Restoration of Desertified Grassland and Challenges in Northern China--for the Possibility of Sustained Desertification Reversion

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Restoration of desertified grassland and challenges in northern China—for the possibility of sustained desertification reversion

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Key points : There is about 0 .39 billion ha of grassland in China , covering about 40% of the country s land , of which 52% is in the western five provinces . However , about 70% of the grassland is desertified due to climate and land use changes . Through more than 50 years of efforts in combating desertification , grassland desertification was reversed in northern China , particularly in Horqin Sand Land of Inner Mongolia .

Research in Horqin Sand Land showed that desertification of grassland has been reversed since the middle of the 1980s . Reversion occurs over a much longer time period than degradation and the restoration of grassland function is far slower than that of grassland vegetation characteristics , such as height and coverage . However , this reversion is challenged by several factors , such as reduction of water availability and increasing land use change .

Key words : grassland , desertification , climate change , land use change , reversion

Introduction

Grassland is one of the important biomes in the world , and it has nourished not only lives , but also different cultures in the long history of its succession . However , grassland has been rapidly decreased due to degradation caused by climate change and human activity (UNEP , 1997) .

China is one of the countries in the world with the largest grassland . The total grassland in China is about 390 million hm^2 , covering about 40% of the country s land (Q . Zhang , etc . , 1998) , and about 52% of the grassland is distributed in Inner Mongolia , Gansu Province , Qinghai Province , Xinjiang Uyur Autonomous Region and Tibet . However , grassland has been severely degraded in the last century threatening about 120 million people and more livestock , and unknown wild species (Zhao Halin , 2004) . The agro-pastoral transitional area , covering 0 .80-1 .00 million km^2 in northern China has been identified as one of the areas of high risk of desertification due to its ecological fragility .

In the last 50 years , the Chinese Central Government and local organizations have made a great effort in restoration of degraded grassland . However , the general trend of desertification expansion has not changed . That is why people persistently ask how desertification has changed and what are the challenges or obstacles to the reversion of grassland desertification now and in the foreseeable future . These questions on desertification in Northern China were discussed with Horqin Sand Land as a case study in this article .

Horqin Sand Land is a typical agro-pastoral transitional area , located in the northeastern part of Inner-Mongolia of China . The landscape is mainly characterized with gently undulating sandy land dotted with various sizes of dunes , meadows and farmlands . The zonal soil is chestnut , but it is almost replaced with eolian sandy soil due to desertification . The underground water table is 2-5 m . The aboriginal vegetation is tree-scattered steppe , but now , mostly replaced by psammophytes . Desertified land was increased from 20% of the total land in the 1950s to 53% in the 1970s and 70% in the 1980s . In the past 40 years , approximately 400 ,000 ha grassland and 270 ,000 ha farmland had been buried under drifting sand in Tongliao Prefecture , which covers about 56% of Horqin Sand Land . Monitoring has found that desertification , as a whole , in Horqin Sand Land has been revered since 1987 . However , this reversion is challenged by the reduction of water availability , degraded vegetation components and function .

Materials and methods

Data of grassland and desertification changes and sand and dust storms are from the database of Naiman Desertification Research Station , Chinese Ecosystems Research Network (CERN) . Vegetation data is from the Grazing Experiment . MS Excel 2003 and SPSS 11 .4 were used to analyze the data .

Results

Grassland Distribution in China

As mentioned above , China is one of the countries with the largest grassland in the world . However , grassland distribution is very diverse , about 52% of the grassland is distributed in the five western provinces , such as Inner Mongolia , Gansu , Ningxia , Xinjiang and Tibet . Inner Mongolia has the largest area of grassland . Of this grassland , about 70% has been degraded due to

overgrazing and fuel wood harvesting (Liu Xinming , etc . , 1993) .

This distribution pattern means that grassland is mainly distributed in the arid and semi-arid and sub-humid area of China and this puts the grassland ecosystems into severe risk of high fragility . Since the late 19th century , cropland has invaded the frontier of grassland , the agro-pastoral area , and this invasion has been identified as one of the primary forces leading to desertification (Zhu Zhenda , 1994 ; Zhao Halin , 2004) .

Grassland Degradation

It is calculated that desertified land covers about 740 ,000 km^2 in China and is expanding at an annually averaged rate of 1 ,560 km^2 in the period of 1950's to 1970's , 2 ,100 km^2 from 1970's to late 1980's , and 2 ,460 km^2 in the period from 1980's to 1990's , as well as-1250 km^2 from 2001 to 2004 (Zhu Zhenda , 1989 ; 1994 ; Wang Tao , 2003 ; Wu Wei , 1997 ; 2001 ; National Forestry Administration , 2005) . About 50% of the desertified land is from grassland degradation in the five provinces due to over-grazing , cropland invasion into grassland , fuel wood collection and misuse of water .

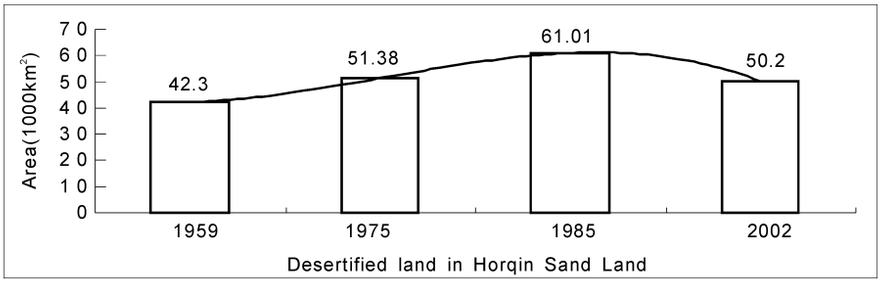

Figure 1 *Desertified land change in Horqin Sand Land (Wu Wei , 2001) .*

Horqin Sand Land is once one of the four larger grasslands in Inner-Mongolia . However , according to Wu Wei (2001) , it went through a phase of rapid desertification from 1959 to 1985 . Since 1987 , desertification has been reversed from 61 .01 thousand km^2 to 50 .2 thousand km^2 in 2002 (Figure 1) . This reversal is being questioned , given the recent increase in the frequency of sand and dust storms and decreased water availability (Zhaohua Huang , 1997 ; Xueyong Zhao , 2001) .

Causes of Grassland Degradation It is impossible to quantify the historic causes of desertification . Fortunately , there is a series of records of sand and dust storm frequencies and population change in the history of China .

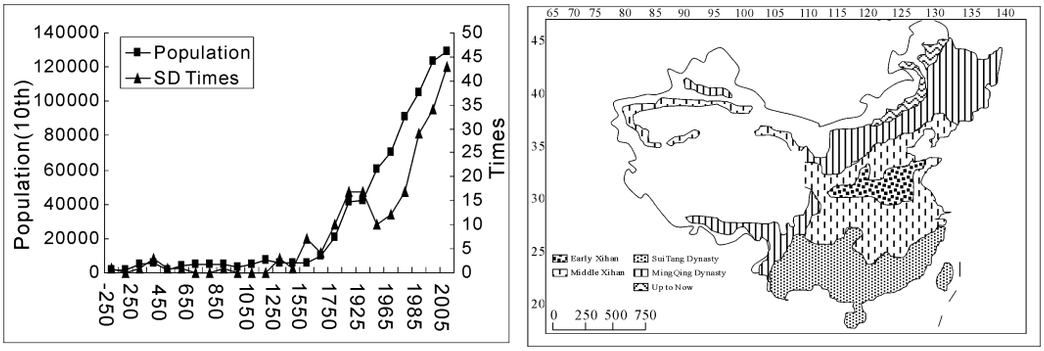

Figure 2 *Population and dust storm changes (left , SD = sand & dust) and land use change (right , redrawn from Gao Qinghua , etc . , 1994) in China .*

Figure 2 (left) shows a close relation between the population and sand and dust storm frequency . Is this relation just a haphazard or reflection of the inner characteristics of these two parameters ? More data and research are needed .

Figure 2 (right) shows the land use change in China since the Xizhou and Xihan Dynasty (206b .c .-a .d . 220) . It is clear that cropland in the Early Xihan was distributed in the Middle of the Eastern Part of China and then expanded to the large area between the Huanghe and Yangtze River and westwards to Southern Xinjiang in the middle of the Han Dynasty . This coincides with the facts of expansion of desert and desertified land in Xinjiang . In the Sui and Tang Dynasty (581-907) , cropland extended further to the Southern Part of China and in the Ming Qing Dynasty , cropland was expanded to the northeastern part

of China and Northern Xinjiang . Since the early of last century , cropland has extended even far northwards into the grassland of Inner Mongolia , which is more fragile to human activity . As one of the results , cropland land in Horqin Sand land accounts for 36% of the total of Inner Mongolia . This change in land use has made this area into a part of the most severely desertified land during the period of 1950s to 1980s and it has become the leading cause of the reduction of water availability and the top challenge to desertification reversion in this region (Zhao Xueyong , 2001) .

Climate Change

Figure 3 showed that in the past 40 years , the air temperature has increased by about 0 .6-0 .98℃ , and the annual mean precipitation has reduced by 50-180 mm in Horqin Sand Land , particularly since 1999 . This change has greatly reduced the water availability , characterized with drying-up of the West Lakes and Xiliao River and the reduction of underground water by 2 .4 to 4 .6 m (Zhao Xueyong , 2001) . It also clearly showed that there is a general trend of aridification in Horqin Sand Land since the late 1990s . This trend has impacted severely on the ecosystems and socio-economic activities .

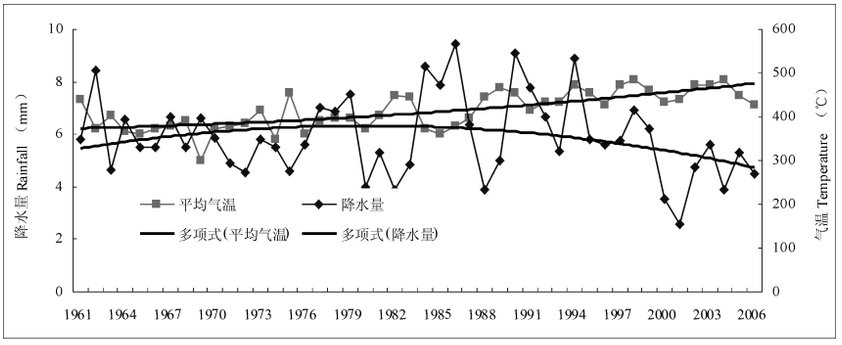

Figure 3 *Changes of annual precipitation and air temperature in Horqin Sand Land(Data from Naiman Desertification Research Station) .*

Restoration of Degraded Grassland

China has put the greatest efforts in desertification control , including promoting desertification research and related techniques for shifting dune fixation and strategies for sustainable land use . The most influential effort is implementation of the national projects Re-afforestation in the Northwestern , Northern and Northeastern Part of China , known as the Three Northes Re-afforestation Project , and Restoration of Cropland into Grassland or Woodland Project . In the past 20 years , the Three Northes Re-afforestation Project has planted 25 .16 million ha of trees and bushes , and about 1 .5 million ha of grassland was protected and 30 .03 million ha of degraded grassland restored from 1999 to 2004 . Inner Mongolia has also restored 2 .44 million ha of cropland into grassland . In addition to these projects , the Chinese government has made a series of laws to enhance and/or secure desertification control , such as the Soil and Water Conservation Law , Forest Law , Law of Desertification Prevention and Control , and Grassland Law . Horqin Sand Land is one of the first places that is implementing these projects and adopting the related laws .

Monitoring has shown that grassland has only changed slightly between 1980 and 2004 in Gansu , Qinhai , Xinjiang and Tibet . However , it has increased from 0 .79 million hm^2 in 1980 to 0 .89 million hm^2 in Inner Mongolia . This increase is mainly attributed to the implementation of the project's restoration of cropland into grassland and/or woodland . For example , about 23 .0 thousand km^2 cropland was restored into grassland from 1999 to 2002 in Inner-Mongolia .

However , either in the restored grassland or abandoned cropland , vegetation restoration needs a long time and is influenced by various factors . Figure 4 (left) presented the results of a grazing experiment . This experiment includes one control of no grazing (NG) , one heavy grazing (HG) , one moderate grazing (MG) and one light Grazing (LG) . From 1991 to 1996 , these three treatments were applied . Since 1996 grazing was prohibited and the grasslands were restored . From Figure 4 , it is clear that the vegetation height was gradually restored after grazing was excluded but has declined since 1999 when this area suffered from drought . Those of the heavily grazed , moderately grazed and slightly grazed treatments decreased from 1991 to 1996 , and then were restored after grazing was excluded in 1996 (Zhao Halin , 2004) .

After 20-years of restoration , the vegetation change of the control represented the natural restoration process of the degraded grassland . It is interesting that *Ulmus pumila* , one of indicative aboriginal species in the region , has been gradually restored . But this restoration is challenged by the evidence that productivity has consistently decreased from about 500g/m^2 in 1937 , to 370 g/m^2 in 1982 , 220 g/m^2 in 1993 and to 192 g/m^2 in 2002 (Figure 4 right) (Zhao Xueyong , 2007) .

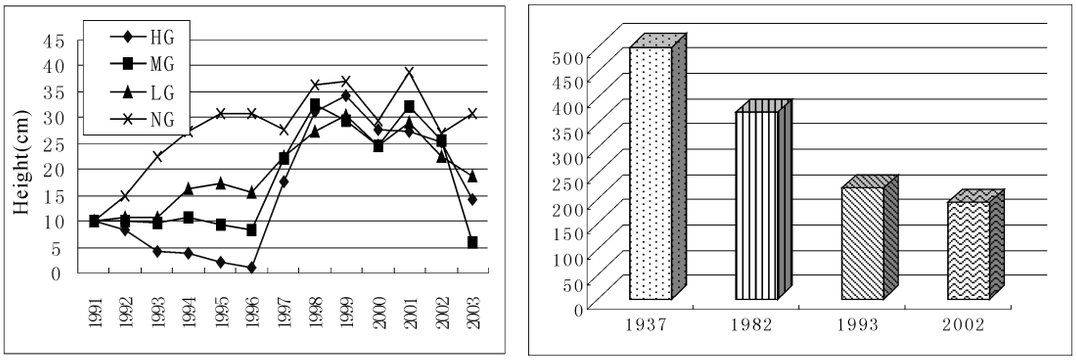

Figure 4 *Height Change of Restored Grasses (left) in Grazing Experiment Sites and aboveground biomass (right) in Horqin Sand Land .*

Discussion

Grassland covers about 0 .4 billion ha in China , and about 52% of this grassland is distributed in Inner Mongolia , Gansu , Ningxia , Xinjiang and Tibet . This distribution pattern puts grassland ecosystems into a high risk of degradation , with about 50% of the grassland in theses provinces degraded .

China has put a great effort into combating desertification , and have been rewarded by local restoration of degraded ecosystems , however as a whole , desertification is still expanding at an arguable rate . Ecological vulnerability of northern China is the leading factor of desertification ; however , problems in the implementation of the laws and projects that are aimed at reversing degradation are obstacles to progresses in desertification prevention and control . The growing population and the expectation of the locals for growing capital income are also driving forces to challenge combating desertification in northern China (Sara Brogaard , 2002) .

Restoration of the degraded ecosystems should include the restoration of both composition and function , such as diversity and bio-productivity , of the ecosystems . Taking the reduction of water availability and bio-productivity into consideration , clearly , desertification reversion in Horqin Sand Land means only restoration of vegetation cover (Zhao Xueyong , 2001 ; 2007) . Even this restoration strongly showed the potential of natural restoration of degraded grassland ecosystems driven by the annual precipitation of 300-500 mm (Xueyong Zhao , 2001) . That is why research-based objective assessment of the restoration of desertified land and the development of a set of indicators for this assessment has become the top two issues in desertification research and desertification prevention in grassland ecosystems .

The emergence of *Ulmus pumila* in the controlled grazing experiment showed the potential and possibility of natural restoration of the degraded grassland to its original state or near-original state (Zuo Xiaoan , 2007) . It seems clear that improper human interference is the key obstacle to restoration of grasslands to their near-original states , as a whole , in China , and how to get sustained reversion of desertification will be the impending challenge that faces both the researchers and decision makers .

Conclusions

From the above , it is tentatively concluded that China has the largest area of grassland in its western , northern and northeastern part , but about 70% the grassland has been desertified . In the past 50 year , China has made some progresses in combating desertification of grassland through restoration of desertified grassland , particularly in the region of annual precipitation of 200 to 500 mm . But the progress has been challenged or even compromised .

These challenges were mainly caused by the problems of inappropriate land use driven by the ever-lasting increase in population , and expectation of the locals for growing capital income , in addition to the high ecological vulnerability of the ecosystem .

Through more than 50 years of efforts in desertification control and rationalization of land use , desertification in Horqin Sand Land was reversed . But reduction of the water availability and nearly stagnant restoration of the degraded ecosystem function and diversity , compared to the degradation process , leave several key issues for researchers and decision makers .

Gratitude

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