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Original Research Paper

Efficiency of an Artificial Fencing Method for Combating Desertification in the Northwest of China, the Case of Yanchi County of Ningxia Hui Autonomous Region

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ABSTRACT

Artificial fencing methods used to combat land degradation have unknown influences on vegetation restoration in the North East of China, especially at Yanchi Ningxia Hui Autonomous region. To determine their efficiency, data have been collected from 2003 to 2013 in several study fields which have implemented different desertification combating methods including: artificial fencing (core, edge and external). Using biodiversity methods based on plant community structure characteristics indices (such as Shannon Wiener diversity index, Simpson dominance index and the evenness index) and the biomass, height and weight have been measured. The results showed that the main factors influencing vegetation growth are not only climatic factors, but also human activities (animal grazing and farming). In addition, the comparison with the natural grassland measurements showed that the average biomass, coverage rate, height and density values of the fencing area are 2343.58 kg/ha ,39.26 %, 16.47 × 10^{-2}m and 106.95 × 10^{4}n/ha respectively larger than the natural grasslands which are 1722.24kg/ha, 33.58%,13.55 × 10^{-2}m and 99.01× 10^{4}n/ha, showing artificial fencing to be more efficient in regard to the soil crust generated that prevented the soil degradation by water and air erosion. To be efficient, the number of fencing years must be similar to the natural biological cycle of the species of the study area (5 years in Yanchi) and frequent checkups are suggested to maintain the plant community dynamic viable and profitable for human well being in order to meet their needs (animals grazing etc.) in such a way that sustainable development may be effective.

INTRODUCTION

Deserts are one of the major landforms on the Earth (Varma et al. 2013) and after war and diseases, desertification has become a serious threat for humankind and their well being. Everywhere in the world, various strategies have been used to combat it or to remediate it. According to the United Nations Convention to Combat Desertification (UNCCD), desertification means land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities (Tengberg et al. 2013). Vegetation fluctuation has been shown to be very different between grassland and forest communities (Peng 1993, Ren et al. 2001). The effects of disturbance and habitat fragmentation at different scales were significantly correlated with community diversity in the semi-arid and arid zones (Xiaodong et al. 2015); therefore, the fight against desertification includes: prevention and/or reduction of land degradation, rehabilitation of partly degraded land and reclamation of desertified land. This definition of desertification refers to the fact that it decreases the capacity of the soil to produce biomass (agricultural production, animal grazing), in other terms, it eliminates the ecosystem services provided by the lands (Zhen & Zhang 2011). It also means that the ecological services value is decreasing over time. Generally speaking, the ecological service values are all the services that are naturally provided by land or the other components of the environment (Daouda et al. 2014), which directly affects humans and their ability to utilize ecosystem services. Hence, decision makers are organizing meetings and conferences at each level (local, national and international) to draw the attention towards desertification phenomenon according to the degree of it importance in an area (Rio-92, Chapter12, Agenda21). Worldwide, Asia and Africa have the most vast degraded land and they are struggling to change the trend of that phenomenon . When focusing on the countries that are experiencing the consequences of desertification Chinese sites can be quoted. Among the ecological issues confronted by China, land degradation in arid zones especially in Western China is one the most serious challenges.

According to the 4th China national survey on desertification in 2009, there are currently a total of 2623700km^2 of desertified land and 173110km^2 of sandified land, accounting for 1/3 and 1/5 of the national land respectively causing an economic loss of 50 million Yuan annually. Compared with those in 2004, over 5 years the net desertified land area decreased by 12.454km^2 with an annual reduction of 2.491km^2 while the sandified land net reduction was 8.587km^2 with an annual average reduction of 1.717km^2 (Jiang et al. 2013). For decision supporting, the land degradation monitoring becomes one of the priorities of the Chinese Government and most of regions are already getting the outcomes (Cao et al. 20011, Zhen & Zhang 2011). Focusing on the county of Yanchi, where projects are ongoing, investigations have been done on enclosure methods. This enclosure method is used to limit soil erosion by air/water and the human influence on vegetation restoration. The disturbance coming from human disturbance will be minimized according to the vegetation period cycle. The analysis of the effects of artificial fencing methods in combating land degradation is the purpose of the paper. In short, this research aims at evaluating the efficiency of that fencing method and the influencing factors of the vegetation restoration in semi-arid zones.

MATERIALS AND METHODS

Study area: The study zone is encompassed between 37°10'04" N and 106°30'41" E, It is located in east of Ningxia Hui Autonomous Region. The total area of Yanchi is 8661.3km^2 with a north-south distance of 110km and east-west of 66km. Yanchi is on the junction of four provinces (regions), Shaanxi, Ningxia, Gansu and Inner Mongolia. The Southern part is characterized by Loess hilly landscape while the middle is occupied by the hilly land with an altitude ranging from 1295m to 1951m (above sea level). According to the weather, the average annual temperature is 8.1°C. The annual highest and lowest average temperatures are 34.9°C and -24.2°C respectively. The annual average frost-free and average precipitation are 165 days and 250-350mm/y respectively, it confirms the drought windy and sandy weather which prevail in this county. The natural landscape is mainly occupied by prairie (sand wilderness). On pedological aspect, Yanchi County is mainly denuded peneplain with a typical soil of serosem, dark humus soil, sandy soil loess and a little salt clay, the white bentonite mainly.

Data collection methods: Sample plots for field survey were established in Yanchi county at Liuyangpu (37°45'53"N and 107°24'01"E), where fences were erected in 1996. Researchers implemented methods for surveying biodiversity by taking biomass measurements and weights. Every year, during the vegetation growing season (July-August), the species richness (number of species), the height (relative biomass) and the abundance (relative recovery) have been collected. GPS was used to geolocate the sample sites. To limit the area of sampling, 1×1m^2 11 quadrats were designed in a radius of 50 m in four cardinal directions in order to have effective information in place, in short, the sample point method and linear transect method is used for sampling and the degree of compactness of the soil was measured also with a metal rod by digging a 0-30cm depth hole every second quadrat.

Fig. 1: Location of the study area.

Data processing: A plant community structure index is a valuable tool to process the involvement of plant diversity in ecological process assessment. Among these tools the plant importance value can be quoted. This index is considered as an integrated index describing relative importance among/ of plant species and in herbage plant studies of grassland vegetation, one to three indices, such as coverage and height, are used by most scientists.

The formulas below were used to calculate plant importance values:

$$\text{Relative abundance, } A = (Ai/A)\times 100 \quad ...(1)$$

Where Ai is abundance of a given plant i and A is abundance of all plants.

$$\text{Relative height } (Rh) = (Hi/H)\times 100 \quad ...(2)$$

Where Hi means height of a given plant i and H means height of all plants.

Relative coverage Rc = (Ci/C)×100 ...(3)

Where Ci is the coverage of a given plant i and C is coverage of all plants

Relative biomass Rb = (Bi/B)×100 ...(4)

Bi is biomass of a given plant and B refers to the biomass of all plants.

Relative frequency Rf = (Fi/F)where Fi is frequency of a given plant i and F is the sum of the frequency of all plants.

Frequency (F) = (Ni/N)×100 ...(5)

Where Ni is quadrate number in which a given plant appeared and N is the sum of frequency of plants.

Plants importance value: The calculation of the plant importance value involves the number of species, their relative biomass, relative height, relative coverage and relative frequency and its general formula is:

$$\text{Importance value I} = \frac{Ra+Rc+Rf+Rh+Rb}{5}$$

Where I is importance value, Ra is relative abundance, Rh relative height, Rc is relative coverage, Rf is relative frequency and Rb is relative biomass. The importance value is used because it takes into account the main characteristic of the plant species in order to calculate the community structure index which will show the state of the community there. The importance value then combined the five parameters above to form a synthetic index where the plant with the highest importance value is the most important; however, in that importance, another index is needed to show the real structure of that community. It means that, the synthetic index is insufficient itself, which is why the index of diversity of Shannon-Wiener and the ecological dominance of Simpson and the Evenness index are combined to the synthetic index to illustrate the whole aspect of that community.

Indices of community structure: The Shannon's diversity index (SW) is commonly used to characterize species diversity in a community and it provides important information about the rarity and commonness of species in a community. And the ability to quantify diversity in this way is an important tool for us trying to understand community structure. In this article, importance value is a metric and the Shannon's diversity index formula is as follows:

$$SW = -\sum_{i=1}^{S} \text{pilnpi}$$

Where pi is the proportion of i^{th} specie's importance value with the total importance value of some region (pi = I i^{th}/Σ I)

Ecological dominance index of Simpson (SP) is represented as follows:

$$SP = 1/\sum_{i=1}^{n} pi^2$$

The community evenness formula is represented as follows:

$$SW = ((e)^{sw} - 1)/(s-1)$$

S is the number of plant species in a transect

The results will lead us to a conclusion that can show the efficiency of the fencing method or practices that are been used.

RESULTS

For the study investigation has been done in three different fields with different measures: natural enclosure area (Liuyangpu), artificial fencing field, and on a farm land transformed into grassland.

Plant community characteristics dynamic in Yanchi county: This paper used 2003-2013 years land management data (natural grassland, artificial fencing) containing variables for vegetation coverage, height, biomass, density and the average value, from the point of view of vegetation quantity characteristic analysis of Yanchi County vegetation changes over the past ten years .

It can be seen from Table 1 that the largest annual average biomass value is 3955.44 kg/ha in 2004, and the minimum is 1922.03 kg/ha in 2008. Vegetation coverage is the largest in 2004 and reached 59.07%, the minimum appears in 2008 and was only 24.87% less than half of the maximum value of the average plant height. The largest annual value is 16.32 $\times 10^{-2}$m in 2004, vegetation coverage and biomass were

Table 1: The plant community quantity characteristics of Yanchi county during 2003 to 2013.

Year	Biomass kg/ha	Coverage rate (%)	Height ($\times 10^{-2}$m)	Density ($\times 10^{4}$n/ha)
2003	3154.42	50.71	11.78	236.51
2004	3955.44	59.07	16.32	187.35
2005	2578.51	32.25	14.74	91.43
2006	2267.96	45.30	11.24	236.73
2007	2597.43	52.54	13.18	233.09
2008	1922.03	24.87	13.76	103.64
2009	2000.78	29.06	12.83	120.28
2010	2110.08	41.08	15.17	141.95
2011	2499.82	39.17	15.33	142.51
2012	2159.52	36.42	14.14	185.34
2013	2102.18	33.23	13.84	128.77
average	2486.20	40.34	13.83	164.33

consistent in 2004 showing that the vegetation restoration effect is good. The vegetation density maximum annual value is 2367300 n/ha 2006 (n is the number of plants), the smallest is for 2005 with only 914300n/ha of value.

As it can be seen from Fig. 2, the largest annual average biomass occurs in 2004 and reached 3955.44 kg/ha, the minimum annual value appears in 2008 and is 1922.03kg/ha. Vegetation coverage is maximum in 2004 and reached 59.07%, the minimum value is only 24.87% and it is in 2008 and it is less than half of the maximum value. The average plant height maximum value occurs in 2004 and is 16.32×10^{-2} m. From the vegetation coverage and biomass it can be noted that 2004 vegetation restoration effect is very good; the vegetation density maximum value appears in 2006 and is equal to 236.73×10^{4} n/ha, the minimum density is for the year 2005 with 91.43×10^{4} n/ha of value.

As it can be seen from the Fig. 2, from 2003 to 2013, Yanchi County vegetation increased at first and then decreased, and finally the level of oscillation strengths, in 2004 reached the maximum level, from the beginning of 2005 basically maintained at 2000 kg/ha to 2500 kg/ha. Biomass increased significantly in 2004 reflecting the positive effect of the county grazing prohibition policy, then as the community structure and stability, many factors such as rainfall and human activities, the biomass maintained at a relatively high level. Vegetation height, density and the community size characteristics show early decline in water which is more serious; however, if the investigation before the rainfall was larger, several years showed rapid growth and a significant increase in vegetation, and *vice versa*. In 2003, 2004, 2007 and 2008 from March to July rainfall increase can be seen; therefore, vegetation density response is larger. The change of vegetation coverage and vegetation height shows small effect in terms of change in vegetation growth. In addition, the investigation process of random sampling and human factors (multi phase visual estimation) on height and coverage shows great influence.

Table 2 shows that throughout ten years of fencing control in Yanchi County, the average diversity index fluctuates between 2.27 and 2.59; the largest annual value index appeared in 2007, the annual minimum index value appeared in 2010. The largest ecological dominance annual value index appeared in 2005, and the annual minimum index value appeared in 2007; community evenness index basically is about 0.60 with small variations, the maximum annual index value came in 2007 at 0.63; the minimum annual value index came in 2006 at 0.51. Overall, in Yanchi county, small amplitude index of community structures have been observed showing the relative stability of the plant community structure.

In Fig. 3, the county fenced grassland in Yanchi County since 2003 shows Shannon-Wiener diversity index with the degree of homogeneity trend. In 2007 and 2011 the trend was relatively high. In those days in Yanchi County, a greater rainfall and also affected grassland in semi arid area with abundant annual herbs. Annual herb plant growth has a direct relationship with the rainfall in years 2007 and 2011, which were typical of the abundant water years. In fact, the growth of a large number of annual herbaceous plants inhibited the growth of perennial herbaceous plants, so the diversity index is higher. In addition, from the oscillation of the index level point view, we can see that, the implementation of the county fencing measures effectively avoid the external impacts of human disturbances on plant recovery.

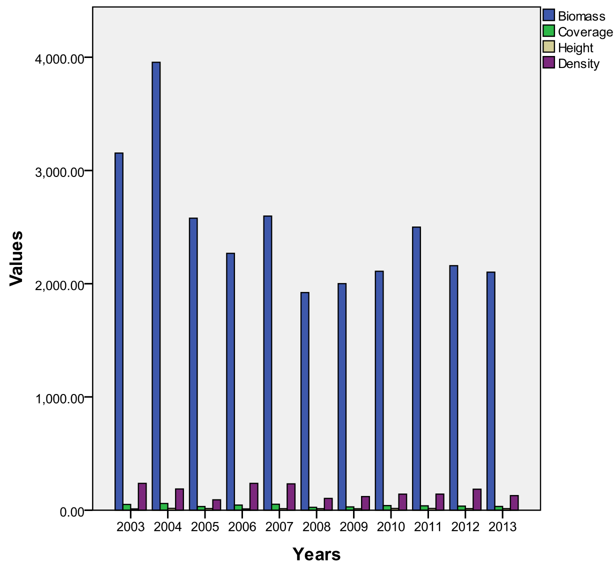

Fig. 2: The plant community quantity characteristics of Yanchi County during 2003 to 2013.

Table 2: The plant community structure indexes of Yanchi county during 2003 to 2013.

Years	Diversity index SW	Ecological dominance index SP	Community evenness index E
2003	2.54	11.03	0.59
2004	2.56	10.89	0.58
2005	2.45	11.54	0.60
2006	2.33	10.23	0.51
2007	2.59	8.66	0.63
2008	2.48	10.50	0.58
2009	2.34	10.23	0.58
2010	2.27	9.43	0.56
2011	2.50	8.80	0.58
2012	2.41	9.47	0.56
2013	2.35	9.31	0.56

As shown in Fig. 3, the ecological dominance index minimum value appeared in 2007 as well as 2011, and the largest annual index value is in 2005. 2005 was the typical dry year, rainfall was only 180mm, and annual herb growing become worse, drought resistant perennial vegetation dominance appeared, so the grassland in Yanchi County of 2005 meant greater ecological advantages. The ecological dominance of minimum annual value is in 2007, which is due to the rainfall influence, since this year the value of greater rainfall, large growth of annual herbaceous plants weakened the perennial herb of the dominant position to have lower ecological dominance index. As it can be observed from Fig. 3, community evenness shows that the uniformity of vegetation distribution reflects the stability of community growth, which benefited from the Yanchi County enclosure for vegetation restoration policy that provides a good external environment to be stable. That fencing is indeed effective to restore the vegetation in the semi arid area.

Trend and changes of vegetation in Yanchi County community characteristic index differences, basic trends to stabilize the climate state. Vegetation restoration educational policy provides good conditions to rely on pasture recovery to achieve a dynamic balance and external environment condition, grassland health and stability.

Natural grassland plant community quantitative characteristic changes: It can be seen from Table 3 that the largest biomass value in natural grassland appeared in the year 2004 with 3045.50kg/ha, as the minimum annual biomass value occurs in a year 2008 with only 923.35 kg/ha, less than the 2004 year's 1/3 value express it's volatility, Vegetation coverage is the highest in 2004 and reached 49.9%, which is nearly the half regional survey of the grassland or vegetation coverage in addition, the smallest vegetation coverage year is 2008 with only 23.75%. Average plant height maximum is in 2011, the average height is 17.75×10^{-2}m, year's minimum value is in 2011, the average height is 17.75×10^{-2}m, the minimum value of the year is in 2003 which is 9.93cm. Vegetation density is maximum in 2006 and reached 2161300 plants/ha, the minimum value is in 2005 with 347000 plants/ha showing the disparity of the two years.

As can be seen from Fig. 4, since 2002, the county grazing, biomass of natural grassland in 2003 and 2004, coverage have increased greatly, this shows that transforming grazing land to grassland restoration created good conditions. From 2005, the index began to decline year by year, until the 2011 rebound, then return to the lower levels.

Quantitative characteristic of artificial fencing area plant community dynamic changes: In Liuyangpu, the three plot utilizing different artificial fencing methods show differences. Therefore, in this paper we discussed the three samples and their development, and explored different fencing years, the relationship between vegetation under enclosure sample changes.

Table 3: The plant community quantity characteristics of natural grassland from 2003 to 2013.

Year	Biomass kg/ha	Coverage rate (%)	Height ($\times 10^{-2}$m)	Density ($\times 10^{4}$n/ha)
2003	2437.70	37.85	9.93	106.95
2004	3045.50	49.90	13.63	74.05
2005	2190.15	29.80	15.22	34.70
2006	1878.93	42.93	11.04	216.13
2007	1761.10	47.25	13.39	139.75
2008	923.35	23.75	12.99	68.25
2009	1233.50	25.35	13.39	82.60
2010	1158.35	23.81	12.57	77.57
2011	1635.29	33.61	17.75	109.51
2012	1356.89	27.89	14.73	90.86
2013	1325.66	27.24	14.39	88.77

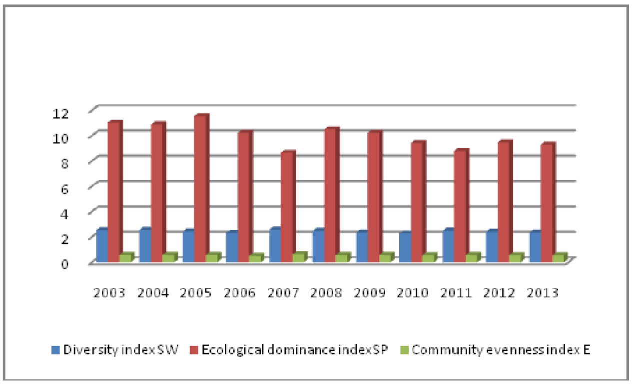

Fig. 3: The plant community structure characteristics of Yanchi county during 2003 to 2013.

From the Table 4 and Fig. 5, it can be seen that the biomass of 2011 is the best one with 2687.46k/ha. The lowest value occurs in 2005 with 2018.46kg/ha value. Also the greatest value of vegetation cover occurs in 2003 and it covers 62.2% as the lowest appears in 2013 with only 22.44%. The lowest vegetation coverage mean appears in the year 2006 with only 11.74×10^{-2}m; the highest value of the vegetation density appears in 2012 with 278.80×10^{4}n/h as the lowest occurs in 2005 year with 34.3×10^{4}n/ha of value.

From the Table 5 it can be seen that the most high value of biomass occurred in 2007 year which is 4056.93kg/ha and the smallest which is the 50% of the greater, appeared in 2003year and is only 2250.86kg/ha. The most high value of coverage occurs in 2004 at 68.75% as the smallest is only 14.88% in 2008 showing a great disparity between these values. The vegetation highest value of height appeared in the year 2005 with a mean value of 24.53×10^{-2} m, the small-

Table 4: The plant community quantity characteristics of enclosure area from 2003 to 2013 (LIUYANGPU).

Year	Biomass kg/ha	Coverage rate (%)	Height ($\times10^{-2}$m)	Density ($\times10^4$n/ha)
2003	2538.56	65.20	20.17	82.50
2004	2349.78	58.75	20.89	56.25
2005	2018.46	35.33	15.99	34.30
2006	2155.88	36.93	11.74	230.33
2007	2538.49	51.36	14.40	149.00
2008	2187.15	23.65	16.59	40.10
2009	2324.84	23.91	13.77	45.40
2010	2378.54	45.55	16.67	41.00
2011	2687.46	38.92	15.98	75.33
2012	2245.65	29.84	15.57	278.80
2013	2354.65	22.44	19.40	143.50

Table 5: The plant community quantity characteristics of edge enclosure area from 2003 to 2013.

Year	Biomass kg/ha	Coverage rate (%)	Height ($\times$0.01m)	Density ($\times10^4$n/ha)
2003	2250.86	60.7	16.42	60.25
2004	2301.48	68.75	19.96	101.00
2005	2683.57	31.09	24.53	16.00
2006	3533.86	42.65	14.08	36.11
2007	4056.93	56.15	19.68	78.00
2008	3551.28	14.88	14.97	23.73
2009	3628.41	30.24	17.72	135.33
2010	3574.28	55.77	18.03	149.10
2011	3785.41	34.64	18.33	64.70
2012	3058.47	35.33	13.93	295.40
2013	2987.58	41.67	15.20	137.60

est appeared in 2012 with 13.93×10^{-2} m of value. The plant density highest value occurred in 2012 with 295.4×10^4n/ha and the smallest value occurred in 2005 at $16\times.10^4$n/ha.

The Fig. 6 shows that the edge area's biomass changes are rising up, following the level of amplitude oscillation trend with a summit reached in 2007, which is among the recent ten years, the year with the most abundant rainfall. On other hand, many research papers show that in the 5 years of enclosure the biodiversity index reached the maximum value. This means that although the enclosure method is very economic and convenient way to maintain the vegetation cover, the longer it last the lesser it influences the vegetation restoration.

The Table 6 shows that the biomass of the external region of the enclosure land value reached the maximum value in 2011 at 4087.92kg/hm^2, and the lowest value appeared in 2005 with only 1425.87kg/ha. The vegetation coverage reached its maximum value in the year 2003 and its minimum in 2013 with respective values of 65.20% and 22.44%. In addition, the average height maximum value appeared in 2004 with 20.89cm, and the lowest value occurred in 2006

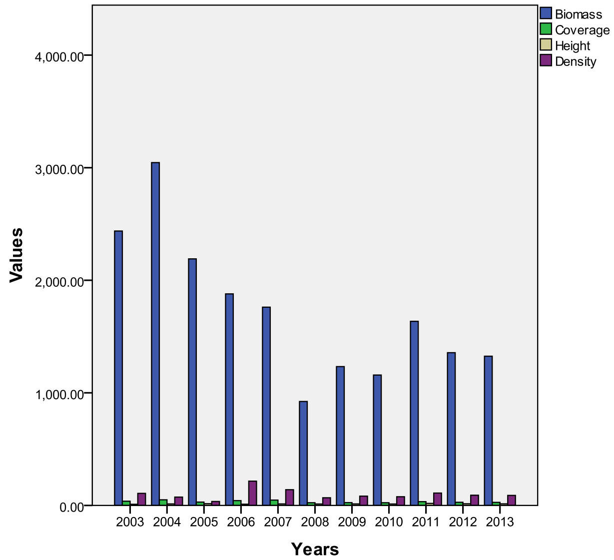

Fig. 4: The plant community quantity characteristic of natural grassland from 2003 to 2013.

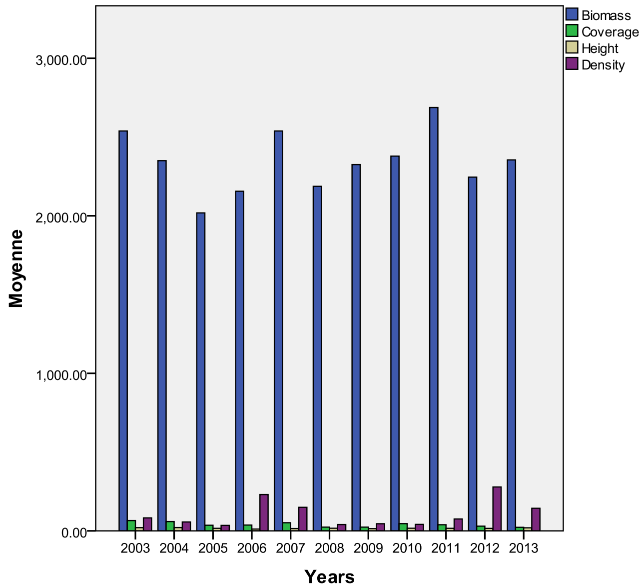

Fig. 5: The plant community quantity characteristic of edge enclosure area from 2003 to 2013.

with 11.74×10^{-2}m. It is also seen that the plant vegetation's density reached greatest value in the year 2012 with 278.8×10^4n/ha, and the lowest value appeared in 2005 with only 34.30×10^4n/ha.

The Fig. 7 represents the growing up trend of the external enclosure area during the recent decade in Yanchi County except two years negative variation trend. In 2002 the enclosure area, because of the disturbance of the external fac-

Table 6: The plant community quantity characteristics of outside enclosure area from 2003 to 2013.

Year	Biomass kg/ha	Coverage (%)	Height ($\times 10^{-2}$m)	Density ($\times 10^{4}$n/ha)
2003	1835.68	65.20	20.17	82.50
2004	1678.18	58.75	20.89	56.25
2005	1425.87	35.33	15.99	34.30
2006	1756.56	36.93	11.74	230.33
2007	2101.76	51.36	14.40	149.00
2008	2547.38	23.65	16.59	40.10
2009	2698.41	23.91	13.77	45.40
2010	3037.49	45.55	16.67	41.00
2011	4087.92	38.92	15.98	75.33
2012	3027.54	29.84	15.57	278.80
2013	2976.35	22.44	19.40	143.50

Table 7: The precipitation and biomass of Yanchi county from 2003 to 2013.

years	Total annual (mm)	Biomass (kg/ha)
2003	293.9	2250.86
2004	262	2301.48
2005	180	2683.57
2006	212.1	3533.86
2007	284.1	4056.93
2008	266.7	3551.28
2009	280.7	3628.41
2010	248.4	3574.28
2011	352.6	3785.41
2012	308.4	3058.47
2013	320	2987.58

Table 8: Comparative table between fencing area and natural grassland in Yanchi.

Type area	Biomass kg/ha	Coverage rate (%)	Height 0.01m	Density n/ha)
Fencing area	2343.59	39.262	16.47	106.96
Natural area	1722.24	33.580	13.55	99.01

tors, continued to get down and reached 1425.87 kg/ha and this situation lasted in 2004 and 2005; this trend increased and reached the summit during 2011 with 4087.92kg/ha. From the variations observed in the external enclosure area, the short period of enclosure area influenced the vegetation restoration in such a way that the longer it is placed, the better the restoration is.

The Fig. 6 shows that, the most stable biomass area is the enclosure core area, on the basis of the protection level oscillation the average is equal to 2300kg/ha; the mean value of the edge maximum biomass is about 3200kg/ha, the maximum average value of the core enclosure area is about 900 kg/ha. The most high changes amplitude are observed in the external enclosure area, the ten years period variation fluctuates from 1425.87kg/ha to 4087.92kg/ha.

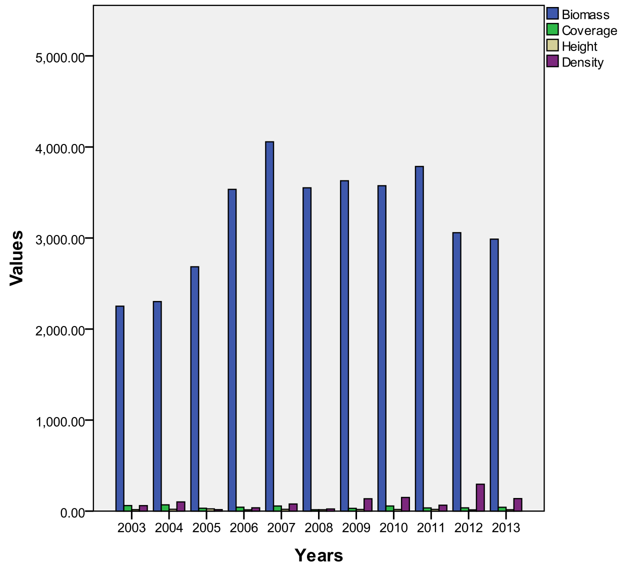

Fig. 6: The plant community characteristics of edge enclosure (Liuyangpu) from 2003 to 2023

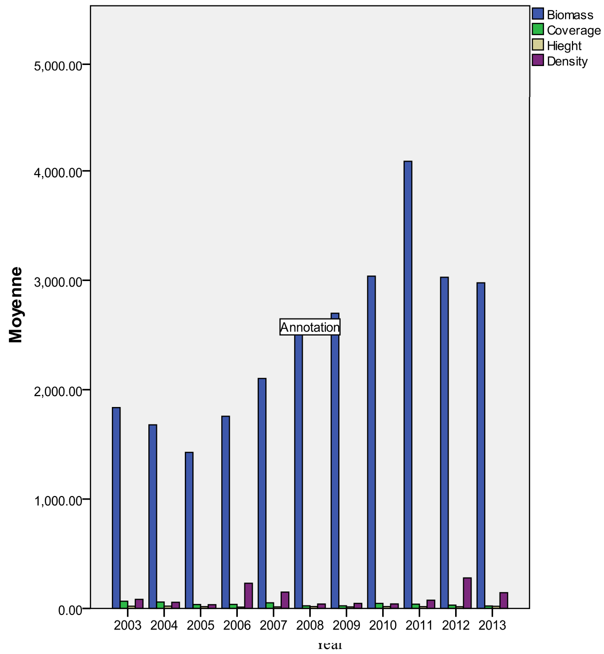

Fig. 7: The plant community quantity characteristics of outside enclosure area from 2003 to 2013.

From the Table 7, it can be seen that the years of the highest rainfall and the highest biomass are 2011 and 2007 with a value of 352.6 mm and 4056.93 kg/ha respectively. The smallest rainfall is 180mm in 2005 and the smallest biomass is 2250.86 kg/ha in 2003.

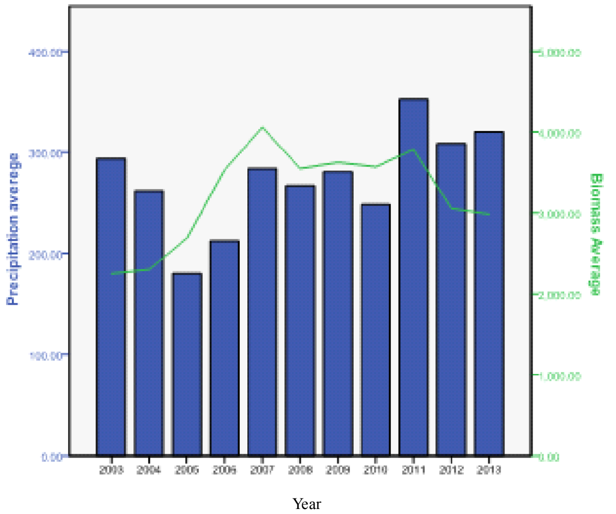

Fig. 8a: Correlation graph of biomass and precipitation average in Yanchi (2003-2013).

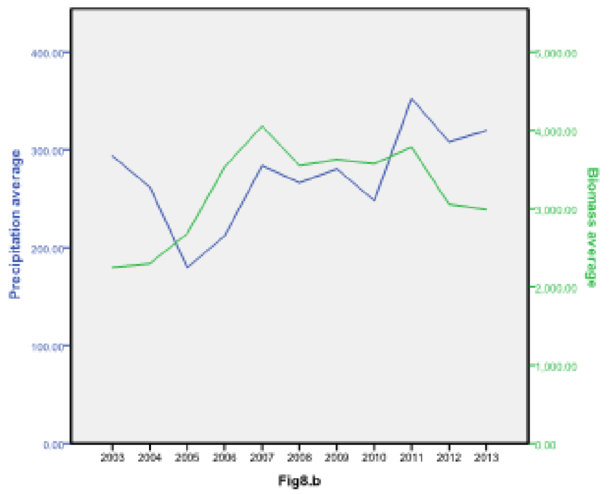

Fig. 8b: Correlation graph of biomass and precipitation average in Yanchi (2003-2013).

The Fig. 8a,b show that there is a close relationship between the precipitation factors and the vegetation growth by the biomass measures. This shows that the meteorological factors influence the vegetation growth by biomass production, but these climatic factors are not the only influencing factors of the vegetation restoration in arid zones or semi-arid and deserts. It confirms the fact that human factors (animal grazing, farming etc.) are combined with the natural factors (rain fall and soil crust) and can be the main factors that influence the vegetation restoration.

Table 8 shows that the plant quantitative characteristics of the artificial fencing area are larger than those of the natural grasslands. This confirms the efficiency of that method on the vegetation restoration.

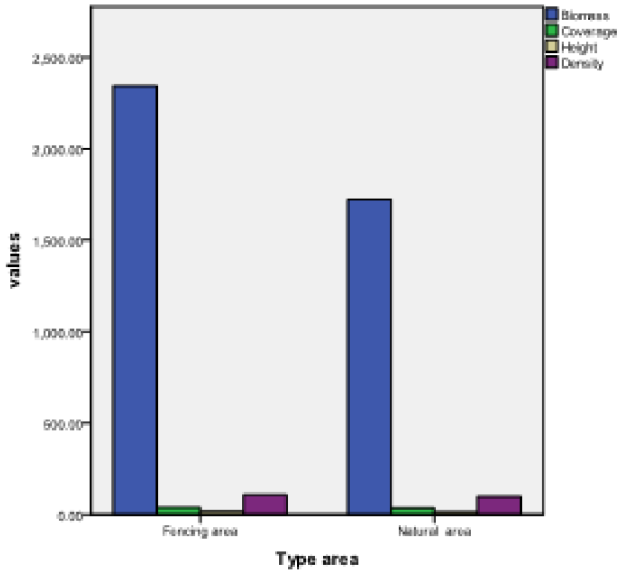

Fig. 9: Plant community quantitative characteristics of fencing area and natural grassland.

Fig. 9 expresses graphically the differences between the biomass, coverage, height and density of the artificial fencing and the natural grassland. Between these two areas the biomass of the fencing area is higher than the biomass of the natural area and so are the coverage rate, the height and the density.

DISCUSSION

Through field survey results, it has been found that by the implementation of the county pasture grazing regulations, by using the artificial fencing method, Yanchi sectional storage volume has been effectively restored, even if the illegal herd phenomenon still occurs and has had the adverse effect on the pasture. The analysis shown in Fig. 8 shows the uptrend of the biomass generated along the first five years of data correlate with the rainfall, so the natural grassland vegetation in Yanchi County, annual herbaceous plants is mainly influenced by the climate; indicating that a strong influence comes from rainfall. In fact, in 2005 and 2006, the rainfall of county was only 180mm and 212mm respectively and consequently the biomass of those years was 2683.57 kg/ha and 3533.86kg/ha lower than the highest which occurs in 2007 of 4056.96kg/ha. This uptrend situation of the biomass reached it first pick in 2007 and then started decreasing, due to the abundance of the precipitation. In fact, during the first year of enclosure, the soil generated a crust that became thick over time. In the arid and semi arid zones, crust binds the sandy soil and limits it erosion and that is a positive point on soil degradation assessment or monitoring. On the other side, the thickness of the crust limits the water infiltration as a major determinant of the cropping or grazing potential of a soil is the rate and amount of water that can infiltrate both through the soil surface and within the soil profile, the crust generated becomes then an obstacle for vegetation growth and this is why the biomass became to decrease from the first pick in 2007. This observation uncovers one of the limits of the artificial fencing methods because the economic part seems neglected.

In the edge enclosure area, the human activities brought some good condition for vegetation growth. Because of the treads of the grazing animals, the crust is destroyed and the rain water can infiltrate easily the soil to improve the vegetation growth. This shows the positive effects of animal grazing at an appropriate time on the soil.

This means that to reach the sustainable development goals for human welfare and environment protection, the soil protection methods must cover those two benefits of economic gain and combating land degradation. A correct moment which is favourable for such activities can be determined according to the vegetation growth by the cooperation between the scientific results and the local administrator's regulations as a holistic management that involves each factors concerned by the environmental good health. In this study area the appropriate period of enclosure is about 5 years.

CONCLUSION

During these ten years in Yanchi, the different measures in the enclosure areas showed not only the efficiency of the artificial fencing method but also the influencing factors of the vegetation restoration or land degradation combating. Among these influencing factors we can quote: (1) precipitation, (2) human disturbance, (3) soil nature and (4) the length of the fencing time. In fact, precipitation which is climatic factor showed that in the abundant rainfall years the biomass is greater and the contrary is proved in the dry years. Moreover, in the fencing areas, the biomass and density and height are larger than in the natural grassland showing the efficiency of the artificial fencing that limit the human disturbance and generated a soil crust that stopped the soil erosion by water or air by stabilizing the soil. It has been also remarkable that the length of the enclosure period has not necessary a good impact on the vegetation restoration, because in the enclosure period, the biomass has an increasing trend for the first years and after this period it lowered down. So, these past 10 years in Yanchi County, the number of features changes in natural grassland vegetation shows that natural grassland restoration on the one hand, is closely linked with climate change, especially the changes in rainfall, and on the other hand is closely related with human activities (animal grazing) which can be limited by the artificial fencing method. It is then suggested to increase the intensity of grassland for implementing animal husbandry policy because of their direct relationship and positive impacts on vegetation restoration in the semi-arid zones. Also, the methods used to combat land degradation must take into account the economic benefit of that method and not focusing only on their environmental or ecological efficiency.

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