Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 13	No. 1	pp. 191-196	2014

Original Research Paper

Study on the Ecological Characteristics and Change Analysis of Xin Jiang Junggar Basin Based on the NDVI

He Lingyun[1], Meng Xianyong[2], Du Jing[3], Wang Yuejian[1*], Cai Yongge[4] and Tang Xiangling[1]
[1]College of Science Geography Department, Shihezi University, Shihezi, 832000, China
[2]School of Resources and Environment Science, Xinjiang University, Urumqi 830046, China
[3]School of Computer Science and Technology, Xinjiang Normal University, Xinjiang 830054, China
[4]College of Agriculture, Shihezi University, Shihezi, 832000, China
*Corresponding author: Wang Yuejian

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 22-12-2013
Accepted: 28-1-2014

Key Words:
Junggar basin
Ecological characteristics
Ephemeral vegetation
SPOTVGT NDVI
Change analysis

ABSTRACT

The SPOTVGT NDVI data of 1998 to 2008 were selected to analyse the ecological pattern and variation characteristics of Junggar basin in China. Conclusions are as follows: The overall ecological pattern of the basin is that, an apparent and continuous oasis belt was formed in the north, a small oasis area was distributed in the northern basin, and the ecological condition in the centre of the basin is poor but stable. The most flourishing period of the natural vegetation in the basin is in August, while in the central part of the basin, it lasts from late May to early June; vegetation also apparently appears flourishing during this period with subsequent downfall of ephemeral plants. While the ephemeral plants are distributed in the whole basin except the artificial farmland, flourished in the oasis edge, rare in the central part of the basin, but a slightly prosperous area was formed in the middle of the basin (North of Hutubi). The biomass in the basin has increased within basin in recent years mainly due to the agricultural expansion. The development activities of human mainly affect the edge of the oasis with the range of 50 km, and the greatest impact area is near the edge of the oasis with 5-10 km.

INTRODUCTION

Junggar Basin is located between the mountains of Tianshan in northern of Xinjiang and western of Altai, in which, there exists China's second largest desert Gurbantonggut. It is different from other deserts in China with high biological diversity and stability. In recent years, many scholars all around the world analysed it from the ecological and environmental aspect, considering that there was a growth trend of vegetation in the basin, but it mainly refers to the growth of artificial vegetation in the centre of oasis. While the desert vegetation near the circle of oasis was destroyed, and the coverage of some region was decreased, which is significantly lower than the area far from the circle of the oasis (Ren & Tao 2005, Wang 2010, Chen et al. 1983, Zhang 2010, Zhang 1985, Wang 1993, Jiu Zili et al. 1995, Zhang 2002, Zhu et al. 2009, Liu & Shi 2007, Qian et al. 2007). However, these researches mostly studied the ecological changes of Junggar Basin from the local, microcosmic or qualitative description level, and it is difficult to fully grasp the ecological status of Junggar Basin.

SPOTVGT of NDVI data were selected in this paper to analyse the dynamic changes and the ecological characteristics of Junggar Basin from the quantitative perspective, which can make the people to understand the possible ecological changes in future of Junggar Basin from the macro view during the past period.

DATA SOURCES AND PROCESSING METHODS

The data used in this paper are NDVI data produced from SPOTVGT obtained from National Natural Science Foundation of Western China Environmental and Ecological Science Data Center (http://westdc.westgis.ac.cn). This data were processed by the Vegetation Processing Centre, CTIV, Flemish Institute for Technological Research, Vito. They preprocess global data daily within 1 km. Pretreatment includes atmospheric correction, radiometric calibration, geometric correction, and this process can produce the synthesis of NDVI data of ten days at most. They set the value to -0.1, and then calculate through the formula $DN = (NDVI + 0.1)/0.004$ and convert to DN value of 0-250. The data (from 1998 to 2008) with the time resolution of ten days (spatial resolution of 1km) were used in this paper. First, we cut out the images of Xinjiang region by using Chinese provincial administrative 1:4,000,000 map, then used the relief map provided by Mapping Institute of Xinjiang combining with the remote sensing image of Xinjiang. We defined the scope of the Junggar basin as an irregular triangular with 910km length from east to west and nearly 426km width from north to south (Qu Guosheng et al. 2009).

The Maximum Synthesis method and Decision Tree classification are used in this processing. The Maximum Synthesis method can use a certain period of images to eliminate short-term fluctuations, reflecting the overall state of the data during this study. Algorithms of Decision Tree classification are designed based on the basic level of the NDVI values, NDVI represents the vegetation coverage area. Generally, when NDVI value is high, the vegetation coverage is correspondingly higher.

RESULTS AND DISCUSSION

The overall ecological patternspatterns in Junggar basin: Firstly, we processed 36 images of the basin from January to December per year by Maximum Synthesis method. Then based on the spatial variation analysis of NDVI value of synthetic images per year, referring to the farmland boundary in the ETM image with the year 2000 and 2008 of Manas River Basin, a simple decision tree classification was applied in the Maximum Synthesis Image of NDVI in each year. The region whose NDVI value was greater than 160, was considered as the main part of the artificial oasis (mainly refers to the farmland), as per the regional distribution feature brightness values in the image, and the others were divided into six categories with 130-160,100-130, 80-100, 60-80, <60 and so on, and then implement classifications to the maximum synthetic graph of the year. The classification maps (Fig. 1) are the higher vegetation coverage in 1998 and the lower vegetation coverage in 2001.

It can be found from Fig. 1 that, the biomass of Junggar basin mainly concentrates in the south and north area of Junggar basin; the south region is more apparent, mainly presented as a forming oasis belt along the Tianshan alluvial plain and piedmont from east to west, whose centre is the high value of artificial oasis and surrounded by a small amount of areas whose NDVI value is between 130 and 160 and 100 and 130. The belt is wide and continuous in more rainfall years, the width is about 50 km away from the eastern end of the basin, and about 100 km away from the centre-western end of the basin. While it is narrow and intermittent in less precipitation years (such as 2001), the natural vegetation is almost connected as the whole except the artificial oasis.

From the oasis belt to the central basin, NDVI values are dropped from 80 to generally 60-70. This reduction in some oasis band edge has leaping mutations, but some edge is gradual, it seems difficult to find out the regularity of the NDVI. Overall, in little precipitation years (such as year 2000 and 2001), there are more mutations. Conversely, in more precipitation years, it is gradual. The gradient range is between 5 km and 10 km, a few with 15 km. All the above characteristics reflect a strong dependence of the natural vegetation in the area on precipitation.

In addition to the low value area of NDVI formed by Ebinur Lake and Fuhai owing to the water in the southwest corner and the northern area, another two low value zones are formed, one is located in the middle of the basin, which lines along Karamay and Wulasitai Port from west to east, represented as a eastern-western end area in more precipitation years, the other one is a vast and contiguous area formed in less precipitation years whose NDVI values are mostly between 45-55, comparing with the years of more precipitation, this value has reduced about 7-15.

Moreover, along part edges of the artificial oasis (farmland), there exist some low value zones of NDVI, as can be seen from the south-north section line of the basin, NDVI values present many ups and downs within the range of 20 km to 30 km from the high value area of farmlands to the interior basin; the highest value is up to 140, while the lowest value is directly down to 60. Does the rapid fluctuation reflect the natural imbalance of soil distribution in the oasis? Or the destruction caused by the artificial oasis development to its surrounded vegetation? It is unclear now according to the revealed images.

Basin vegetation ecological changes during analysis: This study does not consider the change within the year of the farmland in artificial oasis, whose vegetation characteristics are controlled by human activities, merely the nature of vegetation outside the farmland is considered. We selected the maximize composite image per year, extracted the NDVI values which are greater than 160 representing the pixel of the agricultural area, then mask the farmland area in the images of each year, and calculated the average value of NDVI. We found that nature of vegetation changes within the year and shares a quality. The paper lists 10 days NDVI average values in 2003 (Fig. 2).

As we can see from the Fig. 2, the vegetation index increases rapidly starting from mid-March, and reaches the highest level during the end of May to September. It starts to decline in November. This change matches with the precipitation (snow) and temperature changes during the year.

In Fig. 2, there are many multiple inflection points between May to September, which have no commonality in other years, it may be a random variation associated with precipitation and temperature. But there is an undulating fast inflection point whose data fluctuation is big and fast, which is also clear in other years. That is to say, the NDVI values will generally reach a high value in the late May and early June, then will quickly reduce to a low value within the next 10 days, and began to increase later, and will reach a high value again within

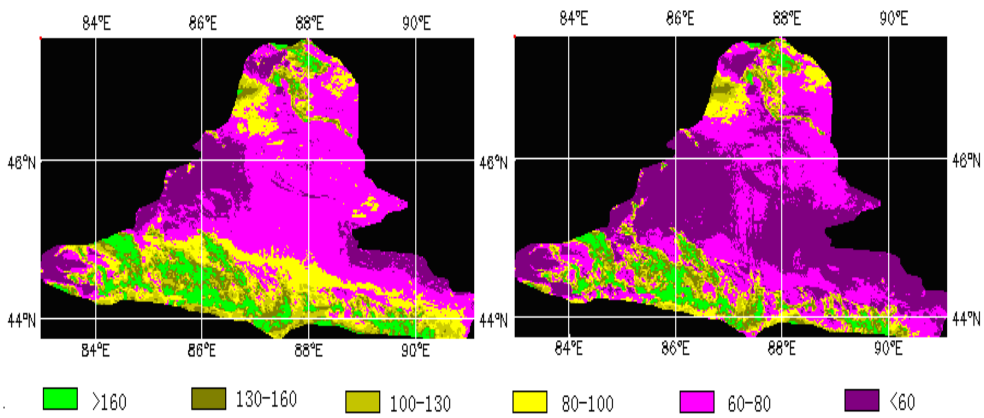

Fig. 1: The vegetation classification result of Junggar basin in 1998 and 2001.

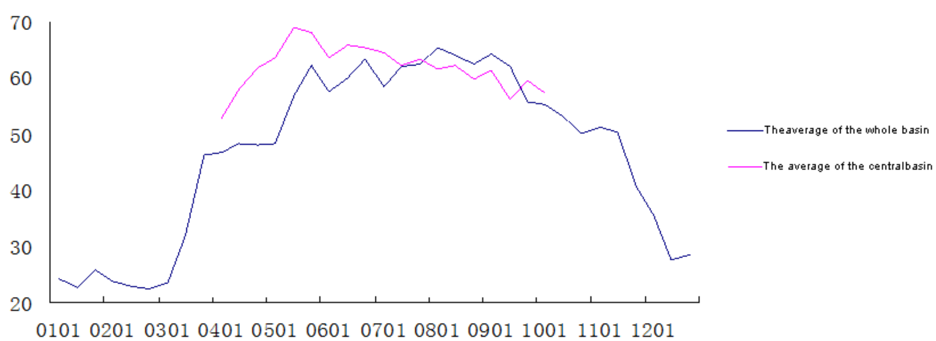

Fig. 2: The NDVI average value of per 10 days in whole 2003 of Junggar basin.

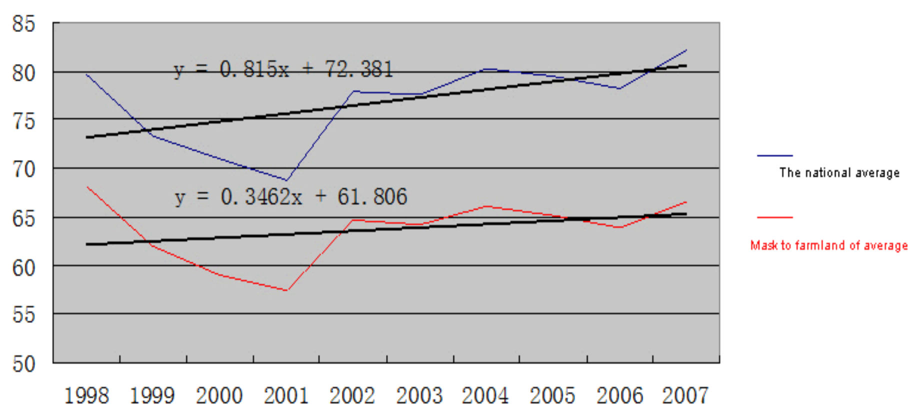

Fig. 3: Change curve of vegetation of Junggar basin between 1998-2007.

20 days. The appearing date of the high value is different each year, but range is between May 21 and June 11. The reason may be that the ephemeral plants flourish in April-May in the Junggar basin which has made the vegetation index increasing rapidly and reaching the peak in mid-late May. The ephemeral plants complete their growth cycle in the next 10 days and rapidly decline which also rapidly reduce the vegetation index. After that, with the lush growth of xeric vegetation, the average vegetation index in the basin began to increase (Wang et al. 2003).

Besides, The NDVI maximum value generally appears from July to August and occasionally appears in late May or early June. Does the appearing time of maximum value in different parts of the basin is consistent? Now, we consider only the central part of the basin. Based on the centre part of the basin, avoiding the low value area in the east-west edge and the oasis area in the south-north ends, we draw a square with its length 300 kilometres, count the average value of

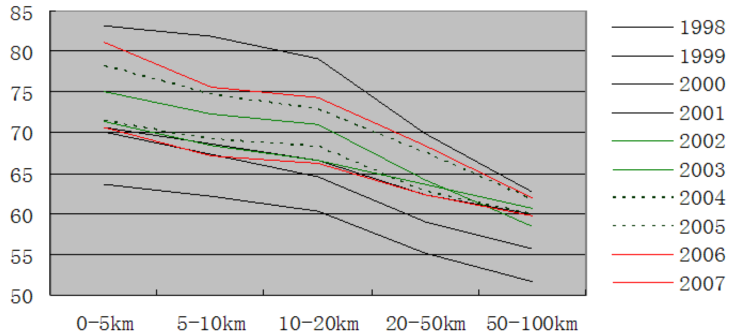

Fig. 4: The change of NDVI average data of variety regions of the artificial oasis edge during 1998-2007.

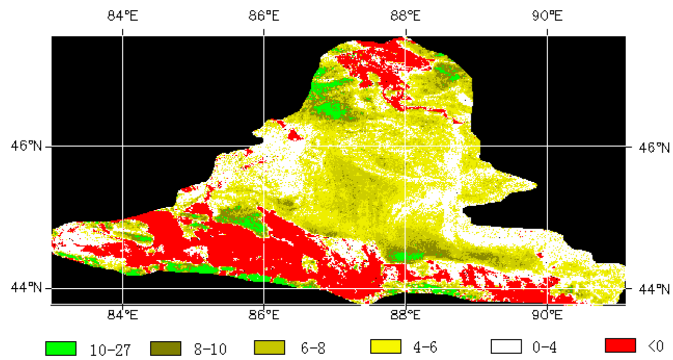

Fig. 5: The subtract and add diagram of high value and low value images of 1998-2008.

NDVI between April and October, and finally we find that the maximum NDVI value occurs in mid-late May, which is significantly higher than in July and August. The situation is the same each year. In the second half of May, the xerophytes just begin to grow; it should be the ephemerals contribution to its high NDVI value. In April, May and June, the dust of Junggar basin gets into the heyday, ephemeral plants reach the peak earlier than the xerophytes during this period, which has an important significance for basin sand.

The analysis of annual vegetation growth status in basin: Two cases are considered here, the first one is to analysis of interannual variability of all vegetation within the basin, and the second one is to mask the farmland area, and then the average values of NDVI in each year were analysed. In the second situation, the farmland area of this region is decreased in a few years, while the area in other years is increasing rapidly. So, the farmland expansions always preferentially occupy the natural vegetation region which is originally well covered. If we mask the farmland area in the current year, it will be lack of contribution of natural vegetation with high NDVI value to the average value compared with the previous year, and the obtained data can not truly reflect the annual dynamics of the natural vegetation. Therefore, we maximize the maximum synthetic graphs in each year within 1998-2007. We did not consider the year 2008, because its data ended on July 21, which cannot represent the annual maximum value. We make a farmland boundary, when the NDVI value is greater than 160, and extract farmland pixels during those years, then select the largest synthetic graph to mask these pixels, so the remaining pixels are of the natural vegetation during the investigation period, and after counting, we obtain the NDVI average value of natural vegetation in each year. The results are shown in Fig. 3.

From Fig. 3, we find that the two curves have the same basic trend, both of them show a significant declining trend from year 1999 to 2001, which is possible and associated with the little precipitation of the basin during the period, or connected with the returning farmland to forest advocated by the State at that time. The NDVI values in year 1998 which are greater than 160 pixel account for 3.8% and only 2.57% in year 2001. Although farmland has been returned to woodland, the natural vegetation has failed to grow up quickly in the cropland, thus it makes NDVI value of the whole basin decreasing. The difference between the two curves is that the average NDVI value of natural vegetation remains unchanged after 2002, while the average value of all the vegetation in the basin including artificial oasis has increased significantly. It also reflects the increase of vegetation in the basin performed as the increase in farmland. From the images, it can be found that the NDVI values in year 2001 greater than 160 pixels (mainly farmland, may also include the riparian vegetation) account for only 2.57% of the whole basin area. The value increases to 6.22% in year 2008, an increase of 1.4 times.

The impact of human behaviour on the basin oasis ecological analysis: Through the method of buffer analysis to the core oasis region, we merely consider the impact of the development of the southern oasis, which is the largest oasis in the basin in the surrounding environment. Firstly, we maximize the synthesis to all images from 1998 to 2008 in the southern part of the basin as per the NDVI values which are greater than 160 to extract all farmland pixels during the past period, and make them as main body or core part of the oasis. Since the polygons of some farmlands are too small, the presence of scattered small polygons can interfere with the consistency of the analysis results if we simply put buffer analysis directly to the plaque. So, we process digitization along the edge of the core oasis carefully which will draw all the polygons of farmland in a large area of farmland. Scattered polygons are also included in this area as the core of the oasis, then make a buffer zone along its borders outward 0-5km, 5-10 km, 10-20 km, 20-50 km and 50-100 km of the oasis respectively. This will guarantee the buffer zone in all years as natural vegetation area, and has a consistent range. The mean value of NDVI between year 1998 and 2007 can be seen from Fig. 4.

Due to the different annual precipitation, the average value in buffer zone in each year has a large fluctuation, but it can still be found that, except the whole low value from year 1999 to 2001, the difference of each belt near the edge of the core oasis in other years performs significantly. As the distance increases from the oasis, the gap gradually decreases to 50-100 km range, and its value shows gradual consistency. Or we can consider that the development activities of human behaviour mainly affect the 50km edge range of the oasis, while the ecological environment in the centre of the basin is more stable unless there is a large fluctuation of natural precipitation, otherwise it will remain stable all the year round.

At the same time, in the early time of investigation stage, we can see that the trend of the curves in each year maintains the basic linear decrease away from the core oasis within 20 km, but rises slightly at the range of 5-10 km in 1998. While in the later years of the investigation period, it gradually shows a declining and bent at the range of 5-10 km, this decline is more obvious in the later period, such as the curves of year 2006 and 2007. To some extent, it illustrate that the development of artificial oasis does affect the growth of surrounded natural vegetation. But the largest impact is in the range of 5-10 km away from the core oasis rather than the nearest edge of the oasis. The reason may be the raising of the level of underground water in the near edge and by much watering to the inside of artificial oasis, the growth of vegetation within 0-5 km is not significantly affected. While within 5-10 km, it is almost free from the impact of groundwater elevation, resulting in variation of vegetation growth. Even most of the water is used for the interior oasis, where groundwater level has been declined and the growth of vegetation has become worst.

Ephemeral plant changes and distribution in the basin: The ephemeral plants have an important impact on the ecological stability in the Junggar basin. As we know from the previous analysis, there is always one of the images showing a high value at the end of May and early of June every year, but shows the low value about ten days later, it can be considered that it is caused by the prosperous and decline of ephemeral plants to certain extent. If the two figures are subtracted, the higher value of the pixel can illustrate the higher coverage of the ephemeral plants to some extent.

We subtract the selected high value images per year from the low value image which is decreased rapidly later, and the results show that in most years, the obviously high value areas in the subtraction images display general characters, but in some years it is different. It indicates that the distribution of ephemeral plants is not fixed and unchanging, and may be connected with interannual variation of local precipitation and temperature (Sufen & Haiping 2010), but may also be related to the noise and error of the image itself (the images have the mosaic and colour variation). If we ignore this difference, and add up the subtracted images of each year, then divided by the total years 11, we can get the figures with average values, the obtained high value areas are consistent with the high value areas in most years (Fig. 5).

The red area in Fig. 5 represents the pixels whose value is negative in the subtracted images, which is consistent with the scope of farmland and water. Other colours represent the positive regions in the subtracted images, and it can be considered that there exist ephemeral plants in these regions to some extent, while the numbers of the value reflect the prosperity of ephemeral plants. From Fig. 5, we can see that except the artificial oasis area, ephemeral vegetation is distributed in the whole basin everywhere, and mainly flourished in the north and south end of the basin, and less in centre of the basin. It forms two prosperous belts with south-north direction around the southern part of the basin, as stated in the previous studies, from the oasis to the basin, the distribution of ephemeral plants is gradually or rapidly reduced (Qian et al. 2007).

For the distribution of ephemeral plants in the central basin, the middle is better than the eastern and western ends. The middle east is slightly better than the midwest part, which is basically consistent with the survey carried out by Yibin

Qian in 2006 (Qian et al. 2007). Meanwhile, in the central basin and north of Changji and Hutubi, it is very common for us to find ephemeral plants in most years, which are forming slightly prosperous area. On the other hand, it also proves the previous conclusions that the maximum values of NDVI in central basin occur at the end of May and in early June and then decreased rapidly. Ephemeral plants have important significance for sand fixation in the basin.

CONCLUSIONS

The conclusions from the study can be drawn as follows:

1. The general ecological pattern of the basin is that the continuous oasis belt is apparently formed in the south, in the north region there is a small oasis area, and the ecological condition is poorer in the centre of the basin but stable.
2. The natural vegetation in the basin has increased rapidly in the second half of March, and maintains a high stable level between late May and September, then began to decrease and the situation is very apparently in November. The prosperous and subsequent decline of ephemeral vegetation during this period has shown inflection point in late May and early June. The ephemeral plants are distributed in the whole basin except the artificial farmland, flourished in the oasis edge, and are rare in the central part of the basin. Ephemeral plants are very important for the sand fixation in the basin, the main evidence is the highest value of NDVI in the centre of the basin appearing in late May and early June.
3. The average value of NDVI in the basin is low during 1999-2001, keep increasing after year 2002, but the natural vegetation remains unchanged. It indicates that the increase of NDVI value in the basin is mainly from the agricultural expansion.
4. The developmental activities of human mainly affect the edge of the oasis with the range of 50 km; the greatest impact area is near the edge of the oasis with 5-10 km, and the reason may be the raising of underground water level in oasis within the range of 5-10km causing the decline of groundwater level within the range of 5-10km away from the basin.

The conclusion of this paper is only according to the remote sensing image, and there may be errors in the analysis results owing to splicing boundaries and noise in some images with no corrections. Especially, the distribution of ephemeral plants in space shows as one similar distribution in some subtraction diagrams, while it shows another similar distribution in other years. It is difficult to measure the influence caused by the image errors.

ACKNOWLEDGEMENTS

This research is financially supported by the National Key Basic Research Development Plan (973) Project (2010CB951004) and National Natural Science Foundation of China (41201113, 41130531).

REFERENCES

Chen Changdu, Zhang Liyun and Hu Wenkang 1983. The basic characters of sand plant distribution in the Gunbantunggut desert. Plant Ecology and Ground Botany Cluster, 7(2): 89-99.

Zhang Linjing 2002. Diversity and soil factors in ecotone between desert and Oasis in Fukang, Xinjiang. Chinese Journal of Applied Ecology, 13(6): 658-662.

Liu Zili, Huang Peiyou and Liu Li 1995. The relationship of ephemeral plants and part geography in Mo Suo Wan 150 regiment. Xinjiang Environmental Protection, 17(3-4): 7-10.

Liu Maoxiu and Shi Yanjiang 2007. The ecology environment and manage method in south of Junggar basin. Protection Forest Science and Technology, 79(7): 66-67.

Pan Xiaoling and Chang Hungta 1996. Research on the characteristics of vegetation and the forming of flora in Zhungeer basin, Xinjiang. Supplement to the Journal of Sunyatsen University, 2(96): 11-17.

Qian Yibin, Wu Zhaoning and Zhang Liyun 2007. The space distribute of ephemeral plants in the Gunbantunggut desert. Science Notifies, 52(19): 2299-2306.

Qu Guosheng, Ma Zongjin and Chen Xinfa 2009. Study on Structure and evolution of Junggar basin. Xinjiang Petroleum Geology, 30(1): 1-5.

Ren Jun and Tao Ling 2005. Multivariate characterization of vegetation in Junnger basin. Acta Agrestia Sinica, 13(2): 134-139.

Sufen Yuan and Haiping Tang 2010. Patterns of ephemeral plant communities and their adaptations to temperature and precipitation regimes in Dzungaria desert, Xinjiang. Biodiversity Science, 18(4): 346-354.

Wang Ye 1993. Phenological observation of the early spring ephemeral and ephemeroid plant in Xinjiang. Arid Zone Research, 10(3): 34-39.

Wang Xueqin, Jiang Jin and Lei Jiaqiang 2003. The distribution of ephemeral vegetation on the longitudinal dune surface and its stabilization significance in the Gunbantunggut desert. Acta Geographica Sinica, 58(4): 598-605.

Wang Ji, Lv Zhaozhi and Qian, Yi 2010. Soil Nutrients under vegetation of different desert landscapes in Junggar basin, Xinjiang. Journal of Desert Research, 30(6): 1367-1373.

Zhang Liyun 1985. A Preliminary study on the ephemerals of Mosowan district, Xinjiang. Acta Phytoecologica Geobotanica, 9(3): 213-222.

Zhang Linjing, Yue Ming and Gu Fengxue 2002. Coupling relationship between plant communities' species diversity and soil factors in ecotone between oasis and desert in Fukang, Xinjiang. Chinese Journal of Applied Ecology, 13(6): 658-662.

Zhu Yuwei, Chen Qiming and Liu Maoxiu 2009. The research of artificial promoting natural vegetation renewal on the southern fringe of Junggar basin. Xinjiang Agricultural Sciences, 46(5): 1144-1148.

Zhang Shijun 2010. Initially search on south of the Songorine basin in the reason activation sand dune vegetation restores naturally-take the Sacsaoul, The White Sacsaoulas the Example. Arid Environmental Monitoring, 24(3): 153-157.