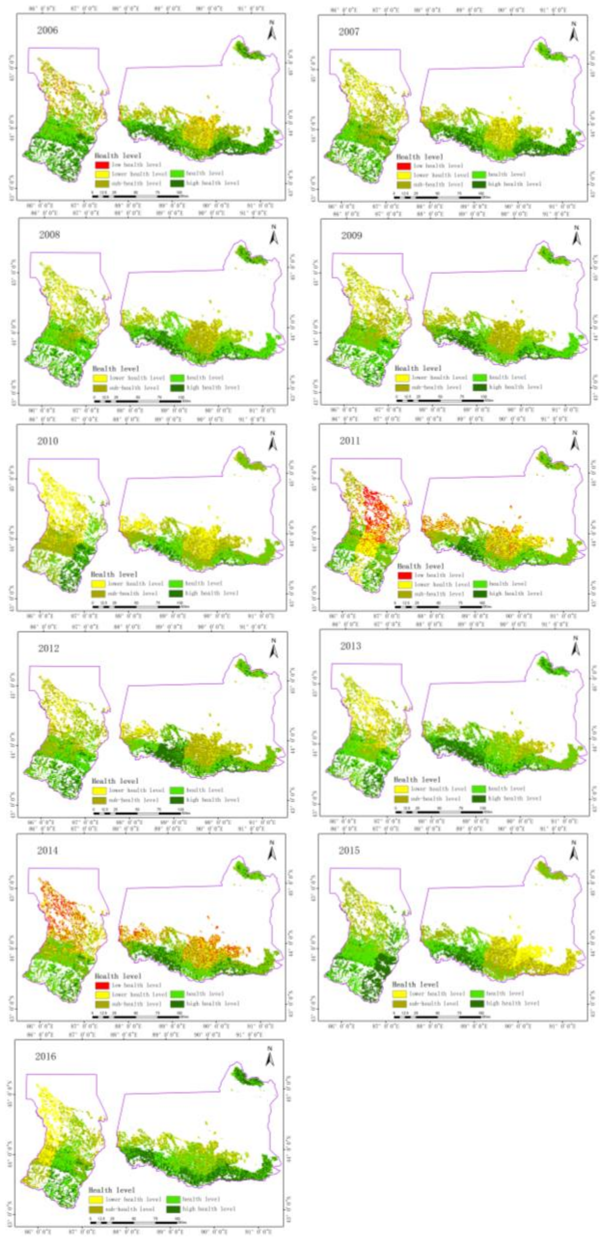


Figure 3.Health grading map of grassland ecosystem in Changji prefecture

Frome 2000 to 2016, the health status of grassland in Changji prefecture was mainly distributed in high, healthy, sub-healthy and low health levels. Most of southern Changji prefecture areas were in healthy and high-healthy, the grassland health in the western region was low. Among them, there were only low health level areas in the grassland health level in 2000, 2003, 2006, 2007, 2011 and 2014, the areas with low health levels in 2011 and 2014 were mostly found in Hutubi County and Manas County. In 2004, most grassland in Mulei County and Qitai County exhibited relatively low health levels. In 2016, most of the grasslands in Hutubi County exhibited lower health levels. In addition, the changes in the health status of grassland in other regions were stable.

The grassland health in Changji City has changed from 2000 to 2016. As a whole, Changji City's grassland health level showed a fluctuating trend, but the change was modest and basically remained stable.

The change of grassland health in Fukang City from 2000 to 2016 is complex, and its grassland health changes show a downward trend. The health level of grassland in Fukang City has deteriorated since 2009. In 2013, the health level of grassland has picked up. It didn't show a high level of health until 2013, and the subsequent grassland in the region showed a lower level of health in 2014. The recovery began in 2015. It can be seen that grassland in Fukang City has shown a low recovery capacity. Overall, the level of grassland health in Fukang City has declined.

Grassland health in Jimusar County has shown a stable trend since 2000-2016 and is basically at a healthy level.

Grassland health in Qitai County has shown a downward trend since 2000-2016, and grassland health is low. During the 17 years of research, there was frequent occurrence. Compared with flat areas, the health conditions of grasslands in high altitude areas were mostly healthy.

Grassland health in Mulei County showed a steady growth trend from 2000 to 2016, and grassland was mostly at a healthy level. It is worth mentioning that in 2004, the area showed a relatively low level of health, which may be directly related to the intensity of human activities and land use during the year.

Grassland health in Manasi County has shown stable fluctuations since 2000-2016, and most grassland are in healthy and sub-healthy conditions. On the whole, the Manas grassland is in a state of stable fluctuation and the grassland recovery capacity is strong.

The grassland health in Hutubi County showed a slow decline from 2000 to 2016, and most of the grasslands were in sub-health and low health levels. The grassland conditions in this area are basically toward a lower level of health development, and there is no certain year that can show a rebound in certain degree. It can be seen that the ability to restore grassland in Hutubi is week.

4.3 Spatial Analysis of Grassland Health in Changji Region

In order to characterize the distribution characteristics of grassland health in 17 years in Changji prefecture, ArcGIS software was used to calculate and map the distribution of grassland health in Changji prefecture from 2000 to 2016.

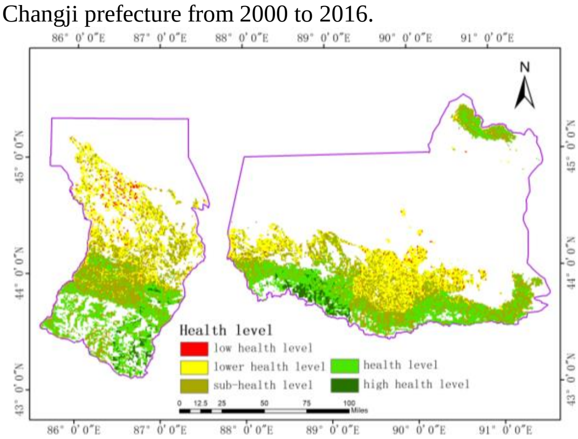


Figure 4.Spatial distribution of grassland ecosystem mean health in Changji prefecture between 2000 and 2016

The average spatial distribution of grassland health in Changji Grassland from 2000 to 2016 is shown in the figure. The health index ranges from 0.12375 to 0.82963. The grassland health level showed a clear north-to-south height, and gradually increased along with the elevation; among them, Changji City, Fukang City, Jimsar County and Mulei County had higher levels of grassland health, and Manas County, The health level of grassland in Hutubi County and Qitai County is relatively low. Overall, according to the grassland type map, the grassland area of Changji Prefecture is 18.94504 km^2, of which, Changji Prefecture, 1.46% of the grassland is of low health, 27.67% of the grassland is of lower health, and 38.35% of grassland is of sub-health. 29.21% of grassland belongs to healthy level and 3.31% of grassland belongs to high health level.

According to the Changzhi County grassland health grading standard and the spatial distribution statistics of the health index above, statistics were made on the grassland health status of each county and city. Among them, 40.64%, 37.56% and 36.73% of the grasslands in Qitai County, Hutubi County and Manas County respectively belong to low health level; 89.4% of Jimsar County, Changji City, Mulei County and Fukang City respectively. The grassland of 86.98%, 76.68% and 69.64% belonged to higher health level. The health status of grassland in Changji County was ranked in descending order of Jimsar County, Changji City, Mulei County, Fukang City, Manas County, Hutubi County and Qitai County.

Table 3. Spatial distribution of grassland health in Changji prefecture counties and cities between 2000 and 2016 unite;%

Health level	Manas County	Hutubi County	Changji City	Fukang City
Low health level	2.63	3.14	0.11	0.73
Lower health level	34.10	34.42	12.91	29.63
Sub-health level	36.34	47.41	30.51	34.38
Health level	26.93	14.89	46.06	32.81
High health level	——	0.14	10.41	2.45

Health level	Jimsar County	Qitai County	Mulei County
Low health level	0.24	1.29	1.14
Lower health level	10.36	39.95	22.18
Sub-health level	30.86	42.11	39.50
Health level	41.95	17.25	37.18
High health level	16.59	——	——

Note:——indicates the default value

4.4 Analysis of Grassland Health Trends in Changji Prefecture

According to the trend analysis calculation formula and the trend level classification, the grassland health change trend chart in Changji prefecture was obtain.

Table 4. Statistical analysis on the result of grassland health trends in Changji Prefecture between 2000 and 2016

Grassland health trends	Degree description	Area (km^2)	Area ratio (%)
Slope≤-0.0035	Severe deterioration	0.9774	5.16
-0.0035<Slope≤-0.0025	Moderate deterioration	2.7531	14.53
-0.0025<Slope≤-0.0015	Mild deterioration	3.5496	18.73
-0.0015<Slope≤0.0015	Basically unchanged	4.5234	23.87
0.0015<Slope≤0.0025	Mild improvement	4.4937	23.71
0.0025<Slope≤0.0035	Moderate improvement	1.9233	10.15
Slope>0.0035	Significant improvement	0.7299	3.85

From 2000 to 2016, the deteriorated grassland health status of Changji County was slightly larger than that of the improved region. The deteriorated grassland accounted for 38.42% of the total grassland area of Changji State, with severe deterioration of 5.16%, moderate deterioration of 14.53, and mild deterioration. 18.73%; Grasslands with improved grassland health status accounted for 37.71% of the total grassland area of Changji, with mild improvement of 23.71% and moderate improvement of 10.15%. The significant improvement was only 3.85%, mostly concentrated in high altitude areas.

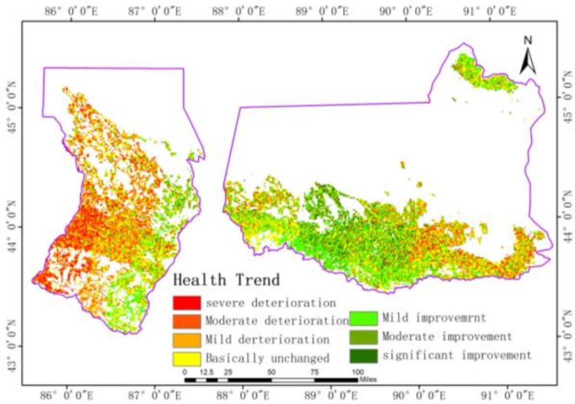


Figure 5. Trend of grassland ecosystem health in Changji prefecture between 2000 and 2016

Based on the analysis of grassland health trends in Changji Prefecture, grassland health trends in the counties and cities under the jurisdiction of Changji Prefecture were analyzed with the same range of slope values, including grassland health in Changji City, Fukang City, Jimsar County, and Qitai County. With improvement, Changji City’s grassland health improvement area accounted for 48.15% of the total grassland area in the city, and the slightly improved area was 33.45%; the grassland health level improvement area in Fukang City accounted for 42.84% of the total grassland area in the city, and the slight improvement area was 30.81. %; The area of grassland health improvement in Jimusar County accounted for 84.77% of the total area of grassland in the county, the area of mild improvement was 37.64%, and the area of moderate improvement was 32.33%; the area of grassland health improvement in Qitai County accounted for 59.56% of the total area of the grassland in the county, and the mild improved area was 35.24%.

The grassland health conditions in Manasi County, Hutubi County and Mulei County have deteriorated, among which the deteriorated grassland in Manasi County accounted for 76.78% of the total grassland area in the county, of which the slight deterioration rate was 23.18%, and the deterioration was moderate. It was 34.04%, with a severe deterioration of 19.56%; the deterioration of grassland health in Hutubi County accounted for 65.94% of the total grassland area in the county, slightly worsened by 30.94%, moderately deteriorated by 29.04%, and moderately deteriorated by 5.96%; The deteriorated area of grassland in Lai County accounted for 47.25% of the total grassland area of the county, with a slight deterioration of 27.39%, moderate deterioration of 14.68%, and severe deterioration of 5.18%.

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Table 5. Statistical analysis on the result of grassland health trends in Changji Prefecture counties and cities between 2000 and 2016 unite:%

Health level	Manas County	Hutubi County	Changji City	Fukang City
Severe deterioration	19.56	5.96	0.78	1.22
Moderate deterioration	34.04	29.04	4.63	6.94
Mild deterioration	23.18	30.94	12.27	15.70
Basically unchanged	16.23	23.08	34.17	33.30
Mild improvement	5.48	8.99	33.45	30.81
Moderate improvement	1.38	1.88	12.05	8.61
Significant improvement	0.13	0.11	2.65	3.42

Health level	Jimsar County	Qitai County	Mulei County
Severe deterioration	0.23	0.92	5.18
Moderate deterioration	0.91	4.50	14.68
Mild deterioration	2.86	11.95	27.39
Basically unchanged	11.23	23.07	27.12
Mild improvement	37.64	35.24	20.98
Moderate improvement	32.23	16.88	3.78
Significant improvement	14.90	7.44	0.87

5. CONCLUSION

Based on the time scale, the level of grassland health in Changji County experienced a first increase and then a decrease in the final stable fluctuation from 2000 to 2016. During the period, the grassland health of Changji Prefecture fluctuates in varying degrees. The grassland health status in Changji City is basically stable and is in a stable state. Higher health level; grassland health in Fukang City showed a declining trend; grassland in Jimusan County was basically at a healthy level; grassland in Qitai County had a low level of health but grassland in high altitude areas in the region was at a healthy level; Mulei County Grassland is mostly at a healthy level; grassland health in Hutubi County is on a downward trend.

Based on the spatial scale, the average grassland health index of Changji County in the period from 2000 to 2016 was 0.47673; the grasslands under its jurisdiction in Zhongqitai County, Hutubi County, and Manas County were 40.64%, 37.56%, and 36.73% respectively. In the low health level, 89.4%, 86.98%, and 76.68% of the grasslands in Jimsar County, Changji City, and Mulei County have higher health levels. The grassland health status of Changji Prefecture is ranked in descending order. Jimsar County > Changji City > Mulei County > Fukang City > Manas County > Hutubi County > Qitai County.

Based on changes in trends, from 2000 to 2016, the deteriorated grassland in Changji County reached 38.42%, with severe deterioration of 5.16%, moderate deterioration of 14.53, and mild deterioration of 18.73%. The deterioration of grassland health status was slightly greater than improvement. In the region, the overall trend is slightly declining; According to the statistical data of counties and cities under the jurisdiction of the city, the grassland health in Changji, Fukang, Jimsar County, and Qitai counties has improved, and in Manas and Hutubi counties. The grassland health condition in Mulei County has been deteriorating. Through comparative analysis, the grassland health status in Changji Prefecture has shown a slight downward trend, but more attention needs to be paid to prevent further degradation of the grassland health level.

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