Temporal and spatial pattern variation analysis of grassland resources in Huize County, Yunnan, China

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Abstract. In order to study the spatial and temporal pattern variations of grassland resources and to promote the sustainable utilization of grassland resources, this paper, taking Huize County as an example, discusses the temporal and spatial pattern variations of grassland resources from the perspective of grassland resources comprehensive dynamic degree, different topographic conditions, geoscience information map and landscape pattern index. Remote sensing images in 2009 and 2016, the second national land survey database and the 2016 land use variation survey database were selected as the basic data source. The results show that: 1) from 2009 to 2016, Xinjie town and Tianba town have great variations in the comprehensive dynamic degree of grassland resources, while Wuxing town and Jinzhong town are the smallest variations. The number of grassland resources in the study area presents a spatial feature of "high in the north and south parts and low in the middle"; 2) topographic conditions have a certain impact on grassland resources. The grassland resources in the study area mostly exist in the areas with the elevation of 1800-2500m, the slope of over 25° and the aspect of sunny and semi-sunny. From 2009 to 2016, grassland resources net increase was 21134.51hm². 3) From the perspective of geomatics information map and landscape pattern index, grassland resources have both increased and decreased from 2009 to 2016. The land conversion categories that have increased and decreased mainly include cultivated land, garden land, forest land, construction land, water area and other land types, among which the proportion of forest land variations greatly. Although the area of grassland resources increased, the number of grassland resources patches decreased. The average patch area increased, the proximity and aggregation between patches increased, and landscape fragmentation decreased, and the overall landscape pattern developed towards the aggregation direction.

1. Introduction

Grassland resources are not only an important part of the terrestrial ecosystem, but also play a very important role in soil erosion prevention and ecological environment maintenance [1-2]. Due to the impact of global climate change, economic development and human activities, grassland resources in
some areas have been degraded, which leads to a series of ecological problems such as grassland quality decline and biodiversity decline [3]. With the advent of the information era and computer technology, spatial analysis technology develops rapidly. Based on studying traditional grass, it begins to explore and research the grass spatial distribution pattern.

In recent years, domestic scholars have done a lot of research on the grassland spatial pattern variations, including: grassland surface soil, spatial pattern analysis of carbon content [4-5], spatial distribution variation characteristics of grassland types [6-8], spatial and temporal characteristics analysis of grassland degradation [9-10] and other aspects. However, few studies have been conducted on the grassland resources spatial and temporal pattern variations by the comprehensive land use dynamic degree, geo-information map and landscape pattern index.

Taking Huize County of Yunnan province as an example, using remote sensing images in 2009 and 2016, the second national land survey database and the 2016 land use variation survey database as the basic data source, with the aid of ArcGIS10.0 and Fragstats4.2 software, it analysed grassland resources spatial and temporal characteristics variations in 2009-2016 from the perspective of grassland resources comprehensive dynamic degree, different terrain conditions, geological information and landscape pattern index.

2. Overview of the research area
Huize County is located in the northeast of Yunnan province and northwest of Qujing city, which stands between longitude 103°03'~103°55' and latitude 25°48'~27°04'. It located at the junction of eastern Yunnan plateau and western Guizhou plateau, which located in the main peak section of Wumeng mountain system. The terrain is high in the south and low in the north, which shapes in a step-like form with a relative height difference of 3322.3 meters within the territory. Huize County has a prominent three-dimensional climate, which is distributed from subtropical to cold temperate climate. It is rich in grassland resources, mainly including warm scrub-grass, hot scrub-grass and mountain meadow, among which mountain meadow accounts for 64.57% of the total grassland resources.

In 2009, the total land area of the county was 588912.70hm², among which grassland resources were 75928.38hm², accounting for 12.89% of the total land area of the research area.

3. Data sources and research methods

3.1 Data sources and processing
Basic data sources of this paper: grassland resource data are derived from two issues of remote sensing image data in 2009 and 2016, with a resolution of 0.5m. And the second national land survey database of Huize County and the 2016 land use variation survey database are also used as basic data sources. In this paper, the methods of visual interpretation, supervision classification and field verification of abundant grass stage were adopted to obtain grassland resource patches. The data were processed based on ArcGIS10.0 and Fragstats4.2 software, which provide data basis for the following research.

3.2 Research methods

3.2.1 Comprehensive dynamic variation degree of grassland resources. Comprehensive dynamic variation degree of land use refers to the degree of dynamic variation of land use in a certain period of
time [11], which includes the degree of material and energy, value and energy consumption between land resources and human social and economic activities. In order to reflect the dynamic variation range of grassland resources, the comprehensive dynamic variation degree of grassland resources is used to reflect the intensity of grassland resources variation in the study area. The calculation model of comprehensive dynamic variation degree of grassland resources is:

\[
LC = \left( \frac{\sum_{i=1}^{n} \Delta \text{LU}_{i} - \sum_{i=1}^{n} \text{LU}_{j}}{2 \sum_{i=1}^{n} \text{LU}_{i}} \right) \times \frac{1}{T} \times 100\%
\]

(Formula 1)

Where: \( LC \) is the comprehensive dynamic variation degree of grassland resources; \( \text{LU}_i \) is the grassland resource area at the beginning of the study; \( \Delta \text{LU}_{i} \) is the area of conversion of grassland resources to other land types during the study period; \( T \) is the research period.

3.2.2 Spatial distribution characteristics of grassland resources under different topographic conditions.
As the distribution of grassland resources varies in different terrain conditions, the analysis of the number of grassland resources under different terrain conditions can not only reflect the influence of human beings in the utilization process of grassland resources, but also reflect the variations of grassland resources.

In this paper, DEM data with a grid unit size of 10m*10m is adopted to select three topographic factors (elevation, slope and aspect) to analyse the spatial and temporal pattern variations of grassland resources under different topographic conditions from 2009 to 2016[12].

3.2.3 Geographic information map. Geospatial information maps have the function of expressing the geospatial structure characteristics and the time dynamic variations simultaneously [13].

The essence of using geospatial information mapping method to study the temporal and spatial pattern grassland resources variations is to extract the grassland resources map patch data in the research area with the GIS and RS technical support [14], and it generates a series of related grassland resource variation information by spatial analysis means and other methods. In this paper, the spatial and temporal patterns of grassland resources in the study area are analysed by using geoscience information map.

3.2.4 Landscape pattern index. Landscape pattern index is a quantitative index that can highly concentrate landscape pattern information and reflect its structural composition and spatial distribution characteristics [15]. In order to reflect the spatiotemporal variation characteristics of landscape pattern in the study area comprehensively and to reduce information redundancy effectively, the paper uses ArcGIS10.0 and Fragstats4.2 software to process the grassland resource patches and the 7 index Total (Class) area (CA), Number of patches (NP), Patch density (PD), Mean Patch size (MPS), Mean Patch fractal dimension (MPFD), Mean proximity index (MPI) and Aggregation index (AI) are selected to analyst spatial and temporal pattern variations of grassland resources in the study area from 2009 to 2016 through the landscape pattern information map.
4. Results and analysis

4.1 Comprehensive dynamic variation analysis of grassland resources

In this paper, towns are taken as the research scale. According to formula 1, the comprehensive dynamic variation degree of grassland resources of each town in the research area from 2009 to 2016 can be obtained, as shown in figure 1.

![Figure 1. Comprehensive dynamic variation degree of grassland resources in each town](image)

The comprehensive dynamic degree of grassland resources can better reflect the intensity of the dynamic variation of grassland resources in each town than the single dynamic degree of grassland resources. From the results of the comprehensive dynamic degree of grassland resources, the comprehensive dynamic degree of grassland resources in the whole county is 5.85%. Xinjie town and Tianba town had the most drastic variations, reaching 14.21% and 14.00% respectively, which were mainly affected by factors such as returning the forest to grass. The number of grassland resources increased greatly compared with that in 2009. Then Yulu town (9.40%), Jiache town (7.89%) and Dajing town (7.68%). And smaller stable relatively variation towns are Wuxin town (2.53%), Jinzhong town (3.41%) and Huohong town (3.44%). Some area of grassland resource in the period of 2009-2016 has already increased; also some area of grassland resource has decreased. The number of increase and decrease area keeps a basic dynamic balance. So the overall comprehensive dynamic variation degree is smaller, the grassland resource quantity is relatively stable.

4.2 Spatial distribution characteristics of grassland resources under different terrain conditions

4.2.1 Spatial distribution characteristics of grassland resources based on elevation gradient difference.

According to topographical features in the study area and combining with the actual field verification, the elevation in the study area is divided into four different gradient, respectively: 720 m to 1800 m (low hill), 1800 m to 2500 m (medium hill), 2500 m to 3000 m (mountain), more than 3000 m (high mountain). Calculating study area of composition within different elevation gradient in 2009 and 2016, as shown in figure 2. The results showed that the number of grassland resources was more distributed in the elevation gradient of 1800–2500m, which reaches more than 55%. In the low hill area of
720m~1800m, due to the influence of human factors and factors such as weeding and ploughing, the proportion of this area in the elevation gradient decreased to some extent in 2016 compared with 2009. However, in regions altitude from 1800m to 2500m, 2500m to 3000m and above 3000m, the variation in 2016 is relatively small compared with that in 2009. It indicates that the influence of human activities on the spatial characteristics of grassland resources is mainly concentrated in the low altitude area.

Figure. 2 Area ratios of different elevation gradients in 2009 and 2016

4.2.2 Spatial distribution characteristics of grassland resources based on slope difference. With reference to the technical regulations of land use status survey and combined with the actual situation of the study area, the slope is divided into five different grades, which are 0° ~ 2°, 2° ~ 6°, 6° ~ 15°, 15° ~ 25° and above 25°. The area proportion of different slopes in the study area in 2009 and 2016 is calculated, as shown in figure 3. The results show that in 2016 and 2009, there was an increase in the distribution of each slope grade except for the regions above 25°slope. The largest increase was in the 6° ~ 15° grade, which reaches 1.99%. The proportion of areas above 25° decreased significantly, which reaches 3.73%. However, in terms of the distribution of grassland resources slope grades in 2009 and 2016, as the slope increases, the number of grassland resources shows an increasing trend. The region above 25° accounts for more than 60%, which fully indicates that most of the grassland resources in the study area are mainly distributed in the areas with large and steep slopes.

4.2.3 Spatial distribution characteristics of grassland resources based on aspect difference. According to the aspects, the south aspect and the southwest aspect are divided into sunny aspects. The north aspect and the northeast aspect are divided into cloudy aspects, and the west aspect and the southeast aspect are divided into the semi-sunny aspects, and the east aspect and the northwest aspect are divided into semi-cloudy aspects. The aspect was divided into sunny aspect (157.5° ~ 247.5°), cloudy aspect (0° ~ 67.5°, 337.5° ~ 360°), semi-sunny aspect (112.5° ~ 157.5°, 247.5° ~ 292.5°) and semi-cloudy aspect (67.5° ~ 112.5°, 292.5° ~ 337.5°), as shown in figure 4. According to the results of area ratio of different aspect, the number of the sunny aspects and the semi-sunny aspects is decreased in 2016 compared with 2009, while the number of cloudy aspects and semi-cloudy aspects is increased in 2016 compared with 2009. Among them, the decrease ratio of the sunny aspect was 2.16%, and the increase ratio of the cloudy aspect was 2.37%. The decrease of semi-sunny aspect and the increase of semi-cloudy aspect are not too large; the main reason is that the grassland resources on the sunny aspect are more easily occupied by other land types. On the whole, the dominance of grassland resources distribution in sunny
aspect and semi-sunny aspect is significantly higher than that in cloudy aspect and semi-cloudy aspect, which indicates that grassland resources distribution, has certain selectivity in aspect.

![Graph](image)

**Figure 3.** Area ratios of different slopes discrepancy in 2009 and 2016

4.3 Geographic information map analysis of grassland resources spatial and temporal patterns Spatial and temporal pattern variation of grassland resources can be analysed through geoscience information maps, which generally include increasing potential maps and decreasing potential maps [14]. In this paper, increasing potential map refers to the part of grassland resources transferred from non-grassland resource land use type to grassland resources from 2009 to 2016, which is called new grassland resources. The decreasing potential map refers to the part of land use type from grassland resources to non-grassland resources from 2009 to 2016, which is called grassland resource reduction. The increasing and decreasing potential maps of grassland resources in this paper are shown in figure 5, table 1 and table 2.
Figure 5. Grassland resources increasing potential maps from 2009 to 2016

Table 1. Evolution map of added grassland resources from different sources in 2009-2016

| Types                                      | Number of patches | Area of patches (ha) | Change rate (%) |
|--------------------------------------------|-------------------|----------------------|-----------------|
| Cultivated land transformed into grass resources | 5185              | 2645.94              | 6.31            |
| Garden plot transformed into grass resources      | 72                | 57.27                | 0.14            |
| Forest land transformed into grass resources     | 11352             | 21202.77             | 50.54           |
| Construction land transformed into grass resources | 731               | 66.83                | 0.16            |
| Waters transformed into grass resources         | 163               | 44.91                | 0.11            |
| Other land transformed into grass resources     | 7622              | 17935.71             | 42.75           |
| Sum                                          | 25125             | 41953.43             | 100.00          |

Table 2. Evolution map of grassland resources transformed into other lands in 2009-2016

| Types                                      | Number of patches | Area of patches (ha) | Change rate (%) |
|--------------------------------------------|-------------------|----------------------|-----------------|
| Grass resources transformed into cultivated land | 3865              | 1166.93              | 5.61            |
| Grass resources transformed into garden plot    | 34                | 9.32                 | 0.04            |
| Grass resources transformed into forest land     | 12225             | 9698.56              | 46.59           |
| Grass resources transformed into construction land | 410               | 54.50                | 0.26            |
| Grass resources transformed into waters        | 92                | 7.81                 | 0.04            |
| Grass resources transformed into other land     | 7101              | 9881.80              | 47.47           |
| Sum                                          | 23727             | 20818.92             | 100.00          |

From table 1 and 2, it can be concluded that from 2009 to 2016 among the new sources of grassland resources total proportion of forest land and cultivated land is 56.85%, which is mainly caused by two reasons: first, local ecological protection measures such as returning forest to grass have achieved certain results; Secondly, in the process of image interpretation, due to the periodicity of forest land planting, when the trees are small, the image is interpreted as grassland, so that more new grassland resources come from forest land. When the trees grow thick, the grassland resources are covered, so the image is interpreted as forest land, and the grassland resources variation to forest land. The other land types of newly increased grassland resources mainly include scattered grassland patches, bare land and inland
mudflats, etc., while the proportion of garden land, construction land and water areas added to grassland resources is relatively small.

From 2009 to 2016, it can be seen that the grassland resources transform to the forest land and cultivated land accounts for 52.2% of the total, which is mainly affected by the implementation of the reducing grass policy and returning farmland and the above image interpretation.

Grassland resources transform to garden land, construction land, and water area accounts for less proportion; other land types including a certain proportion of grassland. The main reason is that grassland resources refer to concentrated and contiguous grasslands, and grassland resources are interfered by human factors, which makes part of grassland resources turn into scattered grassland patches.

From increased grassland resources and grassland resources variation into different class found that unchanged part of grassland resource in the 2009-2016 is 55109.46 hm$^2$ and net increase area is 21134.51 hm$^2$. The dynamic variation of grassland resources quantity has less correlation with construction land, while the dynamic variation of grassland resources quantity has greater relevance with forest land.

4.4 Landscape index evolution of grassland resources spatial pattern
In this paper, the grassland resource patch data in 2009 and 2016 were classified and converted into raster data with a unit size of 10m*10m. With the help of Fragstats4.2 software and the landscape ecology principle, it has 7 landscape pattern indexes to be selected and to analyse the grassland resources evolution characteristics index of spatial and temporal pattern landscape in 2009-2016, it can be seen from table 3.

| Year   | CA/hm$^2$  | NP  | PD/(one/hm$^2$) | MPS/hm$^2$ | MPFD | MPI  | AI    |
|--------|------------|-----|----------------|------------|------|------|-------|
| 2009   | 75928.38   | 7174| 0.6151         | 485.48     | 1.1558| 0.9426| 94.9865|
| 2016   | 97062.89   | 4088| 0.3505         | 779.91     | 1.1545| 0.9591| 96.4311|

It can be concluded from table 3 that from 2009 to 2016, the total area of grassland resource patches increased, but the number of patches decreased and the average area of patches increased, which indicates that the spatial and temporal landscape pattern of grassland resources in the research area was developing towards agglomeration. The decrease of patch density indicates that the fragmentation degree of the patch decreases. The average fractal dimension of the patch is between 1 and 2. The closer its value to 1, the simpler the shape of patch is, and the closer its value to 2, the more complex the shape of the patch is. From 2009 to 2016, the variation of grassland resources average fractal dimension in the study area is slim, which means relatively low complexity and simple shape. The average adjacent index and aggregation degree increased, which indicates that adjacent and aggregation degree of the same type patches were increased. Landscape connectivity was good and fragmentation was reduced. In general, the patch shape of grassland resources in the study area from 2009 to 2016 is simple. The adjacent and aggregation degree of the same class patch increase and the landscape fragmentation degree decreases.
Compared with 2009, the landscape pattern index showed that there exist some spatial differences in 2016, but the landscape pattern developed towards aggregation in all.

5. Conclusion

1) From the perspective of the comprehensive dynamic degree of grassland resources, different topographic conditions, geoscience information map and landscape pattern index, this paper analyses the spatial and temporal pattern variation characteristics of grassland resources in the study area from 2009 to 2016. The selected methods complement each other and can represent the variation characteristics of grassland resources from different perspectives.

2) Topographic conditions have a certain impact on mountain grassland resources. Grassland resources in the study area have the largest distribution area (about 55%) between the altitudes of 1800-2500m, followed by 2500-3000m (about 20%). The distribution area of the slope above 25° is the largest (more than 60%), followed by that between 15° and 25° (about 20%). The distribution area of the sunny aspect and semi-sunny aspect is large (more than 60%). Combined with the quantity distribution of grassland resources, it formed "high at both edges and low in the middle" spatial and temporal distribution characteristics in the study area.

3) From the perspective of geoscience information map and landscape pattern index, grassland resources have both increased and decreased from 2009 to 2016. Land types that increase and decrease mainly include cultivated land, garden land, forest land, construction land, water area and other land types, among which forest land accounts for a large proportion. From local geological information mapping results, ecological protection measures such as "returning farmland to grassland, forest to grass" has a certain effect. The net increase of grassland resource in the period 2009-2016 is 21134.51 hm². Grassland resources area was increased, but the number of grassland resource patches was decreased. Average patch area, patch adjacent degree and aggregation degree were increased and the landscape fragmentation was decreased, landscape pattern developed towards aggregation in all.

4) In this paper, only two periods of images (2009 and 2016) are selected to analyse the grassland resources temporal and spatial pattern variation in the study area. Multi-period remote sensing images will be selected for analysis and comparison in the future studies to further explore the driving factors of grassland resources dynamic variation.

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