Developing stages and causes of desertification in the Mu Us sandland

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Abstract Based on historical aerial photography of three periods and together with field investigation, the status of desertification development after the 1950s in the Mu Us sandland was analyzed, the difference of the desertification developing speed at two stages was compared, and its possible causes were explored. The results show that the developing speed of desertification from the late 1970s to the early 1990s is apparently slowed down, compared with that from the late 1950s to the late 1970s and there exists an obvious recovery trend at the second stage. The difference between the two stages accounts for severely over-reclaiming, over-grazing and unrestricted cutting during the first stage, which are the main causes of desertification development in the semi-arid steppe and arid desert steppe areas.

Keywords: **Mu Us sandland, desertification developing stage, over-reclaiming, over-grazing, unrestricted cutting.**

THE status of desertification development provides the important basis for making the strategies of desertification control and the rational plan of land use in arid and semi-arid areas. Zhu *et al*. compared the status

of some typical desertification areas of northern China by using the aerial photographs and satellite images and predicted their developing trends[1, 2]. In this note, by interpreting the black-and-white aerial photographs of three periods and six typical sites from the late 1950s to the late 1970s and from the late 1970s to the early 1990s and associated landscape mapping, the status of desertification development of the two stages in the Mu Us sandland located in the agro-pasture transitional zone of northern China was analyzed and compared and, furthermore, the causes of the desertification in this area were explored.

1 Methods

(ⅰ) Typical sites selection. Nine typical sites in the Mu Us sandland were selected according to the spatial differences in physical and socioeconomic conditions, and components and structure of landscape. However, the aerial photographs (in scale 1:36 000—1:65 000) of three periods (1958, 1977, 1993) were only available in four typical sites, two of which were divided into two parts according to their interior differences, thus there are six typical sites used in this research (table 1).

Table 1 Features of the typical sites

No.	Typical site	Administrative region	Area/km^2	Annual precipitation/mm	Topography	Land use
1	Chengchuan-1	Chengchuan Sum, Front Otog Banner	98.86	350—400	terrain sandland in ridge	grazing
2	Chengchuan-2	Chengchuan Sum, Front Otog Banner	63.03	350—400	river beach	farming
3	Kekegai	Kekegai Xiang, Yulin City	58.27	350—400	terrain sandland in the transitional zone between ridge and river beach	grazing
4	Bulanghe	Bulanghe Xiang, Yulin City	28.60	350—400	terrain sandland in the transitional zone between ridge and river beach	farming and grazing
5	Taoli	Taoli Sum, Uxin Banner	105.80	280—330	river beach and terrain sandland in the transitional zone between ridge and river beach	grazing
6	Chengjiao	Chengjiao Xiang, Yanchi County	92.24	250—350	transitional zone between sandland and hills	farming and grazing

(ⅱ) Landscape classification and cartography. According to the resolution of aerial photographs, the Mu Us sandland can be classified into 17 landscape element categories. They are: (1) grassland; (2) fixing sandland; (3) transitional type between fixing and semi-fixing sandland; (4) semi-fixing sandland; (5) shifting sandland; (6) complex of sand dunes and salinized and/or damp lowlands between sand dunes; (7) river beach salinized and/or damp; (8) complex of fixing or semi-fixing sand dunes and willow lowlands; (9) complex of shifting sand dunes and willow lowlands; (10) farmland; (11) complex of farmland and fixing sand dunes; (12) shrubs; (13) artificial forests; (14) water body; (15) town; (16) village, and (17) stock-raising households. On the basis of the field investigation, the interpretation indicators were determined and the landscape maps were completed by visual interpretation. These maps were digitized and processed with ARC/INFO. The 1:50 000 topographic maps were used for spatial modification and match. As a result, 18 landscape category maps were completed for 6 typical sites and three periods.

2 Results

So far, there have not been standard and reliable indicators that can be generally adopted in desertification monitoring and evaluating. Categories (3), (4), (5), (6) and (9) were recognized as desertification land, in which category (3) is the transitional type from fixing sandland to semi-fixing sandland and

was slightly degraded. Grassland and farmland were degraded to varying degrees, but it is difficult to identify on landscape scale.

The area of the desertification land and its major components at three stages, including semi-fixing sandland and shifting sandland, were compared (fig. 1). At Chengjiao, Taoli and Kekegai, the area of desertification land increased continuously; at Chengchuan-1 and Chengchuan-2, increased and then decreased, and at Bulanghe, decreased continuously. The area of the semi-fixing sandland and shifting sandland presented the same trend as that of the desertification land at Chengjiao, Taoli, Kekegai and Chengchuan-1. The area of the semi-fixing sandland increased continuously at both Chengchuan-2 and Bulanghe, while at Chengchuan-2, the shifting sandland first decreased and then increased, and at Bulanghe decreased continuously.

In general, from the 1950s to the 1990s, the area of desertification land increased obviously except Chengchuan-2 and Bulanghe. However, the developing speed of desertification was different at two stages, i.e. from the late 1950s to the late 1970s (1958—1977) and from the late 1970s to the early 1990s (1977—1993). The speed at the first stage was much faster which was 2.6, 3.4 and 2.3 times as much as that at the second stage at Chengjiao, Taoli and Kekegai, respectively. The area of desertification land at Chengchuan-1 and Chengchuan-2 increased at the first stage and decreased at the second stage, and at Bulanghe, it decreased slowly at the first stage and decreased rapidly at the second stage (table 2). The results indicated that the developing speed of desertification at the second stage was apparently slowed down and desertification land at some local areas showed an obvious recovery trend.

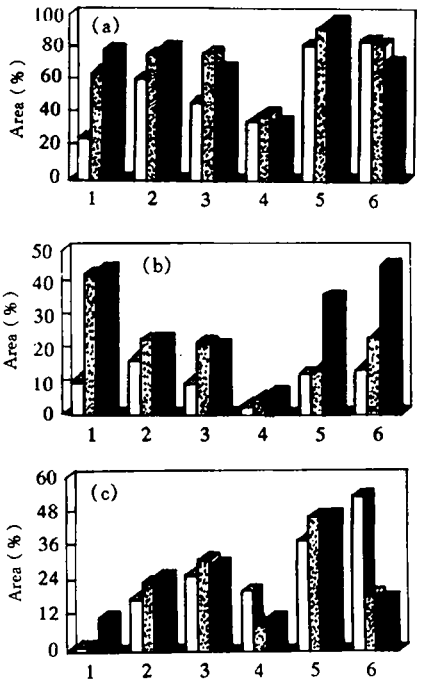

Fig. 1. Increasing speeds of desertification land (a), semi-fixing sandland (b) and shifting sandland (c) at six typical sites. 1, Chengliao; 2, Taoli; 3, Chengchuan-1; 4, Chengchuan-2; 5, Kekegai; 6, Bulanghe. □, 1958; ▨, 1977; ■, 1993.

Table 2 Developing speeds of desertification at different stages ($km^2/a \cdot 100\ km^{-2}$)

Typical site	1958—1977	1977—1993	1958—1993	Typical site	1958—1977	1977—1993	1958—1993
Chengchuan-1	2.08	0.81	1.50	Bulanghe	0.26	-0.39	-0.03
Chengchuan-2	0.79	0.23	0.53	Taoli	0.52	0.23	0.39
Kekegai	1.57	-0.61	0.58	Chengjiao	-0.10	-0.71	-0.38

3 Cause analysis

Desertification seems to result from the interaction of climatic variations and human activities. Since the 1950s, in the Mu Us sandland, the annual mean temperature has been rising gradually (about 0.1℃ per 10 years) but the annual precipitation has decreased (fig. 2). Therefore, the climate tends to drought, which favors the development of desertification. On the contrary, the speed of desertification development at the second stage was lower than that at the first stage, and the desertification land was rehabilitated at some areas due mainly to the less effect of human activities. Over-reclaiming, over-grazing and unrestricted cutting are the three principal factors to cause the desertification[3, 4].

(1) Over-reclaiming. It is reported that[5] the Ordos area was involved in three large-scale reclamations from the 1950s to the 1970s, the grassland of $4.0 \times 10^3\ km^2$ was reclaimed in Ih Ju League, resulting in the land desertization of $1.2 \times 10^4\ km^2$. At Sanduandi, Erdaochuan, Chengchuan, etc. of Front Otog Banner, $1.53 \times 10^2\ km^2$ of grassland was reclaimed from 1956 to 1958. $3.67 \times 10^2\ km^2$ of grassland

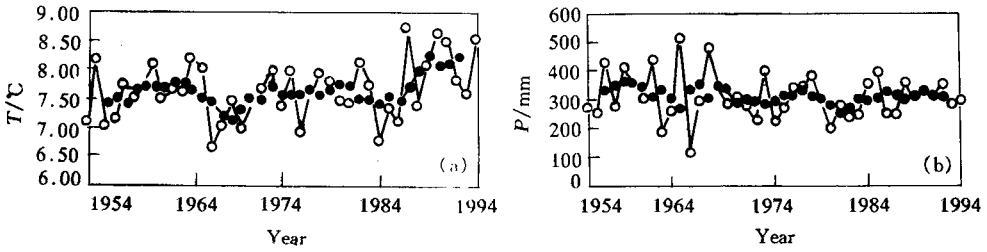

Fig. 2. The annual mean temperature (T) and annual precipitation (P) from 1954—1994 in the Mu Us sandland (average of the data from 10 meteorological stations). —○—, Annual mean; —●—, 5-year running mean.

was reclaimed at Sandaoquanzi and Mogoit from 1960 to 1962. 1.8×10^2 km^2 of grassland was reclaimed at Bulag, Mogoit, etc. from 1969 to 1971. During the three large-scale reclamations, 3.73×10^2 km^2 of grassland was reclaimed into farmland in total at Unix Banner. From the 1980s later, unrestricted reclamation decreased greatly. According to the statistic data[1)], the mean area of farmland during the 1950s, 1960s, 1970s and 1980s at Otog Banner, including Front Otog Banner, is 8.7×10^3, 6.45×10^3, 3.72×10^3 and 1.21×10^3 km^2 respectively, which decreased continuously. The area of farmland in the 1980s is equivalent to 14% of that in the 1950s and 42.8% in the 1960s.

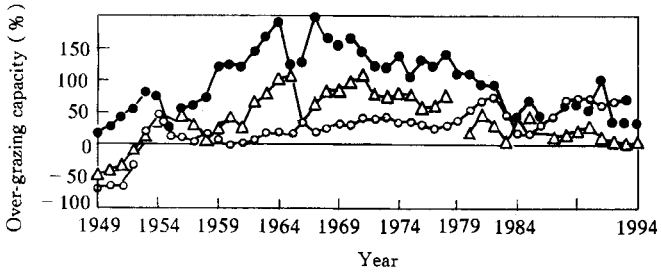

Fig. 3. Over-grazing capacity at some counties from 1949—1994 in the Mu us sandland. —△—, Otog; —●—, Uxin; —■—, Yulin.

(ii) Over-grazing. Over-grazing in the Mu Us sandland was quite severe in the 1960s and 1970s. At Uxin Banner, over-grazing was nearly 200% above the carrying capacity. Livestock gradually decreased after the 1980s (fig. 3). Simultaneously, the proportion of raised goat decreased, for example, the ratios of goat to sheep were 4:1 and 1:10 in 1961 and 1991, respectively.

(iii) Unrestricted-cutting. It is surveyed that in mid-1970s, 13 700 households at Uxin Banner destroyed 2.4×10^2 km^2 of fixing sandland annually due to collecting firewood. The fixing sandland in the extent of 10-km radius at Dabuqah Town, in which the Uxin Banner government is located, was almost destroyed. This town is now completely surrounded in the sea of shifting sandland. Digging medicinal herbs such as licorice root and Chinese ephedra also contribute to the serious damage of pasture. Since the 1980s, due to adopting the tenure system fixing to each household and the effective management of pasture by herdsman himself, over-reclaiming, over-grazing, and unrestricted cutting have gradually decreased.

In the semi-arid steppe and arid desert steppe areas, the principal causes of desertification are over-reclaiming, over-grazing and unrestricted cutting. Provided the restriction was given to the human activities, the desertification would be slowed down and reversed.

Acknowledgement We are grateful to Profs. Cui Haiting, Wang Naibin and Chen Baiming for their assistance and to Prof. Dong Guangrong for many suggestions. This work was supported by the "Ninth-Five-Year" Key Project (Grant No. 96-017-01-05) of the State Science and Technology Commission and the Fund for Science and Technology Development of Chinese Academy of Forestry.

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