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Original Research Paper

# Studies on Plant Community Complexity in Fenced Region of Ningxia, Northern China

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## ABSTRACT

Biocomplexity theory is becoming increasingly important in understanding natural vegetation dynamics and interrelation among all components of ecosystems. A study was conducted under this concept in order to investigate the impacts of different fencing periods and measures on plant community complexity in desert grasslands of Yanchi County of Ningxia Hui Autonomous Region. The study was carried out by using a quadrat method and based on the average length of the Huffman code to describe total complexity *L(S)*, Rényi entropy *H(S)* as disorder-based complexity, and the difference $\Delta(S) = L(S)-H(S)$ as structural complexity. The relationship was also studied between three kinds of complexity index and the number of species, Importance value of dominant species. The results showed that enclosure increases disorder-based complexity index and structural complexity index, which makes total complexity index to increase. Therefore, fencing is an effective measure for vegetation restoration and rehabilitation while long-term fencing is not conducive to vegetation restoration. In this study disorder-based complexity index is higher than structural complexity index, which means that disorder-based complexity index has great effects on total complexity index. The relationship between *L(S )* and *H(S)* is very close whereas the correlation between *H(S)* and $\Delta(S)$ is negative. There is significant relationship between the number of species and the three kinds of complexity index. The importance value of dominant species is not significantly correlated with structural complexity, which has significant negative correlation with the other indices.

## INTRODUCTION

Complexity theories appeared in the mid-20th century, and attracted wide attention from scientists, and became a new paradigm of natural science (Wu 2001). Biocomplexity has become an important research discipline in biology, which enables better understanding of the interaction between complex living systems and their environments and the dynamic characteristics of these systems (Anand & Tucker 2003, Covich 2000, Michener et al. 2001, Colwell 1998). Ecological relationships evolve in complex ecological factors, patterns and functions, which determine complexities of ecology research (Wang et al. 2007). Ecological complexity, as an important component of biocomplexity, reflects structural and functional diversity at multiple scales in ecosystems. It is a combination of ecology theories and ecosystem models and has become a keenly contested issue and key research discipline of ecology in recent years (Zhao 2001, Tan & Yu 2004, Ye et al. 2006). The principles and methods of complexity science are used to study how living systems respond and adapt to their environments, and illustrate structure and function of plant communities, which is an important part of plant community ecology research. Complexity refers to the diversity of ecological structure and function, self-organization and orderliness at different levels within the ecosystem (Zhang et al. 1998). Ecology complexity index is a measure of ecosystem properties, which not only includes the complexity of diversity of the various scales in ecosystems, but also the roles and links between the various components. Community complexity reflects ecological complexity at the specific community level, and embodies integrated features of community structure and function, and is also an important component of an ecosystem (An et al. 2008). The measure of complexity is always an important theoretical basis to ecology complexity study (Jin 2006). It is difficult to describe quantitatively the species interactions within communities, and thus more difficult to measure total interaction between species. In view of this, the research on species interaction effects at a community level is particularly urgent.

Community complexity research plays an increasingly important role in understanding community dynamics and interrelation between various components of community (You & Fujiwara 2011, Ye et al. 2009). At present, the biodiversity measure is mainly used to describe quantitatively the community complexity ( McElhinny et al. 2005), although it can provide some understanding of complexity, but lacks characteristic description about self-organization and orderliness. Complexity measure theory did not originate from ecology, but evolved in computer science (Jin 2006), and structural complexity measure method is no exception. In this paper, the computational complexity measure method is constructed by using computer coding theory, namely a description of the algorithm of an object, and use of the algorithm value as the complexity of the object. To study community complexity, incorporating computational complexity is necessary, and its concept is different from diversity. Currently, the use of this quantified complexity measure is seldom studied, especially with respect to community structure study in grassland ecosystem.

Artificial enclosure is one of the means of restoring degraded pastures. As an important measure for pasture rehabilitation, enclosure has been used extensively all over the world (Meissner & Facelli 1999, Turner 1990). Based on the project of national desertification monitoring of China, this article takes the artificial fenced region in Liu Yangpu of Yanchi County in Ningxia as an example of a farming-pastoral region suffering from the most severe desertification in northern China. It is used to analyse and evaluate quantitatively plant community complexity and related factors under different enclosure measures and periods. Considering the existence of complex environment and living systems in this area, the research on its biocomplexity holds considerable significance. The objectives of this study were to investigate: (1) plant complexity in the study area; (2) how biocomplexity changes with fencing periods and measures; (3) the relationship between community complexity and the number of species, importance value of dominant species.

## OVERVIEW OF THE STUDY AREA

Yanchi County is located in the east of Ningxia Hui Autonomous Region and the southern edge of Mu Us desert and in the junction zone of four provinces (autonomous regions) of Shaanxi, Gansu, Ningxia and Inner Mongolia. The geographic position and condition of desertification of the study area is shown in Fig. 1. It is located in the coordinates of 37°05'-38°10'N and 106°30'-107°39'E. The north-south distance of the county is 110km, and east-west distance is 66km. The whole area of Yanchi County is 8661.3 km$^2$, which is the largest county in Ningxia accounting for 16.7%

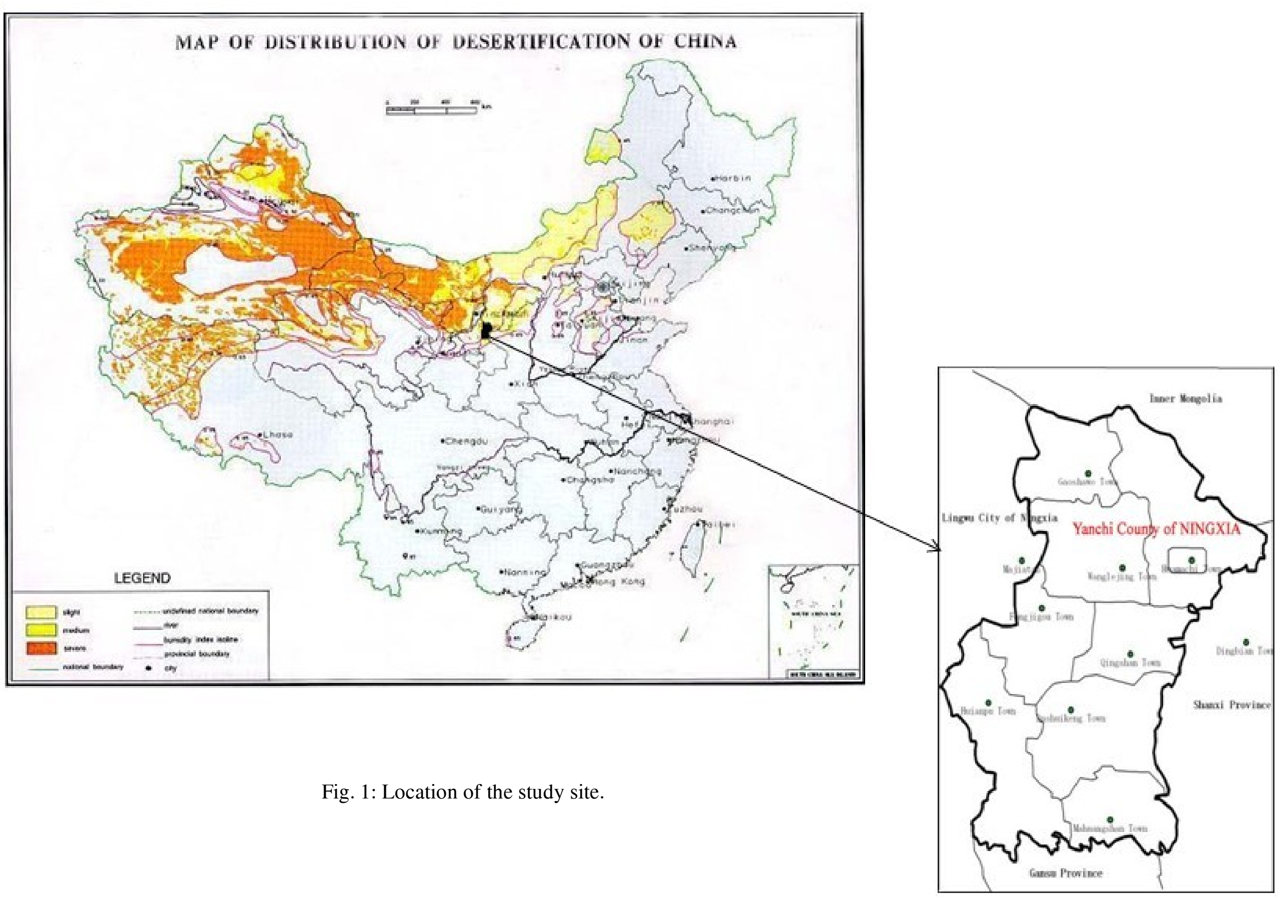


Fig. 1: Location of the study site.

Table 1: Size of plots.

| Sample plot number | Latitude N | Longitude E | Elevation/m | Community name |
|---|---|---|---|---|
| E | 37°502'443" | 107°242'153" | 1365 | *Artemisia ordosica + Heteropappus altaicus* |
| $E_1$ | 37°502'453" | 107°242'043" | 1366 | *Artemisia ordosica + Salsola ruthenica* |
| $E_2$ | 37°502'473" | 107°232,473" | 1363 | *Artemisia ordosica + Sophora alopecuroides* |

of the total area of Ningxia. The southern part of the county is higher than the northern part. The southern part comprises of a loess hilly area and the middle is hilly land with gentle slopes of the Erdos, which is a typical transition zone between cropping and nomadic area, the altitude of which ranges between 1295 and 1951m a.s.l. The county belongs to a typical temperate continental climate, its annual average temperature is 8.1°C, the annual highest average temperature is 34.9°C, while the lowest is -24.2°C. The yearly average frost-free period is 165 days and the annual average precipitation is 250-350 mm. The precipitation decreases progressively from southeast to northwest. With typical temperate of middle continental climate, Yanchi County is dry with little rainfall and it is windy and sandy at the same time. All the conditions mentioned above define the natural landscape of Yanchi County as a temperate zone and wilderness prairie. The terrain is mainly denuded peneplain. The soil type there is primarily sierozem, then dark humus soil and sandy soil, loess, a little salt clay, and white bentonite. The vegetation in Yanchi belongs to European-Asian grassland and Central Asia sub-regions. It is the transitional area of central China's grassland. The vegetation types there include thickets, grasslands, meadows, sandy vegetation and desert vegetation. Among them, of thickets, grasslands and sandy vegetation is the largest with wide distribution. There is no natural forest in Yanchi County. It only has a few artificial forests, and large area shrub including *Salix psammophilia* and *Caragana microphylla.* Grasslands can be divided into dry grassland and desert grassland, typical steppe include *Stipa grandis*, *Stipa bungeana*, *Agropyron crisatum*, *Thymus serphyllum* var. *mongolicus* and so on. Desert grassland includes *Caragana tibetica*, *Oxytro pisaciphylla*, *Nitraria sibirica* and *Kalidiu foliatum.*

## MATERIALS AND METHODS

**Sample plot choosing:** By referring to the achievements of the China National Desertification Monitoring Project and based on the land use types and the types of desertification control projects, fixed sample plots by GPS have been chosen for positioning monitoring. The artificial fenced region in Liu Yangpu was chosen as the study area belonging to the desert grassland region and located in the southwest edge of the Mu Us desert, which is one of China's four sandy deserts. Due to fragile ecological environment, sandy vegetation in this area can easily be destroyed. The basic experimental plots are given in Table 1.

Three processing methods were adopted: core area (E), edge area ($E_1$) and outside area ($E_2$). The core area is the national experimental demonstration area of desertification control in China, from which wild animals and livestock have been ruled out completely by barbed wire fence since 1991. Enclosure measures have been taken in the edge area since 2002. Enclosure measures have also been taken in the outside area since 2002, but this area is still affected by human interference and herding to a certain degree. The natural conditions of three types of sample plots are basically the same (Wang et al. 2014).

**Field investigation**: In this study, the investigation was carried out each July from 2003 to 2013 in the aspects of plant species, quantity, degree of coverage, height and biomass, etc. The investigation method is to arrange a quadrat at approximately 30 m interval in the direction of belt transect and the size of the quadrat is 1m × 1m. There are 10 quadrats in E, $E_1$ and $E_2$ respectively.

**Data processing methods:** Through field investigation, a sandy vegetation database was established in the research area, and an importance values matrix of plant species was calculated from different fenced areas. Firstly, Huffman coding procedures of community complexity were written by the MATLAB 7.0, the average code length was calculated by using species importance values and then converted to a binary code for complexity statistics. Correlation analysis between community complexity and number of species, importance values of dominant species was carried out by SPSS 16.0 software for two-tailed *t* Pearson test, and average value of community complexity was analysed by using SPSS 16.0 ANOVA and Duncan multiple comparison. Rainfall data in the study area were obtained from Meteorological Bureau of Yanchi County and China Meteorological Data Sharing Service System (http://cdc.cma.gov.cn/cdc_en/home.dd).

**Calculation of plant importance value:** Importance value indicates the relative importance of plant species in the community by the comprehensive quantity of characteristic values and is described in the formula below (Li et al. 2008).

$$I = \frac{A + H + C + F + B}{5}$$

Where I = importance value, A = relative abundance, H = relative height, C = relative coverage, F = relative frequency, B = relative biomass.

**Measuring community complexity:** The methods proposed by Anand & Orlóci (1996) and Li (2000) were used to calculate the plant community complexity, which divides the total complexity into two components, Rényi's entropy (disorder-based complexity) and structural complexity.

***Total complexity*:** The calculation quantifies total complexity of plant community in quadrats by multiplying the ratio of relative importance value of a given species ($p_j$) in the sampling unit by the length of its codeword from Huffman coding ($l_j$) and taking the sum of this multiplication for all species in quadrats (Desrochers & Anand 2005, Li 2001):

$$L(S) = \sum_{j=1}^{q} p_j l_j \quad \text{(Bits)}$$

Where, $l_j$ is the length of the Huffman (1952) codeword (number of symbols), $p_j$ is the relative importance value for the species j, which satisfies $\sum_{j=1}^{q} p_j = 1$ and $q$ is the total number of plant species in a transect.

The coding method of Huffman was adopted to calculate the length of $l_j$, which meets the criterion for parsimonious coding, because low $p_j$ values are encoded into long code words and high *pj* values into short code words (Anand & Tucker 2003). MATLAB 7.0 was used to write the codes.

**Rényi's entropy (disorder-based complexity):** Rényi's entropy is employed to measure the disorder-based complexity:

$$H_a(S) = \frac{1}{1-a}\log_2 \sum_{j=1}^{q} p_j^a \quad \text{(Bits)}$$

According to previous research (Anand & Tucker 2003, Li 2000), there is a general rule that high-order entropy indices are preferred. It was found in previous studies that $H$ could not change much after $\alpha$ was higher than 12. So this article takes $\alpha = 12$.

**Structural complexity:** The structural complexity can reflect the character of the components and the structure of a community. The difference between $L(S)$ and $H_a(S)$ is the structural complexity:

$$\Delta(S) = L(S) - H_a(S) \quad \text{(Bits)}$$

## RESULTS AND ANALYSIS

### Comparison and Analysis of Plant Community Complexity Situation in Different Years

**The influence of enclosure periods and measures on total complexity:** Total complexity index is influenced by disorder-based complexity index and structural complexity index. Total complexity index reflects how complex is the plant community in the sample plot. The degree of plant species complexity of the sample plot depends on various ecological and non-ecological factors, such as conditions of soil nutrients, soil water content, habitat gradient, landform, human activities and so on. The total complexity index of the core area and edge area fluctuates substantially in the range of 2.5 to 3.5. Total complexity index of the outside area decreases first and then goes up year by year in the form of fluctuations as shown in Table 2 and Fig. 2. *L(S)* of the edge area was 3.254 in 2003, and the index continued to decrease to minimum 2.431 in 2006, but the index began moving up from 2007 again and ascended to maximum 3.565 in 2012, and in 2013 it began to drop. *L(S)* of core area was 3.456 in 2003, and then in the following two years it began to drop to a minimum of 2.463 in 2005, but it increased gradually to reach another high point of 3.334 in 2008, after rising to the maximum of 3.528 in 2011, but later fluctuated. In the outside area, the lowest value appeared in 2004, which was 1.303, after rising volatility, a maximum of 3.637 was attained in 2012 (Table 2).

Generally speaking, in the core area and edge area, total complexity index was higher than most of the outside area, and the volatility of index is relatively stable. This is explained because the two areas were fenced to avoid the external interference from human and livestock, which restored the community vegetation, increased species richness indicating that community structure in the core area and edge area is more stable than the outside area, and more suitable for sandy vegetation growth. On the one hand, with the extension of the fencing period, the vegetation has more suitable habitat, and then fluctuation increases overall species richness, the ability to resist outside interference is enhanced in grassland ecosystem. On the other hand, the study area belongs to semi-arid area, which has a fragile ecological environment, especially the desert grassland ecosystem is more clearly influenced by rainfall. Rainfall is an important growth-limiting factor to vegetation. It can be seen that rainfall in the study area under different fencing conditions is closely related to total complexity (Fig. 3).

**The influence of fencing periods and measures on disorder-based complexity:** It shows that disorder-based complexity index *H(S)* of the core area was basically in the range from 1.0 to 2.5, and *H(S)* of the edge area was basically in the range from 1.5 to 2.5; while *H(S)* of outside area decreased first and then moved up fluctuating year by year

Table 2: Community complexity index, number of species and importance value of dominant species under different fencing conditions.

| Year | Sample plot number | *L(S)* | *H(S)* | *Δ(S)* | Number of species | Importance value of dominant species |
|---|---|---|---|---|---|---|
| 2003 | E | 3.456 | 2.187 | 1.269 | 16 | 0.249 |
| | $E_1$ | 3.254 | 1.561 | 1.693 | 15 | 0.371 |
| | $E_2$ | 2.049 | 0.828 | 1.221 | 9 | 0.591 |
| 2004 | E | 2.819 | 1.544 | 1.275 | 10 | 0.375 |
| | $E_1$ | 3.016 | 1.716 | 1.300 | 13 | 0.336 |
| | $E_2$ | 1.303 | 0.432 | 0.871 | 4 | 0.760 |
| 2005 | E | 2.463 | 1.379 | 1.085 | 8 | 0.416 |
| | $E_1$ | 2.944 | 1.569 | 1.375 | 11 | 0.369 |
| | $E_2$ | 1.595 | 0.677 | 0.918 | 6 | 0.650 |
| 2006 | E | 3.126 | 1.847 | 1.279 | 13 | 0.309 |
| | $E_1$ | 2.431 | 1.804 | 0.627 | 7 | 0.316 |
| | $E_2$ | 2.331 | 0.999 | 1.332 | 9 | 0.530 |
| 2007 | E | 3.225 | 2.103 | 1.122 | 18 | 0.262 |
| | $E_1$ | 3.197 | 1.851 | 1.346 | 18 | 0.308 |
| | $E_2$ | 2.100 | 1.229 | 0.871 | 10 | 0.458 |
| 2008 | E | 3.334 | 2.020 | 1.314 | 18 | 0.277 |
| | $E_1$ | 2.886 | 2.178 | 0.708 | 12 | 0.245 |
| | $E_2$ | 1.916 | 0.838 | 1.078 | 7 | 0.587 |
| 2009 | E | 2.621 | 1.208 | 1.413 | 15 | 0.464 |
| | $E_1$ | 2.890 | 1.856 | 1.034 | 12 | 0.307 |
| | $E_2$ | 2.186 | 1.306 | 0.880 | 10 | 0.436 |
| 2010 | E | 2.772 | 1.087 | 1.685 | 16 | 0.501 |
| | $E_1$ | 3.369 | 2.475 | 0.894 | 17 | 0.207 |
| | $E_2$ | 3.026 | 1.497 | 1.529 | 15 | 0.386 |
| 2011 | E | 3.528 | 2.390 | 1.138 | 20 | 0.218 |
| | $E_1$ | 3.273 | 1.794 | 1.479 | 18 | 0.320 |
| | $E_2$ | 2.834 | 1.698 | 1.136 | 15 | 0.340 |
| 2012 | E | 3.297 | 1.991 | 1.306 | 18 | 0.282 |
| | $E_1$ | 3.565 | 2.739 | 0.826 | 16 | 0.174 |
| | $E_2$ | 3.637 | 2.864 | 0.773 | 18 | 0.158 |
| 2013 | E | 3.455 | 2.188 | 1.267 | 19 | 0.249 |
| | $E_1$ | 3.058 | 1.982 | 1.076 | 15 | 0.284 |
| | $E_2$ | 3.436 | 2.477 | 0.959 | 16 | 0.206 |

(Fig. 4). *H(S)* of outside area showed volatility rising trend; there was the lowest value in 2003 (1.561), which reached maximum 1.991 in 2012 (Table 2). In core area, *H(S)* index was fluctuation change, the high peak value appeared in 2003, 2007, 2011, of which there was the maximum value of 2.390 in 2011; while low peak value appeared in 2005, 2009, 2010, of which the lowest value was 1.087 in 2010. In outside area, *H(S)* index fluctuated with upward trend; the lowest value appeared in 2004 (0.432), and then volatility rising, the maximum reached 2.864 in 2012.

Broadly speaking, fluctuation of disorder-based complexity index is consistent with the total complexity index change. Core area and edge area have significantly smaller changes magnitude than the outside area, which indicates that the community structure is relatively stable under the fencing conditions, and enclosure contributes to increased disorder-based complexity. In view of time scale, with the extension of fencing time, disorder-based complexity has an increasing trend under different fencing conditions, and index of later period emerges within a high value range. This result is caused due to climate effects of more precipitation in the study area, growth environmental conditions have improved gradually with fencing time, and there is relative reduction in competition for resources for species, which make the number of species increase. But, long-term enclosure makes disorder-based complexity volatility and community stability decreased, which indicates that a long-term, single enclosure management makes grassland ecosystem degradation, so it should be encouraged for ploughing, mowing and mild seasonal grazing after 5-10 years fencing.

**The influence of enclosure periods and measures on structural complexity:** Structural complexity *Δ(S)* of the core area was basically in the range from 1.1 to 1.7 in 2003-2013; *Δ(S)* of edge area had the maximum fluctuation, which was basically in the range from 0.5 to 1.7; in the outside

Table 3: Mean of community complexity under different fencing measures.

| Community complexity | E | $E_1$ | $E_2$ |
|---|---|---|---|
| Total complexity *L(S)* | 3.100±0.112a | 3.080±0.091a | 2.401±0.224c |
| Disorder-based complexity *H(S)* | 1.813±0.132a | 1.957±0.111ab | 1.350±0.227ac |
| Structural complexity $\Delta(S)$ | 1.287±0.049a | 1.123±0.103ac | 1.052±0.070c |

Note: The data in the table are the means ± standard deviations; different lowercase letters indicate significant differences at the 0.05 level with rows.

Table 4: Correlation analysis between community complexity, number of species and importance value of dominant species.

| Index | *L(S)* | *H(S)* | $\Delta(S)$ | Number of species | Importance value of dominant species |
|---|---|---|---|---|---|
| *L(S)* | 1 | | | | |
| *H(S)* | 0.898** | 1 | | | |
| $\Delta(S)$ | 0.237 | -0.215 | 1 | | |
| Number of Species | 0.896* | 0.744** | 0.346* | 1 | |
| Importance value of dominant species | -0.923** | -0.977** | 0.109 | -0.761** | 1 |

Note: Two-tailed *t*-test probability, **indicates a significant correlation at the 0.01 level, *indicates a significant correlation at the 0.05 level .

area, $\Delta(S)$ was basically in the range from 0.8 to 1.5 (Fig. 5). In the core area, the structural complexity $\Delta(S)$ changes in the fluctuations, the maximum appeared in 2010, was 1.685; while low peak values appeared in 2005, 2007, 2011, of which the minimum was 1.085 in 2005. In the edge area, $\Delta(S)$ had large fluctuations, the maximum was 1.221 in 2003; low peak values appeared in 2006, 2008, 2010, 2012, of which the minimum was 0.627 in 2006. In outside area, the maximum appeared in 2010 (1.529), while the minimum was 0.773 in 2012 (Table 2).

Generally speaking, community structural complexity index sorted in descending order of the core area, edge area and outside area. It illustrated that fencing improved community structure complexity. At the same time, with the extension of fencing time, structural complexity index had downward trend, which might lead to decreased stability of community structure.

## The Analysis of Overall Community Complexity

To further study, the overall community complexity index changed under different fencing conditions, this paper has analysed three kinds of indices of the multi-year average complexity changes (Table 3).

From the horizontal analysis, the annual average values of total complexity showed a trend of core area > edge area > outside area. The total complexity index at the 0.05 level in the core and edge area had higher significant differences than in outside area. The changed trend of the annual average of disorder-based complexity index was: edge area > core area > outside area. The disorder-based complexity index in the edge and outside area at the 0.05 level was significantly higher than in core area; comparison result of structural complexity showed a pattern of core area > edge area > outside area. The structural complexity index in the core and edge area had higher values than in outside area. The structural complexity index in the core area had significant difference within outside area at the 0.05 level.

In short, fencing increases disorder-based complexity and structural complexity, moreover total complexity also increases. From vertical comparison, disorder-based complexity index is higher than structural complexity, which indicates that total complexity is affected greatly by disorder-based complexity.

## Correlation Analysis between Community Complexity and Number of Species, Importance Value of Dominant Species

In this paper, the correlation between community complexity index, the number of species and importance values of dominant species were analysed by using two-tailed *'t'* Pearson test probability.

The data from the Table 4 showed that the total complexity index had significant correlation with disorder-based complexity at the 0.01 level but there is no significant correlation with structural complexity. This indicates that total complexity related to closely disorder-based complexity and negative correlation between disorder-based complexity and structural complexity, but the correlation was not significant at the 0.05 level. The number of species correlated significantly with three kinds of community complexity index, which had extremely significant correlation with disorder-based complexity at the 0.01 level, and sig-

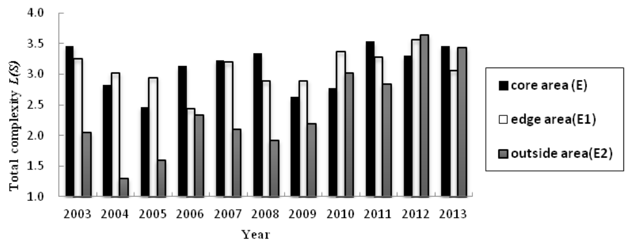


Fig. 2: *L(S)* under different fencing conditions in 2003-2013.

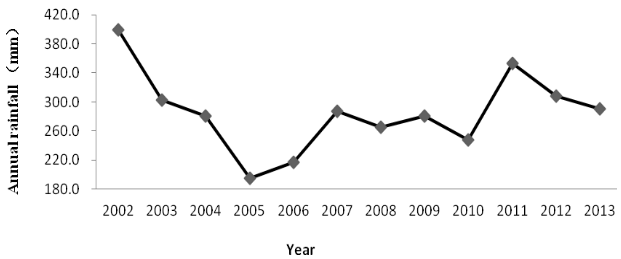


Fig. 3: The changes of annual rainfall in 2003-2013.

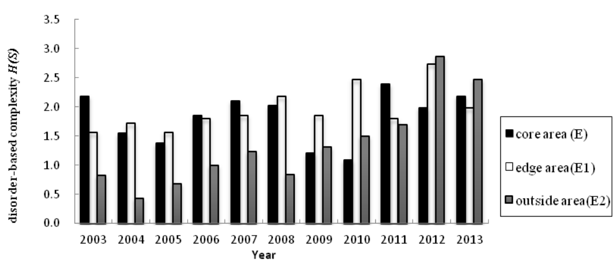


Fig. 4: *H(S)* under different fencing conditions in 2003-2013.

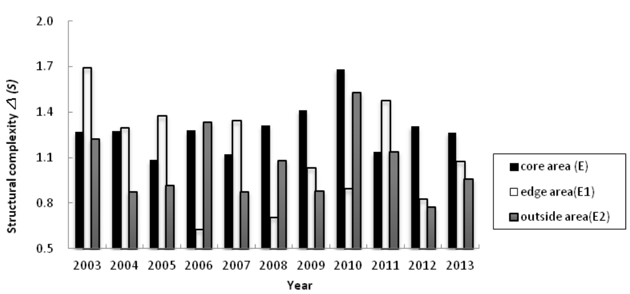


Fig. 5: $\Delta$*(S)* under different fencing conditions in 2003-2013.

nificant correlation with structural complexity and total complexity at the 0.05 level was 0.773 indicating that the number of species were affected closely by disorder-based complexity, followed by total complexity, while minimum impact was on structural complexity. The importance value of dominant species was not significantly related to structural complexity, and was significantly negatively correlated with total complexity, disorder-based complexity and the number of species at 0.01 level. It indicated that when dominance of dominant species enhanced in the grassland ecosystem, total complexity, disorder-based complexity and the number of species all decreased.

## DISCUSSION AND CONCLUSION

The impacts of fencing periods and measures to the structure and functions of the plant community are very complicated. Most previous research focused on the relationships between the community diversity and different fencing measures, and only few studies were available on the relationships between the community complexity and fencing time and measures.

By studying community complexity index under different enclosure measures, it has been discovered that: (1) fencing increases disorder-based complexity and structural complexity in desert grassland, thus making total complexity to increase. Community complexity index in enclosed grassland with relatively little interference is higher than non-fencing area (Li 2000). This suggests that enclosure can improve ecological complexity and make community composition stable, but long-term enclosure is not conducive to vegetation restoration. After some time with fencing, grassland should be used, and the fencing length of time should be based on the degree of grassland degradation and the situation of grassland restoration (Wang et al. 2014 ). (2) In the past, considerable attention has been paid for studying the relationships between environmental factors and the plant community diversity, and the previous results indicated different patterns at different study areas. The results of this study showed that there are significant positive correlations between the number of species and three kinds of community complexity index. The increase of number of species results in increasing community complexity (Jin 2007). (3) The importance value of dominant species is not significantly correlated with structural complexity, while it has significant negative correlation with disorder-based complexity and total complexity. The previous research showed that the greater community dominance is associated with the smaller community complexity. There is a very significant linear relationship between disorder-based complexity, total complexity and the number of species (Wang & Wang 2013).

Currently, cellular automata and genetic algorithms are the main methods of ecology complexity study, but are difficult to measure a particular community complexity (Li 2001). In ecology theory, there also have been some measures of the complexity, but they originate from the deformation of biodiversity index (Li 2000), although these index can also reveal part of community complexity mechanism, and do not describe fully features of self-organization and orderliness. In addition, biodiversity and ecological complexity measures are not the same, but both can complement each other for elucidating complexity phenomenon (Wang et al. 2002). Therefore, using computational complexity measures, the study of community structure is feasible and meaningful (Jin 2007).

The environmental factors are diverse and complex to the impact of plant community structure and function (Wang et al. 2013). For more in-depth research, the next step, it needs to integrate other environmental factors such as how the soil factors are affecting community complexity, study on correlations among the measures of the complexity, diversity, evenness and stability.

Community complexity reflects integrated features of the community structure and function; the computational complexity measure is used to study the plant community in desert grassland ecosystem, which can deepen the mechanism of understanding and provide scientific reference for grassland ecosystem research.

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